

# INTERNATIONAL YEDITEPE SCIENTIFIC RESEARCH



## CONGRESS-III

OCTOBER 11-12 | 2025  
ISTANBUL, TÜRKİYE



# PROCEEDINGS BOOK

EDITORS

Prof. Francisco Javier Jiménez Tecillo

Dr. German Martínez Prats



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ISARC

INTERNATIONAL SCIENCE AND ART RESEARCH CENTER

# 3<sup>rd</sup> INTERNATIONAL YEDITEPE SCIENTIFIC RESEARCH CONGRESS

*October 11-12, 2025 / Istanbul, Türkiye*

## PROCEEDINGS BOOK

### EDITORS

Prof. Francisco Javier Jiménez Tecillo  
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by

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# CONGRESS ID

## CONGRESS TITLE

3<sup>rd</sup> International Yeditepe Scientific Research Congress

## DATE and PLACE

October 11-12, 2025 / Istanbul, Türkiye

## PARTICIPATION

Keynote & Oral

## PARTICIPANTS COUNTRY

Türkiye, Albania, Algeria, Azerbaijan, Greece, Hungary, India, Indonesia, Kazakhstan, Kosovo, Lithuania, Mexico, Morocco, Nigeria, Pakistan, Serbia, Slovakia, Tunisia, Ukraine, Vietnam

## CONGRESS COORDINATOR

Umida MAVLYANOVA

NUMBER of ACCEPTED PAPERS-133 (Türkiye- 65, Other Countries- 68)

NUMBER of REJECTED PAPERS-15

## EVALUATION PROCESS

All applications have undergone a double-blind peer review process

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*Scientific Development and Innovative Approach*

# INTERNATIONAL YEDITEPE SCIENTIFIC RESEARCH CONGRESS

October 11-12, 2025 / Istanbul, Türkiye

## Congress Program

*Participant Countries: Albania, Algeria, Azerbaijan, Greece, Hungary, India, Indonesia, Kazakhstan, Kosovo, Lithuania, Mexico, Morocco, Nigeria, Pakistan, Serbia, Slovakia, Tunisia, Türkiye, Ukraine, Vietnam*

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To be able to make a meeting online, login via <https://zoom.us/join> site, enter ID instead of “Meeting ID or Personal Link Name” and solidify the session. The presentation will have **15 minutes** (including questions and answers). The Zoom application is free and no need to create an account. The Zoom application can be used without registration. The application works on tablets, phones and PCs. Speakers must be connected to the session **10 minutes before** the presentation time. All congress participants can connect live and listen to all sessions. During the session, your camera should be turned on at least %70 of session period. Moderator is responsible for the presentation and scientific discussion (question-answer) section of the session.

### TECHNICAL INFORMATION

Make sure your computer has a microphone and is working. You should be able to use screen sharing feature in Zoom. Attendance certificates will be sent to you as pdf at the end of the congress. Moderator is responsible for the presentation and scientific discussion (question-answer) section of the session. **Before you login to Zoom please indicate your name surname and hall number, exp. Hall-1, Fatih KARIPOĞLU**

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### TEKNİK BİLGİLER

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**ZOOM MEETING ID: 830 0628 1090 / PASSCODE: 798608**

**<https://us02web.zoom.us/j/83006281090?pwd=Lf5PlWCGjczhseGh2lp05oEGIVdTFy.1>**

## 12.10.2025 / Hall-1, Session-1



ANKARA LOCAL TIME

10<sup>00</sup> : 12<sup>00</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

HEAD OF SESSION: Dr. Seyfaddin JAFAROV

TOPIC TITLE	AUTHORS	AFFILIATION
Yağmur KIVRAK Serkan YILMAZSÖNMEZ Ahmet Can ÜNAL	R&D Specialist, Marshall Paint and Varnish San. A.Ş.	EFFECTS OF PARTICLE MORPHOLOGY, FILM HARDNESS, AND HYDROPHOBIC STRUCTURE ON SCUFF-RESISTANCE IN PAINT FILM
Merve Konuk Ziya Kemal Arş. Gör. Ozan Toker Prof. Dr. Orhan İçelli	Yıldız Technical University	COMPARISON OF ARTIFICIAL INTELLIGENCE APPROACHES FOR AUTOMATIC DETECTION OF LOW-GRADE GLIOMAS
Dr. Seyfaddin JAFAROV	Nakhchivan State University	OPTICAL PROPERTIES OF DOPED SEMICONDUCTOR CdSe;0.5%Ho NANOCRYSTALS
Sevil Güneralp Prof. Dr. Uğursoy Olgun	Sakarya University	SYNTHESIS, CHARACTERIZATION, AND DOPING OF CONDUCTIVE POLYANILINE AND ITS COPOLYMERS
Kübra KOP TÜRKÖĞLU Assoc. Prof. Dr. Nihal ŞİMŞEK ÖZEK Prof. Dr. Ömer ANDAÇ	Ondokuz Mayıs University Atatürk University	DETECTION OF ADULTERATION IN HEMP SEED OIL USING FTIR SPECTROSCOPY AND CHEMOMETRIC METHODS
Assoc. Prof. Dr. Gülşah SAYDAN KANBEROĞLU Nurcan KAYA Prof. Dr. Mehmet Salih AĞIRTAŞ	Van Yuzuncu Yil University	DEVELOPMENT OF A PHTHALOCYANINE BASED PVC MEMBRANE POTENTIOMETRIC SENSOR FOR THE DETERMINATION OF LEAD(II)
Şekip DALGAÇ Kağan Murat PÜRLÜ Kholoud ELMABRUK	Sivas University of Science and Technology	PROPAGATION OF HOLLOW HIGHER- ORDER COSH-GAUSSIAN BEAMS IN TURBULENT ATMOSPHERE
Şekip DALGAÇ Kağan Murat PÜRLÜ Kholoud ELMABRUK	Sivas University of Science and Technology	ELECTRICAL CHARACTERIZATION OF 3D PRINTABLE RESINS FOR X BAND (8-12 GHZ) FREQUENCIES

## 12.10.2025 / Hall-2, Session-1



ANKARA LOCAL TIME

10<sup>00</sup> : 12<sup>00</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

HEAD OF SESSION: Assoc. Prof. Dr. Erhan Kılınç

TOPIC TITLE	AUTHORS	AFFILIATION
Hakan Kadir TOPALOĞLU Prof. Dr. Ercan KARAKOÇ	Yıldız Technical University	THE INFLUENCE OF THE MASSES ON FOREIGN POLICY: REFAH PARTY EXAMPLE
Prof. Dr. Recep Yücel Assoc. Prof. Dr. Erhan Kılınç	Kırıkkale University Selçuk University	AN ANALYSIS BASED ON THE MARITIME LEADERSHIP OF BARBAROS HAYRETTİN PASHA
Assoc. Prof. Dr. Erhan Kılınç Prof. Dr. Recep Yücel	Selçuk University Kırıkkale University	THE IMPACT OF SOCIAL MEDIA USAGE ON SOCIETAL CULTURE
Sinem GENÇ Prof. Dr. Ercan KARAKOÇ	Yıldız Technical University	A COMPRATIVE STUDY OF THE WORKS OF NUTUK (THE SPEECH) AND İSTİKLAL HARBİMİZİN ESASLARI (THE PRINCIPLES OF OUR WAR OF INDEPENDENCE)
Elnur ALIZADE Prof. Dr. Arif MAMMADZADE	Azerbaijan State Oil and Industry University Scientific Research Institute Geotechnological Problems of Oil, Gas and Chemistry	GEOMAGNETIC VARIABILITY EFFECTS ON RESERVOIR-SCALE MAGNETIC INVESTIGATIONS
Assist. Prof. Dr. Tuțku SECKIN	Istanbul Medeniyet University	THE EFFECT OF PERCEIVED SOCIAL SUPPORT AND LOCUS OF CONTROL ON MOBBING AND VICTIMIZATION
Assist. Prof. Dr. Tuțku SECKIN Prof. Dr. Jale MINIBAS-POUSSARD	Istanbul Medeniyet University Institute of Management Research (IRG- EA2354), Université Paris-Est	PROCEDURAL JUSTICE AND WORKPLACE EMOTIONS: THE MEDIATING ROLE OF AFFECTIVE COMMITMENT
Feyzullah ŞAHİN	İzmir Demokrasi University	THE MILITARY AND CULTURAL USES OF THE TRUMPET IN THE ANCIENT MEDITERRANEAN WORLD



## 12.10.2025 / Hall-3, Session-1



ANKARA LOCAL TIME

10<sup>00</sup> : 12<sup>00</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

HEAD OF SESSION: Assist. Prof. Dr. Ömer ÇOBAN

TOPIC TITLE	AUTHORS	AFFILIATION
Assist. Prof. Dr. Ömer ÇOBAN	Atatürk University	GRASS-LIKE SILICON NANOSTRUCTURES FOR DETECTING ACETONE VAPOR AT ROOM TEMPERATURE
Res. Assist. Kağan Murat PÜRLÜ Res. Assist. Şekip DALGAÇ Assoc. Prof. Dr. Kholoud ELMABRUK	Sivas University of Science and Technology	INVESTIGATION OF NEGATIVE CURVATURE FIBERS DESIGNED BY COMSOL AND FABRICATED VIA SLA TECHNIQUE
Res. Assist. Kağan Murat PÜRLÜ Res. Assist. Şekip DALGAÇ Assoc. Prof. Dr. Kholoud ELMABRUK	Sivas University of Science and Technology	INVESTIGATION OF DIELECTRIC PROPERTIES OF SLA-PRINTED POLYMER STRUCTURES BASED ON INFILL RATIO IN TERHERTZ BAND
Marya ALHAJMOHAMMADOTHMAN Dr. Deniz BALTA Assoc. Prof. Dr. Ceyda Aksoy TIRMIKÇI	Sakarya University	FORECASTING GLOBAL HORIZONTAL IRRADIANCE IN SAKARYA AND DAMASCUS CITIES USING DEEP LEARNING ALGORITHMS AND BIG DATA TOOLS
Serhat Işıklı	Global Enco Energy and Technology Inc.	DIGITAL TWIN MODELING OF TRANSMISSION LINES FOR DYNAMIC LINE RATING (DLR) APPLICATIONS: CLIMATE-DRIVEN THERMAL MONITORING AND CAPACITY ENHANCEMENT
Serdar ŞAHİN Prof. Dr. Hakan AYDIN	ÜÇGE Store Equipment, R&D Center Bursa Uludag University	INVESTIGATION OF THE TRIBOLOGICAL PERFORMANCE OF GLASS CRUSHING BLADES USED IN DEPOSIT RETURN SYSTEMS IN RELATION TO MATERIAL AND SURFACE TREATMENTS
Atasoy DURUKAN Assist. Prof. Dr. Murat DEMİR	Bakırçay University	MACHINE LEARNING AND MONTE CARLO SIMULATION FOR TURKEY ELECTRICITY DEMAND PROJECTIONS
Assist. Prof. Dr. Zihni Alp ÇEVİK Prof. Dr. Meftin KÖK	Adıyaman University Kahramanmaraş Sütçü İmam University	EFFECT OF REINFORCEMENT TYPE ON MATERIAL REMOVAL RATE AND SURFACE ROUGHNESS IN MACHINING



# 12.10.2025 / Hall-4, Session-1



ANKARA LOCAL TIME

10<sup>00</sup> : 12<sup>00</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

HEAD OF SESSION: Dr. Ervis KRYMBI

TOPIC TITLE	AUTHORS	AFFILIATION
Fitimtar Zekthi	European University of Tirana	DEPOLITICIZED DEMOCRACY: ELECTORAL INVINCIBILITY AND THE EROSION OF ACCOUNTABILITY IN ALBANIA (2013–2025)
Dr. Ervis KRYMBI	University of Shkoder “Luigj Gurakuqi”	TERRITORIAL DEVELOPMENT AND THE IMPACT OF INFORMAL SETTLEMENTS: THE CASE OF SHKODER CITY, ALBANIA
PHD(C) Besmira Petriti	Albanian University	ALBANIAN ASYLUM SEEKERS IN EUROPE (2015–2025): MIGRATION DYNAMICS AND POLITICAL RESPONSES
Assoc. Prof. Dr. Pham Duc Thuan Nguyen Thi Thuy My	CanTho University	THE FRENCH GOVERNOR - GENERAL REGIME IN VIETNAM FROM THE EARLY 20TH CENTURY TO 1945
Daritzta del Carmen Arcia González Gloria Auristela Hernández Pérez	Universidad Juárez Autonoma de Tabasco	CLAUDIA SHEINBAUM PARDO: LEGAL AND GENDER ANALYSIS ON THE LEADERSHIP OF THE FIRST PRESIDENT OF MEXICO
Aastha Kaushik Agomacharyya Nikita Das Assistant Professor Bandana Chowdhury	Gauhati University	CLIMATE CHANGE AND ITS IMPACT IN NORTH EAST INDIA: AN OVERVIEW
PhD. Student Andi ÇAUSHI	University of Elbasan	ECONOMIC GROWTH: A COMPARATIVE ANALYSIS BETWEEN ALBANIA AND THE NORTH MACEDONIA
PhD. Eva HABIŇÁKOVÁ	The University of SS. Cyril and Methodius in Trnava	THE REFLECTION OF MIGRATION PHENOMENON IN NEWSPAPERS



## 12.10.2025 / Hall-5, Session-1



ANKARA LOCAL TIME

10<sup>00</sup> : 12<sup>00</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

### HEAD OF SESSION: Dr. Shqiponje Leksi

TOPIC TITLE	AUTHORS	AFFILIATION
Nguyen Huy Hoang	Tra Vinh University – School of Economics and Law	DIVORCE INVOLVING PERSONS LACKING LEGAL CAPACITY UNDER VIETNAMESE LAW
Nguyen Huy Hoang	Tra Vinh University – School of Economics and Law	THE RETURN OF BRIDE PRICE IN VIETNAMESE FAMILY LAW: LEGAL FRAMEWORK AND JUDICIAL PRACTICE
Lupita de los Ángeles Leonicio Pérez Gloria Auristela Hernández Pérez Doctora en Derecho	Universidad Juárez Autónoma De Tabasco	VIOLENCE AGAINST WOMEN IN THE PRESENT ERA: CAUSES AND CONTEMPORARY REALITIES
Karen Lizeth Zetina Gómez Gloria Auristela Hernández Pérez Doctora en Derecho	Universidad Juárez Autónoma De Tabasco	THE INTERNATIONAL PROTECTION OF WOMEN'S RIGHTS: PROGRESS AND CHALLENGES
Orinda Malltezi	Albanian University	THE DECLINE OF US HEGEMONY AND THE ROLE OF TRUMP'S ADMINISTRATION
Sindy Fabiola Chablé Gallegos Gloria Auristela Hernández Pérez	Universidad Juárez Autónoma De Tabasco	PATRIARCHY AND VIOLENCE: A CHALLENGE FOR WOMEN'S RIGHTS
Dr. Marjeta SHAHOLLI	Albanian University	TRANSPARENCY AND THE DUTY OF PRE-CONTRACTUAL INFORMATION IN EU CONSUMER LAW: CHALLENGES OF ONLINE PLATFORMS AND DARK PATTERNS
Najwa Aulia Rastrianda Salma Syakira Larasati Siti Zahra Maulidya	Universitas Lampung	BIG DATA'S ROLE IN ACCOUNTING FRAUD DETECTION
DR. Shqiponje Leksi	"Aleksander Xhuvani" University	IMPACT OF DIGITAL ACCOUNTING SYSTEMS ON SME'S PERFORMANCE IN EMERGING ECONOMIES



# 12.10.2025 / Hall-6, Session-1



**ANKARA LOCAL TIME**

**10<sup>00</sup> : 12<sup>00</sup>**



**MEETING ID: 830 0628 1090**

**PASSCODE: 798608**

## HEAD OF SESSION: Laroaena Nadia Ayu FATHMASARI

TOPIC TITLE	AUTHORS	AFFILIATION
Alifa Rahma OKTANTIA Sheza Aura NAFASYA	K.H. Abdurrahman Wahid State Islamic University of Pekalongan	ISLAMIC BANKING AND GLOBAL ECONOMIC DYNAMICS: A QUALITATIVE EXPLORATION
Laroaena Nadia Ayu FATHMASARI	K.H. Abdurrahman Wahid State Islamic University of Pekalongan	THE ROLE OF MONETARY POLICY IN MAINTAINING INFLATION STABILITY AND ECONOMIC GROWTH IN INDONESIA
Nabila Yumna SULTHANA Diva Eka SAPUTRI Irma Dwi MULYANTI	K.H. Abdurrahman Wahid State Islamic University of Pekalongan	IMPLEMENTATION OF MAQASHID SYARIAH ON THE OPERATIONS OF MICRO, SMALL, AND MEDIUM ENTERPRISES IN THE ISLAMIC ECONOMY
Roikhatul Jannah Sadira Rima' u Nadilla Rofiatun Fitriani	K.H. Abdurrahman Wahid State Islamic University of Pekalongan	THE ROLE OF SOCIAL MEDIA IN CONSUMER BEHAVIOR IN THE DIGITAL ECONOMY ERA
Salsabila Sakinah Kharisma Nur Samudra Tri Jaya Dimas	K.H. Abdurrahman Wahid State Islamic University of Pekalongan	THE ROLE OF PUBLIC RELATIONS IN MENGORI VILLAGE GOVERNMENT IN DELIVERING SOCIAL ASSISTANCE TO THE COMMUNITY DURING THE PANDEMIC: STRATEGIES, CHALLENGES, AND IMPACTS ON PUBLIC TRUST
Widia Reza Valentina Windi Rizki Febrianingtyas Nala Maghfiroh	K.H. Abdurrahman Wahid State Islamic University of Pekalongan	MILLENNIAL CUSTOMER EXPERIENCE WITH SERVICES ON BSI MOBILE APPLICATION
Nabila Meca Asri Nabila Suci Rahmadani Arina Manasikana	K.H. Abdurrahman Wahid State Islamic University of Pekalongan	SHARIA ECONOMICS AS A PILLAR OF TODAY'S ECONOMY
Juhaida Valda Putri Amelia Andini Fida Putri Nainawa	K.H. Abdurrahman Wahid State Islamic University of Pekalongan	THE ROLE OF MARKETING IN BUSSINESS STRATEGY AND BUSSINESS PLANNING
Khaerul UMAR Lailatul MAULIDYA Wildan MAHARODDIN	K.H. Abdurrahman Wahid State Islamic University of Pekalongan	THE ROLE OF GOVERNANCE AND TRANSPARENCY IN ENHANCING CUSTOMER TRUST IN ISLAMIC BANKING IN INDONESIA
Alena ADELIA Avidah Sirley SALSABILA Athaya CANDRAKANTA	K.H. Abdurrahman Wahid State Islamic University of Pekalongan	AN ANALYSIS OF ISLAMIC FINANCIAL LITERACY AMONG THE PEKALONGAN COMMUNITY ON ISLAMIC BANKING PRODUCTS



## 12.10.2025 / Hall-1, Session-2



ANKARA LOCAL TIME

12<sup>30</sup> : 14<sup>30</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

HEAD OF SESSION: Assoc. Prof. Dr. Engin NAS

TOPIC TITLE	AUTHORS	AFFILIATION
Assist. Prof. Dr. Mehdi ÖZTÜRK Msc. Mahmut KARSLI	Istanbul Arel University	FUND UTILIZATION AND ECONOMIC SUSTANABILITY IN URBAN TRANSFORMATION
Assist. Prof. Dr. Feyza KUYUCU Assist. Prof. Dr. Esra GÜRBÜZ YILDIRIM Assist. Prof. Dr. Gaye CANSUNAR YETKİN	Gaziantep University	MODERNIZATION, COLLECTIVE URBAN MEMORY, AND THE TRANSFORMATION OF PUBLIC SPACE: GAZIANTEP STATION STREET
Assist. Prof. Dr. Gaye CANSUNAR YETKİN Assist. Prof. Dr. Feyza KUYUCU Assist. Prof. Dr. Esra GÜRBÜZ YILDIRIM	Gaziantep University	EARTHQUAKE DAMAGES AND MONITORING OF RESTORATION PROCESSES IN HISTORICAL STRUCTURES: THE CASE OF BAYAZHAN, GAZIANTEP
Assist. Prof. Dr. Ahunur AŞIKOĞLU METEHAN	Dokuz Eylül University	A BIBLIOMETRIC ANALYSIS OF LIFE CYCLE COSTS IN ENERGY-EFFICIENT BUILDINGS
Assist. Prof. Dr. Muhammed ULUCAN	Fırat University	AN EXAMINATION OF THE EFFECT OF SUPPLEMENTARY CEMENTITIOUS MATERIALS USE ON ENERGY CONSUMPTION AND GLOBAL WARMING POTENTIAL
Mehmet AVCI Assoc. Prof. Dr. Engin NAS	Düzce University	INVESTIGATION OF CHIP MORPHOLOGY IN MACHINING AISI 4140 STEEL WITH END MILLS WITH DIFFERENT HELICAL ANGLES
Assist. Prof. Dr. Benek HAMAMCI	Kafkas University	ARTIFICIAL NEURAL NETWORK-BASED PREDICTION OF ADHESIVE BOND STRENGTH



## 12.10.2025 / Hall-2, Session-2



ANKARA LOCAL TIME

12<sup>30</sup> : 14<sup>30</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

HEAD OF SESSION: Assist. Prof. Dr. Burcu SAVAŞ ÇELİK

TOPIC TITLE	AUTHORS	AFFILIATION
Assist. Prof. Dr. Burcu SAVAŞ ÇELİK	İstanbul Gelişim University	THE RELATIONSHIP BETWEEN THE CHINESE STOCK MARKET AND UNCERTAINTY IN US MONETARY POLICY
Mehmet Ulaş Ergin Derya Gültekin	Istanbul Technical University	AI READINESS IN THE APPAREL INDUSTRY: INSIGHTS FROM THE TURKISH CONTEXT
İbrahim ÇELİK Assist. Prof. Dr. Oylum EKŞİ	Kocaeli University	A BIBLIOMETRIC ANALYSIS OF ARTIFICIAL INTELLIGENCE APPLICATIONS IN SUSTAINABLE TOURISM MARKETING
Dr. Ayşe YAVUZ	Selçuk University	THE POWER OF LITERARY NARRATIVE IN DIGITAL PUBLIC RELATIONS: STORYTELLING, METAPHORS, AND CULTURAL CODES IN TURKISH AIRLINES' DIGITAL CAMPAIGNS
Assist. Prof. Dr. Hatice Kübra Altunsoy Coşkun	Kafkas University	THE ROLE OF LOCAL ADMINISTRATIONS IN TURKEY'S RENEWABLE ENERGY POLICIES



## 12.10.2025 / Hall-3, Session-2



ANKARA LOCAL TIME

12<sup>30</sup> : 14<sup>30</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

HEAD OF SESSION: Assoc. Prof. Dr. Ayşe ÇUVADAR

TOPIC TITLE	AUTHORS	AFFILIATION
Assoc. Prof. Dr. Ayşe ÇUVADAR Hande BARIŞ Maral OVEZOVA	Karabük University	THE RELATIONSHIP BETWEEN VACCINE HESITANCY AND DEMOGRAPHIC FACTORS: A CROSS-SECTIONAL STUDY
Assist. Prof. Dr. Gamze Şanlı Ak Şirin Sevat	İstanbul Nişantaşı University	THE EFFECT OF DIET ON GUT MICROBIOTA IN CHILDREN WITH AUTISM SPECTRUM DISORDER: A REVIEW OF CURRENT EVIDENCE
Res. Assist. Dr. Ali Kâmil GÜNGÖR	Bursa Uludağ University	EFFECTS OF CAFFEINE CONSUMPTION BEFORE RESISTANCE EXERCISE ON HEART RATE VARIABILITY DURING POST-EXERCISE RECOVERY: A SYSTEMATIC REVIEW
Sena ÜNAL Assist. Prof. Dr. Ebrar İLİMAN	Sivas Cumhuriyet University	EXAMINATION OF TREATMENT EFFECTIVENESS AND SATISFACTION LEVELS OF PATIENTS RECEIVING HYDROTHERAPY AND ELECTROTHERAPY
Dr. Begüm YULUĞ TAŞ Dr. Yiğithan GÜZİN	Tepecik Training And Research Hospital	PSYCHOPATHOLOGICAL OUTCOMES IN CHILDREN FROM DIVORCED FAMILIES
Ecem BAKIŞ Prof. Dr. Diler AYDIN YILMAZ	Susurluk State Hospital Bandırma Onyeddi Eylül University	THE ANATOMY OF GROOMING: CHILDREN'S EXPOSURE TO DIGITAL RISKS
Assist. Prof. Dr. Hüseyin TOPÇU	Bursa Uludağ University	COMPARISON OF RUNNING DISTANCES IN HOME AND AWAY MATCHES IN THE TURKISH SUPER LEAGUE



## 12.10.2025 / Hall-4, Session-2



ANKARA LOCAL TIME

12<sup>30</sup> : 14<sup>30</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

HEAD OF SESSION: Dr. Abdelmajid AGNAOU

TOPIC TITLE	AUTHORS	AFFILIATION
Kaoutar EL HAJJAMI Prof. Mohamed BERRABAH	Mohammed First University	PHYTOCHEMICAL ANALYSIS AND ANTIOXIDANT ACTIVITY OF MULTIPLE EXTRACTS DERIVED FROM PTYCHOTIS VERTICILLATA
Bipul Mondal SAGAR Md. Sahadat HOSSAIN	Institute of Glass and Ceramic Research and Testing	MXENE-BASED COMPOSITE FOR ELECTROCHEMICAL SENSING OF HEAVY METALS IN THE AQUEOUS SYSTEM
Djellouli Amir Yagoub Mohamed Guesmia Hadjer	Center for Scientific and Technical Research on Arid regions CRSTRA Mohamed Khider University	USE OF LOW-COST ACTIVATED CARBON FOR 2-NITROPHENOL ADSORPTION IN BATCH AND FIXED-BED COLUMN
Abubakar Abdulkadir	Umaru Musa Yar'adua University	QUANTUM ENTANGLEMENT MEETS DIVINE ASCENSION: AN EMPIRICAL FRAMEWORK FOR INTEGRATING AL-ISRĀ' WAL-MI'RĀJ WITH MODERN PHYSICS IN CROSS-CULTURAL EDUCATION
Dr. Abdelmajid AGNAOU	Cadi Ayyad University	STRUCTURAL, OPTICAL AND ELECTRICAL PROPERTIES OF A MIXED VALENCE BISMUTH OXIDE $\delta$ -Bi <sub>2</sub> O <sub>3+x</sub> PREPARED BY SOLID-LIQUID REACTION
Mr. BEDDACH Younes	Cadi Ayyad University	MODIFIED BIOCHAR FOR PU COMPOSITES: FOAM CONTROL AND ADAPTED CELL ARCHITECTURE IN BUILDING MATERIALS
Arun Eshwar Senthil Kumar Karthika K	Vellore Institute of Technology	THE HOSOYA INDEX OF A GRAPH: AN ALGORITHMIC APPROACH



## 12.10.2025 / Hall-5, Session-2



ANKARA LOCAL TIME

12<sup>30</sup> : 14<sup>30</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

HEAD OF SESSION: Dr. Sameer Nanivadekar

TOPIC TITLE	AUTHORS	AFFILIATION
LAFTANI Yasmine CHATIB Baylassane	Cadi Ayyad University	OPTIMIZATION OF AZO DYE DEGRADATION IN SALINE WATER USING DESIGN OF EXPERIMENTS APPROACH
PhD. Lorena SALIAJ	Mediterranean University of Albania	BEYOND CONNECTIVITY: BUILDING RESILIENT IOT SYSTEMS
Dr.S.Rajeswari, Associate Professor/ECE Dr.S.Rajeswari	Saranathan College of Engineering	ID ALLOCATION FOR MULTI-ACCESS EDGE COMPUTING IN 5G NETWORKS
Dr. Sameer Nanivadekar	A.P. Shah Institute of Technology Thane	AI-DRIVEN PSYCHOMETRIC TESTING: ENHANCING ACCURACY, ADAPTABILITY, AND INSIGHT
A. Elakkiya M. Yamuna M. Sivasankari	Sri Sairam Institute of Technology Vellore Institute of Technology	FROM SIMPLE TO SECURE: A COMPLEX SUBSTITUTION CIPHER FOR SYMMETRIC ENCRYPTION
M. Sivasankari M. Yamuna A. Elakkiya	Vellore Institute of Technology Sri Sairam Institute of Technology	A DOMINATION THEORY APPROACH TO GRAPH BASED CRYPTOGRAPHY



## 12.10.2025 / Hall-6, Session-2



ANKARA LOCAL TIME

12<sup>30</sup> : 14<sup>30</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

HEAD OF SESSION: Assoc. Prof. Dr. Alina Solnyshkina

TOPIC TITLE	AUTHORS	AFFILIATION
Hasib Ahmed	Manarat International University	THE IMPACT OF GUILT AND RELIGIOUS REMINDERS ON WORSHIP DELAYS: A COGNITIVE DISSONANCE STUDY
Anthonia Velona Latumapina	Graduate Program in Christian Religious Education Program	PARTICIPATORY DECISION-MAKING IN SCHOOL MANAGEMENT: PRINCIPLES, PROCESSES, AND TEACHERS' ROLE
Boban STANKOVIĆ	University of Kragujevac	COMPARATIVE ANALYSIS OF PRIMARY EDUCATION CURRICULA IN NATURE AND SOCIETY: THE CASE OF SERBIA AND ENGLAND
Assoc. Prof. Dr. Albana Tahiri	Albanian University	MOTHER TONGUE AND DIGITAL COMPETENCES: DIDACTIC INNOVATIONS FOR THE EDUCATION OF THE ALBANIAN DIASPORA
Tanko Linus	Kaduna State College of Education	THE IMPACT OF PLAY AND PLAY MATERIALS ON COGNITIVE DEVELOPMENT IN NUMERACY AMONG PRE-PRIMARY SCHOOL CHILDREN IN KAURA, KADUNA STATE
Dr. Zekirja SHABANI	Institute of Albanology	OTTOMAN ARCHIVAL PERSPECTIVES ON ALCOHOL IN THE SANJAK OF SKOPJE IN THE LATE OTTOMAN ERA
Ph.D Kehinde Oyelayo Oyelade	Alex Ekwueme Federal University Ndufu-Alike Ebonyi State	INQUIRY INNOVATIVE TEACHING STRATEGY IMPACT ON BIOLOGY PERFORMANCE OF STUDENTS IN ABAKALIKI EBONYI STATE
Assoc. Prof. Dr. Alina Solnyshkina	Oles Honchar Dnipro National University	THE ROLE OF CREATIVITY AND THE DEVELOPMENT OF CRITICAL THINKING IN THE PREVENTION OF EMOTIONAL BURNOUT AMONG SOCIAL WORKERS



## 12.10.2025 / Hall-1, Session-3



ANKARA LOCAL TIME

15<sup>00</sup> : 17<sup>00</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

### HEAD OF SESSION: Dr. Ahmet ALKAYA

TOPIC TITLE	AUTHORS	AFFILIATION
Asst. Prof. Dr. Leila MEHDIZADEHTAPEH Assoc. Prof. Dr. Mehmet ÖZBİL Prof. Dr. Pınar OBAKAN YERLİKAYA Sinem Nur AÇIKGÖZ Dr. İsmail Hakkı TEKİNER	Recep Tayyip Erdoğan University Gebze Technical University Istanbul Medeniyet University Gebze Technical University Independent Researcher	FOOD SAFETY ASSESSMENT OF PLANT-BASED SOY, PEA AND HAZELNUT SKIN PROTEINS
İrfan İNAN Dr. Savaş DEMİR Prof. Dr. Zehra EKİN	Van Yüzüncü Yıl University	IMPACTS AND FUTURE PERSPECTIVES OF ORGANIC AGRICULTURE WITHIN THE FRAMEWORK OF AGRICULTURAL SUSTAINABILITY
Dr. Savaş DEMİR İrfan İNAN Prof. Dr. Zehra EKİN	Van Yüzüncü Yıl University	THE ROLE AND IMPORTANCE OF MEDICINAL AND AROMATIC PLANTS IN ANIMAL FEEDING
Prof. Dr. Hülya ŞERFLİŞAN Ögr. Gör. Menderes ŞERFLİŞAN Dr. Ahmet ALKAYA	Iskenderun Technical University	METHODOLOGICAL CONTRIBUTIONS OF SCIENTIFIC DIVING TECHNIQUES IN HABITAT MONITORING OF FRESHWATER MUSSELS
Prof. Dr. Hülya ŞERFLİŞAN Dr. Ahmet ALKAYA	Iskenderun Technical University	VALUATION OF WASTE MUSSEL SHELLS: INTEGRATION INTO THE CONSTRUCTION SECTOR WITHIN THE FRAMEWORK OF THE ZERO WASTE POLICY
İrem Lara KOCA Prof. Dr. Burak DİK	Selçuk University	THE EFFECTS OF ECHINACEA AND GINGER ON THE IMMUNE SYSTEM IN ANIMALS: A PHYTOBIOTIC APPROACH
İrem Lara KOCA Prof. Dr. Burak DİK	Selçuk University	THERAPEUTIC EFFECTS OF POSTBIOTICS ON INTESTINAL DISEASES: MECHANISMS, CLINICAL FINDINGS AND FUTURE PERSPECTIVES



## 12.10.2025 / Hall-2, Session-3



ANKARA LOCAL TIME

15<sup>00</sup> : 17<sup>00</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

HEAD OF SESSION: Assist. Prof. Dr. Emrullah YİĞİT

TOPIC TITLE	AUTHORS	AFFILIATION
Assist. Prof. Dr. Recai BAZANCİR Assist. Prof. Dr. Emrullah YİĞİT	Van Yüzüncü Yıl University	FROM TRADITION TO DIGITAL: THE DIGITAL REFLECTIONS OF FOLKLORE IN EDUCATION
Assist. Prof. Dr. Recai BAZANCİR Assist. Prof. Dr. Emrullah YİĞİT	Van Yüzüncü Yıl University	THE STORYTELLER IN THE AGE OF ARTIFICIAL INTELLIGENCE: THE AUTOMATIC PRODUCTION OF FOLK NARRATIVES AND DIGITAL AUTHENTICITY
Emel ZENGİN Prof. Dr. Lilian Maria TONELLA TÜZÜN Assoc. Prof. Dr. Çiğdem TAŞ ALİCENAP Assoc. Prof. Dr. Yılmaz SARIER Assist. Prof. Dr. EMİN BAKAN Demet EKER KILIÇ Çiğdem ALTUN	Odunpazarı District Directorate of National Education Anadolu University	ART FOR MIDDLE SCHOOL STUDENTS: THE NATURE AND HEALING POWER OF ART
Res. Assist. Dr. Gülden UÇAR	Burdur Mehmet Akif Ersoy University	ON THE ROLE OF THE READER: RECEPTION AESTHETICS AND FRENCH STRUCTURALIST/POST-STRUCTURALIST THEORIES
Recep ÜN	Ministry of National Education, Hatay	TEACHERS' DISTANCE MASTER'S EXPERIENCE IN THE CONTEXT OF THE HAPPINESS PHENOMENON: A CASE STUDY
Assist. Prof. Dr. Rahim KIZGUT	Giresun University	THE INTELLECTUAL AND EDUCATIONAL DEVELOPMENT OF ANCIENT ROMAN MEDICINE
Assist. Prof. Dr. Büşra Gülşah AKBABA	Erzincan Binali Yıldırım University	DIGITAL TRANSFORMATION IN ISLAMIC FAMILY LAW FROM THE PERSPECTIVE OF MAQÂSİD AL-SHARIA



## 12.10.2025 / Hall-3, Session-3



ANKARA LOCAL TIME

15<sup>00</sup> : 17<sup>00</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

HEAD OF SESSION: Assoc. Prof. Dr. İdris KIRHAN

TOPIC TITLE	AUTHORS	AFFILIATION
Assoc. Prof. Dr. Fariz SELİMLİ Res. Assist. Sittiye BAYAR	Mustafa Kemal University	PERIPHERAL GIANT CELL GRANULOMA IN THE POSTERIOR MAXILLA: CLINICAL AND SURGICAL APPROACH – CASE REPORT
Assist. Prof. Dr. Ahmet Can HASKAN Res. Assist. Mahmut ÖZTÜRK Assoc. Prof. Dr. Osman Fatih ARPAÇ	Mustafa Kemal University	DENTIGEROUS CYSTS ASSOCIATED WITH IMPACTED TEETH: THREE CASE REPORTS ACROSS A WIDE AGE SPECTRUM
Assoc. Prof. Dr. Zeynep GÜMRÜKÇÜ	Recep Tayyip Erdoğan University	SUBPERIOSTEAL IMPLANT APPLICATION IN ATROPHIC MANDIBLE: A CASE REPORT
Assoc. Prof. Dr. İdris KIRHAN	Harran University	DIFFUSE ESOPHAGEAL SPASM PRESENTING WITH DYSPHAGIA AND CHEST PAIN: A CASE REPORT
Assist. Prof. Dr. Ali KOÇ	Harran University	A RARE ROTATOR CUFF TEAR: FROSBURY FLOP TEAR
Dr. Zülfer OBUZ KOÇ	Mehmet Akif Inan Training and Research Hospital	A RARE INTERSTITIAL LUNG DISEASE: PULMONARY ALVEOLAR MICROLITHIASIS CASE REPORT
Assist. Prof. Dr. Melek BEDER Assist. Prof. Dr. Andaç DOĞAN	Recep Tayyip Erdoğan University	ALVEOLAR BONE AUGMENTATIONS USING DIFFERENT SURGICAL TECHNIQUES: 2 CASE REPORT
Osman DERE	Harran University	BILIARY STONE FORMATION IN INTRAHEPATIC BILE DUCTS ASSOCIATED WITH CAROLI DISEASE: A CASE REPORT



## 12.10.2025 / Hall-4, Session-3



**ANKARA LOCAL TIME**



**15<sup>00</sup> : 17<sup>00</sup>**



**MEETING ID: 830 0628 1090**



**PASSCODE: 798608**

**HEAD OF SESSION: Dr. Jurij TEKUTOV**

TOPIC TITLE	AUTHORS	AFFILIATION
Ph.D. lecture. Sulaiman Mustafa Khazaal Al-Timmimi Assist. Prof. Dr. Szávai Szabolcs	Miskolc University	INVESTIGATION OF THE PROPERTIES OF IRON-BASED COMPOSITES REINFORCED WITH ALUMINIUM OXIDE AND ZIRCONIUM OXIDE
Ján Duplák Maryna Yeromina Darina Dupláková Samuel Mikuláško	Technical University of Kosice	DESIGN APPROACHES TO ROBOTIC WORKSTATIONS FOR DENTAL MANUFACTURING
Engr. Ayaz Saleem Qureshi	University of Engineering and Technology	FINITE ELEMENT FORMULATION OF FRETTING WEAR FOR AERO-ENGINE SPLINE COUPLINGS
Dr. Jurij TEKUTOV Julija SMIRNOVA	Klaipeda University Klaipėdos valstybinė kolegija/ Higher Education Institution	GENERIC MODELLING APPROACH FOR REQUIREMENTS ENHANCEMENT BASED ON THE STRUCTURED MODEL
Muhammad Mateen Afzal Awan	University of Management and Technology Lahore	GENERATIVE AI FOR ACCELERATING NOVEL MATERIAL INVENTION IN PHOTOVOLTAIC CELL DESIGN
Muhammad Mateen Afzal Awan	University of Management and Technology Lahore	LEVERAGING GENERATIVE AI FOR TRANSISTOR MATERIAL INNOVATION AND DEVICE OPTIMIZATION
Aravindhan. R Ramshin Rahiman	B.S. Abdur Rahman Crescent Institute of Science and Technology	FIRE-ADAPTIVE ARCHITECTURE: INTEGRATING INDIGENOUS FIRE STEWARDSHIP FOR CLIMATE-RESILIENT AND REGENERATIVE DESIGN



## 12.10.2025 / Hall-5, Session-3



ANKARA LOCAL TIME

15<sup>00</sup> : 17<sup>00</sup>



MEETING ID: 830 0628 1090

PASSCODE: 798608

HEAD OF SESSION: Assistant Professor Sathisha

TOPIC TITLE	AUTHORS	AFFILIATION
Habeebat Abiola Suleiman Saheed Ayodeji Adekola	University of Abuja	AMELIORATING EFFECTS OF ETHYL ACETATE FRACTIONS OF CNESTIS FERRUGINEA ROOTS ON ANASTROZOLE-INDUCED POLYCYSTIC OVARIAN SYNDROME IN FEMALE WISTAR RATS
Assistant Professor Sathisha A. B. Assistant Professor Ashwini M. Rao Professor K. S. Basavarajappa	Government First Grade College Bapuji Institute of Engineering and Technology	MATHEMATICAL ANALYSIS ON PHYSIOLOGICAL EFFECT OF CHRONIC OBSTRUCTIVE PULMONARY CANCER DUE TO HABIT OF SMOKING
Aishat Faderera Akere Aisha Muhammad Galalain Muslim Yusuf	Bayero University Umaru Musa Yar'adua University Katsina	BIOPROSPECTING OF ENDOPHYTES IN MEDICINAL PLANTS FOR ANTIFUNGAL PROPERTIES AGAINST CANDIDA ALBICANS (ZUCC): A CASE STUDY OF MITRACARPUS SCABER



## 12.10.2025 / Hall-6, Session-3



ANKARA LOCAL TIME

15<sup>00</sup> : 17<sup>00</sup>



MEETING ID: 830 0628 1090

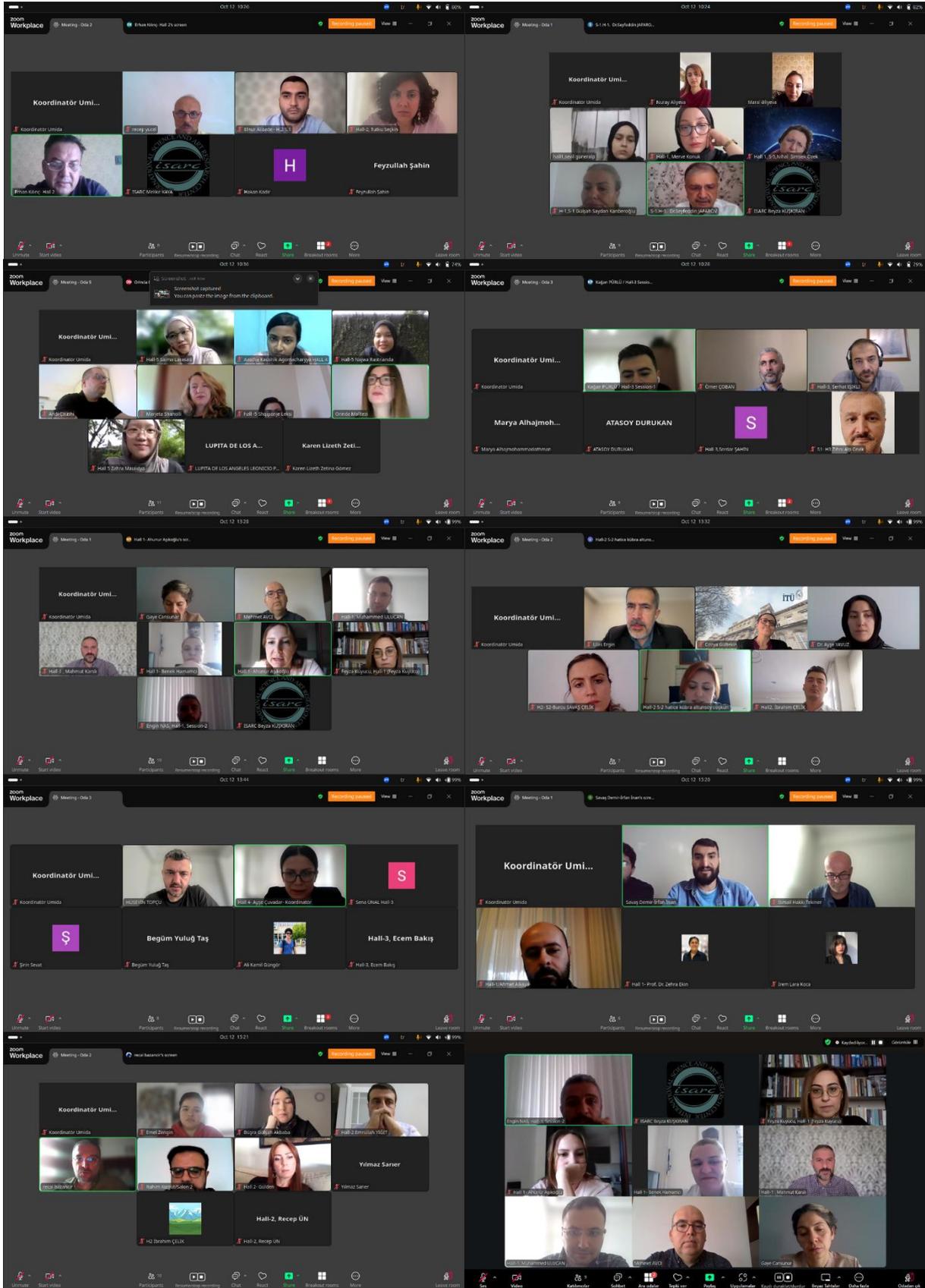
PASSCODE: 798608

HEAD OF SESSION: Prof. Asoc. Dr. Anila ÇEKREZI

TOPIC TITLE	AUTHORS	AFFILIATION
Ibitoye Stella Opeyemi	Landmark University	BLOCKCHAIN TECHNOLOGY ADOPTION AND AUDIT QUALITY IN SMES: EVIDENCE FROM ILORIN, KWARA STATE, NIGERIA
Prof. Asoc. Dr. Anila ÇEKREZI	Aleksander Xhuvani University	FACTORS THAT INFLUENCE MARKET PRICE OF PROPERTIES IN ALBANIA
Phd. Aida Gjika	University of Tirana	SMOKING PREVALENCE AND TAX POLICY IN ALBANIA: A REGIONAL PERSPECTIVE
PhD©. Ardita HYKAJ	The Mediterranean University of Albania	THE ROLE OF FISCAL POLICY IN MODERN MACROECONOMICS: CLASSICAL, KEYNESIAN, AND CONTEMPORARY PERSPECTIVES
Dr. Zhitao Li	Narxoz University	INVESTMENT STRATEGIES IN OIL TRANSPORTATION: ADAPTATION TO CHANGING MARKET CONDITIONS
Cindy Monika Sirait Lia Rosalia Sianturi	Universitas Kristen Indonesia	MSMES DEVELOPMENT STRATEGIES IN THE DIGITAL ERA: OPPORTUNITIES AND CHALLENGES
Dr. Vasylyna PODLIESNA	Institute for Economics and Forecasting of the National Academy of Sciences of Ukraine	ECONOMIC INTERESTS IN THE DISCOURSE OF GLOBAL MILITARY- ECONOMIC CYCLICALITY
Baba Ahmed Abla Narimene	University of Tlemcen	THE EFFECT OF RISK MANAGEMENT ON BUSINESS PERFORMANCE: EVIDENCE FROM ALGERIAN CONSTRUCTION FIRMS
MSc, MEd, PhD Cand. Maria KIOUMOURTZI Klimis NTALIANIS	University of West Attica	ENHANCING SCHOOL EVACUATION STRATEGIES THROUGH PREDICTIVE ANALYTICS AND POPULATION PROFILING



# Photo Gallery



Zoom Meeting - Oct 12 15:37

Koordinator Umi...

Maria Kloumour...

Hall 6 - Li Zhitao

Zoom Meeting - Oct 12 10:06

EXPERIMENTAL

Before MACE process Low-resistivity p-type silicon (100) ( $\rho = 0.01 - 0.02 \Omega\text{cm}$ ) was cut into 10 mm  $\times$  10 mm pieces.

Cleaned with RCA-1 (10:1:1:1 HCl:H<sub>2</sub>O<sub>2</sub>:H<sub>2</sub>O) and RCA-2 (10:1:1:1 HCl:H<sub>2</sub>O<sub>2</sub>:H<sub>2</sub>O). RCA-1 clean is used to remove organic residues from silicon wafers.

Then MACE process was started.

After second spot of the etching process, the remaining silver precipitates are removed with HNO<sub>3</sub> (6:1:1 Nitric acid) solution.

0.3 g AgNO<sub>3</sub>, 3 ml HF, 60 ml H<sub>2</sub>O, 30 s

4.6 M HF, 0.5 M H<sub>2</sub>O<sub>2</sub>, 15 min

3. Ulasman, Yedigöze Bilimel Anzamlari Kongresi, 2025, Istanbul

RESEARCH METHODOLOGY

Data collection:

- The research workflow begins by collecting hourly data for Sakarya and Domasicus cities from Meteoblue website in csv format for years in the range of 01/2022 until 01/2025.
- Kafka producer and Apache Spark consumer are utilized to stream the input csv datasets.
- Data was processed real-time using Apache Kafka and Spark pipeline integration using Kafka python API for producer and Pyspark as Consumer.

EDA and data preprocessing:

- Filling the detected nan or null values was done using linear interpolation technique as it's a popular method to deal with missing values in time series datasets (Xu et al., 2024).
- The outliers were identified and detected using boxplot and IQR method because these methods are the common techniques used to

DATA STREAMS

Zoom Meeting - Oct 12 10:11

Real GDP of North Macedonia

Maddala (2006) pointed that among transition economies, Albania's growth experience during the transition has been a success story.

Real GDP of North Macedonia has increased with about 150% over a decade. The highest economic growth period was from 2006 to 2008 with 5% and after that a negative growth period followed. This was in the years 2009 - 2012, period when the global economic crisis took place. Since then, a stabilization and a positive growth of GDP can be seen. The most important factor of economic growth in the Republic of North Macedonia is the physical capital.

Figure 1. The growth path of North Macedonia from Q1 2007 to Q4 2022 (in %)

Source: Lazarov, D., Simenovski, K. (2023).

Zoom Meeting - Oct 12 10:28

Geleceğe Yönelik Öneriler

Zoom Meeting - Oct 12 10:53

BIG DATA'S ROLE IN ACCOUNTING FRAUD DETECTION

Nurwa Aulia Rastranda,  
Salsma Syahira Larasati,  
Siti Zahra Maulidya

Universitas Lampung  
Faculty of Economics and Business  
Accounting Study Program

Zoom Meeting - Oct 12 10:54

01 ABSTRACT

Accounting has evolved from manual systems to data-driven digital environments. Big Data enables large-scale, real-time analysis that strengthens fraud detection.

Traditional auditing often fails to identify hidden or complex fraud.

Integration of predictive analytics and machine learning improves anomaly detection.

Study links Big Data's role with Fraud Triangle, Fraud Diamond, and Restive Accounting Theory. Despite challenges like data accuracy and system complexity, Big Data promotes financial transparency and accountability.

Zoom Meeting - Oct 12 10:23

Causas profundas: desigualdad y discriminación estructural

Raíces sociales y estructurales:

- Desigualdad en acceso a poder, recursos y educación.
- Normas que normalizan control masculino sobre cuerpos y decisiones.
- Socialización de roles y violencia hacia la violencia.

Factores de riesgo: educación baja, exposición temprana a violencia, consumo excesivo de alcohol, pobreza y entornos que la normalizan.

LET'S PATRIARCHY LALE

WOMEN IS DISCRIMINATED PATRIARCHY

Zoom Meeting - Oct 12 10:28

THz Time-Domain Spectroscopy Analysis Results

Zoom Meeting - Oct 12 10:23

Cdse:0,5%Ho-un sintezi

Kalimatun selen nasaxatallanun sinteti facta bintifa edilan sado taul saykayla qazaymasun usaxatliq diagrama gosterile:

**Şekil 1. Bilgisayar kontrollü potansiyometrik ölçüm sistemi**

**Şekil 2. Kurşun(II)-seçici sensörler,  $1.0 \cdot 10^{-3}$  M- $1.0 \cdot 10^{-6}$  M konsantrasyon aralığında deiyonize suda hazırlanmış kurşun(II) iyonları ile potansiyometrik cevapları. (a)  $1.0 \cdot 10^{-3}$  (b)  $1.0 \cdot 10^{-4}$  (c)  $1.0 \cdot 10^{-5}$  (d)  $1.0 \cdot 10^{-6}$  (e)  $1.0 \cdot 10^{-7}$  (f)  $1.0 \cdot 10^{-8}$  M**

**Free Space Optical Communication**

- Free-space optical (FSO) communication technology is the transmission of data through a modulated optical beam in atmospheric conditions.
- Advantages:**
  - Large bandwidth
  - High data rate
  - Less power
  - No limitations on frequency and bandwidth

**Turbulence Modelling**

- The random phase screen approach alleviates all the difficult and lengthy formulations that analytical approaches own.

**Urban Transformation**

Urban transformation refers to the process of demolishing existing structures that have been identified as unsafe and replacing them with new, durable, and earthquake-resistant buildings. The principal goals of urban transformation include ensuring structural safety, improving living standards, and creating resilient, aesthetic, and sustainable urban environments. Among these, the financial dimension is often the most decisive. Both implementing institutions and homeowners face substantial fiscal responsibilities, and the lack of viable financing mechanisms can hinder progress. In light of this background, the present study focuses on the role of fund utilization in the success and sustainability of urban transformation projects. Ultimately, the research argues that sustainable urban transformation in Turkey requires a holistic framework that integrates financial realism, social equity, and environmental resilience into every stage of the process.

**URBAN TRANSFORMATION**

For an urban transformation project to be initiated, the building in question must first be identified as a "vulnerable" by experts. One of the most critical aspects of urban transformation is its social dimension. The transformation of a neighborhood does not only entail the renewal of physical structures but also brings about profound changes in the lives of its residents. Ultimately, the socio-cultural dimension of urban transformation is as crucial as its technical and financial components.

**Bulgular Birim Kök Analiz Sonuçları**

Birim	Kök	Analiz	Sonuçlar
...	...	...	...

**Complete Decryption Example**

**A. Elakkiya**

**Methodology**

**Step 3: Etching and MXene Formation**

- Salt removed by washing with deionized water
- Selective etching of Al using 48% HF for 22 hours
- Converted  $Ti_3AlC_2 \rightarrow 2D TiO_2-Ti_3C_2Tx$  (MAX powder (MAX) composite)

**Bipul Mondal**

### Structural Analysis (FTIR + XRD)

**Bipul Mondal**

### INTERNATIONAL YEDITEPE SCIENTIFIC RESEARCH CONGRESS

Laboratory of Applied Chemistry and Environment,  
Faculty of Sciences, University Mohammed VI, Oujda  
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#### Phytochemical analysis and antioxidant activity of multiple extracts derived from *Ptychotis verticillata*

Prepared by: **EL MAJAJMI KAGUTAR** Supervisor: **BERABAH Mohamed**

**Kaoutar EL hajja...**

### Objectives

**Extraction**  
Maceration, Infusion, Hydrodistillation

**Phytochemical characterization**

**Analysis by GC-MS/HPLC-UV**

- Total polyphenol content assay
- Determination of antioxidant activity (DPPH)

**Kaoutar EL hajja...**

### Results and Discussion

#### Analysis of essential oil composition by GC-MS

Table 1: Chemical composition of the plant's essential oil

Compound	RT (min)	Area (%)
α-Cymene	6.781	7.42
D-Limonene	6.770	13.47
γ-Terpinene	7.207	13.23
Thymol	11.423	9.96
Cineolol	11.139	49.49

Monoterpene hydrocarbons (34.40%) → Oxygenated monoterpenes (65.60%) → 100% of monoterpenes

**Kaoutar EL hajja...**

### Let's take an example

Let there be four public companies in form of shares. They have 400 and 4000 shares.

Can't find objective weights for the group represented by the 400 shares?

Let all independent variables represent the 4000 shares. Then the 400 shares are represented by the 4000 shares.

**Arun Eshwar S**

### GROOMINGİN ANATOMİSİ

#### GROOMINGİN AŞAMALARI

Çevresel grooming, yetişkin fillerin çocukları çevresel platformda güven hissi kurarak orlan mantıkla etkileşim kurmaya başlamasıdır. Bu süreç genellikle dört aşamada ilerler: güven kazanma, gölge oluşturma, manipülasyon ve istilâ (Cramer, Brown, & Gilman, 2008).

Grooming sırasında filler, savunmasız çocukları duygusal zorlukları kullanarak güven hissi kurar ve manipülasyonun sonucu olarak çevre platformunda güven kazanarak çocukları etkiler. Çocukların güven kazanması, çocukların güven kazanmasını sağlar. Çocukların güven kazanması, çocukların güven kazanmasını sağlar.

**Hall 3, Etem Başg**

### Dijital Platformlar ve Etkileşim Gözlemleme Yöntemi

Filler çevresel grooming için en sık sosyal medya, anak meclisler, uygulamalar ve çevre dijital platformları kullanırlar. Etkileşim gözlemleme çocukları koruma etmektedir.

Türkiye'de çocukların %60'ı dijital platformlar açtığı gözlemlenmiştir ve %32,9'u interaktifliğine ilişkin korkulardır. Bu durum çevresel etkileşim için bir risk olarak değerlendirilmektedir. Bu nedenle çocuklarda dijital etkileşim ve güvenlik farkındalığının artırılması büyük önem taşır.

**Hall 3, Etem Başg**

### 3.2 Bulgular ve Değerlendirme

#### 3.2.1 Yarıyılın Yılına Göre Değerlendirme

İlk soru, WOS veritabanından istatistiksel veriler elde edilmiştir. İlk olarak yarıyılın yılına göre değerlendirilmiştir.

2010 yılında yayınlanan EPID raporunda, yayın sayısında hızlı bir artış gözlemlenmiştir. Bu durumda, Türkiye'de çevresel performansını artırarak çevresel etkileşim LCCA'ya bir çözüm olarak gelebilecek yarıyılın yılına göre değerlendirilmiştir.

Ayrıca, 2025 yılına kadar ilk 3 soruyu tamamlayarak alınması sağlanmıştır. 2024 ile birlikte yayın sayısında hızlı artış gözlemlenmiştir.

**Hall 3, Muhammed Uluçan**

### Türkiye'nin Enerji Politikalarında Yenilenebilir Dönüşüm

Yenilenebilir Enerji Kaynakları Kurulu (YEK) 2010-2023 Strateji Planı

2023 Net Enerji Dengeleme Raporu

Yenilenebilir Enerji Kaynakları Kurulu (YEK) 2010-2023 Strateji Planı

2023 Net Enerji Dengeleme Raporu

**Hall 2-5, Nurcan Kalkan**

### 3.1.1 Yarıyılın Yılına Göre Değerlendirme

SUNUM PLANI

1. Giriş
2. Yarıyılın yılına göre değerlendirme
3. Yarıyılın yılına göre değerlendirme
4. Yarıyılın yılına göre değerlendirme
5. Yarıyılın yılına göre değerlendirme
6. Yarıyılın yılına göre değerlendirme
7. Yarıyılın yılına göre değerlendirme

**Hall 3, Muhammed Uluçan**

Zoom Workplace Meeting - Data 1 Hall 1, Muhammed ULUCAN

3. Ekim 2023 Yılında Bilim Akademisi Kongresi 11-12 Ekim 2023 tarihinde

**SUNUM PLANI**

1. Giriş
2. İç saha ve deplasman koşularının karşılaştırılması
3. Hız ve kuvvet testleriyle karşılaştırılması
4. Çevresel koşulların etkisi
5. Sonuçlar

VARİS, SCM kullanımını besin dayanımı açısından karşılaştırmalı olarak

Zoom Workplace Meeting - Data 3 Ali Gültekin TOPÇU'nun ekranı

**trendyol süperLig**

**TÜRKİYE SÜPER LİGİNDE İÇ SAHA VE DEPLASMAN MAÇLARINDAKİ KOŞU MESAFELERİNİN KARŞILAŞTIRILMASI**  
Dr. Öğr. Üyesi HÜSEYİN TOPÇU

Zoom Workplace Meeting - Data 1 Ali Gültekin TOPÇU'nun ekranı

**Toplam Koşu Mesafesi**

Kategori	Mesafe
İç saha	10432
Deplasman	10029

**TOPLAM KOŞU MESAFESİ**  
(Oransız etki büyüklüğü)  
 $p = 0,20, d = 0,068$

Zoom Workplace Meeting - Data 1 Hall 3, Ercan Bakır

YAPAY ZEKA KULLANILARAK YAPITIRICI BAĞLANTI KUKAVİMLİĞİNİN TANINMI

Hibrit yüzey hazırlama Kurumları + TM NaOH

İşlem sonrası yüzey SEM görüntüsü

Zoom Workplace Meeting - Data 1 Hall 6, Uğur ZİHAO'nun ekranı

Zoom Workplace Meeting - Data 1 Narmene Baba Ahmed

**METHODS**

1. Giriş	2. İç saha ve deplasman koşularının karşılaştırılması
3. Hız ve kuvvet testleriyle karşılaştırılması	4. Çevresel koşulların etkisi
5. Sonuçlar	

Zoom Workplace Meeting - Data 1 Narmene Baba Ahmed

The environment in which construction companies operate has changed significantly over the past decade. Risks have changed and evolved, making them no longer the same. Today, companies face a wide range of challenges, including technological risks, radioactive hazards, terrorism, as well as data intrusion and cyberattacks.

Zoom Workplace Meeting - Data 1 Narmene Baba Ahmed

# CONTENT

CONGRESS ID	I
SCIENTIFIC & REVIEW COMMITTEE	II
PHOTO GALLERY	III
PROGRAM	IV
CONTENT	V

ABSTRACTS		
Author	Title	No
Yağmur KIVRAK Serkan YILMAZSÖNMEZ Ahmet Can ÜNAL	EFFECTS OF PARTICLE MORPHOLOGY, FILM HARDNESS, AND HYDROPHOBIC STRUCTURE ON SCUFF-RESISTANCE IN PAINT FILM	1
Merve Konuk Ziya Kemal Ozan Toker Orhan İçelli	COMPARISON OF ARTIFICIAL INTELLIGENCE APPROACHES FOR AUTOMATIC DETECTION OF LOW-GRADE GLIOMAS	3
Sevil Güneralp Uğursoy Olgun	SYNTHESIS, CHARACTERIZATION, AND DOPING OF CONDUCTIVE POLYANILINE AND ITS COPOLYMERS	5
Kübra KOP TÜRKÖĞLU Nihal ŞİMŞEK ÖZEK Ömer ANDAÇ	DETECTION OF ADULTERATION IN HEMP SEED OIL USING FTIR SPECTROSCOPY AND CHEMOMETRIC METHODS	8
Gülşah SAYDAN KANBEROĞLU Nurcan KAYA Mehmet Salih AĞIRTAŞ	DEVELOPMENT OF A PHTHALOCYANINE BASED PVC MEMBRANE POTENTIOMETRIC SENSOR FOR THE DETERMINATION OF LEAD(II)	10
Hakan Kadir TOPALOĞLU Ercan KARAKOÇ	THE INFLUENCE OF THE MASSES ON FOREIGN POLICY: REFAH PARTY EXAMPLE	12
Sinem GENÇ Ercan KARAKOÇ	A COMPARATIVE STUDY OF THE WORKS OF NUTUK (THE SPEECH) AND İSTİKLAL HARBİMİZİN ESASLARI (THE PRINCIPLES OF OUR WAR OF INDEPENDENCE)	14
Feyzullah ŞAHİN	THE MILITARY AND CULTURAL USES OF THE TRUMPET IN THE ANCIENT MEDITERRANEAN WORLD	16
Ömer ÇOBAN	GRASS-LIKE SILICON NANOSTRUCTURES FOR DETECTING ACETONE VAPOR AT ROOM TEMPERATURE	18
Atasoy DURUKAN Murat DEMİR	MACHINE LEARNING AND MONTE CARLO SIMULATION FOR TURKEY ELECTRICITY DEMAND PROJECTIONS	20
Zihni Alp ÇEVİK Metin KÖK	EFFECT OF REINFORCEMENT TYPE ON MATERIAL REMOVAL RATE AND SURFACE ROUGHNESS IN MACHINING	22
Ervis KRYMBI	TERRITORIAL DEVELOPMENT AND THE IMPACT OF INFORMAL SETTLEMENTS: THE CASE OF SHKODER CITY, ALBANIA	24
Besmira Petriti	ALBANIAN ASYLUM SEEKERS IN EUROPE (2015–2025): MIGRATION DYNAMICS AND POLITICAL RESPONSES	25
Pham Duc Thuan Nguyen Thi Thuy My	THE FRENCH GOVERNOR - GENERAL REGIME IN VIETNAM FROM THE EARLY 20TH CENTURY TO 1945	26

<b>Aastha Kaushik Agomacharyya Nikita Das Bandana Chowdhury</b>	CLIMATE CHANGE AND ITS IMPACT IN NORTH EAST INDIA: AN OVERVIEW	27
<b>Eva HABIŇÁKOVÁ</b>	THE REFLECTION OF MIGRATION PHENOMENON IN NEWSPAPERS	28
<b>Alifa Rahma OKTANTIA Sheza Aura NAFASYA</b>	ISLAMIC BANKING AND GLOBAL ECONOMIC DYNAMICS: A QUALITATIVE EXPLORATION	29
<b>Laroaena Nadia Ayu FATHMASARI</b>	THE ROLE OF MONETARY POLICY IN MAINTAINING INFLATION STABILITY AND ECONOMIC GROWTH IN INDONESIA	30
<b>Nabila Yumna SULTHANA Diva Eka SAPUTRI Irma Dwi MULYANTI</b>	IMPLEMENTATION OF MAQASHID SYARIAH ON THE OPERATIONS OF MICRO, SMALL, AND MEDIUM ENTERPRISES IN THE ISLAMIC ECONOMY	31
<b>Roikhatul Jannah Sadira Rima'u Nadilla Rofiatun Fitriani</b>	THE ROLE OF SOCIAL MEDIA IN CONSUMER BEHAVIOR IN THE DIGITAL ECONOMY ERA	32
<b>Salsabila Sakinah Kharisma Nur Samudra Tri Jaya Dimas</b>	THE ROLE OF PUBLIC RELATIONS IN MENGORI VILLAGE GOVERNMENT IN DELIVERING SOCIAL ASSISTANCE TO THE COMMUNITY DURING THE PANDEMIC: STRATEGIES, CHALLENGES, AND IMPACTS ON PUBLIC TRUST	33
<b>Widia Reza Valentina Windi Rizki Febrianingtyas Nala Maghfiroh</b>	MILLENNIAL CUSTOMER EXPERIENCE WITH SERVICES ON BSI MOBILE APPLICATION	34
<b>Nabila Meca Asri Nabila Suci Rahmadani Arina Manasikana</b>	SHARIA ECONOMICS AS A PILLAR OF TODAY'S ECONOMY	36
<b>Juhaida Valda Putri Amelia Andini Fida Putri Nainawa</b>	THE ROLE OF MARKETING IN BUSSINESS STRATEGY AND BUSSINESS PLANNING	38
<b>Khaerul UMAR Lailatul MAULIDYA Wildan MAHARODDIN</b>	THE ROLE OF GOVERNANCE AND TRANSPARENCY IN ENHANCING CUSTOMER TRUST IN ISLAMOIC BANKING IN INDONESIA	39
<b>Alena ADELIA Avidah Sirley SALSABILA Athaya CANDRAKANTA</b>	AN ANALYSIS OF ISLAMIC FINANCIAL LITERACY AMONG THE PEKALONGAN COMMUNITY ON ISLAMIC BANKING PRODUCTS	40
<b>Feyza KUYUCU Esra GÜRBÜZ YILDIRIM Gaye CANSUNAR YETKİN</b>	MODERNIZATION, COLLECTIVE URBAN MEMORY, AND THE TRANSFORMATION OF PUBLIC SPACE: GAZIANTEP STATION STREET	41
<b>Gaye CANSUNAR YETKİN Feyza KUYUCU Esra GÜRBÜZ YILDIRIM</b>	EARTHQUAKE DAMAGES AND MONITORING OF RESTORATION PROCESSES IN HISTORICAL STRUCTURES: THE CASE OF BAYAZHAN, GAZIANTEP	43
<b>Mehmet Ulaş Ergin Derya Gültekin</b>	AI READINESS IN THE APPAREL INDUSTRY: INSIGHTS FROM THE TURKISH CONTEXT	45
<b>Hatice Kübra Altunsoy Coşkun</b>	THE ROLE OF LOCAL ADMINISTRATIONS IN TURKEY'S RENEWABLE ENERGY POLICIES	46
<b>Begüm YULUĞ TAŞ Yiğithan GÜZİN</b>	PSYCHOPATHOLOGICAL OUTCOMES IN CHILDREN FROM DIVORCED FAMILIES	48
<b>Kaoutar EL HAJJAMI Mohamed BERRABAH</b>	PHYTOCHEMICAL ANALYSIS AND ANTIOXIDANT ACTIVITY OF MULTIPLE EXTRACTS DERIVED FROM PTYCHOTIS VERTICILLATA	50
<b>Bipul Mondal SAGAR Sahadat HOSSAIN</b>	MXENE-BASED COMPOSITE FOR ELECTROCHEMICAL SENSING OF HEAVY METALS IN THE AQUEOUS SYSTEM	51

<b>Djellouli Amir Yagoub Mohamed Guesmia Hadjer</b>	USE OF LOW-COST ACTIVATED CARBON FOR 2-NITROPHENOL ADSORPTION IN BATCH AND FIXED-BED COLUMN	52
<b>Abubakar Abdulkadir</b>	QUANTUM ENTANGLEMENT MEETS DIVINE ASCENSION: AN EMPIRICAL FRAMEWORK FOR INTEGRATING AL-ISRĀ' WAL-MI'RĀJ WITH MODERN PHYSICS IN CROSS-CULTURAL EDUCATION	53
<b>Abdelmajid AGNAOU</b>	STRUCTURAL, OPTICAL AND ELECTRICAL PROPERTIES OF A MIXED VALENCE BISMUTH OXIDE $\delta$ -Bi <sub>2</sub> O <sub>3+x</sub> PREPARED BY SOLID-LIQUID REACTION	54
<b>BEDDACH Younes</b>	MODIFIED BIOCHAR FOR PU COMPOSITES: FOAM CONTROL AND ADAPTED CELL ARCHITECTURE IN BUILDING MATERIALS	55
<b>Arun Eshwar Senthil Kumar Karthika K</b>	THE HOSOYA INDEX OF A GRAPH: AN ALGORITHMIC APPROACH	56
<b>LAFTANI Yasmine CHATIB Baylassane</b>	OPTIMIZATION OF AZO DYE DEGRADATION IN SALINE WATER USING DESIGN OF EXPERIMENTS APPROACH	57
<b>Lorena SALIAJ</b>	BEYOND CONNECTIVITY: BUILDING RESILIENT IOT SYSTEMS	58
<b>S.Rajeswari</b>	ID ALLOCATION FOR MULTI-ACCESS EDGE COMPUTING IN 5G NETWORKS	59
<b>A. Elakkiya M. Yamuna M. Sivasankari</b>	FROM SIMPLE TO SECURE: A COMPLEX SUBSTITUTION CIPHER FOR SYMMETRIC ENCRYPTION	60
<b>Hasib Ahmed</b>	THE IMPACT OF GUILT AND RELIGIOUS REMINDERS ON WORSHIP DELAYS: A COGNITIVE DISSONANCE STUDY	61
<b>Anthonia Velona Latumapina</b>	PARTICIPATORY DECISION-MAKING IN SCHOOL MANAGEMENT: PRINCIPLES, PROCESSES, AND TEACHERS' ROLE	62
<b>Tanko Linus</b>	THE IMPACT OF PLAY AND PLAY MATERIALS ON COGNITIVE DEVELOPMENT IN NUMERACY AMONG PRE-PRIMARY SCHOOL CHILDREN IN KAURA, KADUNA STATE	63
<b>Zekirja SHABANİ</b>	OTTOMAN ARCHIVAL PERSPECTIVES ON ALCOHOL IN THE SANJAK OF SKOPJE IN THE LATE OTTOMAN ERA	64
<b>Kehinde Oyelayo Oyelade</b>	INQUIRY INNOVATIVE TEACHING STRATEGY IMPACT ON BIOLOGY PERFORMANCE OF STUDENTS IN ABAKALIKI EBONYI STATE	65
<b>Leila MEHDIZADEHTAPEH Mehmet ÖZBİL Pınar OBAKAN YERLİKAYA Sinem Nur AÇIKGÖZ İsmail Hakkı TEKİNER</b>	FOOD SAFETY ASSESSMENT OF PLANT-BASED SOY, PEA AND HAZELNUT SKIN PROTEINS	66
<b>Emel ZENGİN Lilian Maria TONELLA TÜZÜN Çiğdem TAŞ ALİCENAP Yılmaz SARIER EMİN BAKAN Demet EKER KILIÇ Çiğdem ALTUN</b>	ART FOR MIDDLE SCHOOL STUDENTS: THE NATURE AND HEALING POWER OF ART	68

<b>Gülden UÇAR</b>	ON THE ROLE OF THE READER: RECEPTION AESTHETICS AND FRENCH STRUCTURALIST/POST-STRUCTURALIST THEORIES	70
<b>Rahim KIZGUT</b>	THE INTELLECTUAL AND EDUCATIONAL DEVELOPMENT OF ANCIENT ROMAN MEDICINE	72
<b>Büşra Gülşah AKBABA</b>	DIGITAL TRANSFORMATION IN ISLAMIC FAMILY LAW FROM THE PERSPECTIVE OF MAQÂSID AL-SHARIA	74
<b>Ahmet Can HASKAN Mahmut ÖZTÜRK Osman Fatih ARPAĞ</b>	DENTIGEROUS CYSTS ASSOCIATED WITH IMPACTED TEETH: THREE CASE REPORTS ACROSS A WIDE AGE SPECTRUM	76
<b>İdris KIRHAN</b>	DIFFUSE ESOPHAGEAL SPASM PRESENTING WITH DYSPHAGIA AND CHEST PAIN: A CASE REPORT	78
<b>Ali KOÇ</b>	A RARE ROTATOR CUFF TEAR: FROSBURY FLOP TEAR	80
<b>Zülfer OBUZ KOÇ</b>	A RARE INTERSTITIAL LUNG DISEASE: PULMONARY ALVEOLAR MICROLITHIASIS CASE REPORT	82
<b>Osman DERE</b>	BILIARY STONE FORMATION IN INTRAHEPATIC BILE DUCTS ASSOCIATED WITH CAROLI DISEASE: A CASE REPORT	84
<b>lecture. Sulaiman Mustafa Khazaal Al-Timmimi Szávai Szabolcs</b>	INVESTIGATION OF THE PROPERTIES OF IRON-BASED COMPOSITES REINFORCED WITH ALUMINIUM OXIDE AND ZIRCONIUM OXIDE	85
<b>Ján Duplák Maryna Yeromina Darina Dupláková Samuel Mikuláško</b>	DESIGN APPROACHES TO ROBOTIC WORKSTATIONS FOR DENTAL MANUFACTURING	86
<b>Ayaz Saleem Qureshi</b>	FINITE ELEMENT FORMULATION OF FRETTING WEAR FOR AERO-ENGINE SPLINE COUPLINGS	88
<b>Jurij TEKUTOV Julija SMIRNOVA</b>	GENERIC MODELLING APPROACH FOR REQUIREMENTS ENHANCEMENT BASED ON THE STRUCTURED MODEL	89
<b>Muhammad Mateen Afzal Awan</b>	GENERATIVE AI FOR ACCELERATING NOVEL MATERIAL INVENTION IN PHOTOVOLTAIC CELL DESIGN	90
<b>Muhammad Mateen Afzal Awan</b>	LEVERAGING GENERATIVE AI FOR TRANSISTOR MATERIAL INNOVATION AND DEVICE OPTIMIZATION	91
<b>Aravindhan. R Ramshin Rahiman</b>	FIRE-ADAPTIVE ARCHITECTURE: INTEGRATING INDIGENOUS FIRE STEWARDSHIP FOR CLIMATE-RESILIENT AND REGENERATIVE DESIGN	92
<b>Habeebat Abiola Suleiman Saheed Ayodeji Adekola</b>	AMELIORATING EFFECTS OF ETHYL ACETATE FRACTIONS OF CNESTIS FERRUGINEA ROOTS ON ANASTROZOLE-INDUCED POLYCYSTIC OVARIAN SYNDROME IN FEMALE WISTAR RATS	93
<b>Sathisha A. B. Ashwini M. Rao K. S. Basavarajappa</b>	MATHEMATICAL ANALYSIS ON PHYSIOLOGICAL EFFECT OF CHRONIC OBSTRUCTIVE PULMONARY CANCER DUE TO HABIT OF SMOKING	94
<b>Aishat Faderera Akere Aisha Muhammad Galalain Muslim Yusuf</b>	BIOPROSPECTING OF ENDOPHYTES IN MEDICINAL PLANTS FOR ANTIFUNGAL PROPERTIES AGAINST CANDIDA ALBICANS (ZUCC): A CASE STUDY OF MITRACARPUS SCABER	95
<b>Ibitoye Stella Opeyemi</b>	BLOCKCHAIN TECHNOLOGY ADOPTION AND AUDIT QUALITY IN SMES: EVIDENCE FROM ILORIN, KWARA STATE, NIGERIA	96

<b>Aida Gjika</b>	SMOKING PREVALENCE AND TAX POLICY IN ALBANIA: A REGIONAL PERSPECTIVE	97
<b>Ardita HYKAJ</b>	THE ROLE OF FISCAL POLICY IN MODERN MACROECONOMICS: CLASSICAL, KEYNESIAN, AND CONTEMPORARY PERSPECTIVES	98
<b>Cindy Monika Sirait Lia Rosalia Sianturi</b>	MSMES DEVELOPMENT STRATEGIES IN THE DIGITAL ERA: OPPORTUNITIES AND CHALLENGES	99
<b>Vasylyna PODLIESNA</b>	ECONOMIC INTERESTS IN THE DISCOURSE OF GLOBAL MILITARY- ECONOMIC CYCLICALITY	100
<b>FULL TEXTS</b>		
<b>Seyfaddin JAFAROV</b>	OPTICAL PROPERTIES OF DOPED SEMICONDUCTOR CdSe;0.5%Ho NANOCRYSTALS	101
<b>Şekip DALGAÇ Kağan Murat PÜRLÜ Kholoud ELMABRUK</b>	PROPAGATION OF HOLLOW HIGHER-ORDER COSH-GAUSSIAN BEAMS IN TURBULENT ATMOSPHERE	108
<b>Şekip DALGAÇ Kağan Murat PÜRLÜ Kholoud ELMABRUK</b>	ELECTRICAL CHARACTERIZATION OF 3D PRINTABLE RESINS FOR X BAND (8-12 GHZ) FREQUENCIES	114
<b>Recep Yücel Erhan Kılınç</b>	AN ANALYSIS BASED ON THE MARITIME LEADERSHIP OF BARBAROS HAYRETTIN PASHA	119
<b>Erhan Kılınç Recep Yücel</b>	THE IMPACT OF SOCIAL MEDIA USAGE ON SOCIETAL CULTURE	127
<b>Elnur ALIZADE Arif MAMMAZADE</b>	GEOMAGNETIC VARIABILITY EFFECTS ON RESERVOIR-SCALE MAGNETIC INVESTIGATIONS	134
<b>Tutku SECKIN</b>	THE EFFECT OF PERCEIVED SOCIAL SUPPORT AND LOCUS OF CONTROL ON MOBBING AND VICTIMIZATION	141
<b>Tutku SECKIN Jale MINIBAS-POUSSARD</b>	PROCEDURAL JUSTICE AND WORKPLACE EMOTIONS: THE MEDIATING ROLE OF AFFECTIVE COMMITMENT	154
<b>Kağan Murat PÜRLÜ Şekip DALGAÇ Kholoud ELMABRUK</b>	INVESTIGATION OF NEGATIVE CURVATURE FIBERS DESIGNED BY COMSOL AND FABRICATED VIA SLA TECHNIQUE	160
<b>Kağan Murat PÜRLÜ Şekip DALGAÇ Kholoud ELMABRUK</b>	INVESTIGATION OF DIELECTRIC PROPERTIES OF SLA-PRINTED POLYMER STRUCTURES BASED ON INFILL RATIO IN TERHERTZ BAND	169
<b>Marya ALHAJMOHAMMADOTHMAN Deniz BALTA Ceyda Aksoy TIRMIKÇI</b>	FORECASTING GLOBAL HORIZONTAL IRRADIANCE IN SAKARYA AND DAMASCUS CITIES USING DEEP LEARNING ALGORITHMS AND BIG DATA TOOLS	175
<b>Serhat Işıklı</b>	DIGITAL TWIN MODELING OF TRANSMISSION LINES FOR DYNAMIC LINE RATING (DLR) APPLICATIONS: CLIMATE-DRIVEN THERMAL MONITORING AND CAPACITY ENHANCEMENT	191
<b>Serdar ŞAHİN Hakan AYDIN</b>	INVESTIGATION OF THE TRIBOLOGICAL PERFORMANCE OF GLASS CRUSHING BLADES USED IN DEPOSIT RETURN SYSTEMS IN RELATION TO MATERIAL AND SURFACE TREATMENTS	198
<b>Fitimtar Zekthi</b>	DEPOLITICIZED DEMOCRACY: ELECTORAL INVINCIBILITY AND THE EROSION OF ACCOUNTABILITY IN ALBANIA (2013–2025)	210
<b>Daritzta del Carmen Arcia González Gloria Auristela Hernández Pérez</b>	CLAUDIA SHEINBAUM PARDO: LEGAL AND GENDER ANALYSIS ON THE LEADERSHIP OF THE FIRST PRESIDENT OF MEXICO	218

<b>Andi ÇAUSHI</b>	ECONOMIC GROWTH: A COMPARATIVE ANALYSIS BETWEEN ALBANIA AND THE NORTH MACEDONIA	223
<b>Nguyen Huy Hoang</b>	DIVORCE INVOLVING PERSONS LACKING LEGAL CAPACITY UNDER VIETNAMESE LAW	231
<b>Nguyen Huy Hoang</b>	THE RETURN OF BRIDE PRICE IN VIETNAMESE FAMILY LAW: LEGAL FRAMEWORK AND JUDICIAL PRACTICE	239
<b>Lupita de los Ángeles Leonicio Pérez Gloria Auristela Hernández Pérez</b>	VIOLENCE AGAINST WOMEN IN THE PRESENT ERA: CAUSES AND CONTEMPORARY REALITIES	249
<b>Karen Lizeth Zetina Gómez Gloria Auristela Hernández Pérez</b>	THE INTERNATIONAL PROTECTION OF WOMEN'S RIGHTS: PROGRESS AND CHALLENGES	258
<b>Orinda Malltezi</b>	THE DECLINE OF US HEGEMONY AND THE ROLE OF TRUMP'S ADMINISTRATION	264
<b>Sindy Fabiola Chablé Gallegos Gloria Auristela Hernández Pérez</b>	PATRIARCHY AND VIOLENCE: A CHALLENGE FOR WOMEN'S RIGHTS	271
<b>Marjeta SHAHOLLI</b>	TRANSPARENCY AND THE DUTY OF PRE-CONTRACTUAL INFORMATION IN EU CONSUMER LAW: CHALLENGES OF ONLINE PLATFORMS AND DARK PATTERNS	278
<b>Najwa Aulia Rastriana Salma Syakira Larasati Siti Zahra Maulidya</b>	BIG DATA'S ROLE IN ACCOUNTING FRAUD DETECTION	291
<b>Shqiponje Leksi</b>	IMPACT OF DIGITAL ACCOUNTING SYSTEMS ON SME'S PERFORMANCE IN EMERGING ECONOMIES	299
<b>Mehdi ÖZTÜRK Mahmut KARSLI</b>	FUND UTILIZATION AND ECONOMIC SUSTANABILITY IN URBAN TRANSFORMATION	307
<b>Ahunur AŞIKOĞLU METEHAN</b>	A BIBLIOMETRIC ANALYSIS OF LIFE CYCLE COSTS IN ENERGY-EFFICIENT BUILDINGS	318
<b>Muhammed ULUCAN</b>	AN EXAMINATION OF THE EFFECT OF SUPPLEMENTARY CEMENTITIOUS MATERIALS USE ON ENERGY CONSUMPTION AND GLOBAL WARMING POTENTIAL	331
<b>Mehmet AVCI Engin NAS</b>	INVESTIGATION OF CHIP MORPHOLOGY IN MACHINING AISI 4140 STEEL WITH END MILLS WITH DIFFERENT HELICAL ANGLES	339
<b>Benek HAMAMCI</b>	ARTIFICIAL NEURAL NETWORK-BASED PREDICTION OF ADHESIVE BOND STRENGTH	348
<b>Burcu SAVAŞ ÇELİK</b>	THE RELATIONSHIP BETWEEN THE CHINESE STOCK MARKET AND UNCERTAINTY IN US MONETARY POLICY	360
<b>İbrahim ÇELİK Oylum EKŞİ</b>	A BIBLIOMETRIC ANALYSIS OF ARTIFICIAL INTELLIGENCE APPLICATIONS IN SUSTAINABLE TOURISM MARKETING	370
<b>Ayşe YAVUZ</b>	THE POWER OF LITERARY NARRATIVE IN DIGITAL PUBLIC RELATIONS: STORYTELLING, METAPHORS, AND CULTURAL CODES IN TURKISH AIRLINES' DIGITAL CAMPAIGNS	383
<b>Ayşe ÇUVADAR Hande BARIŞ Maral OVEZOVA</b>	THE RELATIONSHIP BETWEEN VACCINE HESITANCY AND DEMOGRAPHIC FACTORS: A CROSS-SECTIONAL STUDY	395

<b>Gamze Şanlı Ak Şirin Sevat</b>	THE EFFECT OF DIET ON GUT MICROBIOTA IN CHILDREN WITH AUTISM SPECTRUM DISORDER: A REVIEW OF CURRENT EVIDENCE	403
<b>Ali Kâmil GÜNGÖR</b>	EFFECTS OF CAFFEINE CONSUMPTION BEFORE RESISTANCE EXERCISE ON HEART RATE VARIABILITY DURING POST-EXERCISE RECOVERY: A SYSTEMATIC REVIEW	421
<b>Sena ÜNAL Ebrar İLİMAN</b>	EXAMINATION OF TREATMENT EFFECTIVENESS AND SATISFACTION LEVELS OF PATIENTS RECEIVING HYDROTHERAPY AND ELECTROTHERAPY	428
<b>Ecem BAKIŞ Diler AYDIN YILMAZ</b>	THE ANATOMY OF GROOMING: CHILDREN'S EXPOSURE TO DIGITAL RISKS	442
<b>Hüseyin TOPÇU</b>	COMPARISON OF RUNNING DISTANCES IN HOME AND AWAY MATCHES IN THE TURKISH SUPER LEAGUE	449
<b>Sameer Nanivadekar</b>	AI-DRIVEN PSYCHOMETRIC TESTING: ENHANCING ACCURACY, ADAPTABILITY, AND INSIGHT	456
<b>M. Sivasankari M. Yamuna A. Elakkiya</b>	A DOMINATION THEORY APPROACH TO GRAPH BASED CRYPTOGRAPHY	461
<b>Boban STANKOVIĆ</b>	COMPARATIVE ANALYSIS OF PRIMARY EDUCATION CURRICULA IN NATURE AND SOCIETY: THE CASE OF SERBIA AND ENGLAND	468
<b>Albana Tahiri</b>	MOTHER TONGUE AND DIGITAL COMPETENCES: DIDACTIC INNOVATIONS FOR THE EDUCATION OF THE ALBANIAN DIASPORA	483
<b>Alina Solnyshkina</b>	THE ROLE OF CREATIVITY AND THE DEVELOPMENT OF CRITICAL THINKING IN THE PREVENTION OF EMOTIONAL BURNOUT AMONG SOCIAL WORKERS	500
<b>İrfan İNAN Savaş DEMİR Zehra EKİN</b>	IMPACTS AND FUTURE PERSPECTIVES OF ORGANIC AGRICULTURE WITHIN THE FRAMEWORK OF AGRICULTURAL SUSTAINABILITY	503
<b>Savaş DEMİR İrfan İNAN Zehra EKİN</b>	THE ROLE AND IMPORTANCE OF MEDICINAL AND AROMATIC PLANTS IN ANIMAL FEEDING	515
<b>Hülya ŞERFLİŞAN Menderes ŞERFLİŞAN Ahmet ALKAYA</b>	METHODOLOGICAL CONTRIBUTIONS OF SCIENTIFIC DIVING TECHNIQUES IN HABITAT MONITORING OF FRESHWATER MUSSELS	526
<b>Hülya ŞERFLİŞAN Ahmet ALKAYA</b>	VALUATION OF WASTE MUSSEL SHELLS: INTEGRATION INTO THE CONSTRUCTION SECTOR WITHIN THE FRAMEWORK OF THE ZERO WASTE POLICY	538
<b>İrem Lara KOCA Burak DİK</b>	THE EFFECTS OF ECHINACEA AND GINGER ON THE IMMUNE SYSTEM IN ANIMALS: A PHYTOBIOTIC APPROACH	552
<b>İrem Lara KOCA Burak DİK</b>	THERAPEUTIC EFFECTS OF POSTBIOTICS ON INTESTINAL DISEASES: MECHANISMS, CLINICAL FINDINGS AND FUTURE PERSPECTIVES	562
<b>Recai BAZANCİR Emrullah YİĞİT</b>	FROM TRADITION TO DIGITAL: THE DIGITAL REFLECTIONS OF FOLKLORE IN EDUCATION	570
<b>Recai BAZANCİR Emrullah YİĞİT</b>	THE STORYTELLER IN THE AGE OF ARTIFICIAL INTELLIGENCE: THE AUTOMATIC PRODUCTION OF FOLK NARRATIVES AND DIGITAL AUTHENTICITY	580

<b>Recep ÜN</b>	TEACHERS' DISTANCE MASTER'S EXPERIENCE IN THE CONTEXT OF THE HAPPINESS PHENOMENON: A CASE STUDY	587
<b>Fariz SELİMLİ Sittiye BAYAR</b>	PERIPHERAL GIANT CELL GRANULOMA IN THE POSTERIOR MAXILLA: CLINICAL AND SURGICAL APPROACH – CASE REPORT	596
<b>Zeynep GÜMRÜKÇÜ</b>	SUBPERIOSTEAL IMPLANT APPLICATION IN ATROPHIC MANDIBLE: A CASE REPORT	603
<b>Melek BEDER Andaç DOĞAN</b>	ALVEOLAR BONE AUGMENTATIONS USING DIFFERENT SURGICAL TECHNIQUES: 2 CASE REPORT	610
<b>Anila ÇEKREZİ</b>	FACTORS THAT INFLUENCE MARKET PRICE OF PROPERTIES IN ALBANIA	618
<b>Zhitao Li</b>	INVESTMENT STRATEGIES IN OIL TRANSPORTATION: ADAPTATION TO CHANGING MARKET CONDITIONS	626
<b>Baba Ahmed Abla Narimene</b>	THE EFFECT OF RISK MANAGEMENT ON BUSINESS PERFORMANCE: EVIDENCE FROM ALGERIAN CONSTRUCTION FIRMS	633
<b>Maria KIOUMOURTZI Klimis NTALIANIS</b>	ENHANCING SCHOOL EVACUATION STRATEGIES THROUGH PREDICTIVE ANALYTICS AND POPULATION PROFILING	645

## BOYA FİLMİNDE PARTİKÜL MORFOLOJİSİ, FİLM SERTLİĞİ VE HİDROFOBİK YAPININ SCUFF/SÜRTÜNME DAYANIMININ ETKİLERİ

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### ÖZET

Silinebilir mat iç cephe boya ları, uzun ömürlü kullanım avantajı ve basit bakım süreçleri sunması nedeniyle günümüzde ön plana çıkmaktadır. Boya endüstrisi derin bir dönüşüm geçirmektedir, çünkü su bazlı polimer dispersiyonları (lateksler), çevresel düzenlemelerin ve müşteri tercihlerinin bir araya gelmesi nedeniyle boya sektöründe solvent bazlı polimerlerin yerini almaktadır [1].

Lateks bağlayıcıların Minimum Film Oluşum Sıcaklığı (MFFT) değerlerinin boyanın mekanik dayanımını doğrudan etkilediği görülmüştür [2]. MFFT değeri düşük olan lateksler, film oluşumunu düşük sıcaklıklarda sağlarken, sertliği ve mekanik dayanımı azaltabilir [3]. Öte yandan, yüksek MFFT değerine sahip lateksler, sert ve dayanıklı bir film oluştururken, düşük sıcaklıklarda film oluşumunu engelleyebilir. Bu dengeyi optimize etmek için farklı MFFT aralıklarında latekslerin karşılaştırıldığı çalışmalar yapılmış ve formülasyonda doğru bağlayıcının seçiminin kritik olduğunu ortaya koymuştur [4] [3]

Bu çalışmanın ışığında geliştirilen ürün, su bazlı iç cephe boya larında çizilme direnci ve yüksek dayanım teknolojisini bir araya getirerek, özellikle insan trafiğinin yoğun olduğu hastane, okul ve benzeri alanlarda uzun süreli kullanım imkanı sağlamıştır. Bu özellik, yüzeylerdeki aşınma ve lekelenme problemlerini en aza indirmiştir.

Çalışmada kullanılan stiren akrilik bağlayıcıların yüksek MFFT değerlerine sahip olması, bu bağlayıcıların film oluşumu ve mekanik dayanım üzerindeki etkilerinin incelenmesi açısından önem arz etmiştir. Yüksek MFFT değerine sahip bağlayıcıların düşük sıcaklıklarda film oluşum süreçlerini ve dayanıklılık parametrelerini nasıl etkilediğine yönelik araştırmalar gerçekleştirilmiştir.

Yüksek mekanik dayanım ile daha az yıpranması sağlanan yüzeyler için bakım maliyetlerini önemli ölçüde düşürüldüğü bir çözüm olarak kullanıcılar için daha ekonomik ve düşük VOC salınımla çevre dostu bir çözüm sağlamıştır.

**Anahtar kelimeler:** İç cephe boya, silinebilirlik, MFFT

## EFFECTS OF PARTICLE MORPHOLOGY, FILM HARDNESS, AND HYDROPHOBIC STRUCTURE ON SCUFF-RESISTANCE IN PAINT FILM

### ABSTRACT

Washable matte interior paints are gaining prominence today due to their long-lasting durability and simple maintenance processes. The paint industry is undergoing a profound transformation as water-based polymer dispersions (latexes) replace solvent-based polymers in the paint industry due to a combination of environmental regulations and customer preferences. [1]

It has been observed that the Minimum Film Formation Temperature (MFFT) values of latex binders directly affect the mechanical strength of the paint. [2] Latexes with low MFFT values can reduce hardness and mechanical strength while allowing film formation at low temperatures. [3] On the other hand, latexes with high MFFT values can inhibit film formation at low temperatures while forming a tough and durable film. To optimize this balance, studies comparing latexes at different MFFT ranges have been conducted and have revealed that the selection of the correct binder in the formulation is critical. [4]

The product, developed as a result of this study, combines scratch resistance and high-durability technology in water-based interior paints, enabling long-term use, particularly in high-traffic areas like hospitals, schools, and similar areas. This feature minimizes surface abrasion and staining.

The high MFFT values of the styrene acrylic binders used in this study were important for investigating their effects on film formation and mechanical strength. Studies were conducted to determine how binders with high MFFT values affect film formation processes and durability parameters at low temperatures.

It provides a more economical and environmentally friendly solution for users with low VOC emissions, significantly reducing maintenance costs for surfaces that are less subject to wear and tear with high mechanical strength.

**Keywords:** interior wall paint, scuff-resistance, MFFT

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## DÜŞÜK DERECELİ GLİOMALARIN OTOMATİK TESPİTİ İÇİN YAPAY ZEKA YAKLAŞIMLARININ KARŞILAŞTIRILMASI

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### ÖZET

Düşük dereceli gliomalar (LGG), manyetik rezonans (MR) görüntülerinde düşük kontrast ve belirsiz sınırlar nedeniyle tanıda zorluk oluşturmaktadır. Bu çalışmada sınırlı veri setiyle farklı yapay zeka yaklaşımlarının LGG tespitindeki performansı karşılaştırılmıştır. The Cancer Imaging Archive (TCIA) veri tabanından alınan, tümör varlığına göre etiketlenmiş 110 LGG hastasının MR görüntü serileri kullanılmıştır. Ön işleme adımlarıyla beyin bölgesi izole edilmiş, görüntüler yeniden boyutlandırılmış ve normalize edilmiştir. Veri artırma yöntemleriyle örnek sayısı iki katına çıkarılmıştır. Tümör varlığının tespiti amacıyla çalışma üç aşamalı yaklaşımla gerçekleştirilmiştir. İlk aşamada, piksel düzeyinde özellik çıkarımı yapılarak klasik makine öğrenmesi algoritmaları olan Support Vector Machine (SVM), Random Forest (RF), K-Nearest Neighbors (KNN) ve Extreme Gradient Boosting (XGBoost) kullanılmıştır. İkinci aşamada, DenseNet mimarilerinden (DenseNet-121, -169, -201) elde edilen derin özellikler makine öğrenmesi algoritmalarıyla (SVM, RF, KNN, XGBoost) birleştirilerek hibrit modeller oluşturulmuştur. Son aşamada ise aynı DenseNet mimarileri fine-tuning yöntemiyle uçtan uca eğitilmiş ve derin öğrenme tabanlı tahminleme gerçekleştirilmiştir. Üç yaklaşımın performansları karşılaştırmalı olarak değerlendirilmiştir. Klasik makine öğrenmesi yöntemlerinde SVM ve RF modelleri %74 doğruluk oranı ile en iyi sonuçları vermiştir. Hibrit modellerde DenseNet-201 ile XGBoost birleşimi %87,41 doğruluk sağlamıştır. Fine-tuning sonrası DenseNet-201 modeli %99,33 doğruluk ve receiver operating characteristic (ROC) eğrisi altında

kalan alan (AUC) 0,97 ile en başarılı sonucu vermiştir. Bu bulgular, fine-tuned DenseNet-201 modelinin sınırlı veri setinde dahi en yüksek doğruluk ve AUC değerini sağladığını göstermiştir. Bu model, LGG tespitinde güvenilir bir yaklaşım olarak öne çıkmaktadır.

**Anahtar kelimeler:** Derin öğrenme, düşük dereceli glioma, hibrit modeller, manyetik rezonans görüntüleme, yapay zeka

## COMPARISON OF ARTIFICIAL INTELLIGENCE APPROACHES FOR AUTOMATIC DETECTION OF LOW-GRADE GLIOMAS

### ABSTRACT

Low-grade glioma (LGG) poses diagnostic challenges in magnetic resonance (MR) imaging due to low contrast and unclear boundaries. In this study, the performance of different artificial intelligence approaches for LGG detection was compared using a limited dataset. MR image series from 110 LGG patients labeled according to tumor presence were obtained from The Cancer Imaging Archive (TCIA). Preprocessing steps included isolating the brain region, resizing, and normalizing the images. Data augmentation methods were applied to effectively double the data set. To detect tumor presence, a three-stage approach was implemented. In the first stage, pixel-level feature extraction was performed and classical machine learning algorithms such as Support Vector Machine (SVM), Random Forest (RF), K-Nearest Neighbors (KNN), and Extreme Gradient Boosting (XGBoost) were employed. In the second stage, deep features extracted from DenseNet architectures (DenseNet-121, -169, -201) were combined with the same machine learning algorithms to construct hybrid models. In the final stage, the same DenseNet architectures were fine-tuned and trained end-to-end for deep learning-based prediction. The performances of the three approaches were systematically compared. Among the classical machine learning methods, SVM and RF achieved the best results with an accuracy of 74%. In hybrid models, the combination of DenseNet-201 and XGBoost achieved 87.41% accuracy. After fine-tuning, the DenseNet-201 model achieved the highest performance with 99.33% accuracy and an area under the receiver operating characteristic (ROC) curve (AUC) of 0.97. These findings demonstrate that the fine-tuned DenseNet-201 model provided the highest accuracy and AUC even with a limited dataset. This model can be considered a reliable approach for LGG detection.

**Keywords:** Artificial intelligence, deep learning, hybrid models, low-grade glioma, magnetic resonance imaging

## İLETKEN POLİANİLİN VE KOPOLİMERLERİNİN SENTEZİ KARAKTERİZASYONU VE DOPLANMASI

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### ÖZET

Polimerler, kovalent bağlarla birbirine bağlanmış tekrarlayan monomer birimlerinden oluşan yüksek moleküler ağırlıklı malzemelerdir ve günümüzde çok çeşitli alanlarda kullanılmaktadır [1,2]. İletken polimerler arasında öne çıkan polianilin (PANI), yarı kristalin yapısı, çevresel dayanıklılığı ve ayarlanabilir elektriksel iletkenliği sayesinde önemli bir araştırma konusu oluşturmaktadır [3]. Anilin monomerlerinin kovalent bağlarla birleşmesiyle oluşan uzun zincirli polianilin, farklı morfolojik yapılar geliştirebilme ve iletken özellik kazanabilme kapasitesine sahiptir. Bu özellikleri sayesinde PANI; sensörler, kapasitörler, antistatik kaplamalar, elektromanyetik koruma sistemleri ve askeri elektronik cihazlar gibi birçok alanda değerlendirilmektedir [4,5,6]

Bu çalışmada, iki referans monomer olan anilin ( $C_6H_5NH_2$ ) ve 1,4-diamino-2,3-dicyano-9,10-anthraquinon (DDAK) kullanılarak polimerizasyon reaksiyonları gerçekleştirilmiştir. İlk olarak anilinden polianilin polimeri sentezlenmiş ve ardından bu yapı üzerinden homopolimer ile kopolimerler elde edilmiştir. Buna paralel olarak, DDAK monomerinden polimer sentezlenmiş ve DDAK'a karşılık gelen homopolimer ile kopolimerler de başarıyla sentezlenmiştir.

Sentezlenen polimerler, hem saf hem de doplanmış formlarıyla FT-IR ve UV-Visible spektroskopisi kullanılarak karakterize edilmiştir. Analizler, polimerleşmenin başarıyla gerçekleştiğini ve iletken özelliklerin kazanıldığını doğrulamıştır. Aromatik halkalarda gerçekleşen polimerizasyon ve fonksiyonel grupların sağladığı hidrofobiklik, film oluşturma kapasitesi ve kendiliğinden düzenlenme potansiyeli, bu yapılar için ileri uygulamalarda önemli bir potansiyel sunmaktadır. Bu kapsamda sentezlenen polimerler, iletken kaplamalar, sensör yüzeyleri, optoelektronik cihazlar, enerji depolama sistemleri ve biyomalzeme uygulamalarında alternatif malzemeler olarak değerlendirilebileceği ön görülmektedir.

**Anahtar Kelimeler:** İletken polimer, polianilin, DDAK, kopolimer, spektroskopi

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## SYNTHESIS, CHARACTERIZATION, AND DOPING OF CONDUCTIVE POLYANILINE AND ITS COPOLYMERS

### ABSTRACT

Polymers are high-molecular-weight materials composed of repeating monomer units linked by covalent bonds and are widely utilized in various fields [1,2]. Among conductive polymers, polyaniline (PANI) has attracted significant attention due to its semi-crystalline structure, environmental stability, and tunable electrical conductivity [3]. Formed through the covalent polymerization of aniline monomers, long-chain polyaniline can develop diverse morphologies and acquire conductive properties. Consequently, PANI has been extensively studied for applications in sensors, capacitors, antistatic coatings, electromagnetic shielding systems, and military electronic devices [4,5,6].

In this study, polymerization reactions were carried out using two reference monomers: aniline (C<sub>6</sub>H<sub>5</sub>NH<sub>2</sub>) and 1,4-diamino-2,3-dicyano-9,10-anthraquinone (DDAK). First, polyaniline polymer was synthesized from aniline, followed by the preparation of its homopolymer and copolymers. In parallel, polymerization of DDAK was performed, and the corresponding DDAK homopolymer and copolymers were successfully obtained.

The synthesized polymers, in both pristine and doped forms, were characterized using FT-IR and UV-Visible spectroscopy. The analyses confirmed successful polymerization and the development of conductive properties. Polymerization on aromatic rings and the presence of functional groups impart hydrophobicity, film-forming capability, and self-organization potential, offering significant opportunities for advanced applications. Accordingly, the synthesized polymers are anticipated to serve as alternative materials in conductive coatings, sensor surfaces, optoelectronic devices, energy storage systems, and biomaterial applications.

**Keywords:** Conductive polymer, polyaniline, DDAK, copolymer, spectroscopy

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## KENEVİR TOHUMU YAĞLARINDA FARKLI YAĞLARLA YAPILMIŞ OLAN TAĞŞIŞIN FTIR SPEKTROSKOPİSİ VE KEMOMETRİK YÖNTEMLERLE BELİRLENMESİ

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### ÖZET

Kenevir tohumu yağı, esansiyel yağ asitleri, vitamin ve antioksidan içeriği açısından zengin olması nedeniyle besinsel, sağlık ve ekonomik ve endüstriyel değeri oldukça yüksek bir üründür. Ancak üretiminin kısıtlı olması, yağın piyasaya daha ucuz bitkisel yağlarla tağşış yapılarak sunulmasına neden olmaktadır. Bu durum hem yağ endüstrisinin sürdürülebilirliği hem de insan sağlığı açısından önemli bir tehdit oluşturmaktadır. Bu nedenle değerli yağdaki olası tağşışların hızlı ve etkin şekilde tespit edilmesi ve miktarının belirlenmesi için bir yöntem geliştirilmesi büyük önem taşımaktadır. Bu çalışmada, ayçiçek yağı, mısır özü yağı ve fındık yağının farklı oranlarda karıştırılmasıyla elde edilen kenevir tohumu tağşışli örneklerinin ayırımını yapabilecek, doğruluk oranı yüksek, kullanıcıdan bağımsız, maliyeti ucuz bir yöntem geliştirilmesi amaçlanmıştır. Tüm bu avantajlara sahip olması nedeni ile yöntem olarak ATR-FTIR (Zayıflatılmış Toplam Yansıma-Fourier Dönüşüm Kızılötesi) spektroskopisi ve kemometrik analizler tercih edilmiştir. %1, %5, %10, %30, %50 ve % 80 oranlarında bitkisel yağlarla tağşış edilen kenevir tohumu yağ örneklerinin FTIR spektrumları toplanmış, gruplar arasında ayırım olup olmadığını belirlemek amacıyla gözetimsiz kemometrik analiz yöntemlerinden PCA (Temel Bileşen Analizi) ile HCA (Hiyerarşik Kümeleme Analizi) uygulanmıştır. Her iki analiz sonucu düşük kenevir tohumu yağı oranlarının % 100 doğrulukla ayrılabilirdiğini ortaya koymuştur. Elde edilen bulgular FTIR ile birlikte kemometrik analize dayalı holistik yöntemin kenevir tohumu yağı tağşışinin güvenilir biçimde tespitinde etkin bir yaklaşım olabileceğini göstermektedir.

**Anahtar Kelimeler:** Kenevir tohumu yağı, tağşış, FTIR, PCA, HCA

## **DETECTION OF ADULTERATION IN HEMP SEED OIL USING FTIR SPECTROSCOPY AND CHEMOMETRIC METHODS**

### **ABSTRACT**

Hemp seed oil stands out because it contains a wide range of essential nutrients including fatty acids and vitamins and antioxidants which make it valuable for health and nutrition and economic and industrial applications. Due to restricted production and comparatively elevated costs, this oil is frequently contaminated with less expensive vegetable oils, including sunflower, corn, and hazelnut oils, before reaching the market. The contamination of oil products results in lower product quality and simultaneously poses health dangers to people and financial damage to the oil industry. Therefore, the detection of hemp seed oil adulteration requires fast reliable cost-effective methods because of these identified issues. This study aimed to develop such a method by using ATR-FTIR (Attenuated Total Reflectance-Fourier Transform Infrared) spectroscopy combined with chemometric analysis. In the current study, we adulterated these oil samples with varying levels (1%, 5%, 10%, 30%, 50%, and 80%) of different vegetable oils. Then we collected IR spectra and then applied to unsupervised chemometric analyses including PCA (principal component analyses) and HCA (hierarchical cluster analysis) to identify whether the studied groups can be discriminated or not.

The results showed that even samples with low levels of adulteration could be accurately distinguished with up to 100% accuracy using this approach. The research shows that FTIR spectroscopy with chemometric analysis provides an efficient method to identify adulteration in hemp seed oil.

**Keywords:** Hemp seed oil, adulteration, FTIR spectroscopy, PCA, HCA

## KURŞUN(II) TAYİNİ İÇİN FTALOSİYANİN TEMELLİ PVC MEMBRAN POTANSİYOMETRİK SENSÖR GELİŞTİRİLMESİ

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### ÖZET

Ağır metallerin çevreye salınımı yüzyıllardır önemli bir sorun teşkil etmekte ve bu durumun başlıca nedeni insan faaliyetleridir. Özellikle de endüstriyel süreçler sonucunda suya, toprağa ve atmosfere ağır metaller salınmaktadır. Ağır metaller yüksek konsantrasyonlarda çeşitli toksik özellikler gösterirler. Bu ağır metallerden biri olan kurşun, araba aküleri, inşaat sektöründe sızdırmazlık maddeleri olarak (örneğin baca üstlerinde), elektrikli ve elektronik eşyaların çeşitli elemanlarında (lehim, TV tüplerinde) ve PVC'de kurşun stabilizatör olarak kullanılmaktadır. Kurşun doz aşımında baş ağrısı, hafıza kaybı, anemi, böbrek yetmezliği, kusma, kanser, depresyon, yüksek tansiyon, periferik nöropati (ellerde ve ayaklarda uyuşma ve karıncalanma), anksiyete, dikkat eksikliği ve davranış bozuklukları gibi sağlık sorunlarına neden olabilir. Ayrıca, kurşuna aşırı maruz kalındığında komaya, nöbete ve ensefalopatiye neden olabilir. Kurşun toksisitesi, geri döndürülemez sağlık sorunlarına neden olma potansiyeline sahip olduğundan kurşun tayini önemlidir. Potansiyometri ucuz, hızlı ve kolay uygulanabilen bir yöntem olduğundan, bu çalışmada iyonofor olarak [2,10,16,24-tetrakis(9,9-bis(4-oksifenilfluoren)ftalonitril)] ftalosiyanın kobalt(II) (BS-Co-1) kullanılarak bir PVC (polivinil klorür) membran potansiyometrik sensör geliştirildi. Sensörün optimum membran bileşimi ise %3 BS-Co-1, %32 PVC, %64 DBP (dibütilftalat) ve %1 KTpCIPB (Potasyum tetrakis(4-klorofenil)borat) olarak belirlendi. Geliştirilen kurşun(II)-seçici sensörün doğrusal çalışma aralığı  $1.0 \times 10^{-1} - 1.0 \times 10^{-6}$  M, pH çalışma aralığı 4.26-9.18, eğimi 29.6 mV/onkat ve cevap zamanı 10 saniye olarak belirlendi.

**Anahtar kelimeler:** Ftalosiyanın, PVC membran, kurşun(II)

## DEVELOPMENT OF A PHTHALOCYANINE BASED PVC MEMBRANE POTENTIOMETRIC SENSOR FOR THE DETERMINATION OF LEAD(II)

### ABSTRACT

The release of heavy metals into the environment has been a significant problem for centuries, and the main reason for this situation is human activities. Especially as a result of industrial processes, heavy metals are released into water, soil and atmosphere. Heavy metals exhibit various toxic properties at high concentrations. Lead, one of these heavy metals, is used in car batteries, as sealants in the construction industry (e.g., in chimney tops), in various components of electrical and electronic equipment (e.g., solder, TV tubes), and as a lead stabilizer in PVC. Lead overdose can cause health problems such as headache, memory loss, anemia, kidney failure, vomiting, cancer, depression, high blood pressure, peripheral neuropathy (numbness and tingling in the hands and feet), anxiety, attention deficit and behavioral disorders. Additionally, excessive exposure to lead can cause coma, seizures, and encephalopathy. Lead determination is important because lead toxicity has the potential to cause irreversible health problems. Since potentiometry is a cheap, fast and easy-to-apply method, in this study a PVC (polyvinyl chloride) membrane potentiometric sensor was developed using [2,10,16,24-tetrakis{9,9-bis (4-oxyphenylfluorene)phthalonitrile} phthalocyaninato cobalt(II) (BS-Co-1) as the ionophore. The optimum membrane composition of the sensor was determined as 3% BS-Co-1, 32% PVC, 64% DBP (dibutylphthalate) and 1% KTpCIPB (Potassium tetrakis(4-chlorophenyl)borate). The developed lead(II)-selective sensor exhibited a linear working range of  $1.0 \times 10^{-1}$ – $1.0 \times 10^{-6}$  M, a pH working range of 4.26-9.18, a slope of 29.6 mV/decade, and a response time of 10 seconds.

**Keywords:** Phthalocyanine, PVC membrane, lead(II)

## KİTLENİN DIŞ POLİTİKAYA ETKİSİ: REFAH PARTİSİ ÖRNEĞİ

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### ÖZET

1980'li yıllar ile beraber ülkede yaşanan ekonomik dönüşüm aynı zamanda topluma da sirayet etmiştir. İzlenen neoliberal politikalar darbe yönetiminin varlığı ile beraber bir nebze başarılı olsa da demokrasiye geçiş sonrasında ekonomik kriz tekrar ülkenin kapısını çalmıştır. Ekonomik kriz yaşanırken neoliberal politikaların bir sonucu olan gelir eşitsizliği de yaşanan bu krizi derinleştirmiştir. Ek olarak özellikle 1980 sonrasında iyice artış gösteren köyden kente göç o dönemde sık sık gündeme gelen gecekondulaşma sorununu da beraberinde getirmiştir. Özellikle yoksul kesimin yaşadığı ve kamu hizmeti alma noktasında yetersiz kalan gecekondu Refah Partisi popüleritesini arttırmıştır. Çeşitli sosyal yardımlar ve kapı kapı gezerek ihtiyaç sahiplerinin sorunları ile ilgilenen Refah Partisi muhafazakar oy tabanına ek olarak gecekondu sakinlerinin de oyu ile iktidara gelmiştir. Refah Partisi'nin bu yükselişi esasen Latin Amerika favelalarındaki suç çetelerinin güç ve alan bulması ile paralellikler göstermiştir. Mevcut kamu düzeninde marjinal sayılan bu iki yapı fakir insanların ihtiyaçlarını karşılayarak ve insanların sorunlarına çözümler sunarak kendilerine faaliyet alanı bulmuştur. Pek tabii Refah Partisi illegal bir suç örgütü olmadığı gibi sadece o dönemde parti ideolojisi olarak aşırı uçta konumlanmıştır. Refah Partisi, iktidara gelmesinde etken olan muhafazakar ve gecekondu sakinini tabanının karakteristik özelliklerini izlediği dış politikaya yansıtmıştır. Dış politikada İslamcı bir çizgi izlenmiş ve bir İslam Birliği hedefi gözetilmiştir. Bu hedef için gerekli adımlar atılmış ve Müslüman ülkelerin kendi aralarında işbirliği yapabilmeleri için D-8 kurulmuştur. Bu politikaya ek olarak Refah Partisi uluslararası arenayı Müslümanlar ve Haçlılar şeklinde ayırmıştır. Birbirinden ayrı olan ve daima çatışan bu iki kutup arasındaki ilişki "ezen-ezilen" şeklinde olmuştur. Refah Partisi tıpkı gecekondu sakinlerinin yanında olduğu gibi bu sömürü düzenine karşı da Müslümanların yanında yer almıştır. Görüldüğü üzere Refah Partisi'nin kısa süren iktidar deneyiminde esasen içinde bulundurduğu ve desteğini aldığı toplumsal kesimlerin özelliklerini dış politikasına yansıtmıştır.

**Anahtar Kelimeler:** Refah Partisi, Dış politika, Gecekondu, Kitle, Latin Amerika,

## THE INFLUENCE OF THE MASSES ON FOREIGN POLICY: REFAH PARTY EXAMPLE

### ABSTRACT

The economic transformation that began in Turkey in the 1980s also had significant social implications. Although the neoliberal policies implemented during the military regime achieved a certain degree of success, the transition to democracy was followed by another wave of economic crisis. Income inequality, which emerged as a consequence of neoliberalism, further deepened this crisis. Moreover, the accelerated rural-to-urban migration, particularly after 1980, brought the issue of informal housing—frequently discussed during this period—into public discourse. In informal settlements, which were predominantly inhabited by the urban poor and lacked adequate access to public services, Refah Party (the Welfare Party) significantly increased its popularity. Through various social assistance programs and direct engagement with individuals in need, Refah Party extended its support base beyond its core of conservative voters to include residents of these marginalized areas. This political ascent bears similarities to the rise of criminal gangs in the favelas of Latin America, which gained strength by responding to the needs of impoverished communities. While Refah Party was by no means a criminal organization, it was ideologically positioned on the far end of the political spectrum at the time. The party's foreign policy approach reflected the characteristics of its electoral base, which consisted largely of conservative and low-income urban populations. Refah Party pursued an Islamist-oriented foreign policy and aimed to establish an Islamic Union. As part of this vision, the D-8 (Developing Eight) organization was founded to enhance cooperation among Muslim-majority countries. Additionally, Refah Party framed the international political landscape as a dichotomy between Muslims and Crusaders. This binary perspective was conceptualized through a narrative of oppressor versus oppressed, wherein the "Crusading" West was portrayed as a historical and ongoing exploiter of the Muslim world. Just as the party advocated for the urban poor in domestic politics, it positioned itself as a defender of Muslims against global exploitation on the international stage. As such, it is evident that during its short-lived tenure in power, Refah Party projected the social characteristics of its support base onto its foreign policy orientation.

**Keywords:** Refah Party, Foreign Policy, Slum, Latin America, Mass,

## NUTUK VE İSTİKLAL HARBİMİZİN ESASLARI ESERLERİNİN KARŞILAŞTIRMALI İNCELENMESİ

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### ÖZET

Mustafa Kemal Atatürk'ün, dokuz yıllık bir devrin kurtuluş ve kuruluş icraatlarını anlattığı eseri Nutuk'un, dönemin askerî erkanıyla bir hesaplaşmayı içerdiği de görülmektedir. Saltanat ve hilafet destekçisi olarak değerlendirdiği ve Kazım Karabekir'in de aralarında bulunduğu birçok paşaya karşı, Millî Mücadele kazanılana kadar görüşlerini "Millî Sır" gibi saklı tuttuğundan bahsetmektedir. Sivas Kongresi süreci ve sonrasında İstanbul Hükümeti ile haberleşmenin kesilmesi, Temsil Heyeti'nin vakitsiz yetki kullanımı, Doğu Temsil Heyeti'nin akıbeti, Mustafa Kemal Paşa'nın telgraflara şahsi imzasını atması ve Karabekir'in emrindeki fırka kumandanı Halit Bey ile habersiz telgraflaşmaları; Meclis-i Mebusan'ın toplanacağı yer gibi konular etrafında fikir ayrılıkları belirlemeye başlamıştır. Milli zaferden sonra Mustafa Kemal Paşa'nın TBMM Başkanlığı, Başkomutanlık ve Müdafaa-i Hukuk Grubu Başkanlığını aynı anda yürütmesi; Birinci Meclis (1920-1923) muhaliflerinin tasfiyesi, Saltanat ve Hilafetin kaldırılması, Ankara'nın başkent yapılması, Halk Fırkası'nın kurulması, Cumhuriyetin ilan şekli, 1921 ve 1924 Anayasaları üzerinden tartışmalar şiddetlenmiştir. İnkılapların tepeden inme şekilde yapıldığı iddiaları, derin siyasi çatlaklara yol açmıştır. Karabekir başkanlığında kurulan Terakkiperver Cumhuriyet Fırkası, politik yol ayrımının somut bir yansıması olmuştur. Fırka, Şeyh Said İsyanı ile ilişkili görülerek kapatılmıştır. İzmir Suikastı davalarında yargılanan Karabekir, beraat etmiştir. 1927'de milletvekilliği sona ermiş, aynı yıl askerlikten emekliye sevk edilmiştir. 1933 yılında Milliyet Gazetesi'nin Nutuk eksenli başlattığı Millî Mücadele Tarihi anlatımında haksızlığa uğradığı düşüncesi, İstiklal Harbimizin Esasları adlı eserini hazırlamasına yol açmıştır. Savunmacı, eleştirel ve Doğu Cephesi ağırlıklı bir Millî Mücadele anlatısı göze çarpmaktadır. Eserindeki "19 Nisan 1919'da Trabzon'a çıktım" ifadesi, Nutuk'un "1919 yılı Mayısın 19'uncu günü Samsun'a çıktım" sözüne nazire niteliği taşımaktadır. Aynı ekol, ideoloji ve modernitenin kuşağı olan iki ismin, Anadolu'da milli bir teşkilat ve hükümetin kurulması hususunda aynı çizgide oldukları açıktır. Ancak gerek Millî Mücadele'nin gerekse inkılapların yapıldığı dönemde yöntem ve zamanlama konusunda ayrıştıkları görülmektedir. **Anahtar kelimeler:** Nutuk, İstiklal Harbimizin Esasları, Mustafa Kemal Atatürk, Kazım Karabekir

## A COMPARATIVE STUDY OF THE WORKS OF NUTUK (THE SPEECH) AND İSTİKLAL HARBİMİZİN ESASLARI (THE PRINCIPLES OF OUR WAR OF INDEPENDENCE)

### ABSTRACT

Mustafa Kemal Atatürk Nutuk, which narrates the rescue and founding processes of a nine-year period, simultaneously functions as a reckoning with the military elite of the era. In this work, Atatürk emphasizes that he deliberately concealed his views “like a national secret” until the achievement of victory, particularly against several pashas he identified as supporters of the sultanate and caliphate, among whom was Kâzım Karabekir. During and after the Sivas Congress, divergences became evident regarding the severance of communications with the Istanbul Government, the premature exercise of authority by the Representative Committee, the fate of the Eastern Representative Committee, Atatürk’s personal signature on official telegrams, his undisclosed correspondence with Halit Bey under Karabekir’s command, and the prospective venue of the Ottoman Parliament (Meclis-i Mebusan). Following the national victory, political tensions intensified around Atatürk’s simultaneous leadership of the Grand National Assembly, the post of Commander-in-Chief, and the Defense of Rights Group; the removal of opposition within the First Assembly (1920–1923); the abolition of the sultanate and caliphate; the designation of Ankara as the capital; the establishment of the People’s Party; the modalities of the proclamation of the Republic; and the constitutional debates surrounding the 1921 and 1924 charters. Criticisms that the reforms were imposed in a “top-down” manner generated profound political fractures. The foundation of the Progressive Republican Party (*Terakkiperver Cumhuriyet Fırkası*) under Karabekir’s leadership represented a concrete manifestation of this divergence, though the party was dissolved after being associated with the Sheikh Said Rebellion. Karabekir, who was tried in connection with the İzmir Assassination cases, was ultimately acquitted. His parliamentary mandate ended in 1927, and in the same year he was retired from military service. In 1933, perceiving himself marginalized in *Milliyet* newspaper’s *History of the National Struggle* series—shaped primarily through the lens of *Nutuk*—Karabekir authored *The Principles of Our War of Independence*. This work reflects a defensive and critical stance, with particular emphasis on the Eastern Front. His statement “I landed in Trabzon on 19 April 1919” serves as a pointed rejoinder to Atatürk’s famous opening declaration in *Nutuk*: “On the 19th of May 1919, I landed in Samsun.” It is evident that both figures, as representatives of the same intellectual tradition, ideological orientation, and generation of modernity, shared a commitment to establishing a national organization and government in Anatolia. Nevertheless, their divergence lay in questions of method and timing, both during the National Struggle and throughout the reform era.

**Keywords:** The Speech, The Principles of Our War of Independence, Mustafa Kemal Atatürk, Kazım Karabekir

## ANTİK DÖNEM AKDENİZ DÜNYASINDA TROMPETİN ASKERİ VE KÜLTÜREL KULLANIMLARI

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### ÖZET

Antik Dönem’de askeri birliklerin savaş alanındaki koordinasyonu, komutların iletilmesi ve düzenin sağlanması, büyük ölçüde hem görsel hem de işitsel işaretlere dayanmaktaydı. Bu çerçevede trompetler, yüksek ses kapasiteleri ve dikkat çekici tınıları sayesinde en etkili araçlardan biri olmuş, askerlerin yönlendirilmesi, birliklere komut verilmesi, tehlikelere karşı uyarılması ve düşman üzerinde psikolojik baskı kurulması gibi pek çok amaçla kullanılmıştır. Bununla birlikte trompetlerin işlevi yalnızca askeri bağlamla sınırlı kalmamış; ritüellerde, törensel uygulamalarda ve toplumsal yaşamın çeşitli alanlarında ve hatta gündelik pratiklerde de önemli roller üstlenmiştir.

Bu bildiri de trompetlerin Mezopotamya ve Mısır’daki ilk görsel ve yazılı temsillerinden başlayarak, Akhaemenid örnekleri, Helen salpinksisi, Galya karnyksi, Paphlagonia trompeti ve Roma’da tuba ile cornu gibi çalgılarla devam eden geleneğe kadar uzanan geniş bir coğrafi ve kronolojik dağılımı ele alınacaktır. Çalışmada, günümüze ulaşabilmiş az sayıdaki orijinal trompet örneği, ikonografik betimler ve antik yazarların aktardıkları karşılaştırmalı biçimde değerlendirilerek, trompetin farklı toplumlarda aldığı biçimler, üretim teknikleri, kullanılan malzemeler ve ses özellikleri ele alınacaktır.

Ayrıca farklı coğrafyalarda ortaya çıkan trompet türleri yalnızca tipolojik açıdan karşılaştırmayacak, aynı zamanda tarihsel bağlamları içinde üstlendikleri işlev ve anlamlar da ele alınacaktır. Özellikle savaş alanındaki kullanımları üzerinde durulacak; bunun yanında gündelik yaşam, dini törenler ve toplumsal pratiklerde kazandıkları sembolik değerler de tartışılacaktır. Böylece, trompetin Akdeniz dünyasındaki askeri ve kültürel önemini bütüncül bir perspektifle değerlendirmek amaçlanmaktadır.

**Anahtar Kelimeler:** Trompet, askeri iletişim, askeri işaretleşme, organoloji, arkeomüzikoloji

## THE MILITARY AND CULTURAL USES OF THE TRUMPET IN THE ANCIENT MEDITERRANEAN WORLD

### ABSTRACT

In Antiquity, the coordination of military units on the battlefield, the transmission of commands, and the maintenance of order relied largely on both visual and auditory signals. Within this framework, trumpets, with their high volume capacity and striking timbre, became among the most effective instruments. They were employed for multiple purposes such as directing soldiers, issuing commands to units, warning against danger, and exerting psychological pressure on the enemy. Yet, the function of trumpets was not confined to the military sphere; they also played important roles in rituals, ceremonial practices, various aspects of social life, and even in everyday activities.

This paper examines the wide geographical and chronological distribution of trumpets, from their earliest visual and textual representations in Mesopotamia and Egypt, through Achaemenid examples,

the Greek salpinx, the Gallic carnyx, the Paphlagonian trumpet, and finally the continuation of the tradition in Rome with instruments such as the tuba and cornu. Surviving original specimens, iconographic depictions, and accounts by ancient authors are evaluated comparatively in order to discuss the forms, production techniques, materials, and sound qualities of trumpets in different societies.

Moreover, the study addresses trumpet types that emerged in various regions not only in terms of typological comparison but also within the historical contexts of their functions and meanings. Particular attention is given to their uses on the battlefield, while their symbolic roles in daily life, religious ceremonies, and social practices are also emphasized. In this way, the study aims to provide a comprehensive perspective on the military and cultural significance of the trumpet in the Mediterranean world.

**Keywords:** Trumpet, military communication, military signaling, organology, archaeomusicology

## ODA SICAKLIĞINDA ASETON BUHARI ALGILAMAYA YÖNELİK ÇİMEN-BENZERİ SİLİSYUM NANOYAPILAR

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### ÖZET

Aseton tespiti hem endüstriyel hem de biyomedikal uygulamalar açısından kritik öneme sahiptir. Boya, kaplama ve çözücü endüstrileri gibi iş yerlerinde aseton buharı, orta düzey konsantrasyonlarda bile yangın ve patlama tehlikesi oluşturmaktadır. Buna paralel olarak, insan nefesindeki aseton seviyelerinin izlenmesi diyabet ve metabolik bozukluklar için invazif olmayan bir biyogösterge olarak kabul edilmektedir. Bu iki gereksinim, oda sıcaklığında gerçek zamanlı aseton tespiti yapabilen hassas ve düşük maliyetli sensörlerin geliştirilmesinin önemini ortaya koymaktadır. Bu çalışmada, iki aşamalı gümüş destekli metal destekli kimyasal aşındırma (MACE) süreci ile bir çimen-benzeri silisyum kimyasal buhar sensörü üretilmiştir. Düşük özdirençli p-tipi Silisyum (100) ( $\rho \approx 0.01-0.02 \Omega \cdot \text{cm}$ ) ilk olarak 30s 0.3gr  $\text{AgNO}_3$ : 18ml HF: 60ml  $\text{H}_2\text{O}$  çözeltisinde bekletilerek Ag tabakasının oluşması sağlanmıştır. Sonraki aşındırma adımında, 15 dakika 4.6 M HF : 0.5M  $\text{H}_2\text{O}_2$  çözeltisine daldırılmış ve yüksek gözenekliliğe ve yüzey alanına sahip, dikey hizalanmış çimen-benzeri silisyum nanotel dizileri elde edilmiştir. Üretilen yapının morfolojisi taramalı elektron mikroskobu (SEM) ile incelenmiş, mikrometre ölçeğinde uzunluklara sahip yoğun, dikey yönelimli nano yapıların oluştuğu doğrulanmıştır. Elektriksel ölçümler için, alüminyum nokta kontaklar doğrudan nano yapı yüzeyine DC püskürtme yöntemi ile kaplanmıştır. Gaz algılama testleri yalnızca aseton buharı ile, 500 ppm ile 7000 ppm arasındaki konsantrasyonlarda gerçekleştirilmiştir. Sensör, en yüksek tepkiyi ( $\Delta R/R_0 \approx 2$ ) 7000 ppm'de göstermekle birlikte, tepkilerin tekrarlanabilir ve geri dönüşümlü olduğu gözlemlenmiştir. Tepki ve iyileşme süreleri 50 saniyenin altında gerçekleşmiş, bu da çimen-benzeri morfolojinin sağladığı etkin adsorpsiyon-desorpsiyon dinamiklerini ortaya koymuştur. Bu sonuçlar, iki aşamalı Ag destekli MACE tekniğinin, Al nokta kontaklarla birleştirildiğinde, oda sıcaklığında hızlı ve hassas aseton tespiti yapabilen silisyum tabanlı sensörlerin geliştirilmesi için doğrudan ve etkili bir yöntem sunduğunu göstermektedir.

**Anahtar kelimeler:** Çimen-Benzeri Silisyum, Aseton Buharı, Gaz Sensör

## GRASS-LIKE SILICON NANOSTRUCTURES FOR DETECTING ACETONE VAPOR AT ROOM TEMPERATURE

### ABSTRACT

Acetone detection is critically important for both industrial and biomedical applications. In workplaces such as paint, coating, and solvent industries, acetone vapor poses fire and explosion hazards even at moderate concentrations. In parallel, monitoring acetone in human breath has been recognized as a non-invasive biomarker for diabetes and metabolic disorders. These dual needs highlight the importance of developing sensitive, low-cost sensors capable of real-time acetone detection at room temperature. In this study, a grass-like silicon chemical vapor sensor was fabricated through a two-step silver-assisted metal-assisted chemical etching (MACE) process. Low-resistivity

p-type silicon (100) ( $\rho \approx 0.01\text{--}0.02 \Omega\cdot\text{cm}$ ) was first immersed for 30 s in a solution of 0.3 g  $\text{AgNO}_3$ , 18 ml HF, and 60 ml  $\text{H}_2\text{O}$  to form a silver layer on the surface. In the subsequent etching step, the samples were immersed for 15 minutes in a 4.6 M HF : 0.5 M  $\text{H}_2\text{O}_2$  solution, resulting in the formation of vertically aligned, grass-like silicon nanowire arrays with high porosity and large surface area. The morphology of the etched structures was examined by scanning electron microscopy (SEM), which confirmed the formation of dense, vertically oriented nanostructures micrometer-scale lengths. To enable electrical measurements, aluminum dot contacts were deposited directly onto the nanostructured surface by DC sputtering. Gas sensing tests were conducted exclusively with acetone vapor at concentrations between 500 ppm and 7000 ppm. The device exhibited reproducible and reversible resistance changes, with the strongest response ( $\Delta R/R_0 \approx 2$ ) at 7000 ppm. Response and recovery times were below 50 seconds, highlighting efficient adsorption–desorption dynamics supported by the grass-like morphology. These results demonstrate that the two-step Ag-assisted MACE technique, combined with Al point contacts, provides a straightforward strategy for realizing room-temperature silicon-based sensors with fast and sensitive acetone detection.

**Keywords:** Grass-like silicon, Acetone Vapor, Gas Sensor

## MAKİNE ÖĞRENMESİ VE MONTE CARLO SİMÜLASYONU İLE TÜRKİYE ELEKTRİK TALEBİ PROJEKSİYONLARI

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### ÖZET

Türkiye’de artan nüfus, sanayileşme ve teknolojik gelişmeler elektrik enerjisine olan talebi sürekli yükseltmektedir. Bu talebin doğru biçimde öngörülmesi, arz-talep dengesinin sağlanması ve olası enerji krizlerinin önlenmesi açısından kritik öneme sahiptir. Enerji talep tahminlerindeki belirsizlikler, üretim fazlası durumunda sistem istikrarsızlıklarına, üretim açığı halinde ise enerji kesintilerine yol açabilmektedir.

Bu çalışmada, Türkiye’nin uzun vadeli elektrik talebi makroekonomik ve demografik göstergeler kullanılarak modellenmiştir. Nüfus, gayri safi yurt içi hasıla (GSYH), ihracat, ithalat, ışık yoğunluğu, kurulu güç, turizm geliri ve sanayi üretim endeksi değişkenleri dikkate alınarak makine öğrenmesi algoritmaları (Lasso, Ridge, Destek Vektör Regresyonu, Yapay Sinir Ağları) uygulanmıştır. Belirsizliklerin modellenmesinde Monte Carlo simülasyonu kullanılmış ve farklı veri pencereleri (1990–2023 uzun dönem ve 2014–2023 kısa dönem) üzerinden analizler gerçekleştirilmiştir.

Elde edilen bulgular, veri penceresinin model çıktıları üzerinde belirleyici bir etkiye sahip olduğunu göstermektedir. Uzun dönemli veri setleri tarihsel büyüme eğilimlerini daha güçlü yansıtarak daha yüksek talep projeksiyonları üretirken, kısa dönemli veri setleri daha ihtiyatlı tahminler sunmuştur. Modeller arası kıyaslamada, DVR en iyimser tahminleri sağlarken, Lasso en tutucu sonuçları vermiştir; Ridge ve YSA ise bu iki uç arasında dengeli projeksiyonlar üretmiştir. Özellikle YSA’nın uzun dönemli verilerle 2030 yılına, Ridge modelinin ise kısa dönemli verilerle 2035 yılına yönelik tahminlerinin Ulusal Enerji Planı hedefleriyle yüksek uyum gösterdiği belirlenmiştir.

Bu sonuçlar, enerji talep projeksiyonlarında tek bir modele veya veri penceresine bağımlı kalmanın risklerini ortaya koymakta; farklı modellerin, değişken setlerinin ve tarihsel veri pencerelerinin birlikte değerlendirilmesinin stratejik önemini vurgulamaktadır.

**Anahtar kelimeler:** Enerji talep tahmini, Makine öğrenmesi, Monte Carlo simülasyonu, Yapay sinir ağları

## MACHINE LEARNING AND MONTE CARLO SIMULATION FOR TURKEY ELECTRICITY DEMAND PROJECTIONS

### ABSTRACT

Turkey's growing population, industrialization, and technological developments are continuously increasing the demand for electricity. Accurately forecasting this demand is critical for ensuring supply-demand balance and preventing potential energy crises. Uncertainties in energy demand forecasts can lead to system instability in the event of excess production and to power outages in the event of a production shortfall.

In this study, Turkey's long-term electricity demand is modeled using macroeconomic and demographic indicators. Machine learning algorithms (Lasso, Ridge, Support Vector Regression, Artificial Neural Networks) were applied, taking into account variables such as population, gross domestic product (GDP), exports, imports, light intensity, installed capacity, tourism revenue, and industrial production index. Monte Carlo simulation was used to model uncertainties, and analyses were performed using different data windows (1990–2023 long term and 2014–2023 short term).

The findings indicate that the data window has a decisive effect on the model outputs. Long-term data sets produced higher demand projections by reflecting historical growth trends more strongly, while short-term data sets provided more conservative estimates. In the comparison between models, DVR provided the most optimistic estimates, while Lasso gave the most conservative results; Ridge and ANN produced balanced projections between these two extremes. In particular, it has been determined that the YSA's long-term projections to 2030 and the Ridge model's short-term projections to 2035 show high alignment with the National Energy Plan targets.

These results highlight the risks of relying on a single model or data window for energy demand projections and emphasize the strategic importance of evaluating different models, variable sets, and historical data windows together.

**Keywords:** Energy demand forecasting, Machine learning, Monte Carlo simulation, Artificial neural networks

## TALAŞLI İŞLEMEDE TAKVİYE TİPİNİN TALAŞ KALDIRMA ORANI VE YÜZEY PÜRÜZLÜLÜĞÜNE ETKİSİ (\*)

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### Özet

Yapılan bu çalışmada takviye elemanı olarak kullanılan bor karbür ( $B_4C$ ), silisyum karbür ( $SiC$ ) ve bunların bir araya getirilmiş halinin talaşlı işleme ile işlenebilirliğinin bu malzemeler üzerindeki etkisi incelenmektedir. Burada üretilen kompozit malzemeler toz metalürjisi yöntemiyle belirli takviye oranlarında takviye elemanı kullanılarak üretildikten sonra polikristalin elmas (PCD) kesici uç kullanılarak belirli parametreler ile talaşlı işleme yapılmıştır. Talaşlı işlemenin değerlendirilmesi için yüzey pürüzlülük ( $R_a$ ) değerlerine ve talaş kaldırma oranı (MRR) değerlerine bakılmıştır. Takviye oranlarının artmasıyla birlikte kompozit malzemenin sertliğini ve kesici uç için bir aşındırma direnci oluşturarak işleme esnasındaki MRR'da azalmanın meydana geldiği gözlemlenmiştir. Kompozit malzemedeki En yüksek MRR değeri takviyesiz olan Al2024'te ortaya çıkarken, en düşük MRR değeri ise hibrit takviyeli %2  $B_4C$  +  $SiC$  karışımı olan kompozit malzemde meydana gelmiştir. Yüzey pürüzlülük değerleri olarak baktığımızda ise,  $R_a$  değerlerinde takviye elemanının artmasıyla birlikte belirgin bir artış olduğu gözlemlenmiştir. Yüzey pürüzlülüğünün en az olduğu kompozit malzeme saf Al2024 üzerinde ortaya çıkarken, Yüzey pürüzlülüğünün en fazla olduğu kompozit malzeme ise Al2024/ $B_4C$ 'de görülmüştür. Burada  $B_4C$  takviye elemanı  $SiC$ 'den daha fazla yüzey pürüzlülüğüne sebep olmakta, bu da  $B_4C$  takviye elemanı ve yüksek oranda olmasının düzensiz bir şekilde deformasyona sebep olması ile birlikte daha hızlı bir takım aşınmasını ortaya çıkarmaktadır. Sonuç olarak kompozit malzemenin üretilmesi esnasındaki takviye elemanının miktarı ve sonrasındaki talaşlı işleme esnasında kullanılacak kesici takım ve parametrelerin önemli olduğu bu çalışmada ortaya konulmaya çalışılmıştır.

**Anahtar kelimeler:** Talaşlı imalat, Kompozit, Yüzey pürüzlülüğü, MRR,

## EFFECT OF REINFORCEMENT TYPE ON MATERIAL REMOVAL RATE AND SURFACE ROUGHNESS IN MACHINING

### Abstract

This study investigates the effects of boron carbide ( $B_4C$ ), silicon carbide ( $SiC$ ), and their combined forms on the machinability of these materials. The composite materials produced here were produced using specific reinforcement ratios using powder metallurgy and then machined using polycrystalline diamond (PCD) cutting tools with specific parameters. Surface roughness ( $R_a$ ) and material removal rate (MRR) were examined to evaluate the machining performance. It was observed that increasing the reinforcement ratios increased the hardness of the composite material and created a wear

resistance for the cutting tool, leading to a decrease in the MRR during machining. The highest MRR value in the composite material occurred in the unreinforced Al2024, while the lowest MRR value occurred in the hybrid reinforced 2% B<sub>4</sub>C + SiC composite. When we examine the surface roughness values, a significant increase in Ra values was observed with increasing reinforcement. The lowest surface roughness was observed on pure Al2024 composite, while the highest surface roughness was observed on Al2024/B<sub>4</sub>C composite. Here, the B<sub>4</sub>C reinforcement results in greater surface roughness than SiC. This, coupled with the high proportion of B<sub>4</sub>C reinforcement, leads to irregular deformation and accelerated tool wear. Consequently, this study demonstrates the importance of the amount of reinforcement used during composite material production and the cutting tool and parameters used during subsequent machining.

**Keywords:** Machining, Composite, Surface roughness, MRR

*\* B<sub>4</sub>C-SiC takviyeli alüminyum matrisli hibrit nanokompozit üretimi ve işlenebilirliğinin incelenmesi adlı tezden türetilmiştir.*

**TERRITORIAL DEVELOPMENT AND THE IMPACT OF INFORMAL SETTLEMENTS:  
THE CASE OF SHKODER CITY, ALBANIA**

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**Abstract**

This paper was carried with the objectives to determine the causes of failure of conventional land use planning in upgrading informal settlements and the resulting spatial implications. Urban planning in the post-socialism period is presented in this paper through the case study of Shkoder city which has changed radically. Most of the new constructions built after the 1990s in Shkoder were informal and consisted of individual houses built by new migrants from rural areas. Vacant urban land at the edge of Shkoder was either officially belonging to the government or was frozen until claims made by families who had been dispossessed by the former regime. Shkoder and its suburbs are one of the cities which are suffering from informal buildings. Almost every year, during the winter season the suburbs of the city get water flooded. This is a tool that makes the linkage between spatial planning and flooding issues by encouraging specific actions. The challenge of spatial planning in this situation is to integrate the informal area of Shkoder by providing them with infrastructure, and to take into consideration the land valuation and making them part of the market.

**Keywords:** Informal area, spatial analysis, land-use policy, peripheral urbanization, Shkoder city.

## ALBANIAN ASYLUM SEEKERS IN EUROPE (2015–2025): MIGRATION DYNAMICS AND POLITICAL RESPONSES

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### **Abstract**

European Union (EU), as well as the persistent challenges the Union faces in managing the increasing flows of asylum seekers. In a global context where millions of people are displaced from their homes and seek protection abroad, the EU has been compelled to continuously revise and update its legislative and policy frameworks in order to balance its international obligations with growing domestic political pressures. The study focuses on the case of Albanian asylum seekers and provides an analysis of their trajectories and experiences in Europe between 2015 and 2025. It examines how different EU member states have responded to this phenomenon, highlighting both restrictive measures and institutional approaches designed to regulate the flows. Particular attention is given to the period after 2020, when migration pressures intensified and the EU's asylum system underwent significant scrutiny. The research also addresses the interplay between national policies and EU-wide regulations, exploring the discrepancies and convergences that shape the lived realities of Albanian applicants for asylum.

A central element of the paper is the discussion of the New Pact on Migration and Asylum, proposed by the European Commission in December 2023 and formally adopted in May 2024. The paper evaluates the implications of this agreement, with emphasis on how it may alter the political, legal, and social context for Albanian asylum seekers in critically on its outcomes. By filling a gap in existing literature, the paper offers insights into the consequences of EU migration governance for a specific group of Albanian asylum seeker while also contributing to the broader debate on migration, human rights, and policy effectiveness in Europe. Ultimately, this study aims to inform future policy directions and promote more equitable and coherent approaches to asylum across the European Union.

**Keywords:** Albanian asylum seekers, Challenges of the EU, Migration dynamics.

**THE FRENCH GOVERNOR - GENERAL REGIME IN VIETNAM  
FROM THE EARLY 20TH CENTURY TO 1945**

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**ABSTRACT**

This paper examines the role and characteristics of the Governor-General regime established by France in Vietnam and Indochina from the early twentieth century until 1945. The Governor-General held supreme authority across administrative, political, economic, and cultural domains, serving as both the representative of the French Republic and the embodiment of colonial absolutism in the region. Drawing upon primary colonial records and secondary scholarly analyses, this study highlights how the centralized power of the Governor-General shaped governance structures, enabled economic exploitation, and sought to enforce cultural assimilation. It also discusses the contradictions and crises of the regime, particularly during the interwar years and under Japanese occupation. The findings reveal that the Governor-General system embodied both modern administrative techniques and deeply entrenched colonial domination, leaving legacies that profoundly influenced Vietnam's path to independence and state formation.

**Keywords:** Indochina, the Governor-General, France, Vietnam, colonial

## CLIMATE CHANGE AND ITS IMPACT IN NORTH EAST INDIA: AN OVERVIEW

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### ABSTRACT

Climate change refers to the long term change in the average temperatures and weather conditions, posing a great threat to the inhabitants of North Eastern Region (NER) of India. The eight states of the region viz. Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Mizoram, Sikkim and Tripura account for almost 8 percent of the total land area of India. Climate change and associated uncertainties have serious direct and indirect consequences for crop production and food security in the region. Farmers are struggling to cope with altered temperatures and rainfall patterns with extreme weather events at play like droughts, floods, heat waves, and pest infestations. Along with this the region's socioeconomic challenges, including poverty and limited infrastructure, has exacerbated its vulnerability to climate change.

The fragile ecosystems of the North East, including its rich biodiversity, forests and water resources are also under severe stress due to these changes. Traditional practices such as shifting cultivation combined with deforestation and soil erosion further aggravate environmental degradation. Consequently, the livelihoods of indigenous and agrarian communities who remain highly dependent on natural resources are increasingly at risk. This paper is an attempt to outline the scenario of climate change in the region. By assessing these vulnerabilities, this study aims to provide insights for strategies that address both environmental risks and socio-economic constraints to enhance the resilience in the region. The paper also underscores the urgent need for a comprehensive, region-specific approach to mitigate the adverse socio-economic and environmental impacts of climate change in the Northeast.

**Key words:** Climate change, Impact, Biodiversity, Agriculture, Livelihood, North-Eastern India

## THE REFLECTION OF MIGRATION PHENOMENON IN NEWSPAPERS

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### Abstract

The European migration crisis, which reached its peak in 2015, did not emerge spontaneously but rather as the outcome of a complex interplay of global and regional developments. The overthrow of the Libyan regime and the subsequent Arab Spring significantly intensified migration flows from the African continent, as large groups of people sought security and better living conditions in Europe. At the same time, the escalation of armed conflicts in Syria and Iraq, accompanied by the rise of terrorist organizations, contributed to massive displacement and refugee movements toward European Union member states. These dynamics unfolded against the backdrop of Europe's own vulnerabilities, most notably the Greek financial crisis beginning in 2010, which severely affected the Union's economic stability, and the Ukrainian security crisis of 2014, which added further geopolitical tension.

The convergence of these adverse political, social, and economic circumstances produced an unprecedented situation for the European Union, challenging its institutional capacity, solidarity mechanisms, and political cohesion. Importantly, the migration crisis has not been a one-time episode but rather a continuing phenomenon, manifesting with varying intensity up to the present day. Public discourse, as shaped by the media, has played a central role in framing both the causes and consequences of migration, influencing societal perceptions and political decision-making across Europe.

The presented paper examines how the migration phenomenon has been represented in selected print media outlets, with particular emphasis on the crises of 2015 and 2020. By analyzing media narratives and their shifts over time, the study seeks to identify dominant frames, recurring themes, and potential changes in the perception of migration. This approach contributes to a broader understanding of how media discourse mediates the relationship between political realities and public opinion, thereby shaping the societal and institutional responses to migration within the European context.

**Keywords:** migration crisis, European Union, media discourse, content analysis, refugees/migrants, political framing

## ISLAMIC BANKING AND GLOBAL ECONOMIC DYNAMICS: A QUALITATIVE EXPLORATION

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### ABSTRACT

This study investigates how Islamic banks interact with the dynamics of the global economy and their strategies for maintaining Sharia compliance amid international financial changes. Adopting a qualitative approach, the research utilizes interviews, observations, and document analysis to understand the adaptation of Islamic banking practices in response to globalization, digitalization, and cross-border financial integration. The findings suggest that while Islamic banks encounter challenges such as regulatory diversity, global competition, and technological disruption, they also seize opportunities to expand through ethical finance, sustainable investment, and wider international partnerships. The study highlights the crucial role of Islamic banks in contributing to global financial stability, promoting inclusive growth, and strengthening the ethical foundation of the global economic system

**Keywords:** Islamic banking, global economy, qualitative research, financial inclusion, ethical finance

## THE ROLE OF MONETARY POLICY IN MAINTAINING INFLATION STABILITY AND ECONOMIC GROWTH IN INDONESIA

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### ABSTRACT

Monetary policy is a vital instrument used by central banks to regulate economic stability and growth. In Indonesia, managing inflation while supporting economic expansion is a major challenge faced by policymakers. This study aims to analyze the impact of monetary policy on inflation control and economic growth in Indonesia. Utilizing secondary data from Bank Indonesia and the Central Statistics Agency for the period 2015 to 2024, the research employs a quantitative approach with multiple regression analysis to examine how changes in interest rates and money supply affect key macroeconomic variables. The findings reveal that increasing interest rates effectively suppresses inflation, demonstrating the central bank's ability to maintain price stability. On the other hand, the expansion of money supply positively correlates with economic growth, indicating its role in stimulating investment and consumption. These results highlight the delicate balancing act faced by Indonesian monetary authorities: tightening policy to curb inflation without stifling economic growth. Furthermore, the study underscores the importance of coordination between monetary policy and fiscal policy to achieve sustainable development goals. The paper concludes that well-calibrated monetary policy is crucial for Indonesia to sustain inflation stability and foster long-term economic prosperity, ultimately improving the welfare of its population.

**Keywords:** Monetary policy, inflation stability, economic growth, interest rate, money supply, Indonesia

## IMPLEMENTATION OF MAQASHID SYARIAH ON THE OPERATIONS OF MICRO, SMALL, AND MEDIUM ENTERPRISES IN THE ISLAMIC ECONOMY

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### ABSTRACT

This study discusses the role of maqashid syariah in supporting the operations of Micro, Small, and Medium Enterprises (MSMEs) from an Islamic economic perspective. The objective of this study is to provide an explanation of matters related to the implementation of maqashid syariah in the operations of MSMEs in the context of Islamic economics. Using a qualitative method based on literature review, this study highlights the relevance of maqashid syariah as a moral and ethical foundation in guiding business practices to remain in line with the principles of justice, welfare, and sustainability. MSMEs have great potential to improve the community's economy, but practices in the field often face obstacles such as usury, financial manipulation, and violations of business ethics. Through the application of maqashid syariah, which includes the protection of property, life, intellect, religion, and social relations, MSMEs are expected to strengthen their competitiveness while providing tangible benefits to the community. The results of the study show that strengthening the implementation of maqashid syariah is not only important for upholding sharia values in business, but also capable of creating an inclusive, transparent, and welfare-oriented business ecosystem.

**Keywords:** Maqashid Syariah, MSMEs, Islamic Economics, Business Ethics, Economic Empowerment

## THE ROLE OF SOCIAL MEDIA IN CONSUMER BEHAVIOR IN THE DIGITAL ECONOMY ERA

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### ABSTRACT

The digital economy era has changed the landscape of business-consumer interactions, with social media becoming the main backbone. These platforms are no longer just communication tools, but powerful marketing, research, and transaction channels. This study aims to analyze the multidimensional role of social media as a source of information, social space, and influencer influence-on the consumer decision-making process before making online purchases. This study employs a quantitative approach using a survey method. A total of 200 active social media users who have made online purchases in Bandung City were selected through purposive sampling. Data was collected using a structured online questionnaire, measuring consumer perceptions of product information, reviews, and influencer content on Instagram, TikTok, and Facebook. The collected data was then analyzed using multiple linear regression analysis with the help of SPSS 25 software to test the influence of these variables. The results of the analysis show that social media has a significant and positive influence on consumer behavior. Content from influencers or content creators was found to be the most dominant factor (beta coefficient = 0.42,  $p < 0.01$ ), followed by interactions with reviews and testimonials from other users (beta coefficient = 0.35,  $p < 0.01$ ). Meanwhile, product information published by the brand itself was also significant, but with a lower influence. This finding confirms that in the digital economy, consumers trust recommendations from third parties that are considered authentic (such as influencers and fellow consumers) more than direct marketing communications from brands. This discussion highlights the shift in power from brand-centric to consumer-centric marketing. It is concluded that social media plays a crucial role as a mediator of trust and driver of consumer behavior. As a result, businesses need to allocate their strategies toward influencer marketing and proactive customer review management to remain competitive.

**Keywords:** Social Media, Consumer Behavior, Digital Economy, Influencers, Online Purchasing

## THE ROLE OF PUBLIC RELATIONS IN MENGORI VILLAGE GOVERNMENT IN DELIVERING SOCIAL ASSISTANCE TO THE COMMUNITY DURING THE PANDEMIC: STRATEGIES, CHALLENGES, AND IMPACTS ON PUBLIC TRUST

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### Abstract

This research explores the strategic role of Public Relations (PR) within the Mengori Village Government in delivering social assistance programs to the community during the Covid-19 pandemic. The study adopts a descriptive qualitative approach, with data collected through direct observation and interviews with key informants at the village level. Findings reveal that PR functions as a vital communication bridge between the government and its citizens, enabling the dissemination of accurate information, fostering public participation, and strengthening transparency in aid distribution. However, the process faced significant challenges, such as inaccurate beneficiary data, uneven distribution of assistance, and limited public understanding of eligibility criteria. These issues often led to dissatisfaction, suspicion, and even distrust among community members toward local authorities. Despite these obstacles, the implementation of appropriate communication strategies ranging from face-to-face community meetings, socialization campaigns, and the use of both traditional and digital media proved effective in clarifying procedures and reducing misunderstandings. Moreover, the involvement of the community in every stage of distribution was shown to be crucial in building mutual trust and ensuring fairness. The study highlights that PR in village governance should not only act as a one-way transmitter of information but also as a facilitator of two-way dialogue, capable of gathering feedback, addressing concerns, and promoting inclusivity in decision-making. In conclusion, the research underscores the essential contribution of PR in managing crises at the local level, particularly in programs that directly affect citizens' welfare. By adopting transparent, participatory, and culturally sensitive communication practices, PR can enhance the credibility of the government, foster stronger citizen-government relations, and improve the effectiveness of social assistance initiatives. The lessons learned from Mengori Village provide valuable insights for broader applications in rural governance, especially in times of crisis where public trust becomes a key determinant of program success.

**Keywords:** Public Relations, social assistance, transparency, community involvement, public trust, Covid-19 pandemic.

## MILLENNIAL CUSTOMER EXPERIENCE WITH SERVICES ON BSI MOBILE APPLICATION

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### ABSTRACT

#### Introduction and Purpose :

Digital transformation in the Islamic banking industry presents challenges as well as opportunities, especially in meeting the expectations of the millennial generation which is synonymous with the use of application-based technology. BSI Mobile as one of the sharia digital banking services is here to facilitate financial transactions while strengthening Islamic financial inclusion in Indonesia. However, millennial user satisfaction and experience are still crucial aspects that need to be researched. This study aims to explore the perception, experience, and level of satisfaction of millennial customers with the services available on the BSI Mobile application. In addition, this study also wants to identify factors that affect the loyalty of millennial customers in using sharia-based digital services.

This research is important because the millennial generation is the largest market segment in the digital financial ecosystem and has a significant influence on the sustainability of the Islamic banking business. Therefore, understanding the user experience is the foundation for improving service quality and developing new features. In particular, this study seeks to answer the question: whether BSI Mobile services have met millennial expectations in terms of convenience, speed, security, and sharia-based added value

#### Materials and Methods:

This study uses a qualitative approach with a descriptive method to explore the experience of millennial customers in depth. Data was collected through semi-structured interviews with 30 respondents aged 20–35 who were active users of the BSI Mobile app. In addition to interviews, researchers also observed the use of applications and analyzed reviews from digital platforms such as

the Google Play Store to enrich data. The analysis was carried out using *thematic analysis* techniques to identify customer experience patterns. The respondent criteria were determined by *purposive sampling*, namely customers who have used BSI Mobile for at least six months. This was chosen so that respondents have sufficient experience in evaluating application services. The validity of the data is maintained through source triangulation, which is comparing the results of interviews, observations, and secondary data to ensure the consistency of information.

### **Result:**

The results of the study show that most millennial customers consider the BSI Mobile application to be quite easy to use with a simple interface and relatively fast service. However, there are still several complaints related to *bugs*, loading delays, and interruptions when making certain transactions. In terms of security, respondents appreciated the existence of a multi-layered authentication system, although some mentioned that the verification process sometimes takes longer. This creates a dilemma between comfort and security. Sharia-based added value, such as the convenience of *zakat*, *infaq*, and digital alms, was highly appreciated by respondents because it was in accordance with the Islamic lifestyle of millennials who wanted to be practical but still in accordance with sharia principles. Overall, user satisfaction is still in the category of being quite good, but customer loyalty is affected by expectations for improved technology features, system stability, and more responsive customer service

### **Discussion and Conclusion:**

The findings of this study show that millennial customers' experience of BSI Mobile services is influenced by three main aspects: ease of use, technological reliability, and integration of sharia values. The app's advantage lies in the success of combining digital financial services with the value of religiosity. However, technical obstacles such as *bugs* and *slow loading* have reduced the satisfaction of some users. This is in line with previous research that confirms that system stability is a major determining factor in the digital banking experience.

The implication of this research is the importance for BSI to carry out continuous development, especially in improving application stability, expanding interactive features, and strengthening digital customer service. This increase will encourage millennial loyalty to BSI Mobile. In conclusion, even though BSI Mobile has met most of the needs of millennial customers, there is still room for significant improvement. With the right development strategy, BSI Mobile has the potential to become a leading Islamic banking application that is not only efficient, but also relevant to the lifestyle of the millennial generation

**Keywords:** Millennials, Customer Experience, BSI Mobile, Islamic Banking, Digital Banking.

## SHARIA ECONOMICS AS A PILLAR OF TODAY'S ECONOMY

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### ABSTRACT

**Introduction and Purpose:** The rapid growth of the global economy, coupled with recurring crises such as inflation, inequality, and instability in conventional financial systems, has brought renewed attention to the importance of alternative economic models that emphasize justice, transparency, and sustainability. Islamic economics, rooted in sharia principles, has emerged as one of the most promising paradigms to address these challenges and provide stability to contemporary economic structures. Its prohibition of *riba* (usury), *gharar* (excessive uncertainty), and *maisir* (speculation), alongside the promotion of risk-sharing and equitable wealth distribution, positions Islamic economics as a viable solution to current socio-economic issues. The purpose of this study is to analyze the role of Islamic economics as a fundamental pillar of today's economy and to evaluate its impact on financial stability, social welfare, and sustainable development.

**Materials and Methods:** This study employs a descriptive-analytical approach with both qualitative and quantitative methods. Quantitatively, secondary data from Islamic banking performance reports, sukuk issuance, and zakat and waqf management statistics in Indonesia and selected Muslim-majority countries were analyzed to measure the economic contributions of sharia-based instruments. Qualitatively, literature reviews, policy analysis, and expert interviews with Islamic economists and banking practitioners were conducted to capture insights on how Islamic economics addresses contemporary economic challenges. The combined approach allows for a comprehensive understanding of both theoretical and practical aspects of Islamic economics as a pillar of the modern economy.

**Results:** The findings demonstrate that Islamic economics has made a significant contribution to strengthening national and global economies through its institutional frameworks, including Islamic banking, Islamic capital markets, and Islamic social finance. For instance, data shows that Islamic banking in Indonesia has experienced steady growth with increasing asset values and customer bases, driven by rising awareness of sharia-compliant financial practices. Sukuk has become an important

financing instrument for infrastructure and development projects, providing a sustainable alternative to conventional bonds. Meanwhile, zakat and waqf play a crucial role in reducing poverty and fostering social equity, thereby addressing socio-economic disparities. Expert interviews further reveal that the integration of sharia-compliant principles with modern digital innovations enhances both accessibility and efficiency in economic activities.

**Discussion and Conclusion:** The study concludes that Islamic economics is increasingly recognized as a pillar of the modern economy, not only in Muslim-majority countries but also globally, as its values of fairness, risk-sharing, and ethical investment resonate with broader sustainability goals. The system provides resilience against financial crises by discouraging speculative activities and ensuring that economic growth is tied to real productive sectors. Nonetheless, challenges remain, including the need for greater public literacy in Islamic finance, harmonization of regulations across countries, and stronger digital infrastructure to support innovation in Islamic financial products. Addressing these challenges requires collaborative efforts among governments, regulators, financial institutions, and educational bodies. The practical implication of this study is that Islamic economics, when mainstreamed and supported by strong institutions and public awareness, can become a foundation for building an economy that is not only stable and inclusive but also sustainable for future generations.

**Key Words:** Islamic Economics; Financial Stability; Sharia Finance; Social Welfare; Sustainable Development

## THE ROLE OF MARKETING IN BUSSINESS STRATEGY AND BUSSINESS PLANNING

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### ABSTRACT

**Introduction and Purpose:** Marketing is one of the most essential pillars in modern business, functioning not merely as sales activity but as a strategic process to create value and build long-term relationships with customers. This study aims to examine the fundamental concepts of marketing, including its definition, objectives, principles, and core elements, as well as its relevance to business planning. The objective was to highlight how marketing contributes to sustainable business growth and competitive advantage.

**Materials and Methods:** This research employed a descriptive qualitative approach with a literature review method. Data were collected from books, scientific journals, and credible online sources related to marketing and business planning. The information was systematically categorized and thematically analyzed to identify key principles, strategic components, and their implications for business development.

**Results:** The findings indicate that marketing plays a central role in helping businesses understand consumer needs, design appropriate products, and build sustainable relationships. Core principles such as customer orientation, value creation, and competitive positioning are essential in determining business direction. Furthermore, marketing becomes a crucial part of the business plan since it guides product strategy, market segmentation, and communication efforts, all of which influence customer satisfaction and loyalty.

**Discussion and Conclusion:** This study concludes that marketing is not only an operational function but also a strategic driver that supports business sustainability and growth. Its integration within business planning ensures that organizations can effectively compete in dynamic markets while delivering customer value. Therefore, a comprehensive understanding of marketing is indispensable for entrepreneurs and companies to achieve long-term success.

**Key Words:** marketing, business, marketing strategy, customer value, business planning

## THE ROLE OF GOVERNANCE AND TRANSPARENCY IN ENHANCING CUSTOMER TRUST IN ISLAMOIC BANKING IN INDONESIA

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### ABSTRACT

Islamic banking in Indonesia has experienced rapid growth in line with the increasing public awareness of Sharia-based financial systems. However, the main challenge lies in maintaining customer trust through good governance practices and operational transparency. This study aims to analyze the role of governance and transparency in enhancing customer trust in Islamic banking. The research employs a qualitative approach using a literature study method that involves academic journals, official reports from the Financial Services Authority (OJK), and secondary data from the annual reports of several leading Islamic banks in Indonesia. The analysis was conducted through a descriptive-analytical approach to identify the relationship between governance practices, transparency, and customer trust. The results indicate that the implementation of good governance—such as compliance with Sharia principles, managerial accountability, and financial reporting transparency—positively contributes to strengthening customer trust. Islamic banks that consistently apply information disclosure tend to gain higher levels of customer loyalty. These findings reinforce the view that customer trust is not only built on spiritual aspects and Sharia compliance but also on the bank's commitment to professional management practices. The application of Good Corporate Governance (GCG) in Islamic banking needs to be strengthened through consistent regulations and stricter supervision in order to remain competitive with conventional banks. This study concludes that good governance and transparency are key factors in enhancing customer trust in Islamic banking. The implication of this research highlights the importance of long-term commitment from Islamic banking institutions to maintain information disclosure and the necessity of regulatory reinforcement from relevant authorities.

**Key Words:** Perbankan Syariah; Tata Kelola; Transparansi; Akuntabilitas; Good Corporate Governance (GCG); Kepercayaan Nasabah; Regulasi

## AN ANALYSIS OF ISLAMIC FINANCIAL LITERACY AMONG THE PEKALONGAN COMMUNITY ON ISLAMIC BANKING PRODUCTS

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### ABSTRACT

**Introduction and Purpose:** Islamic financial literacy is a crucial factor in promoting understanding and participation in Sharia-based financial services. This study aims to analyze the level of Islamic financial literacy among the Pekalongan community regarding various Islamic banking products.

**Materials and Methods:** The research employed a quantitative approach using questionnaires distributed to Pekalongan residents, both users and non-users of Islamic banks. The data were analyzed through descriptive statistics to classify literacy levels and inferential analysis to examine the effects of demographic variables such as age, education, and banking experience.

**Results:** The findings indicate that the overall Islamic financial literacy of the Pekalongan community remains at a moderate level. Respondents demonstrated stronger knowledge of savings and financing products, while understanding of investment and digital banking services was relatively weak. Demographic factors, particularly education level and prior experience with Islamic banks, showed a significant influence on financial literacy.

**Discussion and Conclusion:** The study highlights the need for enhanced financial education and awareness programs provided by Islamic banks and regulators. Improving Islamic financial literacy is expected to increase public trust, encourage broader use of Islamic banking products, and strengthen financial inclusion in Pekalongan.

**Key Words:** Islamic Financial Literacy; Islamic Bank; Banking Products; Pekalongan Community; Financial Inclusion

**MODERNLEŞME, KENTSEL BELLEK ve KAMUSAL ALANIN DÖNÜŞÜMÜ:  
GAZİANTEP İSTASYON CADDESİ**

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**ÖZET**

Cumhuriyet'in ilk yıllarında Anadolu'nun birçok kentinde yer alan istasyon caddeleri, modernleşmenin simgesel bir ifadesi olarak kentsel dokuyu şekillendiren belirleyici bir kimliğe sahip olmuş ve kolektif kent kimliğinde önemli bir yer edinmiştir. Bu caddeler, dönemin ulaşım politikalarının en önemli bileşeni olan gar binalarını kent merkezlerine bağlamış, cadde üzerinde yer alan kamusal binalar ve açık alanlar modern kent yaşamının deneyimlendiği mekanlar olarak kentsel belleğin oluşumunda merkezi bir rol üstlenmiştir. Gaziantep özelinde, kuzeyde gar binasıyla başlayarak güneyde Cumhuriyet Meydanı'yla son bulan, kuzey-güney doğrultusunda uzanan İstasyon Caddesi, yakın geçmişe kadar stadyum, Arkeoloji Müzesi, İl Jandarma Birlik Komutanlığı, kız enstitüsü, lunapark ve fuar alanı gibi çok işlevli kamusal kullanıma ev sahipliği yapmıştır. Ancak 1990'lı yıllardan itibaren caddenin bu özgün yapısı değişmeye başlamış, özellikle 2000'li yıllardan sonra açık kamusal alanlar hızla yapılaşarak kentsel dokunun niteliği ve mimari karakteri yeniden biçimlenmeye başlamıştır. Özellikle cadde üzerinde yer alan, kent hafızasında önemli bir yere sahip olan stadyum, fuar alanı ve lunapark gibi simgesel mekanların zamanla kaybı veya işlev değişikliği kentsel kimlik ve kültürel süreklilik açısından kritik bir dönüşümün yaşanmasına neden olmuştur. Bu bağlamda çalışma, arşiv kaynakları, haritalar ve fotoğraflar üzerinden caddenin özgün ve güncel durumunu karşılaştırmalı bir şekilde ele alarak, Cumhuriyet sonrası hakim olan modernleşme anlayışı ile biçimlenen kamusal alanın süreç içerisindeki değişimini ortaya koymayı ve bu değişimi kentsel bellek kapsamında sorgulamayı amaçlamaktadır.

**Anahtar kelimeler:** Gaziantep, kamusal alan, kentsel bellek, modernleşme

## MODERNIZATION, COLLECTIVE URBAN MEMORY, AND THE TRANSFORMATION OF PUBLIC SPACE: GAZIANTEP STATION STREET

### ABSTRACT

In the early years of the Republic, station streets in many Anatolian cities emerged as symbolic expressions of modernization, shaping the urban fabric and playing a defining role in the formation of collective urban identity. These streets connected railway stations—the primary components of the era’s transportation policies—with city centers, while the public buildings and open spaces along them served as spaces where modern urban life was experienced, playing a central role in the formation of urban memory. In the case of Gaziantep, Station Street extends along a north-south axis from the railway station in the north to Cumhuriyet Square in the south. Until recently, the street hosted a variety of multifunctional public facilities, including a stadium, the Archaeology Museum, the provincial gendarmerie headquarters, a girls’ institute, a lunapark (amusement park), and a fairground. However, starting in the 1990s, the street’s original character began to change, and particularly from the 2000s onwards, open public spaces were rapidly built over, reshaping both the urban fabric and its architectural character. The loss or functional transformation of symbolic sites such as the stadium, fairground, and lunapark (amusement park), which held a significant place in the city’s collective memory, has led to a critical transformation in terms of urban identity and cultural continuity. In this context, the study aims to comparatively analyze the original and current conditions of the street through archival sources, maps, and photographs, in order to reveal the transformation over time of public space shaped by the modernization approach that prevailed after the Republican period, and to interrogate this transformation within the framework of urban memory.

**Keywords:** Gaziantep, public space, urban memory, modernization

## TARİHİ YAPILARDA OLUŞAN DEPREM HASARLARI VE ONARIM SÜREÇLERİNİN İZLENMESİ: GAZİANTEP BAYAZHAN ÖRNEĞİ

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### ÖZET

Bu çalışma iki aşamadan oluşmaktadır. Öncelikle 2023 Şubat ayında gerçekleşen Gaziantep, Kahramanmaraş, Hatay merkezli depremler sonrası tarihi kent dokusunda yer alan yapılarda oluşan hasarlar ve oluşma nedenleri tespit edilmeye çalışılmıştır. Bu bölümde deprem sonrası tarihi dokuda oluşan hasarlar genel bir çerçeve içerisinde ele alınmıştır. Tarihi dokuda deprem öncesi dönemde yeterli bakım-onarım görmeme, yanlış müdahaleler vb. nedenlerden ötürü strüktürel sorunları olan yapıların deprem sonrasında hasar seviyeleri artmıştır. Ancak çalışmanın ana amaçlarından biri kentte tarihi yapılarda gerçekleştirilen onarım ve koruma müdahalelerin deprem karşısındaki performanslarının ölçülmesidir. Bu nedenle hasar tespitleri deprem öncesinde restorasyonu tamamlanmış, düzenli olarak bakım-onarımları gerçekleştirilen ve güncel bir işlev ile aktif olarak kullanılan anıtsal yapılar üzerinden yapılmıştır. Bu sayede gerçekleştirilen onarımların yapıların sürdürülebilir şekilde korunmaları üzerindeki etkisinin tartışılması amaçlanmıştır.

Çalışmanın ikinci bölümünde, seçilen örnek yapı üzerinde deprem sonrası oluşan hasarların onarımı; uygulanan yöntem, malzeme vb. ölçütler göz önünde bulundurularak değerlendirilmiştir. Bayazhan deprem öncesinde onarım görmüş, aktif olarak kullanılan ve kentsin simgesel değere sahip anıtsal yapılarından biridir. 2023 Şubat depremleri sonrası yapıda esaslı onarım gerektirecek boyutta hasarlar oluşmuştur. Günümüzde yapının onarımı tamamlanmış olup, yeniden kullanıma açılmıştır. Çalışmada yapıda oluşan deprem hasarlarının onarımlarına yönelik izlenen süreç detaylı bir şekilde incelenmiştir. Bu kapsamda uygulanan onarım yöntemlerinin ve kullanılan malzemelerin yapının özgün mimarisi ile uyumu, yapının bundan sonraki süreçte bütüncül bir şekilde korunmasına yönelik etkisi değerlendirilmiştir.

**Anahtar Kelimeler:** Deprem hasarı, tarihi yapı, Bayazhan.

## **EARTHQUAKE DAMAGES AND MONITORING OF RESTORATION PROCESSES IN HISTORICAL STRUCTURES: THE CASE OF BAYAZHAN, GAZİANTEP**

### **ABSTRACT**

This study is structured in two phases. The first phase focuses on identifying the types and causes of structural damage observed in buildings located within the historical urban fabric following the earthquakes centered in Gaziantep, Kahramanmaraş, and Hatay in February 2023. In this section, the damage to the historical fabric after the earthquake is discussed within a general framework. Damage levels of buildings with structural problems in the historical fabric before the earthquake increased after the earthquake due to reasons such as inadequate maintenance and repair, incorrect interventions, etc. However one of the central objective of the study is to evaluate the seismic resilience of historic structures that had previously undergone restoration and conservation interventions. Accordingly, the damage assessments were conducted on selected monumental buildings that had completed restoration prior to the earthquake, were subject to routine maintenance, and were actively used with contemporary functions. Through this approach, the study aims to critically assess the role and effectiveness of conservation practices in enhancing the structural sustainability and earthquake resilience of heritage buildings.

In the second part of the study, the repair of post-earthquake damages on the selected case study building were evaluated considering applied methods, materials and other relevant criteria. Bayazhan is one of the city's monumental structures with symbolic value was repaired and still in active use before the earthquake. The February 2023 earthquakes caused significant damage to the structure, requiring major repairs. Currently, the restoration works have been completed, and the building has been reopened for use. In this study, the process followed for the repair of earthquake damage to the building was examined in detail. In this context, the harmony of the applied restoration techniques and the materials used with the original architecture of the building and their impact on the holistic preservation of the building in the future were evaluated.

**Keywords:** Earthquake damages. historical structure, Bayazhan

## **AI READINESS IN THE APPAREL INDUSTRY: INSIGHTS FROM THE TURKISH CONTEXT**

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### **Abstract**

The apparel and textile sector represents one of the most strategic industries for the Turkish economy, contributing significantly to GDP, exports, and employment, as a result placing Türkiye one of the leading apparel exporters worldwide. At the same time, the global fashion industry is experiencing rapid transformation by emerging artificial intelligence wave, reshaping design, production, supply chains, and customer engagement. For Turkish apparel firms, this presents both opportunities and challenges: the strong manufacturing capacity and global integration provide a foundation, gaps in data maturity, digital skills, and strategic alignment can have negative effects on adoption.

This study aims to explore the concept of AI readiness in the apparel industry, with a particular focus on the Turkish context. Drawing on established frameworks such as the Technology Organization Environment (TOE) model, the Diffusion of Innovations (DOI) theory, TAM/UTAUT, and the 4S scaling perspective, the research proposes the AI Readiness Index (AIRI) as a conceptual model. The framework highlights four key dimensions of readiness: technological and data capabilities, organizational structures and leadership, human factors including skills and trust, and governance elements such as ethics, policies, and regulatory alignment.

There are two main expected contributions: theoretical, by extending AI readiness discussions into a sector specific context, and practical, by outlining a structured guide road that can support apparel firms in preparing for AI driven transformation. This descriptive work presents a foundation for future empirical research and offers insights for policymakers, managers and stakeholders working and studying on the digital and AI shaped future of the Turkish apparel industry.

**Keywords:** Artificial Intelligence, AI, Apparel Industry, Readiness, Barriers, Enablers

## TÜRKİYE'NİN YENİLENEBİLİR ENERJİ POLİTİKALARINDA YEREL YÖNETİMLERİN YERİ

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### ÖZET

Yenilenebilir enerji, doğada kendini sürekli yenileyebilen, tükenmeyen enerji kaynaklarını ifade eder. Fosil yakıtların hızla tükenmesi, çevresel sorunların artması ve enerji maliyetlerinin yükselmesi, bu kaynaklara olan yönelimi artırmıştır. Güneş, rüzgâr, jeotermal, biyokütle, hidrojen ve su kökenli enerjiler (hidroelektrik, dalga, gelgit, okyanus, akıntı) yenilenebilir enerji kaynakları arasında yer almaktadır. Özellikle güneş enerjisi, farklı formlara dönüştürülme potansiyeliyle ön plana çıkmaktadır. Yenilenebilir enerji, çevresel sürdürülebilirlik ve enerji güvenliği açısından günümüz koşullarında stratejik bir öneme sahiptir ve önemi giderek artmaktadır.

Çevre sorunlarının küresel bir nitelik kazanması, çözüm süreçlerinde uluslararası iş birliğini gerekli kılarken, sorunların yerel düzeyde ortaya çıkması yerel yönetimlerin önemini artırmaktadır. Yerel yönetimler, çevre politikalarının planlanması, uygulanması ve sürdürülebilirliğin sağlanmasında temel aktörlerdir. Artan kentleşme ve enerji talebiyle birlikte, yerel düzeyde yenilenebilir enerji kaynaklarına yönelim çevresel sorunların çözümünde stratejik rol oynamaktadır. Bu bağlamda, yerel yönetimlerin görev, yetki ve sorumluluklarının yasal düzenlemelerle netleştirilmesi ve uygulamaya dönük politikalarla desteklenmesi önem arz etmektedir.

Türkiye Cumhuriyeti Anayasası'nın 56. maddesi çevrenin korunması ve geliştirilmesini devlet ve vatandaşlara ortak bir görev olarak yüklemektedir. 2872 sayılı Çevre Kanunu'na göre ise çevrenin korunması, bozulmasının önlenmesi ve kirliliğin giderilmesi süreçlerinde Bakanlık ve yerel yönetimlerin yanı sıra meslek odaları ve sivil toplum kuruluşlarının iş birliği içinde hareket etmesi esastır. Çalışmada Türkiye'nin enerji politikaları içerisinde yerel yönetimlerin üstlendiği roller ve uygulama alanları araştırılmaktadır. Halka en yakın yönetim birimleri olan yerel yönetimler, çevre politikalarının oluşturulması ve uygulanmasında etkin rol üstlenmekte; çevre yönetiminde stratejik aktörler olarak öne çıkmaktadır.

**Anahtar kelimeler:** Yenilenebilir Enerji, Yerel Yönetimler, Çevre Politikaları.

### THE ROLE OF LOCAL ADMINISTRATIONS IN TURKEY'S RENEWABLE ENERGY POLICIES

#### ABSTRACT

Renewable energy refers to energy sources that can continuously replenish themselves in nature and are inexhaustible. The rapid depletion of fossil fuels, increasing environmental problems, and rising energy costs have increased the shift towards these sources. Solar, wind, geothermal, biomass, hydrogen, and water-based energies (hydroelectric, wave, tidal, ocean, and current) are among the renewable energy sources. Solar energy, in particular, stands out due to its potential to be converted

into different forms. Renewable energy is of strategic importance in today's conditions in terms of environmental sustainability and energy security, and its importance is increasing.

The global nature of environmental problems necessitates international cooperation in the solution process, while the emergence of problems at the local level increases the importance of local governments. Local governments are key actors in the planning, implementation and sustainability of environmental policies. With increasing urbanisation and energy demand, the shift towards renewable energy sources at the local level plays a strategic role in solving environmental problems. In this context, it is important to clarify the duties, powers and responsibilities of local governments through legal regulations and to support them with implementation-oriented policies.

Article 56 of the Constitution of the Republic of Turkey assigns the protection and improvement of the environment as a shared responsibility of the state and citizens. According to the Environmental Law No. 2872, cooperation between the Ministry, local authorities, professional associations and civil society organisations is fundamental in the processes of protecting the environment, preventing its degradation and eliminating pollution. This study examines the roles and areas of application of local authorities within Turkey's energy policies. As the administrative units closest to the public, local authorities play an active role in the formulation and implementation of environmental policies and stand out as strategic actors in environmental management.

**Keywords:** Renewable Energy, Local Administrations, Environmental Policies.

## BOŞANMIŞ AİLELERİN ÇOCUKLARINDA PSİKOPATOLOJİ İNCELENMESİ

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### ÖZET

Boşanma, çocukluk döneminde ruhsal ve davranışsal gelişimi olumsuz etkileyebilen önemli bir stresör olarak kabul edilmektedir. Literatürde, ebeveyn ayrılığının çocuklarda kaygı, depresyon, dikkat eksikliği ve hiperaktivite, uyku ve yeme bozuklukları gibi psikiyatrik belirtilerle ilişkili olduğu gösterilmiştir. Bu çalışmada, boşanmış ailelerin çocuklarında psikiyatrik morbidite ve eşlik eden komorbiditelerin değerlendirilmesi amaçlanmıştır. Araştırmaya İzmir Tepecik Eğitim ve Araştırma Hastanesi Çocuk Psikiyatri Polikliniği'ne başvuran 6–12 yaş arası 31 çocuk dahil edilmiş, psikiyatrik tanılar K-SADS-PL-DSM-5-T yarı yapılandırılmış görüşme formu ile belirlenmiş, ek olarak Çocuklarda Anksiyete ve Depresyon Ölçeği-Yenilenmiş (ÇADÖ-Y), Turgay DEHB Ölçeği, Çocuklar İçin Uyku Bozukluğu Ölçeği ve Yaşam Kalitesi Ölçeği kullanılmıştır. Katılımcıların %58,1'i kız, %41,9'u erkek olup yaş ortalaması 10,4 yıl olarak saptanmıştır. Çocukların çoğunluğu tek ebeveynle yaşamakta olup ebeveynlerde psikiyatrik ve tıbbi hastalık öyküsü dikkat çekmiştir. Klinik değerlendirme sonucunda olguların %35,5'inde anksiyete bozukluğu, %25,8'inde dikkat eksikliği ve hiperaktivite bozukluğu, %16,1'inde major depresif bozukluk ve %6,5'inde komorbid tanılar belirlenmiş, ayrıca %58,1'inde uyku sorunları, %45,2'sinde yeme problemleri ve %12,9'unda enürezis gözlenmiştir. Bulgular, boşanma sürecinin çocuklarda belirgin psikiyatrik ve davranışsal risklerle ilişkili olduğunu göstermektedir. Bu sonuçlar, boşanmış ailelerin çocuklarında erken tanı, düzenli psikiyatrik takip ve destekleyici psikososyal müdahalelerin önemini vurgulamaktadır.

**Anahtar kelimeler:** Psikopatoloji, anksiyete, depresyon

### PSYCHOPATHOLOGICAL OUTCOMES IN CHILDREN FROM DIVORCED FAMILIES

#### ABSTRACT

Divorce is recognized as a significant stressor that can adversely affect children's emotional and behavioral development. Previous studies have indicated that parental separation is associated with increased risk for anxiety, depression, attention-deficit/hyperactivity disorder (ADHD), sleep and eating disturbances, and other psychiatric symptoms in children. The present study aimed to investigate psychiatric morbidity and comorbidities among children from divorced families. A total of 31 children aged 6–12 years, who attended the Child and Adolescent Psychiatry Outpatient Clinic at Tepecik Training and Research Hospital in İzmir, were included. Psychiatric diagnoses were assessed using the K-SADS-PL-DSM-5-T semi-structured interview, while additional evaluations included the Revised Child Anxiety and Depression Scale (RCADS), Turgay ADHD Scale, Children's

Sleep Habits Questionnaire, and Pediatric Quality of Life Inventory. Of the participants, 58.1% were female and 41.9% were male, with a mean age of 10.4 years. Most children lived with a single parent, and a notable proportion of parents reported psychiatric or medical histories. Clinical assessments revealed that 35.5% of children met criteria for an anxiety disorder, 25.8% for ADHD, 16.1% for major depressive disorder, and 6.5% presented with comorbid conditions. Additionally, 58.1% exhibited sleep disturbances, 45.2% reported eating problems, and 12.9% demonstrated nocturnal enuresis. These findings indicate that parental divorce is significantly associated with psychiatric and behavioral risks in children. The results underscore the importance of early identification, continuous psychiatric follow-up, and provision of supportive psychosocial interventions for children experiencing parental separation.

**Keywords:** Psychopathology, anxiety, depression

## PHYTOCHEMICAL ANALYSIS AND ANTIOXIDANT ACTIVITY OF MULTIPLE EXTRACTS DERIVED FROM *PTYCHOTIS VERTICILLATA*

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### ABSTRACT

*Ptychotis verticillata*, a medicinal plant traditionally used in North Africa, is recognized for its numerous pharmacological properties, particularly its antioxidant potential. The present study aimed to evaluate and compare the antioxidant activities and polyphenol contents of different extracts obtained from *P. verticillata*, including the methanolic extract, the infusion, and the essential oil. The antioxidant activity was assessed using two complementary *in vitro* assays: the DPPH radical scavenging method and the ferric reducing antioxidant power (FRAP) test. These assays provided quantitative measurements of the free radical scavenging capacity and the reducing power of the studied extracts. In parallel, the total polyphenol content was determined spectrophotometrically using the Folin–Ciocalteu method, expressed as gallic acid equivalents. Preliminary results revealed significant variations in antioxidant capacity among the different extracts. The methanolic extract and the infusion exhibited higher polyphenol contents and stronger antioxidant activities compared to the essential oil, which showed moderate activity. These differences may be attributed to the polarity of the solvents and the nature of the extracted bioactive compounds. Overall, this study highlights the phytochemical richness and antioxidant potential of *Ptychotis verticillata*. The findings suggest that the methanolic extract and infusion could represent promising natural sources of antioxidants, supporting the traditional use of this plant and encouraging further phytochemical and pharmacological investigations.

**Keywords:** *Ptychotis verticillata*, antioxidant activity, polyphenols, methanolic extract, infusion, essential oil, DPPH.

## **MXENE-BASED COMPOSITE FOR ELECTROCHEMICAL SENSING OF HEAVY METALS IN THE AQUEOUS SYSTEM**

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### **ABSTRACT**

Two-dimensional Titanium-based MXenes are increasingly gaining attention for their remarkable electrical conductivity, layered structure, and tunable surface chemistry. These materials are often integrated with semiconductors such as Titanium Oxide (TiO<sub>2</sub>) to form composites that exhibit superior performance by combining the advantages of both components. In this study, a TiO<sub>2</sub>-Ti<sub>3</sub>C<sub>2</sub> MXene-based composite was synthesized using the molten salt synthesis method followed by selective etching. The electrochemical properties of this synthesized sample were analyzed via Linear Sweep Voltammetry (LSV) Stripping, and Cyclic Voltammetry methods. The composite exhibited a significantly enhanced response in sensing heavy metals, such as Pb<sup>2+</sup>, in solution when coated over a glassy carbon electrode. The structural characterization and functional group analysis were performed using X-ray Diffraction (XRD) and Fourier Transform Infrared Spectroscopy (FTIR), respectively. Due to the unique surface chemistry characteristics and morphology, the TiO<sub>2</sub>-Ti<sub>3</sub>C<sub>2</sub> composite exhibited extreme sensitivity and good linear correlations, with a detection limit up to 0.1 ppb. The optimum parameters, like deposition voltage and scan rate, were also determined. The composite even showed good repeatability for five cycles with almost identical results each time. This creates a new method for synthesizing and utilizing two-dimensional MXenes to detect and quantify trace amounts of impurities in water, making it highly relevant for environmental monitoring and public health applications.

**Keywords:** Two-Dimensional Materials, Heavy Metal Detection, Electrochemical Properties, Molten Salt Synthesis Method, Mxene.

## USE OF LOW-COST ACTIVATED CARBON FOR 2-NITROPHENOL ADSORPTION IN BATCH AND FIXED-BED COLUMN

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### Abstract

This paper describes the synthesis of environmentally friendly, low-cost adsorbents and examines their adsorption capabilities in the removal of 2-nitrophenol from wastewater. Simple analysis, FTIR, and SEM were used to characterize unmodified date palm fibers biochar.

The maximum adsorbed quantities for date palm fibers biochar were determined to be 71.076 mg/g, after isotherm experiments in the batch system were examined. Strong coefficient correlation ( $R^2$ ), low RMSE, and  $\chi^2$  in the measurements of isotherms were well-suited for the Langmuir equation.

To assess the column's functionality, fixed bed adsorption was investigated under operational settings, including bed height, 2-nitrophenol flow rate, and 2-nitrophenol inlet concentration.

As the rate flow decreases and bed height increases, breakthrough and breakthrough curves both increase.

With 4 cm (0.5 g) of bed height, 160 mg/L of intake 2-nitrophenol concentration, and 2 mL/min rate flow, the highest percentage of 2-nitrophenol solution treated (65.46%) and highest bed capacity of 31.42 mg/g were achieved.

Nelson, the breakthrough curves were fitted using the Yoon and Thomas models. The models exhibit strong behavior of the breakthrough and an  $R^2$  that is higher than 0.99, indicating their good applicability.

**Keywords:** 2-nitrophenol, Fixed bed adsorption, batch adsorption, biochar.

## QUANTUM ENTANGLEMENT MEETS DIVINE ASCENSION: AN EMPIRICAL FRAMEWORK FOR INTEGRATING *Al-Isrā' wal-Mi'rāj* WITH MODERN PHYSICS IN CROSS-CULTURAL EDUCATION

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### Abstract

This empirical study introduces a pioneering interdisciplinary framework that reinterprets the Islamic story of *Al-Isrā' wal-Mi'rāj*, the Prophet Muhammad's night journey and ascension, through the perspectives of quantum physics and ecological interconnectedness, while evaluating its effectiveness in promoting cross-cultural understanding within Nigerian tertiary institutions. Using a mixed-methods approach, including pre- and post-intervention surveys (N=320 students) and qualitative discourse analysis, the research presents a seven-module curriculum combining Qur'anic exegesis, classical commentaries, and modern scientific theories. Key findings show statistically significant improvements in participants' scientific literacy ( $p < 0.01$ , Cohen's  $d = 0.67$ ) and intercultural competence (IDI score  $\Delta = +14.3$ ,  $p = 0.003$ ), with 82% of students demonstrating greater ability to reconcile spiritual and scientific perspectives. The framework's metaphor of quantum entanglement, which draws similarities between non-local particle behavior and transcendent spiritual experiences, proved especially effective in recontextualizing the Prophet's journey across space and time. The study tests four hypotheses through psychometric tools, rejecting all null hypotheses at  $\alpha = 0.05$ . Quantitative analysis finds strong correlations ( $r = 0.71$ ) between understanding quantum non-locality and acceptance of metaphorical interpretations of *Al-Mi'rāj*'s celestial ascension. Qualitative data from focus groups show paradigm shifts among Sufi enthusiasts, viewing the Buraq (celestial steed) as a symbol of consciousness-mediated spacetime traversal rather than literal transportation. The curriculum's Module 3 on quantum interconnectedness stood out as the most transformative, with 76% of participants recognizing similarities between quantum field theories and Sufi ideas of divine unity (*wahdat al-wujūd*). This research adds to global conversations on faith and science integration by demonstrating how sacred stories can serve as educational tools for 21st-century challenges. The empirical validation of this framework offers replicable models for educational institutions seeking to foster epistemic humility and *Tauhidic* epistemology, as well as promote cross-cultural dialogue through interdisciplinary learning. Through comparing the Prophet's ascension to higher dimensions with modern cosmology's 11-dimensional spacetime models, the study offers a hermeneutic link between Islamic spirituality and contemporary physics, while respecting theological principles.

**Keywords:** Quantum Spirituality, *Al-Isrā' wal-Mi'rāj*, Interdisciplinary Islamic pedagogy, Quantum entanglement metaphors, Cross-cultural hermeneutics.

## KATI-SIVI REAKSİYONU İLE HAZIRLANAN KARIŞIK DEĞERLİKLİ BİZMUT OKSİT $\delta$ - $\text{Bi}_2\text{O}_{3+x}$ İN YAPISAL, OPTİK VE ELEKTRİKSEL ÖZELLİKLERİ

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### Özet

Nano-metrik  $\delta$ - $\text{Bi}_2\text{O}_{3+x}$  tozları, oda sıcaklığında katı-sıvı reaksiyonu ile başarıyla sentezlendi. Elde edilen tozlar, XRD, Raman, FT-IR, DTA/TG, SEM-EDS ve UV-vis teknikleri kullanılarak kapsamlı bir karakterizasyona tabi tutuldu. X-ışını difraksiyonu (XRD) analizi,  $\delta$ - $\text{Bi}_2\text{O}_3$  ile izostrüktürel bir kübik fazın varlığını doğrulamaktadır. Kimyasal analiz, elde edilen bileşiğin karışık değerlikli (üç değerlikli ve beş değerlikli bizmut) bizmut oksit olduğunu göstermektedir. Havada artan sıcaklıkta ısı işlem, sentezlenen bileşiğin  $\beta$ - $\text{Bi}_2\text{O}_3$ ,  $\alpha$ - $\text{Bi}_2\text{O}_3$  ve  $\gamma$ - $\text{Bi}_2\text{O}_3$  ile izomorfik üç kristal forma dönüşümünü göstermektedir. Havada gerçekleştirilen DTA ve TGA sonuçları, XRD çalışması ile uyumludur. Sentezlenen tozlar, küresel nanoparçacıklarla karakterize edilen bir morfoloji sergilemiştir. UV-vis difüz yansıma spektroskopisi (DRS),  $\delta$ - $\text{Bi}_2\text{O}_{3+x}$  fazının 1,86 eV bant aralığı enerjisine sahip olduğunu göstermektedir. En yüksek elektrik iletkenliği, 280 °C ye yakın bir değerle  $4 \times 10^{-3} \text{ S.cm}^{-1}$  elde edilir.

**Anahtar Kelimeler:** Katı-sıvı reaksiyonu,  $\delta$ - $\text{Bi}_2\text{O}_3$ , beş değerlikli bizmut, XRD, DRS.

### STRUCTURAL, OPTICAL AND ELECTRICAL PROPERTIES OF A MIXED VALENCE BISMUTH OXIDE $\delta$ - $\text{Bi}_2\text{O}_{3+x}$ PREPARED BY SOLID-LIQUID REACTION

### Abstract

Nano-metric  $\delta$ - $\text{Bi}_2\text{O}_{3+x}$  powders was successfully synthesized by solid-liquid reaction, at around room temperature. The resulting powders underwent comprehensive characterization using XRD, Raman, FT-IR, DTA/TG, SEM-EDS, and UV-vis techniques. X-ray diffraction (XRD) analysis confirms the existence of a cubic phase iso-structural to  $\delta$ - $\text{Bi}_2\text{O}_3$ . Chemical analysis shows that the obtained compound is bismuth oxide with mixed valence (trivalent and pentavalent bismuth). Heat treatment at increasing temperature in air shows that the synthesized compound is successively transformed into three crystalline forms isomorph to  $\beta$ -  $\text{Bi}_2\text{O}_3$ ,  $\alpha$ -  $\text{Bi}_2\text{O}_3$  and  $\gamma$ -  $\text{Bi}_2\text{O}_3$ . The results of the DTA and TGA performed in air are in agreement with the XRD study. The synthesized powders exhibited a morphology characterized by spherical nanoparticle. UV-vis diffuse reflectance spectroscopy (DRS) indicates that the  $\delta$ - $\text{Bi}_2\text{O}_{3+x}$  phase has a bandgap energy of 1.86 eV. The highest electrical conductivity is obtained at 280°C with a value close to  $4 \times 10^{-3} \text{ S.cm}^{-1}$ .

**Keywords:** Solid-liquid reaction,  $\delta$ - $\text{Bi}_2\text{O}_3$ , pentavalent bismuth, XRD, DRS.

## **MODIFIED BIOCHAR FOR PU COMPOSITES: FOAM CONTROL AND ADAPTED CELL ARCHITECTURE IN BUILDING MATERIALS**

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### **Abstract**

This work presents a methodology for the preparation of modified biochar in order to obtain a hybrid material suitable for applications in the field of building materials. The biochar is first modified by introducing functional and/or inorganic fillers to improve its interaction with a polymer matrix, in this case polyurethane, in order to promote homogeneous distribution and enhanced adhesion in the final composite. The process relies on mixing the modified biochar with the polyurethane under controlled conditions, with crucial attention paid to operational parameters such as biochar/matrix ratio, temperature and cure time, as well as bubble evacuation and orientation of the resulting foams. The aim is to obtain a foam with a suitable cellular structure (size, uniformity and porosity) that gives the material enhanced mechanical properties, low density and improved thermal conductivity, while ensuring dimensional stability and durability under conditions of use typical of building materials.

**Keywords:** modified biochar; polyurethane; foam; building materials.

## THE HOSOYA INDEX OF A GRAPH: AN ALGORITHMIC APPROACH

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### **Abstract:**

Topological indices play a significant role in many areas such as mathematics, chemistry, computer science, pharmaceutical research, network analysis and more. The Hosoya index is a well-known topological index in chemical graph theory, and it is defined as the sum of non-adjacent edge sets for a given graph  $G$ . In 1971, Haruo Hosoya introduced the concept of  $Z$  – index. It quickly became incredibly important in chemical graph theory and because of its significance, researchers started using the term ‘Hosoya index’ instead of ‘ $Z$  – index’ to honour the author. Studying the physicochemical properties of molecular graphs using graph theory is convenient and efficient. Even though it has a strong theoretical basis, it is nevertheless hard to calculate the Hosoya index for every molecular structure. This is because finding all possible matching for a given graph leads to high time complexity. Few algorithms are already available to find the Hosoya index for certain classes of graphs, but not for all kind of graphs. In this article, we address the problem of computing the Hosoya index by presenting an efficient algorithm to determine it in less time. This algorithm purely depends on the graph theoretical and matrix properties of a graph. Consequently, providing input is simple and we can obtain output rapidly using this method.

**Keywords:** Hosoya index, Algorithm,  $Z$  – index.

## OPTIMIZATION OF AZO DYE DEGRADATION IN SALINE WATER USING DESIGN OF EXPERIMENTS APPROACH

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### Abstract

**Background:** Aquatic environments today face contamination from various compounds originating from industrial wastewater. Advanced oxidation processes (AOPs) are one of the very efficacious solutions for the degradation and mineralization of refractory contaminants from industrial wastewater such as the hazardous Ponceau S dye (PS).

**Methods:** In this novel experimental work, the PS degradation with the Fenton-like process was inspected. The Full Factorial Design (FFD) was applied to study the effect of operating parameters on the PS degradation efficiency. Molecular docking was investigated to study the PS's toxicity, mutagenicity and carcinogenic effect.

**Significant Findings:** The statistical optimization demonstrated a coefficient  $R^2$  of 0.9638. The underlying reasons of each factor's effect on the PS degradation were comprehensively discussed. The optimal conditions established by the experimental design were as follows: the initial dosage of cobalt ions at 0.12 mM, PS dosage at 0.06 mM, and initial  $H_2O_2$  dosage at 1 mM. At optimum conductions, the expected PS degradation was 20.14%.

Ponceau S docked effectively with all five targets, showing the strongest and cleanest binding to CDK8. AKT and PR had strong but slightly less favorable interactions. Hydrophobic and electrostatic forces played a major role in ligand stabilization.

**Keywords:** Ponceau S; Fenton-like process; Industrial wastewater; molecular docking; full factorial design; Toxicity

## BEYOND CONNECTIVITY: BUILDING RESILIENT IOT SYSTEMS

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### Abstract

The accelerated advancement of Internet of Things (IoT) technologies has generated substantial benefits across diverse domains, including industry, healthcare, transportation, and daily life, by facilitating seamless interaction between intelligent devices and communication networks. Nevertheless, this increasing interconnectedness concurrently gives rise to significant challenges in the realm of cybersecurity. Owing to the frequent absence of robust protective mechanisms, IoT devices remain highly susceptible to a wide spectrum of cyberattacks, such as unauthorized access, data manipulation, and Distributed Denial-of-Service (DDoS) assaults.

This study investigates prevalent security threats affecting IoT infrastructures and highlights the necessity of embedding standardized security protocols from the earliest stages of system design, following the principle of “security by design.” Preventive strategies and technical countermeasures—including encryption, multi-factor authentication, and network segmentation—are critically examined as approaches to mitigating systemic vulnerabilities.

Beyond technical considerations, the analysis emphasizes the imperative of inter-institutional cooperation and the continuous refinement of cybersecurity policies within an evolving technological ecosystem. The paper also foregrounds the ethical and legal dilemmas associated with the pervasive deployment of IoT systems, particularly those concerning the protection of personal data and the transparency of its processing. The current absence of a unified regulatory framework, coupled with limited oversight over data collection practices, accentuates the urgency for more advanced legal instruments and decisive institutional interventions.

Drawing on a comparative assessment of international best practices and the guidance of leading organizations such as ENISA and ISO, this work advances an integrated approach to IoT cybersecurity. This framework incorporates technological infrastructure preparedness, user awareness initiatives, and specialized professional training. Ultimately, safeguarding security in the IoT era transcends a purely technical challenge and necessitates comprehensive institutional, societal, and legal commitments.

**Keywords:** Cybersecurity, Data Security, Cryptography, Regulatory Frameworks

## ID ALLOCATION FOR MULTI-ACCESS EDGE COMPUTING IN 5G NETWORKS

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**Abstract**— Multi-Access Edge Computing (MEC) has emerged as a foundational enabler of 5G networks, providing ultra-low latency, localized processing, and context-aware services. A critical component of MEC-5G integration is identifier (ID) allocation, which ensures secure device registration, session continuity, service discovery, and efficient mobility management. This paper presents a comprehensive study of ID allocation mechanisms in MEC-enabled 5G networks. Different types of identifiers—including subscriber identities (SUPI, SUCI), temporary identifiers (5G-GUTI), MEC application identifiers, MEC host identifiers, and network slice identifiers—are explored in detail. Parameter measurements related to latency, throughput, scalability, and security overhead are discussed. Simulation-based analysis and conceptual frameworks are presented to demonstrate the performance of efficient ID allocation. Challenges such as privacy protection, synchronization, and interoperability are analyzed with potential solutions like blockchain-based identity, AI-driven allocation, and federated identity management.

**Keywords:** — Multi-Access Edge Computing (MEC), 5G Networks, Identifier Allocation, Subscriber Identity, Temporary Identifier, MEC Application ID, MEC Host ID, Network Slice Identifier, Scalability, Mobility Management, Security, Blockchain, Federated Identity.

## FROM SIMPLE TO SECURE: A COMPLEX SUBSTITUTION CIPHER FOR SYMMETRIC ENCRYPTION

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### ABSTRACT

In today's digital world, keeping information safe from hackers and other unauthorized people is very important. One of the main ways we protect data is through encryption. Encryption is turning a readable message, called plaintext, into a secret code, called ciphertext. This code looks like random letters and numbers, and only someone with the right key can turn it back into its original form. To undo the process, we use decryption, which changes the ciphertext back into the original message for people who are allowed to see it. Encryption does more than just keep data private. It also helps confirm that the message really came from the right person and hasn't been changed. This paper introduces a symmetric encryption scheme designed to transform textual data into secure cipher text through number-based substitution and positional transformation. The plaintext is initially mapped into integers within a bounded residue system. Cipher text generation is achieved by integrating a dynamic key stream with index-based transformations, wherein the positional component introduces non-linearity to strengthen diffusion. This mechanism ensures that identical symbols occurring at different positions are encrypted into distinct values, thereby mitigating frequency-based cryptanalytic attacks. The proposed approach effectively balances algebraic simplicity with computational efficiency, rendering it suitable for lightweight cryptographic applications. Furthermore, it preserves scalability by supporting extended key sizes and larger symbol domains, thereby enhancing security and adaptability in diverse operational contexts.

**Keywords:** Encryption, Decryption, Cipher text

## THE IMPACT OF GUILT AND RELIGIOUS REMINDERS ON WORSHIP DELAYS: A COGNITIVE DISSONANCE STUDY

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### ABSTRACT

This study investigates the psychological mechanisms underlying worship delay behavior among young Muslims through the lens of Cognitive Dissonance Theory. It focuses on the roles of guilt and religious reminders, aiming to understand both their independent effects and interaction. Drawing on empirical and theoretical foundations, the study posits that emotional discomfort resulting from delayed worship—particularly guilt—can lead to either behavioral correction or avoidance. It further explores whether religious reminders can moderate this dynamic by reducing the impact of guilt on procrastination in worship. A quantitative, cross-sectional survey design was used, with data collected from 133 young Muslim adults aged 16 to 39 across educational and religious settings. Standardized Likert scale instruments measured guilt, worship delay, religious reminders, and cognitive dissonance. Statistical analyses were conducted using SPSS, including multiple linear regression and hierarchical regression modeling. Results indicated that guilt significantly predicted worship delay behavior ( $\beta = .635$ ,  $p < .001$ ), accounting for a substantial portion of the variance ( $R^2 = .398$ ). In contrast, cognitive dissonance did not significantly predict worship delay when entered alongside guilt. Moderation analysis revealed that religious reminders significantly moderated the guilt–worship delay relationship ( $\beta = -.200$ ,  $p = .027$ ), suggesting that exposure to compassionate religious cues may buffer the negative impact of guilt on spiritual procrastination. These findings offer practical implications for religious educators, spiritual counselors, and community leaders, emphasizing the importance of emotionally intelligent religious messaging in supporting consistent religious practice. Theoretically, this study extends Cognitive Dissonance Theory to spiritual contexts and highlights guilt as a key emotional mediator in religious decision-making among youth.

**Keywords:** Guilt, Cognitive Dissonance Theory, Worship Delay, Religious Reminders, Youth and Worship

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**PARTICIPATORY DECISION-MAKING IN SCHOOL MANAGEMENT: PRINCIPLES, PROCESSES, AND TEACHERS' ROLE**

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**Abstract**

Decision-making is the core of the management process, particularly in the context of school management. Effective decisions determine the success of achieving a school's vision, mission, and educational goals. This paper discusses the principles of decision-making, the decision-making process based on management paradigms, types of decisions, and the decision-making styles commonly applied by school principals. Furthermore, it highlights the importance of teachers' participation in decision-making as a strategy to foster a harmonious work environment, improve policy quality, and strengthen a sense of ownership toward the decisions taken. Referring to educational management literature, this paper demonstrates that systematic, data-driven, and stakeholder-involved decision-making positively impacts school management effectiveness and the achievement of educational objectives.

**Keywords:** Decision-Making, School Management, Teacher Participation, Leadership Style, Organizational Effectiveness

## THE IMPACT OF PLAY AND PLAY MATERIALS ON COGNITIVE DEVELOPMENT IN NUMERACY AMONG PRE-PRIMARY SCHOOL CHILDREN IN KAURA, KADUNA STATE

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### ABSTRACT

The study investigates the impact of play and play materials on cognitive development in numeracy among pre-primary school pupils. The study was conducted in Kaura Local Government Area (LGA) of Kaduna State. The study adopted an ex-post-facto research design and was guided by three (3) research questions and three (3) null hypotheses tested at a 0.05 level of significance. A sample of 40 pupils was selected from the population, consisting of 20 males and 20 females, using a multi-stage sampling technique. The instrument used for data collection was the Numeracy Achievements Test (NAT), which consisted of twenty multiple-choice items with three options (A, B, and C). The items in NAT were developed to evaluate lower and higher thinking processes. The study's instruments were validated, and a trial test was conducted to assess the reliability of the instrument. The research questions were addressed using descriptive statistics, including the mean and standard deviation. The hypotheses were tested at a 0.05 level of significance using an independent samples t-test. The findings revealed that pupils taught with play and play materials achieved significantly better results than those taught without them. Similarly, the hypothesis testing the difference in performance between male and female nursery three pupils revealed that there was no difference in the numeracy skills of male and female pupils. It was recommended that Children in preprimary education be taught through the play-way method because it exposes and involves pupils in playing and performing various activities that are capable of arousing their interest in learning.

**Keywords:** Play, Play Materials, Cognitive Development, Numeracy, Pre-primary School

## OTTOMAN ARCHIVAL PERSPECTIVES ON ALCOHOL IN THE SANJAK OF SKOPJE IN THE LATE OTTOMAN ERA

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### **Abstract**

This paper examines the culture and regulation of alcohol in the Sanjak of Skopje during the late Ottoman period, with a particular focus on how archival sources reflect both prohibition and pragmatic control. Drawing on a corpus of documents from the Ottoman Archives of the Presidency of the Republic of Türkiye dating from the late nineteenth and early twentieth centuries, the study analyzes petitions for licenses to sell wine and rakı, records of tavern openings and closures, municipal fines, and reports of disturbances caused by drunken individuals. These materials provide valuable insight into the functioning of meyhanes (taverns) and the role of alcohol in everyday urban life. The aim of this research is twofold: first, to reconstruct the administrative and social practices surrounding alcohol consumption in a multi-confessional Balkan province; and second, to highlight the tension between Islamic legal prohibitions and Ottoman fiscal and regulatory pragmatism. Methodologically, the study combines textual analysis of archival petitions, licenses, and municipal records with a socio-historical approach that situates Skopje within broader late Ottoman transformations. By examining these perspectives, the paper positions Skopje as a case study of how alcohol became both a cultural marker of social interaction and a site of negotiation between state authority, economic interest, and communal practice in the final decades of the empire.

**Keywords:** Ottoman Empire, Sanjak of Skopje, Alcohol Consumption, Meyhane (Taverns), Regulation and Prohibition.

## INQUIRY INNOVATIVE TEACHING STRATEGY IMPACT ON BIOLOGY PERFORMANCE OF STUDENTS IN ABAKALIKI EBONYI STATE

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### ABSTRACT

Inquiry Innovative teaching is a teaching method that challenge students to think deeply and creatively. It is compulsory in this modern age classroom teaching to develop creativity, critical thinking and problem solving skills in secondary school students especially in science subjects like Biology. Inquiry based teaching strategy is a relevant innovative strategy to activate the reasoning of students to a level of becoming critical thinkers. The past educational practices by conventional method have limited creativity in Nigerian students, researchers have emphasized the importance of interactive teaching method to minimize the limitation, but with a little attention to the relevance of inquiry teaching strategy. This necessitate this research to look into the impact of inquiry based teaching as innovative teaching strategy on Biology performance of students in Abakaliki, Ebonyi state. Sample of 60 students through Multi-stage sampling procedure was selected. The study was tested on two null hypotheses at a 0.05 alpha level, employing a quasi-experimental design. Data collection utilized a Biology Achievement Test (BAT), with a reliability of 0.85 using Kuder-Richardson Formula 20. This study found that inquiry-based learning is significant and better than the conventional method in improving the students' academic performance. The study recommends that teachers should adopt the use of inquiry based strategy in the teaching and learning process to develop critical thinking in students which can lead to innovation and better academic performance.

**Keywords:** Innovative teaching strategy, impact on Biology academic performance of Students

## **BİTKİSEL BAZLI SOYA, BEZELYE VE FINDIK ZARI PROTEİNLERİNİN GIDA GÜVENLİĞİ RİSK DEĞERLENDİRMESİ**

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### **ÖZET**

Yeni bitkisel proteinlerin gıda güvenliği hakkında giderek artan sayıda araştırma yapılmasına rağmen, birçok soru hala belirsizliğini korumaktadır. Gıda kaynaklı hastalıklar biyolojik, kimyasal veya fiziksel tehlikelerden kaynaklanabilmektedir. Bu çalışma, bezelye, soya ve fındık kabuğu proteinlerinin gıda güvenliği değerlendirmesi yapmayı amaçlamaktadır. Gıda güvenliği değerlendirmesi, mikrobiyal riskler, mikotoksinler, ağır metal kirleticiler, poliaromatik hidrokarbonlar ve pestisit kalıntılarını içermektedir. Elde edilen bulgulara göre, protein örneklerinde, *Salmonella* spp., *Listeria monocytogenes*, *Escherichia coli* ve *Staphylococcus aureus* tespit edilmemiştir. Ancak, soya proteininde aerobik koloni sayısı, küf ve maya belirlenmiştir. Proteinlerin mikotoksin (AFB1, AFB2, AFG1 ve AFG2) ve 586 adet pestisit kalıntısı içermediği görülmüştür. Ağır metaller (As, Pb, Cd ve Hg) bakımından bezelye proteininde As ve Pb ile soya ve fındık kabuğu proteinlerinde ise uluslararası güvenlik sınırlarının biraz üzerinde As, Cd ve Pb olduğu belirlenmiştir. Ancak, hiç bir örnekte Hg bulunamamıştır. Poliaromatik hidrokarbonlar (PAH) bakımından, proteinlerin benzo[a]piren (BaP) ve AB ΣPAH4 [benzo[a]piren (BaP), benz[a]antrasen (BaA), benzo[b]floranten (BbF) ve krizene (Chr)] değerlerinin EU No 835/2011 yönetmeliğinde belirtilen 1

µg/kg maksimum seviyeyi aşmadıkları tespit edilmiştir. Bu çalışma, artan bitkisel bazlı protein ihtiyacı sebebiyle, protein ekstraksiyonundan ürün formülasyonuna ve depolamaya kadar her aşamada gıda güvenliği risklerinin kapsamlı incelenmesi ve yeni gıda güvenlik sorunlarının dikkatli bir şekilde yönetilmesi gerekliliğini göstermiştir.

**Anahtar kelimeler:** Bitkisel protein, bezelye, soya, fındık zarı, gıda güvenliği riski, sağlık, risk değerlendirmesi

## FOOD SAFETY ASSESSMENT OF PLANT-BASED SOY, PEA AND HAZELNUT SKIN PROTEINS

### ABSTRACT

Although there is a growing research interest in the safety of emerging plant proteins, many questions remain unclear. Foodborne illnesses can arise from biological, chemical, or physical hazards. Thus, this study aims to conduct a food safety assessment of proteins associated with pea, soy, and hazelnut skin. The food safety assessment includes microbial risks, mycotoxins, heavy metal contaminants, polyaromatic hydrocarbons, and pesticide residues. The findings demonstrated that *Salmonella* spp., *Listeria monocytogenes*, *Escherichia coli* and *Staphylococcus aureus* were not detected. But soy protein was slightly contaminated with aerobic colony count, mould and yeast. Mycotoxins (AFB1, AFB2, AFG1, and AFG2), and any pesticide residues out of 586 could not be detected in the samples. The heavy metals (As, Pb, Cd, and Hg) screening showed that As and Pb in pea protein, and As, Cd and Pb in soy and hazelnut skin protein were slightly above the international safety limits. However, no Hg could be detected in the samples. The polyaromatic hydrocarbons (PAH) test revealed that the protein isolates did not exceed the maximum levels of benzo[a]pyrene (BaP) and EU ΣPAH4 [benzo[a]pyrene (BaP), benz[a]anthracene (BaA), benzo[b]fluoranthene (BbF), and chrysene (Chr)] in line with the Commission Regulation (EU) No 835/2011 (1 µg/kg). The recent study indicated that to meet the growing need for emerging plant proteins, their food safety aspects should be extensively examined in each processing stage, from protein extraction to product formulation and storage, to carefully manage the new safety challenges.

**Keywords:** Plant protein, pea, soy, hazelnut skin, food safety risk, health, risk assessment

### Acknowledgements:

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### ÖZET

Bu bildiriye, Odunpazarı İlçe Milli Eğitim Müdürlüğü ve Anadolu Üniversitesi iş birliğiyle yürütülen TÜBİTAK 4004 “Ortaokul Öğrencileri İçin Sanat, Sanatın Doğası ve İyileştirici Gücü” isimli projenin uygulama süreci ve sonuçlarının değerlendirilmesi amaçlanmıştır. Projenin temel amacı, ortaokul öğrencilerinin sanatın iyileştirici ve birleştirici gücünü keşfetmelerini sağlamak, kültürel ve sanatsal birikimlerini artırarak bireysel yaratıcılıklarını geliştirmek ve sanatın doğasını kavramalarına katkıda bulunmaktır.

Proje kapsamında, Eskişehir ili Odunpazarı ilçesindeki farklı okullardan, sanata ilgi duyan, projede yer almaya gönüllü ve istekli olan 24 yedinci sınıf öğrencisi yer almıştır. Katılımcılar, 29 Eylül - 3 Ekim 2025 tarihleri arasında düzenlenen etkinliklerde resim, seramik, müzik, tiyatro, lüle taşı ve animasyon gibi farklı sanat dallarını içeren atölye çalışmalarına katılmıştır. Etkinlikler, Anadolu Üniversitesi, Sanat ve Tasarım Uygulama ve Araştırma Merkezi (SATUYAM), Türk Dünyası Uygulama ve Araştırma Merkezi (TÜDAM), Odunpazarı Modern Müze, Eğitim Karikatürleri Müzesi, Eskişehir Milli Eğitim Girişimcilik Merkezi ve Özkan Halaç Özel Eğitim Meslek Okulu gibi farklı mekânlarda gerçekleştirilmiştir.

Projenin en önemli yönlerinden biri kapsayıcılığa verdiği önemdir. Özel gereksinimli öğrencilerle birlikte yapılan etkinlikler, katılımcı öğrencilerin empati, sosyal uyum ve kapsayıcılık becerilerini geliştirmelerine katkı sağlamıştır. Böylece öğrenciler, farklı bireylerle birlikte üretim yapma deneyimi kazanmış, toplumsal farkındalıkları artmıştır.

Projenin etki değerlendirmesi, katılımcıların proje öncesi ve sonrası görüşleri alınarak yapılmıştır. Sonuç olarak öğrencilerin sanata yönelik farkındalıklarının yükseldiği, duygularını ifade etme becerilerinin güçlendiği, sanatı bir iyileşme ve ifade aracı olarak gördükleri gözlemlenmiştir. Ayrıca, projenin sanat ve toplumsal değerler arasında güçlü bir bağ kurarak öğrencilerin kişisel ve sosyal gelişimlerine önemli katkılar sağladığı belirlenmiştir.

**Anahtar kelimeler:** Sanat Eğitimi, Ortaokul Öğrencileri, Sanatın Doğası, Sanat Terapisi, Kapsayıcılık, TÜBİTAK 4004

## ART FOR MIDDLE SCHOOL STUDENTS: THE NATURE AND HEALING POWER OF ART

### ABSTRACT

This paper aims to evaluate the implementation process and outcomes of the TÜBİTAK 4004 project titled “Art for Middle School Students: The Nature and Healing Power of Art”, carried out in collaboration between Odunpazarı District Directorate of National Education and Anadolu University. The primary goal of the project is to enable middle school students to discover the healing and unifying power of art, enhance their cultural and artistic knowledge, develop their individual creativity, and gain a deeper understanding of the nature of art.

Within the scope of the project, 24 seventh-grade students were selected from different schools in the Odunpazarı district of Eskişehir. The selection criteria prioritized students who had not previously participated in similar projects, were voluntary and motivated, and came from disadvantaged groups. The participants attended a series of activities held between September 29 and October 3, 2025, engaging in various art workshops, including painting, ceramics, music, theater, meerschaum art, and animation. These workshops took place at diverse venues such as Anadolu University, Center for Art and Design Application and Research (SATUYAM), Center for Turkish World Application and Research (TÜDAM), Odunpazarı Modern Museum, Cartoon Education Museum, Eskişehir National Education Entrepreneurship Center, and Özkan Halaç Special Education Vocational School.

One of the most significant aspects of the project is its emphasis on inclusivity. Through joint activities with students with special needs, participants improved their empathy, social cohesion, and inclusion skills. This experience allowed them to collaborate with individuals of different abilities, fostering social awareness and acceptance.

The project’s impact was evaluated through pre- and post-project feedback collected from the participants. Findings revealed an increase in students’ awareness of art, enhanced self-expression skills, and a recognition of art as a tool for healing and communication. Furthermore, the project successfully established a strong link between art and social values, significantly contributing to the students’ personal and social development.

**Keywords:** Art Education, Middle School Students, Nature of Art, Art Therapy, Inclusion, TÜBİTAK 4004

## OKURUN ROLÜ ÜZERİNE: ALIMLAMA ESTETİĞİ VE FRANSIZ YAPISALCI/POSTYAPISALCI KURAMLAR

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### ÖZET

Okurun metinle ilişkisini merkeze alan kuramsal yönelimler, 20. yüzyılda edebiyat eleştirisi alanında köklü bir dönüşüm yaratmıştır. Bu dönemde, metnin anlamının yalnızca yazarın niyetine indirgenemeyeceği, okurun etkin katılımıyla çoğullaştığı fikri giderek daha fazla önem kazanmıştır. Böylece farklı kuramsal bağlamlarda, okurun anlamın kurucu unsuru olduğu görüşü temel bir ortak payda hâline gelmiştir. Bu bağlamda alımlama estetiği, Hans Robert Jauss'un *beklenti ufku*, Wolfgang Iser'in *boşluk* kavramı ve Hans-Georg Gadamer'in *ufukların kaynaşması* görüşleriyle, edebî anlamın oluşum sürecinde okurun etkin rolünü kuramsallaştırmıştır. Buna paralel olarak Fransız düşünce geleneği içinde gelişen yapısalci ve postyapısalci yaklaşımlar da okurun yorumlayıcı katkısını farklı boyutlarda öne çıkarmıştır. Roland Barthes, anlamın kaynağını yazardan okura kaydırarak metnin çoğul yorumlara açık doğasını vurgulamış; Algirdas J. Greimas anlatı modelleriyle; Michael Riffaterre *hipogram* ve *okuma matrisleri* kavramlarıyla okurun rolünü merkeze alan çözümler geliştirmiştir. Bu çalışmada, anlamın oluşumunda okurun merkezi rolü bağlamında alımlama estetiği ile Fransız düşünce geleneğinde gelişen yapısalci ve postyapısalci yaklaşımlar arasındaki kesişim noktaları kuramsal bir çerçevede tartışılmıştır. Jauss'un *beklenti ufku* ile Riffaterre'in okuma stratejileri, Iser'in *boşluk* kavramı ile Greimas'ın anlatı modelleri, Gadamer'in *ufukların kaynaşması* ile Barthes'ın anlamın çoğulluğuna ilişkin görüşleri karşılaştırmalı olarak ele alınmıştır. Yapılan karşılaştırmalar, her iki yaklaşımın da okuru anlamın üretilmesinde merkezî bir unsur olarak gördüğünü, ancak bunu farklı kavramsal araçlarla ortaya koyduğunu göstermiştir. Bu farklılıklar, bir karşıtlık değil, birbirini tamamlayan bakış açıları olarak değerlendirilmiştir. Böylelikle, alımlama estetiğinin tarihsel ve felsefi zemininden gelen okur anlayışı ile Fransız edebiyat kuramındaki yapısal ve yorumsal modeller ortak bir kuramsal bağlamda buluşturulmuş ve iki yaklaşım arasında bir köprü kurulabileceği sonucuna varılmıştır.

**Anahtar kelimeler:** Fransız edebiyat kuramı, alımlama estetiği, okurun rolü, yapısalcılık, postyapısalcılık

## ON THE ROLE OF THE READER: RECEPTION AESTHETICS AND FRENCH STRUCTURALIST/POST-STRUCTURALIST THEORIES

### ABSTRACT

Reader-oriented theoretical approaches brought about a profound transformation in the field of literary criticism in the 20th century. In this period, the idea that the meaning of a text could not be reduced solely to the author's intention and that it multiplied through the active participation of the reader gained increasing importance. Thus, across different theoretical contexts, the view that the reader is a constitutive element of meaning became a common ground. In this framework, reception

aesthetics theorized the active role of the reader in the process of meaning-making through Hans Robert Jauss's *horizon of expectations*, Wolfgang Iser's notion of *gaps*, and Hans-Georg Gadamer's concept of the *fusion of horizons*. In parallel, structuralist and post-structuralist approaches within the French intellectual tradition also foregrounded the interpretive contribution of the reader in different ways. Roland Barthes shifted the source of meaning from the author to the reader, emphasizing the inherently plural nature of the text; Algirdas J. Greimas developed narrative models; and Michael Riffaterre introduced the concepts of *hypogram* and *reading matrices*, all centring on the reader's role. This study discusses, within a theoretical framework, the intersections between reception aesthetics and the structuralist/post-structuralist approaches that developed in the French intellectual tradition, with particular emphasis on the central role of the reader in meaning-making. Jauss's *horizon of expectations* is compared with Riffaterre's *reading strategies*; Iser's notion of *gaps* with Greimas's narrative models; and Gadamer's *fusion of horizons* with Barthes's view of textual plurality. The comparisons demonstrate that both approaches regard the reader as a central agent in the production of meaning, yet articulate this through different conceptual tools. These differences are interpreted not as contradictions but as complementary perspectives. Consequently, it is argued that the reader-centred understanding of reception aesthetics and the structural and interpretive models of French literary theory can be brought together within a shared theoretical framework, thereby establishing a bridge between the two approaches.

**Keywords:** French literary theory, reception aesthetics, role of the reader, structuralism, post-structuralism

## ANTİK ROMA TIBBINİN DÜŞÜNSEL VE EĞİTİMSEL GELİŞİMİ

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### ÖZET

Roma tıbbı, Yunan tıp geleneğinden büyük ölçüde ilham almıştır. Yunan tıbbının ortaya çıkmasından önce Roma tıbbı, dinden ve büyücülükten etkilenmiştir. İlk Roma hekimleri, tıp eğitimi almamış dini şahsiyetler veya aile reisleridir. Daha sonraki dönemlerde tıpkı Yunanlı hekimler gibi, Romalı hekimler de ruhani ritüellerden ziyade yapmış oldukları doğal gözlemlere güvenmişlerdir. Ancak bu durum, ruhani inançların tamamen terk edildiği anlamına gelmez. Kıtliklar ve salgınlar, toplum tarafından genellikle ilahi bir ceza olarak görülmüş, ritüellerin yardımıyla tanrıları yatıştırmanın bu tür olayların etkilerini hafifleteceğine inanılmıştır. Birçok hastalığın temel nedeni olarak bataklıklar, kötü hava ve çürümüş maddelerden gelen organizmalar görülmüştür. Romalılar, halk sağlığı için kamu hijyeni sistemleri kurmuşlardır. Roma'nın ilk önde gelen doktorlarından biri Galenos'tur. O, Yunanistan'da maymunlar da dâhil olmak üzere pek çok hayvanı inceleyerek insan anatomisi konusunda uzmanlaşmıştır. Galenos'a ek olarak; Platon, Hippokrates, Aristoteles, Celsus, Aretaeus, Dioskurides, Soranus gibi pek çok tıp ve düşünce insanı Roma tıbbının gelişimine katkıda bulunmuşlardır. Romalı doktorlar insan anatomisini çok iyi bir şekilde öğrenmişlerdir. Çeşitli hastalıkların teşhisinde ve tedavisinde bu meziyetleri sayesinde başarılı sonuçlar elde etmişlerdir. Roma tıbbında öne çıkan bir başka önemli konu da farmakolojidir. Doğadan toplanan bitkilerin ilaçlara dönüştürülmesi ve hastalıkların tedavilerinde kullanılması botanik ilminin gelişimine yol açmıştır. Bahsi geçen tüm bu nedenlerden dolayı Antik Roma'da tıbbi eğitime büyük önem verilmiştir. Bu eğitim sürecinde çıraklık sistemi uygulanmıştır. Düzenli derslerin verildiği resmi tıp okulları kurulduktan sonra bile bu sistem varlığını uzun süre korumuştur. Tıbbi eğitim süreci içerisinde anatomik diseksiyonlar oldukça önemlidir. Galenos'a göre babaları hekim olan erken çocukluk çağındaki öğrenciler babalarının denetiminde diseksiyon deneyimi kazanmışlardır. Zamanla çocukluk çağında yapılan bu uygulamanın kalkması ile beraber yazılı eğitimin kılavuzluğu gerekli görülmüştür. Bu durum, Roma dünyasında tıp eğitiminin kademeli olarak standartlaşmasına, programlı şekilde ders yapan ve diseksiyon eğitimi veren tıp okullarının kurulmasına zemin hazırlamıştır. Bu dönemden itibaren teori ve pratik arasında kademeli bir ayrım görülmüştür. Cerrahi eğitim genel tıp eğitiminden ayrılmıştır. Buna ek olarak Romalı hekimler birçok konuda kendi kendilerini eğitmişlerdir. İmparatorluğun son dönemlerinden itibaren tıp alanında yazılmış el kitapları sayesinde bu eğitim daha standart bir hal almıştır. Bu çalışmadaki temel motivasyon; yukarıda bahsi geçen düşünürlere ve hekimlere ait verilerin rehberliğinde Roma Tıbbının düşünsel, eğitimsel gelişimi ve bu konudaki uygulamalar hakkında örnekler eşliğinde genel bir değerlendirme yapmaktır.

**Anahtar kelimeler:** Roma, Tıp, Galenos, Diseksiyon, Tıbbi Eğitim.

## THE INTELLECTUAL AND EDUCATIONAL DEVELOPMENT OF ANCIENT ROMAN MEDICINE

### ABSTRACT

Roman medicine was largely inspired by the Greek medical tradition. Before the emergence of Greek medicine, Roman medicine was influenced by religion and witchcraft. The first Roman physicians were religious figures or heads of families who had not received medical training. In later periods, like Greek physicians, Roman physicians relied more on their natural observations than on spiritual rituals. However, this does not mean that spiritual beliefs were completely abandoned. Famines and epidemics were generally seen by society as divine punishment, and it was believed that appeasing the gods through rituals would mitigate the effects of such events. Swamps, bad air, and organisms from decaying matter were seen as the root causes of many diseases. The Romans established public hygiene systems for public health. One of Rome's first leading doctors was Galen. He specialized in human anatomy by studying many animals, including monkeys, in Greece. In addition to Galen, many medical and intellectual figures such as Plato, Hippocrates, Aristotle, Celsus, Aretaeus, Dioscorides, and Soranus contributed to the development of Roman medicine. Roman doctors had a thorough understanding of human anatomy. Thanks to this expertise, they achieved successful results in diagnosing and treating various diseases. Another important aspect of Roman medicine was pharmacology. The conversion of plants collected from nature into medicines and their use in the treatment of diseases led to the development of botanical science. For all these reasons, great importance was attached to medical education in Ancient Rome. The apprenticeship system was applied during this education process. Even after the establishment of formal medical schools where regular classes were held, this system remained in place for a long time. Anatomical dissections were of great importance in the medical education process. According to Galen, students whose fathers were physicians gained dissection experience under their fathers' supervision during their early childhood. Over time, with the discontinuation of this practice in childhood, written education became necessary. This situation paved the way for the gradual standardization of medical education in the Roman world and the establishment of medical schools that taught structured courses and provided dissection training. From this period onwards, a gradual distinction between theory and practice emerged. Surgical training was separated from general medical education. In addition, Roman physicians educated themselves in many areas. From the final stages of the Empire onwards, medical education became more standardized thanks to handbooks written on the subject. The main motivation behind this study is to provide a general assessment of the intellectual and educational development of Roman medicine and examples of its applications, guided by the data from the aforementioned thinkers and physicians.

**Keywords:** Rome, Medicine, Galen, Dissection, Medical Education.

## MAKÂSIDÜ'Ş-ŞERÎA PERSPEKTİFİYLE İSLAM AİLE HUKUKUNDA DİJİTAL DÖNÜŞÜM

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### ÖZET

Bu çalışma, dijitalleşmenin İslam aile hukuku üzerindeki etkilerini hem fırsatlar hem de tehditler çerçevesinde değerlendirmeyi amaçlamaktadır. Günümüzde nikâh, boşanma, mehir, nafaka ve velayet gibi aile hukukuna ilişkin temel işlemlerin dijital platformlar üzerinden gerçekleştirilmesi giderek yaygınlaşmaktadır. Ancak bu durum, hukuki geçerlilik, fikhî uygunluk, sosyal mahremiyet ve veri güvenliği gibi çok boyutlu meseleleri gündeme getirmektedir. Özellikle nikâh akdinde şahitlerin varlığı, tarafların rızasının açık beyanı ve ilan zorunluluğu gibi unsurların dijital ortamda nasıl sağlanacağı; boşanma beyanlarının sosyal medya gibi platformlarda gelişigüzel ifade edilmesinin fikhî sonuçları; mehir ve nafaka gibi mali yükümlülüklerin dijital belgeler üzerinden güvence altına alınmasının imkânı gibi sorular, İslam hukukunun temel prensipleriyle doğrudan ilişkilidir. Bu çalışmada, söz konusu sorunların tahlilinde Makâsıdü'ş-Şerîa (İslam hukukunun amaçları) analitik çerçevesi benimsenmiştir. Şeriatın amaçları olan dinin, canın, aklın, neslin ve malın korunması ilkeleri üzerinden dijitalleşmenin aile hukukuna etkileri değerlendirilmekte ve klasik fıkıh yöntemlerinin çağdaş teknolojik dönüşümlere nasıl cevap verebileceği tartışılmaktadır. Böylece dijital uygulamaların, İslam hukukunun özünü oluşturan adalet, şeffaflık ve aile kurumunun korunması ilkeleriyle ne ölçüde uyumlu olabileceği ortaya konulmaktadır. Çalışma, metodolojik olarak klasik İslam fıkından elde edilen bilgiler ile çağdaş Türk akademik söylemi ve ilgili yargısal uygulamaları bir araya getirmektedir. Bu yaklaşım, gelenek ile modernite arasında köprü kurarak, dijital gerçekliklerin fikhî değerlendirilmesine imkân tanımaktadır. Bir yandan şahitlik, ilan ve rıza gibi hukuki unsurların dijital ortamlarda zedelenme riski; sosyal mahremiyetin ve kişisel verilerin ihlali; dini kuralların keyfi ve bağlam dışı yorumlara açık hale gelmesi gibi endişeler gündeme gelmektedir. Diğer yandan, dijitalleşmenin kadınların hukuki haklara daha hızlı erişim sağlaması, evlilik ve boşanma işlemlerinin belge güvenliği ile desteklenmesi, uzak bölgelerde yaşayan bireylerin adalete erişim imkânının artması gibi kamu yararına uygun fırsatlar sunduğu görülmektedir. Bu çalışma, İslam aile hukukunun dijital çağda geleceğini makâsıd odaklı bir perspektifle ele almakta ve kamu yararını (maslahat) önceliklendiren, aynı zamanda İslam hukukunun temel prensiplerine sadık çözümler geliştirmeyi hedeflemektedir. Böylelikle güncel sorunlara dair incelikli bir anlayış sunmakta ve dijital gerçekliklerin İslam aile hukukuna uyumlu bir şekilde entegrasyonu için yapıcı öneriler ortaya koymaktadır.

**Anahtar kelimeler:** İslam hukuku, aile hukuku, dijitalleşme, Makâsıdü'ş-Şerîa, online fetva

### DIGITAL TRANSFORMATION IN ISLAMIC FAMILY LAW FROM THE PERSPECTIVE OF MAQÂSID AL-SHARIA

### ABSTRACT

This study aims to evaluate the impact of digitalization on Islamic family law within the dual framework of opportunities and challenges. In contemporary practice, fundamental family law processes such as marriage (nikâh), divorce (talâq), dower (mahr), alimony (nafaqa), and

guardianship (wilāya) are increasingly conducted through digital platforms. However, this development raises multi-dimensional questions regarding legal validity, conformity with Islamic jurisprudence, social privacy, and data security. Particularly, issues such as how the requirements of witnesses, explicit consent of the parties, and the obligation of public declaration in marriage contracts can be fulfilled in digital settings; the jurisprudential consequences of casual divorce declarations on social media; and the possibility of safeguarding financial obligations such as mahr and nafaqa through digital documentation are directly connected with the foundational principles of Islamic law. The study adopts the analytical framework of Maqāṣid al-Sharī'a (the objectives of Islamic law) to analyze these issues. By grounding the discussion in the objectives of preserving religion, life, intellect, lineage, and property, the research examines the effects of digitalization on family law and explores how classical methods of Islamic jurisprudence may respond to contemporary technological transformations. In this way, the study evaluates to what extent digital applications can align with the essential principles of Islamic law, namely justice, transparency, and the protection of the family institution. Methodologically, the study integrates insights from classical Islamic jurisprudence (fiqh), contemporary Turkish academic discourse, and relevant judicial practices. This approach seeks to bridge tradition and modernity, allowing for a jurisprudential assessment of digital realities. On the one hand, concerns are raised regarding the erosion of essential legal elements such as witness testimony, public declaration, and consent in digital settings; the potential violation of social privacy and personal data; and the risk of religious rules being subject to arbitrary or contextless interpretations. On the other hand, digitalization also offers opportunities aligned with public interest (maṣlaḥa), including facilitating faster access to legal rights for women, strengthening the security of marriage and divorce documentation, and enhancing access to justice for individuals living in geographically remote areas. This study approaches the future of Islamic family law in the digital age through a maqāṣid-oriented perspective, aiming to develop solutions that prioritize public interest while remaining faithful to the fundamental principles of Islamic law. In doing so, it seeks to provide a nuanced understanding of contemporary challenges and to propose constructive approaches for the harmonious integration of digital realities into the field of Islamic family law.

**Keywords:** Islamic law, family law, digitalization, *Maqasid al-Shariah*, online fatwa

## GÖMÜLÜ DİŞLERLE İLİŞKİLİ DENTİGERÖZ KİSTLER: GENİŞ YAŞ ARALIĞINDA ÜÇ OLGU SUNUMU

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### ÖZET

**Amaç :** Dentigeröz kistler, çenelerde en sık görülen odontojenik kistlerdir ve genellikle gömülü dişlerle ilişkilidir. Bu çalışmada farklı yaş gruplarında görülen dentigeröz kist olgularının klinik özellikleri ve tedavi yaklaşımları değerlendirildi.

**Gereç-Yöntem :** Kliniğimize başvuran üç olgu retrospektif olarak incelendi. Hastaların yaşları 11–82 arasında değişmekteydi. Tüm olgularda gömülü dişlerle ilişkili dentigeröz kist saptandı.

**Bulgular :**

- ✓ Olgu 1: 70 yaş erkek; mandibular sağ üçüncü molar çevresinde semptomatik radyolüsent lezyon.
- ✓ Olgu 2: 11 yaş kadın; maksiller sol kanin bölgesinde kist, bukkal yaklaşımla çıkarıldı.
- ✓ Olgu 3: 82 yaş erkek; mandibular sol üçüncü molar çevresinde ağrı ve akıntı ile başvurdu.

Tüm olgularda diş çekimi sonrası kist enükleasyonu yapıldı ve sorunsuz iyileşme gözlemlendi.

**Sonuç :** Dentigeröz kistler geniş yaş aralığında görülebilen odontojenik kistlerdir. Enükleasyon, farklı yaş gruplarında güvenilir ve etkin bir tedavi yöntemidir.

**Anahtar Kelimeler:** Dentigeröz kist; gömülü diş; enükleasyon

### DENTIGEROUS CYSTS ASSOCIATED WITH IMPACTED TEETH: THREE CASE REPORTS ACROSS A WIDE AGE SPECTRUM

### ABSTRACT

**Aim :** Dentigerous cysts are the most common odontogenic cysts of the jaws and are frequently associated with impacted teeth. This study aimed to evaluate the clinical features and treatment approaches of dentigerous cysts in different age groups.

**Materials and Methods :** Three cases presenting to our clinic were retrospectively analyzed. The patients' ages ranged from 11 to 82 years. All cases were diagnosed as dentigerous cysts associated with impacted teeth.

**Results :**

- ✓ Case 1: 70-year-old male; symptomatic radiolucent lesion associated with the mandibular right third molar.
- ✓ Case 2: 11-year-old female; cyst associated with the maxillary left canine, removed via buccal approach.
- ✓ Case 3: 82-year-old male; pain and discharge in the mandibular left third molar region.

Tooth extraction and cyst enucleation were performed in all cases, followed by uneventful healing.

**Conclusion:** Dentigerous cysts may occur across a wide age spectrum. Enucleation is a safe and effective treatment modality, providing favorable outcomes in different age groups.

**Keywords:** Dentigerous cyst; impacted tooth; enucleation

## **DİSFAJİ VE GÖĞÜS AĞRISI İLE PREZENTE OLAN DİFFÜZ ÖZOFAGEAL SPAZM: OLGU SUNUMU**

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### **ÖZET**

Diffüz özefagial spazm (DÖS), özefagus motilite bozuklukları içerisinde nadir görülen bir hastalıktır. Klinik olarak disfaji ve non-kardiyak göğüs ağrısı ile prezente olabilir. Yaşlı hastalarda ortaya çıktığında koroner arter hastalığı gibi kardiyak nedenlerle kolaylıkla karışabilir. Bu nedenle erken tanı, uygun yönetim ve gereksiz girişimlerden kaçınmak açısından önem taşır. Yetmiş bir yaşında erkek hasta, birkaç aydır süregelen yutma zorluğu ve aralıklı göğüs ağrısı şikayetleri ile başvurdu. Özgeçmişinde belirgin bir kronik hastalık öyküsü bulunmayan hastanın fizik muayene bulguları olağandı. Yapılan özefagografisinde özofagus boyunca belirgin tersiyer kontraksiyonlar izlendi. Görünüm, literatürde DÖS için tipik olarak tanımlanan “tırbuşon” ve “şiş kebab” görünümü ile uyumlu bulundu. Bu radyolojik bulgular doğrultusunda hasta diffüz özofageal spazm tanısı aldı. DÖS, özofagus peristaltizminin bozulması sonucu gelişir. Klinik tabloda en sık disfaji ve non-kardiyak göğüs ağrısı ön plandadır. Tanıda özofagus grafisi tipik bulgular sunmakla birlikte, endoskopi ve özofagus manometrisi de ayırıcı tanıda kullanılabilir. Özellikle ileri yaş grubunda görülen göğüs ağrısının kardiyak nedenlerden ayrımı önemlidir. Tedavi seçenekleri arasında kalsiyum kanal blokerleri, nitratlar, botulinum toksini enjeksiyonu gibi yaklaşımlar bulunmaktadır. Disfaji ve göğüs ağrısı şikayetleri ile başvuran ileri yaş hastalarda diffüz özofageal spazm nadir de olsa akılda tutulmalıdır. Tipik radyolojik bulguların tanınması, doğru tanı konulmasını ve uygun tedavi planının yapılmasını sağlar.

**Anahtar kelimeler:** Diffüz özofageal spazm, Disfaji, Özefagus motilite bozuklukları

### **DIFFUSE ESOPHAGEAL SPASM PRESENTING WITH DYSPHAGIA AND CHEST PAIN: A CASE REPORT**

#### **ABSTRACT**

Diffuse esophageal spasm (DES) is a rare disorder among esophageal motility abnormalities. Clinically, it may present with dysphagia and non-cardiac chest pain. In elderly patients, it can easily be confused with cardiac causes such as coronary artery disease. Therefore, early diagnosis is important for appropriate management and to avoid unnecessary interventions. A 71-year-old male patient was admitted with several months of progressive dysphagia and intermittent chest pain. His past medical history was unremarkable, and physical examination findings were within normal limits. Esophagography revealed prominent tertiary contractions throughout the esophagus. The appearance was consistent with the “corkscrew” and “shish kebab” patterns described in the literature as typical for DES. Based on these radiological findings, the patient was diagnosed with diffuse esophageal spasm. DES results from impaired coordination of esophageal peristalsis. The most common clinical symptoms are dysphagia and non-cardiac chest pain. While esophagography provides characteristic findings, endoscopy and esophageal manometry can also be used for differential diagnosis. In elderly patients, distinguishing chest pain from cardiac causes is crucial. Treatment options include calcium

channel blockers, nitrates, and botulinum toxin injections. Although rare, diffuse esophageal spasm should be considered in elderly patients presenting with dysphagia and chest pain. Recognition of typical radiological features allows accurate diagnosis and appropriate treatment planning.

**Keywords:** Diffuse esophageal spasm, Dysphagia, Esophageal motility disorders

## NADİR BİR ROTATOR MANŞET YIRTIĞI: FROSBURY FLOP TEAR

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### ÖZET

Rotator manşet yırtıkları, omuz ağrısı ve fonksiyon kaybının en sık nedenlerinden biridir. Supraspinatus tendon rüptürleri bu grupta en yaygın görülen patolojilerdendir. Literatürde nadir olarak tanımlanan Frosbury Flop tipi yırtık, tendonun proksimal ucunun akromiona doğru dönmesi ile karakterizedir. Bu olguda tipik manyetik rezonans görüntüleme (MRG) bulguları ile tanı konulan bir Frosbury Flop yırtığı sunulmaktadır.

Elli bir yaşında erkek hasta, sağ omuzda birkaç aydır süren ağrı ve son günlerde artan hareket kısıtlılığı şikâyeti ile başvurdu. Fizik muayenede omuz hareketlerinin ağrılı olduğu ve aktif abduksiyonun mümkün olmadığı görüldü. Çekilen omuz MRG'sinde supraspinatus kas tendonunda kritik zon düzeyinde komplet tam kat rüptür saptandı. Rüptüre tendon uçları arasındaki mesafe en geniş yerinde 2,5 cm olarak ölçüldü. Tendonun proksimal kesiminin akromiona doğru döndüğü ve bu düzeyde tendon kalınlığının belirgin artarak 11 mm'ye ulaştığı izlendi. Bu bulgular ışığında hasta Frosbury Flop Tipi Supraspinatus Tendon yırtığı olarak değerlendirildi. Frosbury Flop yırtığı, nadir görülmekle birlikte rotator manşet cerrahisinde tanınması gereken özel bir varyanttır. Yırtılan tendonun ters dönerek akromion altında kalınlaşmış görünüm oluşturması tanısal ipucu sağlar. Tanıda MRG kritik öneme sahiptir. Bu tip yırtıkların erken tanınması cerrahi planlama ve prognoz açısından belirleyicidir. Omuz ağrısı ve fonksiyon kaybı ile başvuran hastalarda Frosbury Flop yırtığı akılda tutulmalıdır. Tipik MRG bulguları ile doğru tanı konulması, uygun cerrahi yaklaşımın belirlenmesine katkı sağlar.

**Anahtar kelimeler:** Frosbury Flop yırtığı, Supraspinatus tendon rüptürü, Rotator manşet yaralanmaları

## A RARE ROTATOR CUFF TEAR: FROSBURY FLOP TEAR

### ABSTRACT

Rotator cuff tears are among the most common causes of shoulder pain and functional loss. Supraspinatus tendon ruptures are the most frequently observed pathology in this group. The Frosbury Flop tear, rarely described in the literature, is characterized by the proximal end of the tendon flipping upward toward the acromion. In this case, we present a Frosbury Flop tear diagnosed based on typical magnetic resonance imaging (MRI) findings.

A 51-year-old male patient was admitted with right shoulder pain persisting for several months and progressive limitation of motion in recent days. On physical examination, shoulder movements were painful, and active abduction was not possible. Shoulder MRI revealed a complete full-thickness rupture of the supraspinatus tendon at the critical zone. The gap between the torn tendon edges measured up to 2.5 cm at its widest point. The proximal end of the ruptured tendon was observed to be flipped toward the acromion, and tendon thickness at this level had significantly increased to 11 mm. Based on these findings, the patient was diagnosed with a Frosbury Flop-type supraspinatus

tendon tear. Although rare, the Frosbury Flop tear is an important variant that must be recognized in rotator cuff surgery. The flipped tendon beneath the acromion, with a thickened appearance, provides a diagnostic clue. MRI plays a critical role in diagnosis. Early recognition of this tear type is crucial for surgical planning and prognosis. In patients presenting with shoulder pain and functional loss, Frosbury Flop tear should be considered. Recognition of its typical MRI features contributes to accurate diagnosis and appropriate surgical management.

**Keywords:** Frosbury Flop tear, Supraspinatus tendon rupture, Rotator cuff injuries

## NADİR BİR İNTERSTİSYEL AKCİĞER HASTALIĞI: PULMONER ALVEOLAR MİKROLİTİYAZİS OLGU SUNUMU

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### ÖZET

Pulmoner Alveolar Mikrolitiyazis (PAM), intraalveolar kalsiyum fosfat mikrolitlerinin birikimi ile karakterize, nadir görülen ve genetik geçiş gösterebilen bir interstisyel akciğer hastalığıdır. Çoğu zaman uzun süre asemptomatik seyredilebilir. İlerleyen dönemlerde nefes darlığı, öksürük ve göğüs ağrısı gibi solunumsal yakınmalara yol açar. Bu sunumda tipik klinik ve radyolojik bulgularla tanı konulan genç bir kadın hasta sunulmaktadır. Yirmi iki yaşında kadın hasta, nefes darlığı, öksürük ve aralıklı göğüs ağrısı şikâyetleri ile başvurdu. Laboratuvar, fizik muayene bulguları ve ekokardiyografi değerlendirmesinde kardiyak nedenler ön planda düşünülmedi. Göğüs Hastalıkları bölümümüze refere edilen hastanın anamnezinde göğüs ağrısının derin nefes almakla belirginleştiği, hapsirmekle ise dayanılmaz hale geldiği öğrenildi. Çekilen toraks bilgisayarlı tomografisinde bilateral akciğer parankiminde tüm loblarda, özellikle alt loblarda, sağ akciğer orta lob lingula ve sol akciğer linguler segment düzeylerinde daha belirgin diffüz tutulum saptandı. Bulgular arasında kalsifiye retiküler-buzlu cam görünümü, subplevral alanlarda milimetrik kistler, dilate bronş yapıları ve kalsifiye interlobüler septal kalınlaşmalar dikkat çekmekteydi. Bu tipik radyolojik özellikler ışığında hastaya **Pulmoner Alveolar Mikrolitiyazis** tanısı konuldu. PAM, nadir görülmesi ve özgün radyolojik bulguları nedeniyle ayırıcı tanıda akılda tutulmalıdır. Genellikle kardiyak veya daha sık görülen akciğer hastalıkları ile karışabilmektedir. Erken dönemde tanı koymak, hastanın uzun dönem takibinde ve olası komplikasyonların önlenmesinde kritik öneme sahiptir. Genç yaşta nefes darlığı ve göğüs ağrısı ile başvuran hastalarda pulmoner alveolar mikrolitiyazis ayırıcı tanıda düşünülmalıdır. BT'deki karakteristik bulgular, tanı koydurucu değer taşımaktadır.

**Anahtar kelimeler:** Pulmoner alveolar mikrolitiyazis, Buzlu cam opasitesi, İnterstisyel akciğer hastalığı

## A RARE INTERSTITIAL LUNG DISEASE: PULMONARY ALVEOLAR MICROLITHIASIS CASE REPORT

### ABSTRACT

Pulmonary alveolar microlithiasis (PAM) is a rare interstitial lung disease characterized by the accumulation of intraalveolar calcium phosphate microliths, which may also have a genetic basis. Although it often remains asymptomatic for a long period, in advanced stages it may cause respiratory symptoms such as dyspnea, cough, and chest pain. In this report, we present a young female patient diagnosed with PAM based on typical clinical and radiological findings. A 22-year-old female presented with complaints of dyspnea, cough, and intermittent chest pain. Laboratory tests, physical examination findings, and echocardiographic evaluation did not suggest a cardiac cause. The patient was referred to our Pulmonology Department. Anamnesis revealed that chest pain increased with deep inspiration and became unbearable with sneezing. Thoracic computed tomography (CT)

demonstrated diffuse bilateral lung parenchymal involvement, more prominent in the lower lobes, the right middle lobe lingula, and the left lingular segment. Findings included calcified reticular–ground-glass opacities, subpleural millimetric cysts, dilated bronchial structures, and calcified interlobular septal thickening. Based on these characteristic radiological features, the patient was diagnosed with pulmonary alveolar microlithiasis. PAM should be considered in the differential diagnosis due to its rarity and distinctive imaging features. It may often be confused with cardiac or more common pulmonary diseases. Early diagnosis is crucial for long-term follow-up and prevention of potential complications. In young patients presenting with dyspnea and chest pain, PAM should be kept in mind. The characteristic CT findings are of diagnostic significance.

**Keywords:** Pulmonary alveolar microlithiasis, Ground-glass opacity, Interstitial lung disease

## CAROLİ HASTALIĞINDA İNTRAHEPATİK SAFRA YOLLARINDA KALKÜL OLUŞUMU: BİR OLGU SUNUMU

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### ÖZET

Caroli hastalığı, intrahepatik safra yollarının tıkaçıcı olmayan saküler veya fusiform dilatasyonlarıyla karakterize, nadir görülen konjenital bir hepatobiliyer hastalıktır. Bu olguda, 35 yaşında erkek hasta, uzun yıllardan beri aralıklı olarak devam eden sağ üst karın ağrısı, hafif ateş, abdominal şişkinlik ve kilo kaybı şikayetleriyle başvurmuştur. Fizik muayenede epigastrik hassasiyet saptanmıştır. Laboratuvar değerleri genel olarak normal sınırlarda olup karaciğer fonksiyon testlerinde belirgin bir bozulma izlenmemiştir. Abdominal ultrasonografi ve manyetik rezonans görüntüleme safra kesesinin “S” şeklinde olduğu, intrahepatik safra yollarında belirgin kistik dilatasyonlar ve lümende çok sayıda kalküller bulunduğu gözlenmiştir. MR kolanjiografide intrahepatik safra yollarındaki yaygın dilatasyonlar net şekilde izlenmiş, hepatik fibrozis veya renal patolojiye rastlanmamıştır. Tüm bu bulgular doğrultusunda hasta, Caroli hastalığına eşlik eden kalkül oluşumu teşhisi kondu. Caroli hastalığının kalkül oluşumuna zemin hazırladığı, risk oluşturduğunu vurgulamak ve farkındalık oluşturmak istedik.

**Anahtar Kelimeler:** Caroli hastalığı, Safra yolu dilatasyonu, Safra taşı (kalkül) oluşumu

## BILIARY STONE FORMATION IN INTRAHEPATIC BILE DUCTS ASSOCIATED WITH CAROLI DISEASE: A CASE REPORT

### ABSTRACT

Caroli disease is a rare congenital hepatobiliary disorder characterized by non-obstructive saccular or fusiform dilatations of the intrahepatic bile ducts. In this case, a 35-year-old male patient presented with long-standing intermittent complaints of right upper quadrant abdominal pain, low-grade fever, abdominal bloating, and weight loss. Physical examination revealed epigastric tenderness. Laboratory findings were generally within normal limits, with no significant abnormalities in liver function tests. Abdominal ultrasonography and magnetic resonance imaging revealed an “S”-shaped gallbladder, prominent cystic dilatations in the intrahepatic bile ducts, and multiple calculi within the ductal lumen. MR cholangiography clearly demonstrated diffuse dilatation of the intrahepatic bile ducts, without evidence of hepatic fibrosis or renal pathology. Based on these findings, the patient was diagnosed with Caroli disease accompanied by biliary stone formation. With this case, we aim to highlight that Caroli disease predisposes to stone formation and emphasize the importance of awareness regarding this complication.

**Keywords:** – Caroli disease, Biliary duct dilatation, Biliary stone formation

## INVESTIGATION OF THE PROPERTIES OF IRON-BASED COMPOSITES REINFORCED WITH ALUMINIUM OXIDE AND ZIRCONIUM OXIDE

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### Abstract

Metal matrix composites represent a cutting-edge class of materials that combine metals with reinforcing oxides, typically ceramics or other high-performance substances, to deliver properties far superior to those of conventional metals. These composites offer a distinct range of advantages, including increased strength, improved stiffness, enhanced wear resistance, and higher thermal stability, all while retaining the lightweight nature of the metal matrix

In this work, a metal composite sample was prepared using 97 vol% of pure iron powder as the matrix, with 3 vol% of reinforcement. The reinforcement was made from a mixture of 80 vol% aluminium oxide powder and 20 vol% zirconium oxide powder. Iron powder as matrix material used in the present work is a commercial 98% pure iron powder with an average particle size of ~100 µm, Aluminium oxide powder average particle size of ~10 µm, and Zirconium oxide powder is an important material in a variety of industries, including abrasives, ceramics, and metalworking. The average particle size used of ~10 µm. The composite samples were fabricated by a powder compaction process that involved compacting a mixture of metal and oxide powders in a die under high pressure at room temperature, specifically 650 MPa, with a pressing time of about 30 minutes under a hydraulic press. Typically, the tools are held in a vertical orientation with the punch forming the bottom of the cavity. The samples were dried at 150 °C for 30 minutes and sintered at 1120 °C for 30 minutes. The compressive strength and coefficient of friction were measured for the samples. It was found that the compressive strength of iron increased by 20%, and the coefficient of friction decreased by approximately 2.4 %, when aluminium oxide and zirconium oxide were used as reinforcement, indicating improved mechanical properties and better wear resistance of the developed composites.

**Keywords:** Iron, composite, wear resistance, compressive strength

## **DESIGN APPROACHES TO ROBOTIC WORKSTATIONS FOR DENTAL MANUFACTURING**

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### **Abstract**

The development of robotic technologies brings significant opportunities for process optimization in the production of dental products and emphasizes the growing demand for innovative solutions that ensure efficiency and precision in the processing of dental materials and components. The implementation of robotic systems enables manufacturers to address challenges in accuracy, repeatability, and scalability, which are critical factors in the production of high-quality dental implants and prosthetic devices. Among the most important innovations in this field is the implementation of robotic workstations. These systems provide enhanced process repeatability, reduce the risk of errors caused by human factors, and facilitate the integration of Industry 4.0 principles into dental manufacturing environments. This presentation focuses on systematic approaches to the design and implementation of robotic workstations for dental production, with particular emphasis on technological feasibility, process optimization, and compliance with safety requirements. An integral part of the research methodology is the use of advanced software platforms for modeling and simulation of manufacturing processes. Simulation tools allow researchers and engineers to evaluate alternative layout solutions, monitor and optimize handling operations, and identify potential bottlenecks in the early stages of system design. Such preventive analysis reduces development risks and enables more efficient allocation of resources during the transition from concept to physical implementation. Special attention is given to safety aspects, especially those arising from international standards that regulate the use of robotic solutions in healthcare-related industrial sectors. These standards ensure that robotic systems not only achieve technical performance but also meet requirements for reliability and safety. The results of the conducted tasks indicate that simulation-based approaches represent a powerful and cost-effective method for supporting the design of robotic workstations. Their application in dental implant manufacturing contributes to

improved product quality, rationalization of production processes, and the establishment of safe manufacturing systems in line with the principles of advanced industrial practice.

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**Keywords:** robotic workstations, Industry 4.0, dental production.

## FINITE ELEMENT FORMULATION OF FRETTING WEAR FOR AERO-ENGINE SPLINE COUPLINGS

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### ABSTRACT

Spline couplings in aero-engines are essential for transmitting torque and axial loads between rotating shafts, yet they are highly susceptible to fretting wear due to cyclic vibrations and thermal fluctuations. This wear phenomenon can compromise mechanical integrity, reduce transmission efficiency, and lead to premature component failure. To address this challenge, the present study employs a dual-method approach combining Finite Element (FE) analysis and analytical modeling to investigate fretting wear mechanisms in spline couplings.

A detailed FE model was developed using PrePoMax to simulate a pin-on-disc configuration representative of spline coupling behavior. The model incorporates realistic contact mechanics, material properties, and operational loading conditions. It provides insights into stress distribution, displacement fields, wear depth evolution, and contact pressure variations across the interface. Complementing this, an analytical model based on Hertzian contact theory and Archard's wear equation offers theoretical predictions of wear rates and helps interpret the underlying wear mechanisms.

The results from both models show strong correlation, reinforcing the reliability of the proposed framework. Key parameters such as contact pressure, surface roughness, and material hardness are shown to significantly influence wear progression. Critical wear zones are identified, enabling predictive maintenance planning and design optimization.

This integrated approach not only enhances understanding of fretting wear dynamics but also supports the development of more durable spline coupling systems for aerospace applications. Future work will focus on experimental validation and extending the models to more complex geometries and multi-axial loading scenarios.

**Keywords:** Spilne coupling, Pin on disc, PrePoMax, Finite Element Analysis, Hertzian contact theory, Archard wear equation

## GENERIC MODELLING APPROACH FOR REQUIREMENTS ENHANCEMENT BASED ON THE STRUCTURED MODEL

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### **Abstract**

The paper deals with the problem of the requirements enhancement related to a particular problem domain. New requirements related with problem domain are elicited and compared with the old requirements which are documented before. The formalized analysis and modelling of the Function–Process interaction refines a set of new constructs of the Enterprise modelling. The presented approach uses the structured model (modified Value Chain Model) for the description of the enhancement procedure of the problem domain knowledge. As a result, the requirements enhancement processes has been constructed and discussed in this paper. A domain management knowledge modelling procedure was designed, allowing to create a two-level (granular) model for describing knowledge of domain management information interactions: the highest level modified Value Chain Model is further elaborated into a set of Elementary Management Cycle models; the chosen hierarchical structure allows to create new structural knowledge models and to update existing ones. The presented framework of the knowledge-based Enterprise Management System architecture is aimed to develop practical methods for the knowledge-based enterprise modelling and implementation. The resulting method is designed to create a two-level (granular) knowledge description model for the analyzed domain management information interactions, to form current knowledge and domain knowledge models and to perform the analysis of knowledge models.

**Keywords:** formation of the problem domain knowledge, requirements engineering, requirements enhancement, modified Value Chain Model, Elementary Management Cycle.

## GENERATIVE AI FOR ACCELERATING NOVEL MATERIAL INVENTION IN PHOTOVOLTAIC CELL DESIGN

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### **Abstract:**

The efficiency and stability of photovoltaic (PV) cells are largely governed by the choice of semiconductor materials. Conventional material discovery processes rely on trial-and-error experimentation, which is time-consuming and resource-intensive. Generative Artificial Intelligence (GenAI) offers a transformative approach by enabling the prediction and generation of new material candidates with optimized properties such as bandgap tuning, carrier mobility, and thermal stability. This study highlights the role of GenAI in accelerating PV material innovation by integrating high-throughput simulations, physics-informed neural networks, and generative models to identify high-performance organic, perovskite, and hybrid semiconductors. The proposed framework reduces development cycles, enhances efficiency, and supports scalable production pathways for next-generation solar cells, thereby advancing global clean energy solutions.

### **Keywords:**

Generative AI, Photovoltaic Materials, Solar Cell Efficiency, Semiconductor Discovery, Perovskite, Organic Photovoltaics, AI-Driven Material Design

## LEVERAGING GENERATIVE AI FOR TRANSISTOR MATERIAL INNOVATION AND DEVICE OPTIMIZATION

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### **Abstract:**

Transistor scaling and performance improvements have long relied on breakthroughs in material science and device architecture. As conventional silicon-based approaches approach physical and economic limits, the search for novel materials and optimized transistor structures becomes increasingly critical. Generative Artificial Intelligence (GenAI) provides a powerful tool for accelerating this process by predicting atomic-scale properties, generating candidate materials with tailored bandgaps, and proposing innovative device architectures such as multi-gate and nanosheet transistors. This study explores the potential of GenAI in advancing transistor design by enabling data-driven material discovery, rapid prototyping through simulation, and optimization of trade-offs between power, performance, and area (PPA). The integration of GenAI into semiconductor research offers a path toward energy-efficient, high-performance devices for next-generation electronics.

**Keywords:** Generative AI, Transistor Design, Semiconductor Materials, Device Optimization, Nanoelectronics, AI-Driven Discovery, Energy-Efficient Computing

## **FIRE-ADAPTIVE ARCHITECTURE: INTEGRATING INDIGENOUS FIRE STEWARDSHIP FOR CLIMATE-RESILIENT AND REGENERATIVE DESIGN**

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### **Abstract:**

The escalating frequency and intensity of global wildfires, exacerbated by climate change and unsustainable land management practices, demand a fundamental paradigm shift in architectural and urban design approaches. This paper introduces Fire-Adaptive Architecture as a transformative framework that reconceptualizes fire from an adversarial force to an ecological partner in regenerative design. Grounded in the ancient Indian philosophy of Panchabhutas, where fire (Agni) represents transformation and renewal, this approach integrates millennia-old Indigenous fire stewardship wisdom with cutting-edge material science and contemporary architectural innovation. Through comprehensive analysis of case studies from Australia, North America, Africa, and the Mediterranean, we demonstrate how spatial configuration, sacrificial design elements, landscape integration, and community-scale planning can create settlements that not only survive but thrive in fire-prone environments. The framework directly contributes to Sustainable Development Goals (SDGs) 11, 13, and 15, offering scalable solutions for climate adaptation and ecosystem regeneration. Our findings reveal that fire-adaptive strategies reduce structural vulnerability by up to 75% while enhancing biodiversity and community resilience, providing a blueprint for sustainable coexistence with natural fire regimes.

**Keywords:** Fire-adaptive architecture; Indigenous fire stewardship; Climate resilience; Sustainable development; Regenerative ecosystems; Wildfire mitigation

**AMELIORATING EFFECTS OF ETHYL ACETATE FRACTIONS OF *CNESTIS FERRUGINEA* ROOTS ON ANASTROZOLE-INDUCED POLYCYSTIC OVARIAN SYNDROME IN FEMALE WISTAR RATS**

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**ABSTRACT**

**Background:** Polycystic Ovarian Syndrome (PCOS) is a hormonal disorder affecting women of reproductive age. This study investigates the therapeutic potential of ethyl acetate fractions of *Cnestis ferruginea* roots in mitigating anastrozole-induced PCOS in female Wistar rats.

**Methodology:** Sixty-four female Wistar rats were randomized into two groups: control and PCOS-induced. The PCOS-induced group was further subdivided into seven groups, receiving different treatments, including ethyl acetate fractions of *Cnestis ferruginea* roots (EAFCFR) and reference drugs clomide and metformin.

**Results:** Anastrozole induction significantly disrupted hormonal and metabolic parameters (levels of testosterone, follicle-stimulating hormone, luteinizing hormone, prolactin, progesterone, estradiol, insulin, triglyceride, fasting blood sugar, and body weight.), as well as ovarian architecture and estrous cyclicity. Treatment with EAFCFR, clomide, and metformin restored these changes, demonstrating the therapeutic potential of EAFCFR in managing PCOS.

**Conclusion:** The study suggests that ethyl acetate fractions of *Cnestis ferruginea* roots (EAFCFR) may be a valuable adjunct therapy in the management of PCOS, exhibiting efficacy comparable to reference drugs clomide and metformin.

**Keywords:** Polycystic Ovarian Syndrome (PCOS), Female Wistar rats, Ethyl acetate, *Cnestis ferruginea* roots (EAFCFR), Anastrozole.

## MATHEMATICAL ANALYSIS ON PHYSIOLOGICAL EFFECT OF CHRONIC OBSTRUCTIVE PULMONARY CANCER DUE TO HABIT OF SMOKING

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### **Abstract:**

Smoking is a major cause of various types of cancer, including lung, oral, throat, bladder, kidney, pancreas, and stomach cancer, this smoking-related disease mainly affects the lungs' alveoli, or air sacs, and airways. The toxic compounds in tobacco smoke affect the respiratory system and cause damage to the airways, leading to a narrowing of the air passages and mucus production. As a result, the lungs become less efficient at transferring oxygen into the bloodstream, making breathing more difficult. In advanced stages, COPD can also affect the heart, leading to complications such as heart failure. While there is currently no cure for COPD, there are treatments that can help to control the symptoms and delay the illness's progression. In order to effectively manage COPD, changes in lifestyle like giving up smoking, avoiding triggers in the environment, and engaging in regular exercise are essential. Medications like bronchodilators, inhaled corticosteroids, and oxygen therapy are commonly prescribed to improve breathing and reduce inflammation. Mathematical modelling is employed to analyse the effects of smoking lead to lungs problems. Runge- Kutta fourth order method is employed to demonstrate the how the normal cells are converted into diseased cells due to smoking leads to respiratory disease like cancer.

**Keywords:** Cancer, toxic, lung, respiratory, oxygen, bloodstream.

**BIOPROSPECTING OF ENDOPHYTES IN MEDICINAL PLANTS FOR ANTIFUNGAL PROPERTIES AGAINST CANDIDA ALBICANS (ZUCC). CASE STUDY OF MITRACARPUS SCABER**

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**ABSTRACT**

Endophytic fungi are microorganisms that inhabit the living tissues of their host plants without causing harm to the host plant. They are a promising source of bioactive compounds with antimicrobial properties. This study investigated the antifungal activity of extracts of endophytic fungi (*Aspergillus nidulans* and *Fusarium oxysporum*) against *Candida albicans* conducted at the Department of Plant Science and Biotechnology, Bayero University Kano, Nigeria. The sample was collected at the Botanical Garden, Bayero University, Kano. The antifungal properties were tested using the agar well diffusion method (1.0mg/mL, 0.5mg/mL, 0.25mg/mL, 0.125mg/mL, 0.625mg/mL) for two different solvents with Fluconazole as the positive control and distilled water as the negative control. The data was collected, and inhibition zones were determined. The result shows a dose-dependent increase in antifungal activity, with the highest inhibition zone observed at 1.0 mg/mL. Statistical analysis was conducted using ANOVA at  $P < 0.05$ . There was a significant difference between the concentrations and extracts ( $P < 0.01$ ).

**KEYWORD:** Endophytic fungi, antifungal activity, *Aspergillus*, *Fusarium*, *Candida albicans*, Agar Well Diffusion, Bioactive Compounds, Dose-dependent Response, Fluconazole, Statistical Analysis.

## **BLOCKCHAIN TECHNOLOGY ADOPTION AND AUDIT QUALITY IN SMES: EVIDENCE FROM ILORIN, KWARA STATE, NIGERIA**

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### **ABSTRACT**

This study examined Blockchain Technology Adoption and Audit Quality in Small and Medium-Sized Enterprises (SMEs) in Ilorin, Kwara State, Nigeria. The study examined how blockchain technology adoption impacts audit transparency and efficiency in SMEs. A descriptive survey design was used to gather data through a structured questionnaire distributed among eighty (80) respondents from seven (7) pharmacies and nine (9) hotels in Ilorin, Kwara State. Descriptive statistics were used to summarize respondents' opinions, and regression analysis was used to examine the relationship between blockchain technology adoption and audit quality, using the Statistical Package for Social Sciences (SPSS).

The findings revealed that blockchain technology adoption significantly improves both the efficiency and transparency of audits in SMEs. Specifically, the results revealed that higher levels of blockchain adoption improve audit processes by enabling real-time data verification, reducing the risk of manipulation, and promoting better accountability. The results highlighted the importance of blockchain as a powerful tool that can enhance audit quality in SMEs.

The study recommends that promoting wider blockchain adoption among SMEs in Ilorin, Kwara State, can improve audit practices, leading to efficient and transparent financial reporting. Business owners and auditors should embrace blockchain innovations, and policymakers should establish supportive structures to help integrate this technology into auditing practices.

**Keynotes:** Blockchain Technology, Audit Quality, Audit Transparency, Audit Efficiency, SMEs

## SMOKING PREVALENCE AND TAX POLICY IN ALBANIA: A REGIONAL PERSPECTIVE

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### **Abstract**

Tobacco consumption remains a significant public health and economic challenge in the Western Balkans, particularly in Albania. As of 2022, adult smoking prevalence in Albania stands at 22.5%, with 38.7% of men and 6.6% of women identified as smokers. Youth smoking prevalence is 6.3%, highlighting concerns about early initiation. In response, regional governments have increasingly prioritized tobacco taxation as a key control measure. Albania, alongside neighboring countries, has committed to regularly increasing tobacco taxes and strengthening enforcement to combat illicit trade and reduce affordability. In general, tobacco control policies, especially taxes on tobacco products show to have an impact on the imported quantities entering the domestic market, but also on consumption levels. This study provides an overview of tobacco tax policies in the region and assesses their role in shaping consumption trends with special reference to Albania.

**Keywords:** Tobacco Taxation, Smoking Prevalence, Western Balkans Policy.

## THE ROLE OF FISCAL POLICY IN MODERN MACROECONOMICS: CLASSICAL, KEYNESIAN, AND CONTEMPORARY PERSPECTIVES

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### **Abstract**

The role of fiscal policy in modern macroeconomics remains one of the most debated issues in economic thought and practice. Theoretical perspectives have evolved significantly over time, reflecting shifts in economic structures, crises, and evolving policy needs. Classical economists have traditionally argued for fiscal neutrality, stressing the primacy of market forces in ensuring equilibrium and treating government intervention as a distortionary factor with limited long-term benefits. In contrast, Keynesian economics has emphasized the active role of fiscal policy in stabilizing the economy, particularly through countercyclical measures designed to mitigate demand shocks, reduce unemployment, and manage recessions. Keynesian arguments have gained renewed relevance during global crises, including the Great Recession of 2008 and the COVID-19 pandemic, where fiscal stimulus was deployed as a key instrument of recovery.

Contemporary perspectives, including post-Keynesian approaches and Modern Monetary Theory (MMT), extend the debate beyond stabilization. These frameworks view fiscal policy as a strategic tool not only for short-term economic management but also for promoting redistribution, social inclusion, sustainability, and structural transformation. In the face of global challenges such as climate change, technological disruption, and widening inequality, fiscal policy is increasingly perceived as a driver of resilience and long-term economic adaptation.

This paper offers a comparative analysis of classical, Keynesian, and contemporary approaches, examining their underlying assumptions, policy implications, and relevance for present-day economic challenges. By reassessing the cyclical, redistributive, and structural roles of fiscal policy, the study aims to clarify its evolving functions and contribute to ongoing debates about the scope, effectiveness, and limitations of fiscal interventions in shaping macroeconomic outcomes.

**Keywords:** Fiscal Policy; Macroeconomic Stabilization; Keynesian Economics; Modern Monetary Theory; Structural Transformation

## MSMEs DEVELOPMENT STRATEGIES IN THE DIGITAL ERA: OPPORTUNITIES AND CHALLENGES

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### **Abstract**

Micro, Small, and Medium Enterprises (MSMEs) play a crucial role in the national economy amid rapid global digitalization. Digital technology offers significant opportunities for MSMEs to expand their markets, improve operational efficiency, and create more adaptive service innovations. However, challenges such as digital literacy gaps, limited access to technology, and reliance on traditional business models constrain MSMEs' ability to adapt effectively. This study employs a qualitative descriptive approach to formulate sustainable MSME development strategies tailored to local contexts. The findings show that MSME success depends not only on technology adoption but also on the ability to build strong networks, develop flexible hybrid business models, and optimize ecosystem synergy among government, private sector, and communities. This collaborative approach provides a comprehensive new perspective to strengthen MSMEs' competitiveness in the global market. The study's results are expected to serve as a vital foundation for policies and business practices that support the acceleration of inclusive and sustainable digital transformation.

**Keywords:** Development strategy, Digitalization, MSMEs

## ECONOMIC INTERESTS IN THE DISCOURSE OF GLOBAL MILITARY-ECONOMIC CYCLICALITY

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**Abstract.** On the global scale, economic interests drive not only economic activity but also geopolitical processes. The economic interests of geopolitical actors form a dynamic system of contradictions and shared interests. Long-term geopolitical processes are cyclical in nature, generated by the periodic exacerbation of geopolitical contradictions. This is largely due to conflicts in the economic interests of geopolitical actors. The most relevant forms of cyclical geopolitical processes are global military-economic cycles, primarily long cycles of world politics and hegemonic cycles. The periods of greatest conflicts of interest among geopolitical players, primarily economic interests, are the crisis-militaristic phases of global military-economic cycles. These phases unfold in the form of "global" wars, during which military confrontation between competing military-political blocs alternately intensifies and weakens. In the long-cycle theory of global politics by G. Modelski and W. Thompson, the crisis-militaristic period of the cyclical geopolitical process is the "macro-decision" phase – a period of thirty years of global confrontation, in other words, a "global war". According to I. Wallerstein's concept of hegemonic cycles, in each specific historical example, hegemony was achieved through a thirty-year world war, in which, not necessarily continuously, almost all major states were involved. The unfolding of the crisis-militaristic phases of global military-economic cycles leads to a transformation of the global geopolitical system. As a result, either a new leader of the global geopolitical system emerges, or the geopolitical strategy of the incumbent leader, who has retained his dominance, changes. Anyways, the leader of the global geopolitical system subsequently determines the technical, technological, socioeconomic, military, political, environmental, and cultural development guidelines for the entire world. The leading state in the global geopolitical system receives the primary preferences for pursuing its economic interests. Its allied countries also enjoy a more advantageous position than other countries in the system of international economic relations established after yet another crisis-militaristic period. These days, a new crisis-militaristic stage in the development of the world system is beginning, which will change the conditions for realizing the economic interests of states, their associations, and transnational businesses. In particular, historically, during the unfolding crisis-militaristic phases of global cycles, foreign trade relations were conducted in accordance with protectionist policies, and after their completion, another wave of free trade began in the capitalist world system.

**Keywords:** economic interests, military-economic cycles, crisis-militaristic phases, geopolitical leader.

## OPTICAL PROPERTIES OF DOPED SEMICONDUCTOR CdSe;0.5%Ho NANOCRYSTALS

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### ABSTRACT

The article describes the experimental methods used in the study (optical and time-resolved spectroscopy, colorimetry and aberration self-action method), as well as the synthesis methods and technological approaches used for the production of hybrid organic-inorganic light-emitting diodes, in particular the creation of thin films (through thin film deposition) and technological approaches to create a layered structure of devices. The work used modern measuring equipment, as well as modern methods and approaches to the processing of experimental data, the technological part of the study was carried out in clean room conditions, which allowed to achieve successful results in the production of light-emitting devices. The optical properties of doped CdSe;0.5%Ho nanocrystals were considered. For three populations of planar CdSe;0.5%Ho nanocrystals with characteristic lateral dimensions of 20-70 nm, it was shown that they have the narrowest interband luminescence lines ( $\Delta\lambda_{FWHM} = 10$  nm), the positions of their maxima ( $\lambda = 461, 508, 55$  nm depending on the thickness) of the nanocrystals (3, 4 and 5 CdSe;0.5%Ho monolayers), as well as the shortest relaxation time of the excited state ( $\tau < 2$  ns) among all colloidal nanocrystals of various shapes and structures. When studying the absorption of colloidal solutions of 2D CdSe;0.5%Ho nanocrystals with a sphalerite structure of different thicknesses (3, 4 and 5 CdSe monolayers), it was found that in the absorption spectra, according to the dispersion law near the center of the Brillouin zone, a pair of transitions is formed from the peaks below the light and light bands. valence band to the conduction band. In this case, the maxima of these pairs have values of 2.87 and 2.71 eV, 2.61 and 2.46 eV, 2.41 and 2.25 eV, which strongly depends on the thickness of the nanocrystals. An analysis of the color properties of the studied phosphors is carried out. As a result, based on the totality of the data obtained, CdSe;0.5%Ho nanoplates with a thickness of 4 monolayers (emission wavelength  $\lambda = 508$  nm) were selected for the production of organic light-emitting diodes, since these samples had the least dependence on the effect of defects on their properties.

**Keywords;** experimental, spectroscopy, phosphorus, holmium, nanocrystal

### INTRODUCTION

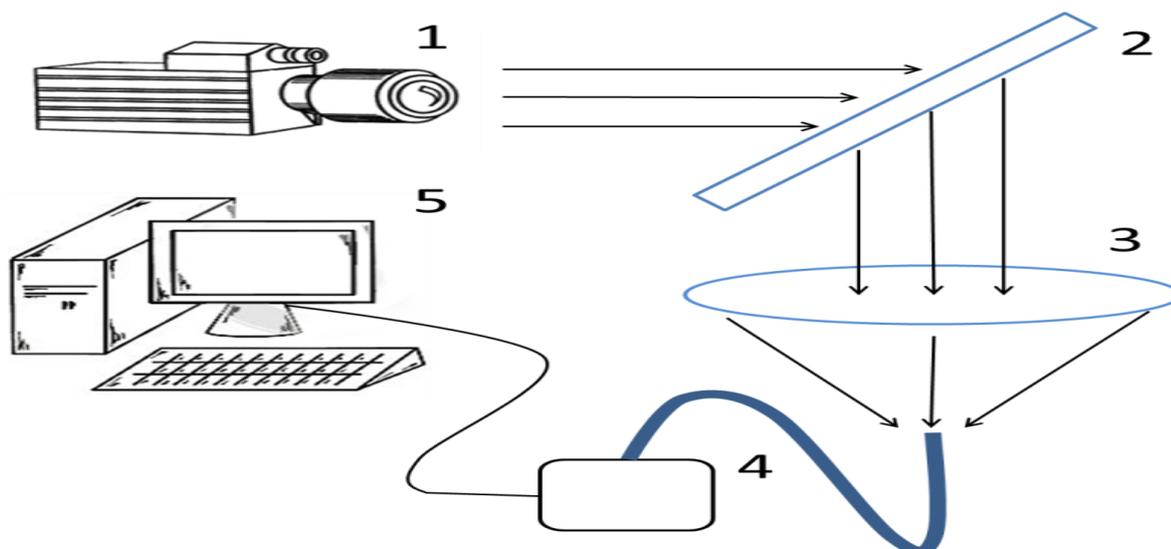
One of the current scientific and practical problems is the creation of an efficient and economical light source. One of the ways to solve this problem was the creation of new light-emitting diodes based on organic luminescent materials [1–3] (OLEDs). In the simplest case, these devices consist of a glass substrate with a transparent anode deposited on it, a metal cathode, and an active emission layer placed between them [4]. When connected to a voltage source, opposite currents of oppositely charged particles (electrons and holes, respectively) begin to flow between the cathode and anode; the particles that meet in the active emission layer recombine with light emission. The advantages of organic light-emitting diodes are the low cost of the technology, high quantum yield of radiation, and the ability to produce a light source in almost any region of the visible spectrum. However, there are

also major disadvantages associated with the failure of such devices, photodegradation, and the short time between electrochemical processes occurring in the organic luminescent layer. In addition, effective organic luminophores themselves are often quite expensive. To eliminate the above-mentioned negative effects, a number of approaches are currently used, such as complete sealing of devices, complexity of the technology for eliminating the effects of organic solvents and impurities. An alternative solution may be to abandon the use of organic luminophores as radiative recombination centers in favor of semiconductor nanocrystals based on direct-hole  $A^2B^6$  semiconductors (CdSe, CdS, etc.). Nanocrystals are practically not subject to degradation and have a high quantum luminescence yield. In addition, using a fairly simple, inexpensive and highly scalable procedure for colloidal synthesis based on the same material, nanocrystals with various emission spectra covering the entire visible spectrum can be obtained, since the emission properties of nanocrystals are primarily determined by the size quantization effect [5]. At the same time, nanocrystals have narrow absorption and emission lines [6-8] and short relaxation times of electronic excitation [8; 9]. At the current stage of development of semiconductor nanocrystalline hybrid OLEDs, LEDs based on spherical nanocrystals (quantum dots) are quite well studied [10-15] and the corresponding technology is already widely used. For such devices, emitters of primary colors (red, green, blue, RGB) have already been obtained, demonstrating high external quantum efficiency (more than 10%) and radiation brightness of units and low operating voltages of the order of 2-3 V with tens of thousands of  $\text{cd/m}^2$ , which opens up attractive prospects for the creation of displays based on quantum indicators.

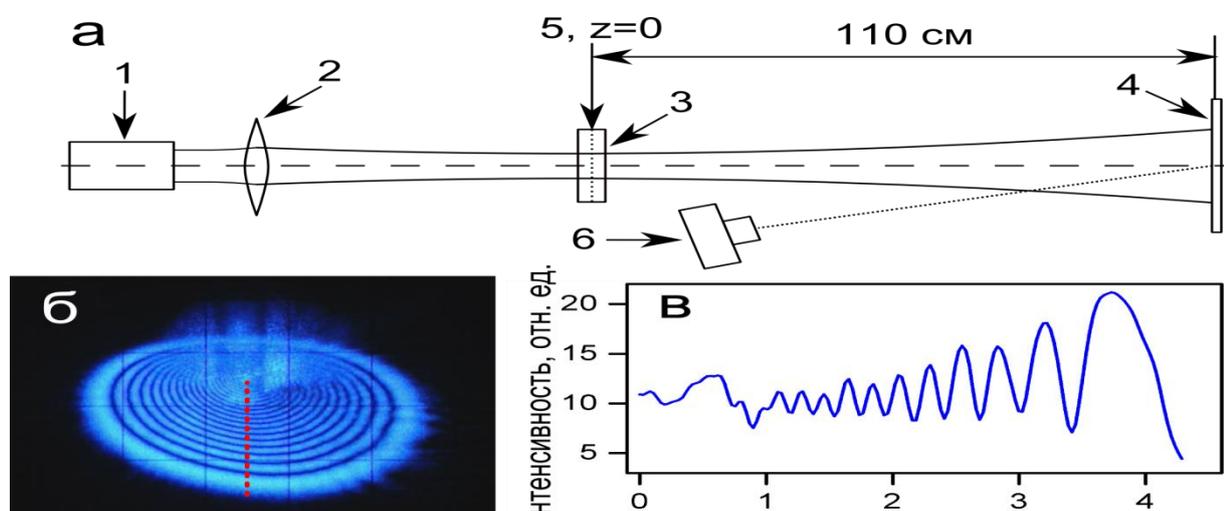
## Research and results

Photoluminescence spectra were measured for solid-phase samples. The experimental samples were glass coated with nanoparticles applied to them from a hexane solution. The particles were applied using a special dispenser. The volume of the applied solution was  $\sim 60 \mu\text{l}$ , and the concentration of the solution was about  $10^{16} \text{sm}^{-3}$ .

Photoluminescence spectra were recorded at room temperature using the following setup (Fig. .1): the excitation source was a PicoQuant 800-B 1 semiconductor pulsed laser with a radiation wavelength of  $\lambda = 405 \text{ nm}$  (corresponding to the radiation energy), a repetition rate of 3.06 v and a pulse duration of  $\Delta\tau = 75 \text{ ps}$ . The radiation from sample 2 was directed to the input end of the fiber (light guide diameter  $100 \mu\text{m}$ ) of an Ocean Optics Maya 2000 Pro spectrometer with a Hamamatsu S10420 CCD matrix using a lens 3 with a focal length of  $f = 25 \text{ cm}$ . The spectrometer was connected to the control computer 5 via a USB 2.0 interface. The spectra were recorded in the wavelength range from 400 to 1000 nm (this corresponds to the energy range of 3.09–1.24 eV).



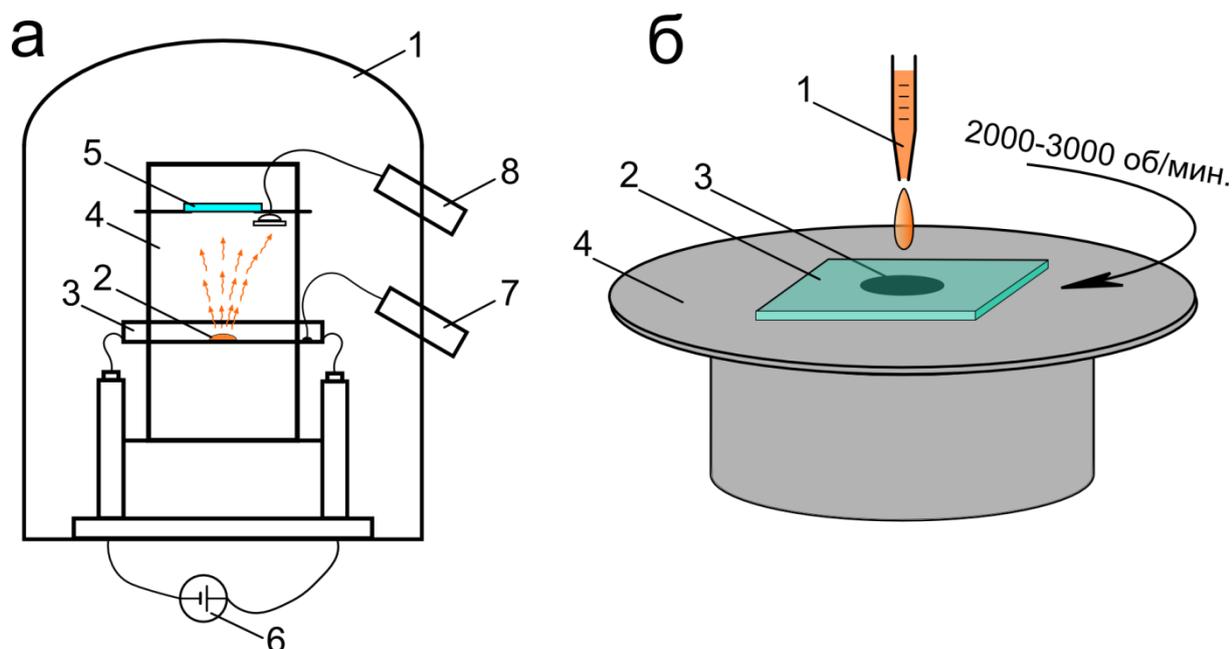
The acquisition time was set in the interval from 20 ms to 2 s depending on the intensity of the radiation recorded by the spectrometer program. The spectral resolution in the experiments was about 2 nm. Since the sensitivity of the detector in different spectral regions was different, it was calibrated with a SIRSH-6-100-1 lamp with a temperature of 2840 K. The nonlinear optical response of colloidal solutions of nanoparticles was measured by the aberration self-action method. The experimental setup is shown in Fig. 2.a. A continuous solid-state laser beam with a wavelength of 473 nm, an average power of 15 mW and an intensity distribution close to kgauss was collected through a focused collector lens-2.



**Figure 2.a**—experimental setup: 1-laser, 2-collecting lens, 3-cuvette with colloidal solution of nanoparticles, 4-screen, 5-laser beam waist (its position is indicated by  $z=0$ ), 6-digital camera; **b**—characteristic trace of the laser beam on the screen in the form of a set of concentric rings, the grid step on the screen is 20 mm; **c** – characteristic intensity distribution obtained from the horizontal section of the beam trace on the screen from the center to the periphery (shown by the dotted line in Figure b).

The sample under study 3 (a cell with an optical path length of  $\ell = 5$  mm containing a colloidal solution of semiconductor nanoparticles) was focused at a distance of 15 cm. The laser beam passing through the cell hit the screen 4 with a grid applied to it with a step of 2 cm; the screen was placed at a distance of  $z = 110$  cm from the axis of the laser beam 5 ( $z = 0$  in Fig. 2.a). As a result, a beam trace

was formed on the screen in the form of a system of concentric rings, which was captured on the screen in video mode at a frequency of 60 frames per second using a Nikon 1 J1 6 digital camera. Then the video files were loaded into the plotter, and the resulting images were processed using special software, which allowed us to determine the intensity distribution on the screen from its center to the periphery (shown by the red dotted line in Fig. 2.4b) (Fig. 2.b), as well as the local maxima, the corresponding number of decimals. and, as a result, the magnitude of the nonlinear phase shift . Using the known relations [14], the beam divergence angle, waist radius and diffraction length were calculated based on the beam radius on the screen in the absence of a cuvette obtained in the experiment. They were:  $\theta = 3.2 \cdot 10^{-3}$  rad,  $\omega_0 = 45 \mu\text{m}$  and  $z_0 = 13$  mm. It was assumed that the laser spot on the screen has a Gaussian intensity distribution. Since the diffraction length exceeds the thickness of the optical path of the cuvette, the beam passing through the colloidal solution can be considered plane-parallel. For the production of organic light-emitting diodes,  $20 \times 20 \text{ mm}^2$  substrates with a pre-coated ITO layer (Ho mixture) were used. The original substrates underwent several cleaning stages: first they were washed in sodium hydroxide solution, and then several times in bidistilled deionized water. To enhance the cleaning process, the procedure was carried out in an ultrasonic bath. After that, the substrates were dried under a stream of compressed air and annealed in an oven for 20 minutes. The deposition methods for low molecular weight organic compounds for the production of light-emitting devices can be divided into two types [15]: (A) thermal evaporation methods and (B) solution deposition methods. (A). The thermal evaporation method in vacuum is used for the deposition of substances that are insoluble/poorly soluble in organic solvents (the setup is schematically shown in Figure 2.6a). The sputtering was carried out in a special vacuum chamber installed in a box with an inert argon atmosphere. The chamber was evacuated in two stages: first, a forevacuum pump was used to achieve a pressure of about  $10^{-2} - 10^{-3}$  Torr, after which a turbomolecular pump was turned on, allowing the evacuation rate to reach  $\sim 10^{-6}$  Torr. Such low pressure values are necessary to minimize the collisions of the molecules of the deposited substance with gas molecules. The required amount of the substance to be deposited ( $\sim 1$  mg) was placed in a special evaporation furnace (tantalum "boat") inside the vacuum chamber. To prevent contamination of the camera with molecules of a low molecular weight compound, the "boat" itself was mounted on a quartz glass. When an electric current passed through the "boat", it was heated, and accordingly the substance inside it heated up, and after reaching the required temperature it sublimed onto a substrate placed in a special holder on top of the quartz glass. The film deposition mode (growth rate and final thickness) could be changed by changing the voltage applied to the "boat", while the temperature of the evaporator was controlled using a calibrated thermocouple. The film thickness was controlled in situ using an Inficon-IC 6000 calibrated quartz crystal resonator. In addition, aluminum cathodes were created by thermal evaporation in vacuum, which were then applied to the finished hybrid organic-inorganic layered structures using special masks, resulting in four active pixels with an area of  $16 \text{ mm}^2$ . The furnace temperature during metal deposition was  $600-800 \text{ }^\circ\text{C}$ , the deposition rate was limited to  $50 \text{ \AA/s}$ , and the final thickness of the aluminum cathode after 2 minutes of deposition was  $100 \text{ nm}$ . (B). Thin films were deposited from the solution by centrifugation in a box with an inert argon atmosphere. The essence of the method is as follows (see Fig. 3b): the substance solution is dropped onto a substrate fixed by a vacuum suction cup in the moving part of the centrifuge; the substrate can either be in a static state and unfold after the substance is dropped, or it can rotate during the dropping. The properties of the resulting film depend on the concentration of the solution, the speed of rotation of the centrifuge, and the dropping method. It should be noted that when applying several layers of the LED in succession, special attention should be paid to the choice of solvents: already applied films should not be dissolved in the solvent used at the current stage of creating the layered structure.



**Figure 3 — Schematic diagrams of thin film deposition devices. a — thermal spraying in vacuum: 1 — vacuum chamber, 2 — material to be sprayed, 3 — evaporation furnace (tantalum “boat”), 4 — quartz glass, 5 — substrate, 6 — power source, 7 — furnace temperature control system, 8 — film thickness control system; b — centrifuge: 1 — solution of the material to be deposited, 2 — substrate, 3 — vacuum suction cup, 4 — centrifuge.**

In addition, surface wetting plays an important role in deposition from a solution - the better the solvent wets the surface on which the thin film is deposited, the higher the quality of the resulting layer. In this work, a composite layer consisting of a PEDOT:PSS [poly(3,4-ethylenedioxythiophene)-poly(styrene sulfonate)] buffer hole layer, as well as a hole-permeable material TPD, was applied by the centrifugation method. [N,N'-bis(3-methylphenyl)-N,N'-bis(phenyl)-benzidine] and planar CdSe;0.5%Ho nanocrystals. PEDOT:PSS aqueous solution (2.6 wt%) was deposited onto static ITO substrates. The substrates were then spun at 3000 rpm and then annealed at 90 °C for 20 min. Under these deposition conditions, the thickness of the PEDOT:PSS films was ~50 nm. The composite active emission layer of the devices was created by dropping a mixture of TPD solutions in toluene (concentration 5 g/l) and CdSe;0.5%Ho nanoplatelets in toluene (concentration 10181/cm<sup>3</sup>) onto the substrates with the deposited PEDOT:PSS layer, and spinning at 2000 rpm. The volume of the mixture of TPD and CdSe;0.5%Ho nanoplatelets deposited during centrifugation was 60 μl. Then, the substrates were dried in an argon atmosphere at 60°C for 20 minutes. As a result, a composite active emission layer with a thickness of ~ 10 nm was formed.

## CONCLUSION

The article describes the experimental methods used in the study (optical and time-resolved spectroscopy, colorimetry and aberration self-action method), as well as the synthesis methods and technological approaches used for the production of hybrid organic-inorganic light-emitting diodes, in particular the creation of thin films (through thin films) and technological approaches to create a layered structure of devices. The work used modern measuring equipment, as well as modern methods and approaches for processing experimental data, the technological part of the study was carried out in clean room conditions, which allowed to achieve successful results in the production of light-emitting devices. A systematic study of the optical properties of CdSe;0.5%Ho screw-shaped nanostructures formed from flat nanocrystals with a significant increase in their lateral dimensions

(up to hundreds of nm) was carried out. It was found that when CdSe;0.5%Ho nanoplatelets are rolled into nanoscrolls under photoexcitation, their interband luminescence maximum redshifts occur ( $\Delta E \approx 33$  meV ( $\sim 6$  nm)), which is due to the formation of internal crystal domains caused by mechanical stresses and deformations of the crystal lattice.

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## ATMOSFERİK TÜRBÜLANS ORTAMINDA YÜKSEK DERECELİ OYUK COSH-GAUSS IŞININ YAYILIMININ İNCELENMESİ

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### ÖZET

Bu çalışmada, oyuk yüksek mertebeli cosh-Gauss (OYCG) ışınlarının türbülanslı atmosfer ortamında yayılım özellikleri incelenmiştir. Kaynak düzlemindeki elektrik alan ifadeleri elde edilmiş ve farklı ışın mertebeleri ile oyukluk değerlerine karşılık gelen elektrik alan dağılımları gösterilmiştir. Ayrıca, ışının türbülanslı bir yol boyunca yayılımı incelenmiş ve 4 km’de olan ışın profilleri elde edilmiştir. Kaynak düzleminde elde edilen sonuçlara göre, oyukluk ve ışın mertebesi parametreleri arttıkça, ışın düzlem üzerinde daha çok genişlemeye başlamaktadır. Ayrıca, oyukluk parametresi 1’e eşit olduğu durumda, ışının 4 km yol atmosfer ortamında yayıldıktan sonra profilini koruduğu görülmektedir. Bu bulgular, ışın mertebesi ve oyukluk parametresinin dikkatli bir şekilde ayarlanmasının, ışın dayanıklılığını artırmak ve gerçekçi atmosfer koşullarında performansı optimize etmek için etkili bir yöntem sağladığını göstermektedir. Sonuçlar, OYCG ışınlarının bütünlüğünün korunmasının ve türbülans etkilerinin azaltılmasının kritik öneme sahip olduğu serbest uzay optik haberleşme, uzaktan algılama ve görüntüleme sistemleri için önemli bir potansiyele sahip olduğunu göstermektedir. Yapısal parametrelerin yayılım üzerindeki etkisini açıklığa kavuşturarak, bu çalışma rastgele ortamlarda yapılandırılmış ışın fiziğinin daha derin anlaşılmasına katkı sağlamakta ve yüksek mertebeli oyuk ışın konfigürasyonlarını kullanan gelişmiş optik sistemlerin tasarımı için pratik kılavuzlar sunmaktadır.

**Anahtar Kelimeler:** Optik haberleşme, atmosferik türbülans, yüksek mertebeli cosh-Gauss ışını, uzaktan algılama, görüntüleme

## PROPAGATION OF HOLLOW HIGHER-ORDER COSH-GAUSSIAN BEAMS IN TURBULENT ATMOSPHERE

### ABSTRACT

This study investigates the propagation properties of hollow higher-order cosh-Gaussian (HhCG) beams within a turbulent atmosphere. Expressions for the source-plane electric field are derived, and the corresponding intensity distributions are illustrated for varying beam orders and hollowness values. Moreover, numerical simulations are conducted to analyze the beam characteristics during its propagation through a turbulent channel, with particular emphasis on intensity profiles over distances of 4 km. Numerical results obtained in the source plane demonstrate that, as the hollowness parameter and beam order increase, the beam begins to spread out. Moreover, the integrity of the beam profile is maintained when the hollowness parameter equals 1 for transmission distances of 4 km. These findings indicate that careful adjustment of beam order and hollowness provides an effective means of enhancing beam robustness and optimizing performance under realistic atmospheric conditions. The results suggest that HhCG beams hold considerable promise for free-space optical communication, remote sensing, and imaging systems, where preserving beam integrity and mitigating turbulence effects are critical. By elucidating the dependence of beam propagation on structural parameters, this study contributes to a deeper understanding of the physics of structured beams in random media and provides practical design guidelines for advanced optical systems employing higher-order hollow beam configurations.

**Keywords:** Optical communication, Turbulent Atmosphere, hollow higher-order cosh-Gaussian (HhCGB), remote sensing, imaging.

### 1. INTRODUCTION

The propagation of structured optical beams through turbulent atmospheric channels holds considerable importance owing to its relevance to a broad spectrum of advanced optical applications, including free-space optical (FSO) communications, remote sensing, and high-resolution imaging systems (Al-Gailani et al., 2021). Atmospheric turbulence, characterized by fluctuations in the refractive index, imposes significant constraints on beam integrity and spatial coherence, resulting in degradation of beam quality and diminished system performance (Kumar et al., 2024). To address these challenges, various beam configurations such as Laguerre-Gauss Bessel-Gauss (Cang et al., 2013; Kotlyar et al., 2024) have been analyzed for their ability to withstand turbulence-induced distortions. However, the specific advantages of HhCG beams, particularly under long-range propagation conditions and varying structural configurations, remain underexplored in the literature. Maintaining beam profile integrity over extended distances is critical for ensuring high-fidelity optical signal transmission.

This study addresses this gap by conducting a detailed numerical investigation into the propagation behavior of HhCG beams in a turbulent atmospheric medium. By deriving the source-plane electric field expressions and analyzing the intensity distributions under varying beam orders and hollowness parameters, the study aims to elucidate the structural dependencies governing beam evolution. Furthermore, simulation results at a propagation distance of 4 km provide insight into the conditions under which beam integrity can be preserved.

### 2. MATERIAL AND METHODS

The electrical field of HhCGB at the source plane ( $z = 0$ ) can be expressed as; (Saad et al., 2022);

$$E_{n,l}(p, z = 0) = A_0 \left( \frac{p}{\omega_0} \right)^l \cosh^n(\Omega p) \exp\left(-\frac{p^2}{\omega_0^2}\right) \quad (1)$$

where  $l$  and  $n$  are integers and represent the hollowness and the order of the beam,  $\omega_0$  is the waist width of Gaussian part and  $\Omega$  is the parameter associated with cosh part.

A random phase screen model was employed to analyze the propagation of the HhCG beam through atmospheric turbulence conditions. This model necessitates dividing the propagation distance ( $L$ ) into  $N_s$  intervals  $\Delta L = \frac{L}{N_s}$  separated by thin phase screen planes. Accordingly, the received electric field intensity after free space propagation can be computed using (2) (Bayraktar et al., 2024);

$$u_r(r, mL) = F^{-1} [F[u_s(r, (m-1)\Delta L) \exp(j\phi(r))] H(f)] \quad (2)$$

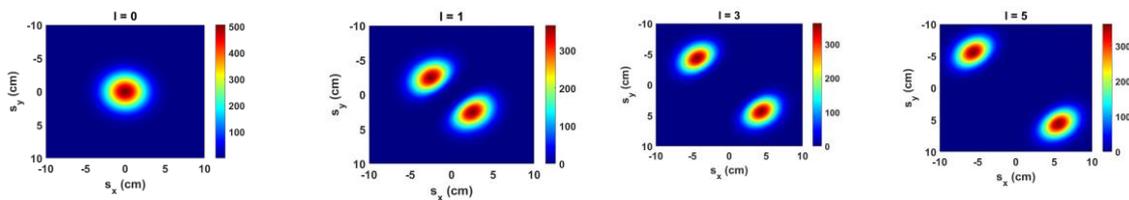
$F$ ,  $F^{-1}$ , represent to Fourier transform and its inverse,  $H(f)$  Fourier transform of transfer function,  $r = (r_x, r_y)$  receiver plane coordinates,  $f = (f_x, f_y)$  are spatial frequencies,  $\Delta L$  equal to partial propagation distance,  $\phi(r)$  denotes the phase power spectral density for each individual in the random phase screen model. Moreover, the Von-Karman power spectral density is used to generate random phase screen model which is shown in (3) (Akcan et al., 2024);

$$\phi_\emptyset(f) = \frac{0.0036LC_n^2k^2L_0^{11/3}}{(L_0^2|f|^2 + 1)^{11/6}} \exp[-1.1265l_0^2|f|^2] \quad (3)$$

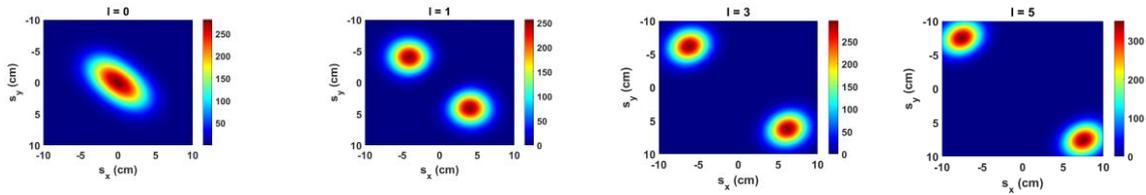
$C_n^2$  is the refractive index structure constant,  $l_0$ ,  $L_0$  are the inner and outer scale of turbulence.

### 3. RESULTS AND DISCUSSION

This section presents the results of numerical simulations regarding the propagation properties of the HhCG beam through the atmosphere turbulence. Both source-plane and far-field (4 km) intensity distributions are analyzed across various beam orders and hollowness parameters, offering insights into how structural parameters influence beam robustness and spatial development. Figure 1 displays the intensity profile of HhCG beams with a beam order ( $n=3$ ) for varying hollowness parameters. It is evident that increasing the hollowness parameter leads to an expansion of the dark central region. Figure 2, on the other hand, shows the received beam profile after 4 km of propagation through atmospheric turbulence for the same beam order  $n=3$ . Beam profile isn't preserved for higher hollowness parameters result in the clear evidence of intensity degradation, increased spreading, and pattern deformation.

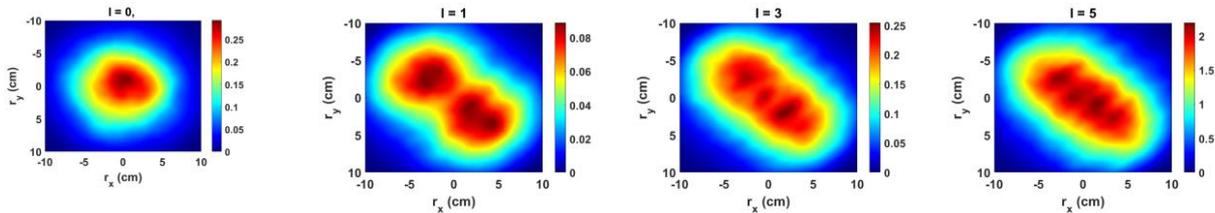


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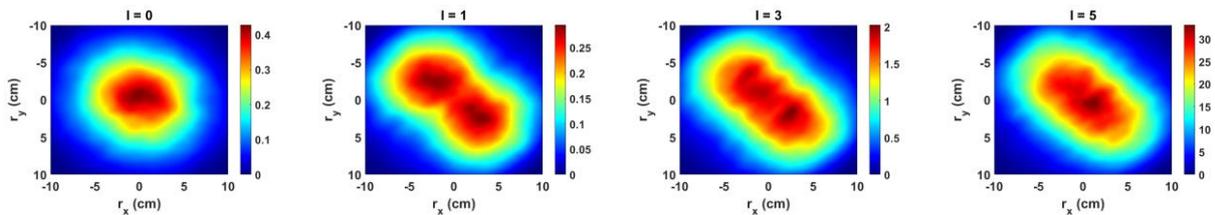


(b)

**Figure 1.** Source plane intensity distribution of HhCG beam with different hollowness, beam order of 3 (a)  $\Omega = 1$ , (b)  $\Omega = 10$



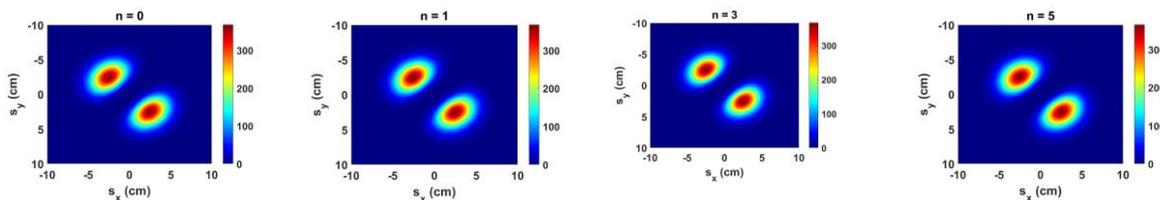
(a)



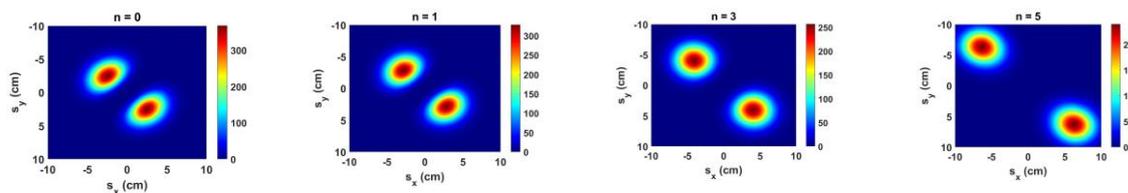
(b)

**Figure 2.** Received intensity distribution of HhCG beam at 4km with different hollowness, beam order of 3 (a)  $\Omega = 1$ , (b)  $\Omega = 10$

Figure 3 presents the transverse intensity distributions at the source plane for HhCG beams with a lower beam order  $n=1$ . As the hollowness increases, the beam generally becomes broader. Also, figure 4 shows the corresponding intensity profiles propagated through turbulence over 4 km. It becomes apparent that lower-order beams are considerably more prone to protect the beam profile. Especially at higher hollowness values, the beam structure breaks down and loses its annular shape.

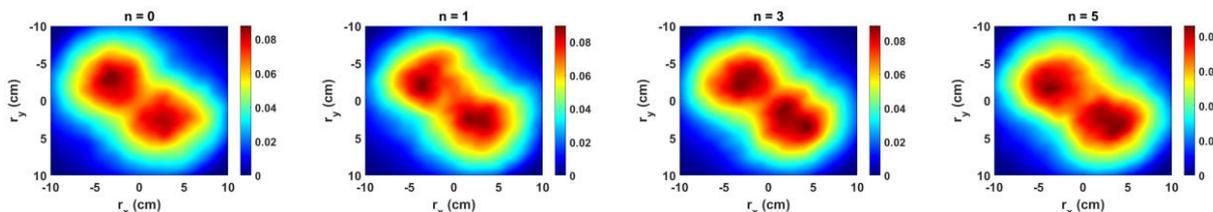


(a)

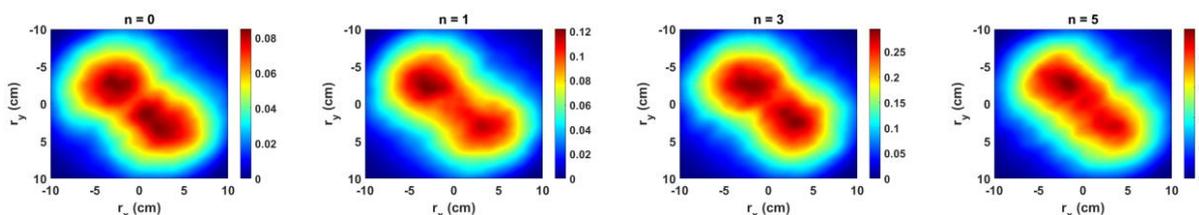


(b)

**Figure 3.** Source plane intensity distribution of HhCG beam with different hollowness, beam order of 1 (a)  $\Omega = 1$ , (b)  $\Omega = 10$



(a)



(b)

**Figure 4.** Received intensity distribution of HhCG beam at 4 km with different hollowness, order of 1 (a)  $\Omega = 1$ , (b)  $\Omega = 10$

The results point to the importance of selecting hollowness values and beam orders in practical applications such as free-space optical communications, where maintaining beam shape is critical under atmospheric turbulence. The findings underscore the potential of these beams in enhancing the performance and reliability of next-generation FSO systems operating under realistic atmospheric conditions.

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## X BAND (8-12 GHZ) FREKANS ARALIĞI İÇİN EKLEMELİ İMALAT İLE UYUMLU REÇİNELERİN ELEKTRİKSEL ÖZELLİKLERİNİN İNCELENMESİ

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### ÖZET

Günümüzde eklemeli imalat ile üretim teknolojisinin mikrodalga aygıtların üretiminde kullanımı gün geçtikçe artmaya devam etmektedir. Bu sebeple eklemeli imalatta kullanılan sıvı reçine malzemelerin elektriksel özelliklerinin elde edilmesi mikrodalga yapıların üretimi için önem arz etmektedir. Bu çalışmada, 8–12 GHz frekans aralığında ticari olarak temin edilebilen eklemeli imalat üretiminde kullanılan çeşitli foto-polimer reçinelerin elektriksel özellikleri incelenmiştir. Deneysel ölçümler, vektör ağ analizöre bağlı dielektrik prob kit kullanılarak gerçekleştirilmiş ve frekansa bağlı olarak dielektrik sabiti ile kayıp tanjantı değerleri elde edilmiştir. Ölçüm sonuçları, incelenen reçineler arasında belirgin farklılıklar olduğunu ortaya koymaktadır. Numuların dielektrik sabiti değeri artan frekans ile azalmakta, kayıp tanjant değeri ise artmaktadır. Karakterize edilen reçineler arasında Clear V4, daha düşük kayıp tanjantı ve kararlı dielektrik sabiti sayesinde diğer reçinelere kıyasla üstün performans sergilemektedir. Bu özellikler, söz konusu reçineyi dalga kılavuz, anten vb. düşük kayıp gerektiren mikrodalga bileşenlerinin üretimi için güçlü bir aday haline getirmektedir. Çalışma kapsamında elde edilen sonuçlar, farklı reçinelerin yeni nesil mikrodalga sistemleri için tasarım kılavuzlarının oluşturulmasına yardımcı olmakta ve eklemeli imalatın gelişmiş elektromanyetik uygulamalar için kompakt, maliyet etkin ve özelleştirilebilir çözümler sunabileceğini göstermektedir.

**Anahtar Kelimeler:** Eklemeli İmalat, foto-polimer reçine, dielektrik sabiti, kayıp tanjant, mikrodalga aygıt.

## ELECTRICAL CHARACTERIZATION OF 3D PRINTABLE RESINS FOR X BAND (8-12 GHz) FREQUENCIES

### ABSTRACT

The adoption of additive manufacturing technologies for manufacturing microwave devices is steadily growing. In this context, evaluating the dielectric behaviour of photopolymer resins is essential to determine their suitability for the efficient design of microwave structures. This study investigates the electrical properties of various commercially available 3D-printable photopolymer resins over the frequency range of 8–12 GHz. Frequency-dependent dielectric constant and loss tangent values were measured using dielectric probe kits and a vector network analyser (VNA), providing insight into the electromagnetic behaviour of the resins across the considered frequency range. The experimental results reveal distinct differences in dielectric responses among the tested materials. In general, the dielectric constant exhibits a decreasing trend with increasing frequency, whereas the loss tangent tends to rise. Among the characterised resins, Clear V4 demonstrates superior performance, maintaining a relatively lower dielectric constant and exhibiting lower loss tangent values than the other candidates. This work provides a practical reference framework for material selection in the design and additive manufacturing of functional microwave components. The findings highlight the potential of photopolymer-based 3D printing to enable the fabrication of waveguides and antennas, where electrical properties are a critical factor for efficiency and reliability. Furthermore, comparing various resins helps establish design guidelines for next-generation microwave systems, showing how additive manufacturing can offer compact, cost-efficient, and customisable solutions for advanced electromagnetic applications.

**Keywords:** additive manufacturing, photopolymer resins, dielectric constant, loss tangent, microwave devices,

### 1. INTRODUCTION

In recent years, advances in wireless communication systems, radar technologies, and high-frequency electronics have generated a significant demand for sophisticated fabrication techniques capable of meeting the rigorous requirements of miniaturisation, performance, and design flexibility. Among these methods, additive manufacturing (AM), often called 3D printing, has attracted significant interest due to its ability to produce complex shapes and shorten prototyping durations (Abdulhameed et al., 2019). As the operating frequency in many microwave systems moves towards the higher end of the electromagnetic spectrum, the need for precise control over structural and material properties becomes increasingly crucial.

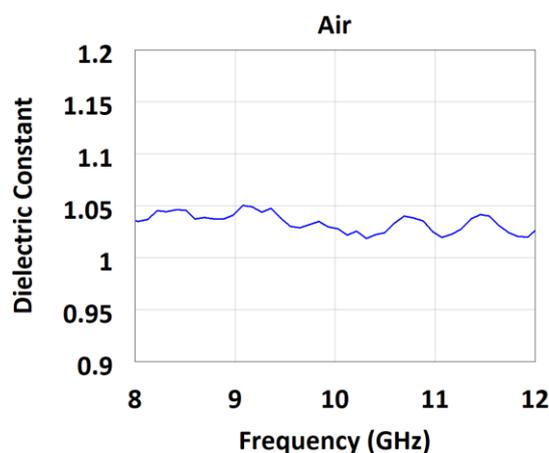
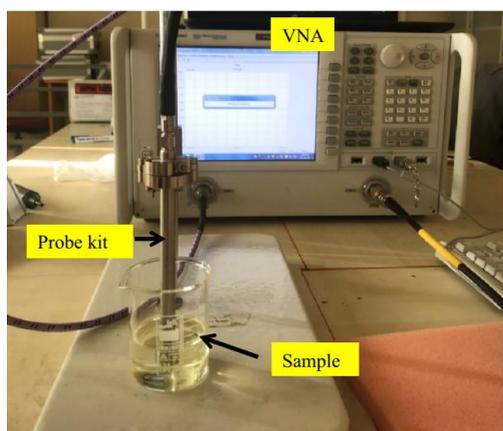
Photopolymer-based stereolithography (SLA) technology has emerged as a promising platform for fabricating functional microwave components such as waveguides, filters, antennas, etc (D'Auria et al., 2015; Sage, 2016). This technology offers high resolution and surface finish compared to other AM techniques, which is advantageous for minimizing electromagnetic losses. However, the electrical characterization of the materials used in these processes, particularly their electrical properties in the microwave frequency range, remains a crucial bottleneck in unlocking their full potential for high-frequency applications. Several studies (Chudpooti et al., 2019; Palazzi et al., 2021; Wang et al., 2020) have reported the dielectric characterization of various SLA-compatible photopolymer materials across the microwave frequency spectrum; however, a considerable number of candidate materials remain uncharacterized, indicating the need for further systematic investigation.

This study explores the frequency-dependent electrical characteristics of commercially available 3D-printable photopolymer resins within the X-band (8–12 GHz) frequency range. An open-ended

coaxial probe method combined with a vector network analyzer (VNA) is employed for characterization. This method is well-known for accurately measuring the complex permittivity of liquid samples. The results reveal that considerable variation in dielectric behavior among the tested materials.

## 2. MATERIAL AND METHODS

The dielectric characterization of the photopolymer resins was performed using the open-ended coaxial probe method, a well-established technique for broadband, non-destructive permittivity measurements. In this approach, dielectric probe kit, coupled with a vector network analyzer (VNA), was utilized to determine the frequency-dependent complex permittivity of the samples in the 8–12 GHz range. This method operates by bringing the open-ended coaxial probe into direct contact with the test material, enabling the measurement of the reflection coefficient ( $S_{11}$ ) at the probe–sample interface (Dalgac et al., 2021). The electromagnetic field penetrates slightly into the material, and the resultant signal is influenced by the dielectric properties of the sample. Through a model-based inversion algorithm, the VNA software translates the measured reflection coefficient into the real part of permittivity ( $\epsilon'$ ) and the loss tangent ( $\tan \delta$ ). Prior to measurement, a three-standard calibration procedure was conducted using air (open), a metallic shorting block (short), and deionized water (load) to ensure high accuracy and minimize systematic errors inherent to the measurement system. This calibration compensates for mismatches, phase delays, and signal reflections not related to the sample. All measurements were conducted at room temperature under controlled humidity conditions to reduce external effect.



(a)

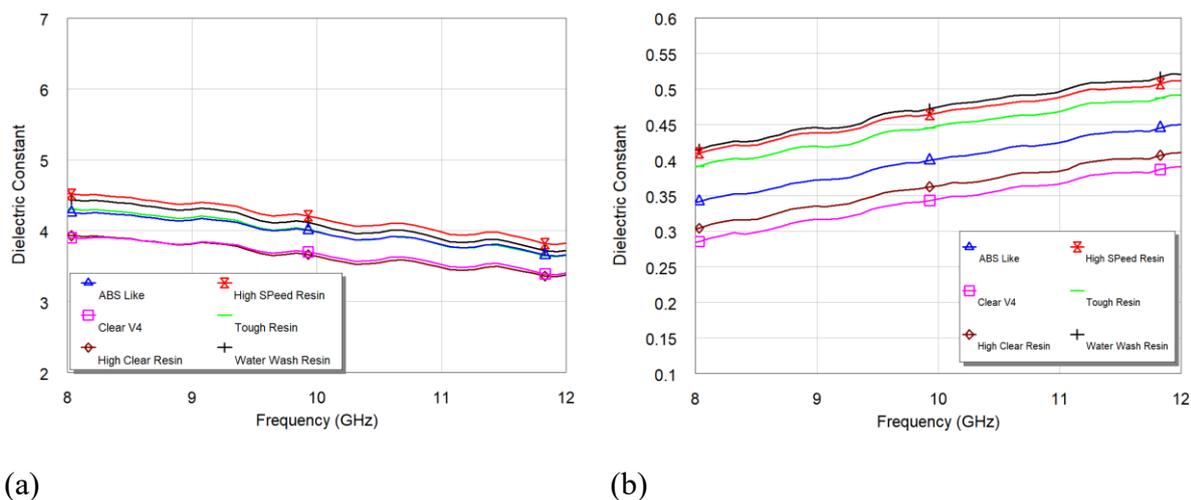
(b)

**Figure 1:** (a) Experimental setup for determining the electrical properties of resins, (b) dielectric constant of air following calibration.

## 3. RESULTS AND DISCUSSION

The dielectric properties of six commercially available 3D-printable photopolymer resins were evaluated over the X-band frequency range (8–12 GHz) to assess their suitability for microwave applications. The measured dielectric constants tend to decrease as frequency increases. High-Speed Resin showed the highest permittivity among the tested materials, whereas Clear V4 and High-Clear resins consistently had the lowest dielectric constants. This characteristic property of materials makes them a promising candidate for dielectric components where low permittivity is desired to minimize signal delay. Furthermore, the loss tangent ( $\tan \delta$ ) values of all resins increased with frequency,

indicating higher losses at elevated GHz levels. Notably, Water-Wash and High-Speed resins showed the highest loss tangent, while Clear V4 maintained the lowest loss tangent, thus providing superior dielectric performance. The combined analysis of permittivity and loss behavior reveals that, Clear V4 as the most advantageous material for applications requiring both low permittivity and low dielectric losses, such as waveguides, antennas, and RF substrates. These findings provide a comparative framework for material selection in the additive manufacturing of functional electromagnetic components.



**Figure 2:** Electrical properties of 3D-printable photopolymer resins. (a) dielectric constant, (b) loss tangent between 8-12 GHz.

**Table 1.** Electrical properties of commercially available 3D-printable photopolymer resins at 10 GHz

	ABS Like	Clear V4	High Clear	High Speed	Tough	Water Wash
<b>Dielectric Constant</b>	3.98	3.67	3.63	4.18	3.98	4.08
<b>Loss Tangent</b>	0.4	0.34	0.36	0.46	0.44	0.47

Overall, this work contributes a valuable perspective to the growing field of additive manufacturing in RF and microwave systems. By providing quantitative insights into the electrical properties of photopolymers, it supports material selection, design optimization, and the broader adoption of AM in microwave system design. Moreover, it paves the way for customized, efficient, and cost-effective RF components manufactured entirely through 3D printing.

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## BARBAROS HAYRETTİN PAŞA’NIN DENİZCİLİK LİDERLİĞİ BAĞLAMINDA İNCELENMESİ

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### ÖZET

Denizcilik, ortam, koşul, yaşam ve çalışma bakımından oldukça riskli, hareketli ve belirsizlik arz etmektedir. Bu nedenle, denizcilik, kendine has özellikleri ve davranış biçimleriyle benzersiz bir yapı göstermektedir. Öte yandan denizcilikte liderlik ve yöneticilik açısından deniz, gemi ve gemi insan gücünün sevk ve idaresi son derece önemli hale gelmektedir. Bu hususlara bir savaş ve onun koşulları da eklenirse, bunun ne kadar zor, hassas ve kritik bir hale dönüştüğü belirtilebilir. Bu bağlamda, Barbaros Hayrettin Paşa, liderlik yeteneği, cesareti, kapasitesi, yönetme becerisi, ileri görüşlülüğü ve dahi kişiliğiyle Osmanlı ve Türk denizcilik tarihinde önde gelen askeri liderlerden biridir. Çalışmanın amacı; “Padişahın Amiralisi Barbaros Hayreddin Korsan ve İmparatorluk Kurucusu” isimli kitap, Bradford’un (2021) doküman incelemesi tekniğiyle Barbaros Hayrettin Paşa’nın liderliğine ilişkin özellikleri ortaya koymaktır. Araştırmanın sonucunda, Barbaros Hayreddin Paşa’nın, denizlerin hâkimi olarak siyasette, devlet adamlığında yetenekli ve tecrübeli olduğu, vizyoner ve stratejik hamlelerle deniz savaşlarında oldukça başarılı bir lider olduğu anlaşılmaktadır.

**Anahtar Kelimeler:** Liderlik, Denizcilikte Liderlik, Denizcilik, Barbaros Hayrettin Paşa.

## AN ANALYSIS BASED ON THE MARITIME LEADERSHIP OF BARBAROS HAYRETTIN PASHA

### ABSTRACT

Maritime activities are quite risky, dynamic, and uncertain in terms of environment, conditions, life, and work. Therefore, maritime activities reveal a unique structure with their own characteristics and behaviors. On the other hand, in terms of leadership and management in maritime, the command and control of the sea, ships, and ship personnel have become extremely important. If war and its conditions are added to these considerations, it can be noted how difficult, sensitive, and critical this becomes. In this regard, Barbaros Hayrettin Pasha is one of the foremost military leaders in Ottoman and Turkish maritime history due to his leadership skills, courage, capacity, management abilities, foresight, and brilliant personality. The aim of the study is to reveal the leadership characteristics of Barbaros Hayreddin Pasha through the document analysis technique in the book titled (The Sultan's Admiral Barbaros Hayreddin Pirate and Empire Builder) by Bradford (2021). As a result of the research, it is understood that Barbaros Hayreddin Pasha, as the ruler of the seas, was talented and experienced in politics and statesmanship, and was a very successful leader in naval warfare with his visionary and strategic moves.

**Key Words:** Leadership, Leadership in Maritime, Maritime, Barbaros Hayrettin Pasha.

## GİRİŞ

Denizcilik, tarih boyunca medeniyetlerin gücünü, etki alanını ve ticari başarısını belirleyen temel unsurlardan biri olmuştur. Bu yüksek riskli ve dinamik ortamda başarı, sadece teknolojik üstünlükle değil, aynı zamanda olağanüstü liderlik vasıflarına sahip komutanların varlığıyla da doğrudan ilişkilidir. Osmanlı İmparatorluğu'nun bir deniz gücü haline gelerek Akdeniz'de hâkimiyet kurmasında, bu türden karizmatik ve yetenekli denizcilerin rolü yadsınamaz. Bu denizciler arasında, gerek stratejik dehâsı gerekse yöneticilik becerileriyle öne çıkan ve denizcilik liderliği bağlamında bir model olarak incelenmeye değer en önde gelen isimlerden biri hiç şüphesiz Barbaros Hayrettin Paşa'dır.

Barbaros Hayrettin Paşa'nın liderlik özellikleri, salt askeri zaferlerle sınırlı değildir. Onun liderliği; askeri strateji, lojistik planlama, farklı milletlerden oluşan mürettebatı yönetme, belirsizlik ve yüksek risk altında etkili kararlar alma ve Osmanlı siyasi sistemine entegre olarak geniş çaplı bir deniz imparatorluğunun inşasında sergilediği vizyoner yaklaşımı da kapsamaktadır. Modern denizcilik liderliği literatüründe vurgulanan dönüştürücü liderlik, güvenlik kültürü oluşturma ve örgütsel etkinliği artırma gibi kavramlar, onun tarihsel pratiğinde somut örnekler bulmaktadır. Bu bağlamda, Paşa'nın kariyeri, yalnızca tarihsel bir figür olarak değil, aynı zamanda günümüz denizcilik yönetimi ve liderlik çalışmaları için de zengin bir veri kaynağı sunmaktadır.

Bu çalışmanın temel amacı, Barbaros Hayrettin Paşa'yı bir denizcilik lideri olarak tüm yönleriyle analiz etmek ve özellikle denizcilik liderliğine ilişkin özelliklerini sistematik bir şekilde ortaya koymaktır. Bu amaç doğrultusunda, çalışmanın birincil kaynağını Bradford'un (2021) "Padişahın Amirali: Barbaros Hayreddin – Korsan ve İmparatorluk Kurucusu" adlı kapsamlı biyografisi oluşturmaktadır. Araştırmada, söz konusu eserin doküman analizi tekniğiyle derinlemesine incelenmesi yoluyla, Barbaros Hayrettin Paşa'nın askeri taktikleri, yönetim anlayışı, astlarıyla ilişkileri, yenilikçi uygulamaları ve karar alma mekanizmalarına odaklanılacaktır. Bu analiz sonucunda, onun liderlik stilini şekillendiren temel özellikler belirlenerek, modern denizcilik liderliği teorileri ile tarihsel bir vakıa arasında bağ kurulması hedeflenmektedir.

## 1. Kavramsal Çerçeve

### 1.1. Liderlik Kavramı ve Kapsamı

Liderlik, örgütlerin başarısı ve çalışan motivasyonu açısından kritik öneme sahip çok boyutlu bir olgudur (Gedik, 2020; Karip, 1998; Bakan ve Doğan, 2012). Özellikle inovasyon ve değişim çağında, örgütlerin başarısı uygun liderlik yaklaşımları ile sağlanabilmektedir (Akyürek, 2020). Bu bağlamda, stratejik liderlik, vizyon oluşturma, esnek düşünme ve işbirliği becerilerini kullanarak örgütlerin belirsiz koşullarda başarılı olmasına katkı sunan ve dönüştürücü, yönetsel, etik ve politik liderlik özelliklerini kapsayan bir tarz olarak öne çıkmaktadır (Uğurluoğlu ve Çelik, 2009). Vizyonerlik ise liderlik kuramlarının pek çoğunda yer alan temel bir özelliktir (Yücel ve Yücel, 2024).

Vizyoner liderlik, takım uyumu, yaratıcılık ve inovasyon ile güçlü bir biçimde ilişkilidir (Mascareño vd., 2019; Van Der Voet ve Steijn, 2020; Cai vd., 2023). Etkili bir vizyon sunan liderler, takım hedeflerini uyumlaştırır, iş birliğini teşvik eder ve deneysel fikir alışverişi için psikolojik güvenli bir ortam yaratır. Bu uyum ve bağlılık, vizyoner liderlik ile takım inovasyonu arasındaki temel araçlardır (Mascareño vd., 2019; Van Der Voet ve Steijn, 2020; Cai vd., 2023). İkna edici vizyoner liderler, ekiplerin ortak hedefler doğrultusunda bağlılığını ve çabalarını artırır (Mascareño vd., 2019; Al-Lawati vd., 2025).

Hedef odaklı liderlik, özellikle vizyoner niteliklerle birleştiğinde, çalışanların kişisel hedeflerini örgütsel amaçlarla uyumlu hâle getirerek motivasyonu artırır (Al-Lawati vd., 2025; Zhou vd., 2018; Jensen vd., 2019). Bu uyum, yaratıcılık ve bağlılığı teşvik eder; ancak etkisi, lider ile takım üyeleri

arasındaki değer uyumuna bağlıdır. Uyumsuzluk motivasyonu düşürebileceğinden, paylaşılan değerler ve açık iletişim kritik önem taşır (Al-Lawati vd., 2025; Cai vd., 2023).

Ayrıca, vizyoner liderlik, çalışanların işe alınması, elde tutulması ve geliştirilmesi gibi yetenek yönetimi süreçleriyle yakından ilişkilidir. Yetenek kazanımını önceliklendiren ve yetenekli bireyleri tanımlayıp geliştiren liderler, çalışan performansını ve örgütsel çıktıları önemli ölçüde artırır (Miharja ve Hayati, 2021; Al-Lawati vd., 2025). Yetenek yönetimi, vizyoner liderliğin performans üzerindeki olumlu etkisini güçlendiren bir aracı rol oynar (Miharja ve Hayati, 2021).

Sonuç olarak, vizyonerlik ve stratejik yönetim tarzı, modern liderlik anlayışının vazgeçilmez bileşenleridir. Vizyoner liderler, yalnızca bir hedef ortaya koymakla kalmaz, aynı zamanda bu hedefe ulaşmak için takımlarında uyum, yaratıcılık ve inovasyonu teşvik eden bir ortam inşa ederler. Hedef odaklılık ve etkili yetenek yönetimi ile desteklendiğinde, vizyoner ve stratejik bir liderlik tarzı, örgütlerin değişen koşullarda sürdürülebilir başarı elde etmelerinin temel dayanağı olmaktadır.

## 1.2. Denizcilik Liderliği

Denizcilik, yüksek risk ve dinamik yapısı gereği etkili liderlik uygulamalarının örgütsel etkinlik ve güvenlik açısından hayati önem taşıdığı bir sektördür. Özellikle örgütsel vatandaşlık davranışı (ÖVD) ve dönüşümcü liderlik, denizcilik işletmelerinin performansını artıran kritik kavramlar olarak öne çıkmaktadır (Öter & Ayan, 2016). Bu alandaki akademik ilgi giderek artmaktadır; 1989-2023 yılları arasında denizcilikte liderlik konusunda yapılan 288 eserin bibliyometrik analizi, yıllık %4,71'lik bir büyüme oranı ve ortalama 11,74 atıf sayısı olduğunu göstermiştir. Araştırmalarda ABD önde gelen ülke konumunda olup, "liderlik", "denizcilik endüstrisi" ve "Güney Çin Denizi" anahtar kelimelerinin yoğunlaştığı tespit edilmiştir (Yücel, 2024).

Liderlik tarzlarının çalışan davranışları ve performansı üzerindeki doğrudan etkisi çeşitli çalışmalarla kanıtlanmıştır. Denizcilik işletmelerinde yöneticilerin sergilediği dönüşümcü liderlik davranışlarının tüm alt boyutları ile çalışanların örgütsel vatandaşlık davranışı arasında pozitif ve anlamlı bir ilişki bulunmaktadır (Öter & Ayan, 2021). Benzer şekilde, uzakyol ticaret gemilerinde kaptanların ilişki odaklı liderlik davranışları, gemi insanların iş performansını anlamlı şekilde artırmaktadır. İş tatmini üzerinde ise ilişki odaklı ve değişim odaklı liderliğin pozitif, görev odaklı liderliğin ise negatif etki gösterdiği belirlenmiştir. İş tatmininin performans üzerindeki pozitif etkisi göz önüne alındığında, liderlerin duyarlılığının kritik bir başarı faktörü olduğu ortaya çıkmaktadır (Yorulmaz, 2022).

Liderliğin en kritik rol oynadığı alanlardan biri güvenlik kültürüdür. Denizcilik kazalarının çoğunun teknik arızalardan ziyade örgütsel, yönetsel ve liderlik eksikliklerinden kaynaklandığı vurgulanmaktadır (Kim, 2020). Ticaret denizciliğinde teknolojik gelişmelere ve artan güvenlik standartlarına rağmen, Sanchi, Sewol feribotu ve Costa Concordia gibi son yıllardaki büyük kazalar, güvenliğin önemini yeniden vurgulamıştır. Güçlü ve uygun liderliğin, yüksek riskli denizcilik endüstrisinde güvenli bir iş ortamı oluşturmak ve sürdürmek için gerekli olduğu kabul edilse de, güvenliği önceliklendiren bir liderlik tarzı olan "güvenlik liderliği"nin denizcilik bağlamında yeterince incelenmediği ve bu alanda doğrulanmış ölçüm araçlarının sınırlı olduğu ifade edilmektedir (Kim, 2020).

Dönüşümcü liderliğin olumlu etkileri liman performansı ve iş tatmini üzerinde de görülmektedir. Vizyoner ve çalışanları güçlendirici özellikleriyle bu liderlik tarzının, uluslararası standartlarla güçlü bir korelasyon gösterdiği ve performans ile iş tatmininde iyileştirme alanları yarattığı tespit edilmiştir (Purba, 2025).

Günümüzde denizcilik sektörü, demografik değişim, nitelikli personel eksikliği ve hızlı teknolojik gelişmeler gibi zorluklarla karşı karşıyadır. Bu değişen ortam, liderlik ve çeşitlilik yönetimi uygulamalarının önemini daha da artırmakta, organizasyon kültürü, değerler ve alışkanlıkların

dönüştürülmesini gerektirmektedir (Lutzkanova, 2019). Bu bağlamda, denizcilik liderliği eğitiminde cinsiyet perspektifi, ekip yönetimi, ayrımcılıkla mücadele, adil kaynak sağlama ve kariyer geliştirme becerilerinin güçlendirilmesi kritik hale gelmektedir.

Liderlik davranışının bir diğer önemli etkisi de bilgi yönetimi uygulamaları üzerindedir. Yapılan bir vaka çalışmasında, paternalistik liderlik modelinin çalışanların motivasyonunu ve üretken bilgi edinme isteğini artırarak bilgi yönetimi uygulamalarını doğrudan etkilediği gözlemlenmiştir. Bu bulgular, çalışanlara öğrenme teşvikleri sağlanması ve teknoloji odaklı bilgi yönetimi uygulamalarının geliştirilmesi için önemli fırsatlar sunmaktadır (Pyrovolaki & Liu, 2020).

Sonuç olarak, denizcilik sektöründe liderlik, çalışan performansı, iş tatmini, güvenlik kültürü ve bilgi yönetimi gibi birçok kritik alanı doğrudan etkilemektedir. Özellikle dönüşümcü ve ilişki odaklı liderlik tarzlarının olumlu sonuçları belirgin olsa da, sektörün karşı karşıya olduğu güvenlik odaklı liderlik eksikliği, demografik değişim ve çeşitlilik yönetimi gibi karmaşık zorluklar, daha kapsamlı ve standartlaştırılmış liderlik geliştirme programlarına duyulan ihtiyacı açıkça ortaya koymaktadır.

### 1.3. Barbaros Hayrettin Paşa

Osmanlı Devleti'nin Akdeniz'deki deniz hakimiyetini inşa etmesinde, doğru jeostratejik mekânların seçimi ile nitelikli insan unsurunun bir araya gelmesi belirleyici bir rol oynamıştır. Bu bağlamda, Gelibolu'nun Osmanlı donanmasının merkez üssü olarak kullanılması, devletin askerî, siyasî ve idarî politikalarında mekânın taşıdığı stratejik önemi açıkça göstermektedir (Bilgin, 2013).

Osmanlı'nın Akdeniz'deki başarısını sağlayan en önemli "insan" örneklerinden biri, asıl adı Hızır olan Barbaros Hayreddin Paşa'dır. 1478 civarında doğan ve Batılıların kızıl sakalından ötürü "Barbaros" (Barbarossa) olarak tanındığı bu önemli şahsiyet, Yavuz Sultan Selim'in kendisine verdiği "Hayreddin" adıyla Osmanlı tarihine geçmiştir (Türk, 2005). Barbaros Hayreddin Paşa'nın Osmanlı hizmetine girmesi, nitelikli insan gücünün denizlerdeki hâkimiyeti tesis etmede ne denli kritik bir faktör olduğunu ortaya koymuştur (Bilgin, 2013). Nitekim, Aralık 1533 sonunda İstanbul'a gelişi Türkler arasında büyük bir heyecan yaratmış ve onun Osmanlı Donanması'nın Amirali (Kaptan-ı Derya) olarak atanması, Osmanlı deniz gücünü zirveye taşıyan bir dönemin başlangıcı olmuştur (Arıkan & Toledo, 1994). Bu süreçte, Cezayir-i Bahr-i Sefid (Akdeniz Adaları) eyaletinin doğru bir mekân seçimi olarak öne çıkması, Barbaros gibi bir denizcinin liderliğiyle birleşerek Osmanlı'nın Akdeniz'deki başarısının temelini oluşturmuştur (Bilgin, 2013).

Sonuç olarak, Osmanlı Devleti'nin Akdeniz'deki üstünlüğü, yalnızca askeri güce dayalı bir olgu değildi. Gelibolu gibi jeostratejik bir üssün sağladığı mekansal avantaj ile Barbaros Hayreddin Paşa örneğinde olduğu gibi yetenekli ve karizmatik bir liderin yönetim becerisinin sinerjik bir bileşimi, bu hakimiyetin temel dayanaklarını oluşturmuştur. Bu durum, devletlerin denizlerdeki gücünün, hem coğrafi faktörlerin akıllıca kullanımına hem de doğru insan kaynağının etkin bir şekilde yönetilmesine bağlı olduğunu göstermektedir.

## YÖNTEM

Bu çalışmada doküman analizi yöntemi kullanılmış olup Bradford'un (2021) kaleme aldığı "Padişahın Amirali Barbaros Hayreddin Korsan ve İmparatorluk Kurucusu" isimli kitap incelemeye alınmıştır. Doküman analizi, bilgi toplamının imkân dâhilinde olmadığı durumlarda belgelerin incelenerek araştırmacının bilgi toplamasının sağlandığı nitel araştırma yöntemlerinden birini oluşturmaktadır (Kıral, 2020, s.172-173; Muşmal ve Gürbüz, 2024, 171-172).

## 4. Barbaros Hayrettin Paşa'nın Denizcilik Liderliği

Bradford'un (2021) kaleminden; Padişahın Amirali Barbaros Hayreddin Paşa hakkında saptamalar şu şekildedir:

“Kuşkusuz, Oruç'un ölümünden önce bile Babıali ile Barbaros kardeşler arasında dostane ve düzenli bir haberleşme vardı. Yüksek komuta görevi otomatik olarak Hızır'daydı artık. 14 yıl boyunca ağabeyinden çok şey öğrenmişti. Çok geçmeden savaşta onun kadar, siyasette ve devlet adamlığında ondan daha yetenekli olduğunu kanıtlayacaktı.” (Bradford, 2021, s.93).

“Cezayir'deki Türkler artık onun sözünü dinliyorlardı. Görünüşü bile doğuştan lider olduğunu gösteriyordu: Endamı heybetli ve haşmetliydi. Dinçti ve gür sakallıydı; kaşları ve kirpikleri sıktı; kılları kırışmadan önce kestane rengiydi, ama kardeşi Oruç'un anısını korumak için ona da kızıl sakal anlamına gelen Barbaros lakabı takıldı” (Bradford, 2021, s. 93).

“Ama yaklaşan düşmandan daha çok Türk hükümdar ve askerlerinden korkuyorlardı. Hayreddin dediklerini harfiyen yerine getirmeyen tüm kaçakların ve yağmacıların derhal idam edileceğini söyleyerek halkı uyarmayı ihmal etmedi” (Bradford, 2021, s. 100).

“Hayreddin, limanlarını, şehirlerini ve topraklarını güvence altına almak için yapılması gerekenlerin icabına baktı. Barbaros Hayreddin, “Kıyı boyunca, Milyana, Şerşel, Tenes ve Mosteganim'de garnizonlarını tahkim edip iç kesimlerdeki Büyük Arap kabileleriyle ittifaklar kurdu”. Aynı zamanda İstanbul'daki sultanla ilişkisini sağlamlaştırdığı da nerdeyse kesin görünüyor”

“Türlere verdiği sözü tutmayıp neden onları öldürdü? İspanyollar, “Efendim onları Araplar öldürdü, İspanyollar değil yanıtını vermiş,” yanıtını vermiş. Hayreddin, “Eğer ben aksi emri vermemiş olsaydım, benim Mağribilerim de aranızdaki tüm ana kuzularını katlederdi. Ama sizin dinsiz generalinizden daha beyefendi ve daha onurlu biri olduğuma sizi inandırmak için, ben de size canınızı ve özgürlüğünüzü bağışlayacağıma söz verdim. Yaşadığınıza göre ilk sözümü tuttum; özgürlüğünüze gelince, herkes kendi yeteneğine göre istediği şekilde özgürlüğünü satın alabilir. Afrika'nın tüm serveti katledilen dostlarımdan hiçbirini bana geri getirmez. Bari şimdiki köleliğiniz ve gelecekteki kurtulmalık bedeliniz onların yokluklarını bir nebze telafi etsin. Bundan böyle, bu da herkesin kendi şeref sözüne daha fazla saygı göstermesi için uyarı olsun” (Bradford, 2021, s. 102).

“Biraz benzer bir üslupla Barbaros Hayreddin de seçtiği savaş yöntemine en uygun teknenin küçük kadirge ya da çektiri olduğunu kanıtlayacaktı. Doğrusu, yelkenli bir gemi rüzgâr estiğinde daha hızlıydı. Ama uzun Akdeniz yazında, özellikle de orta kesimde, deniz günlerce durgun olurdu. Yine, yelkenli teknenin daha fazla su çekmesi koylarda ve küçük limanlarda bariz bir dezavantajdı. Üstelik yelkenli bir gemi avın üzerine ok gibi atılamazdı; ama kadirge atılabilirdi. Daha sonra forsaların çektiği büyük kadirgalara komuta edecek olmasına rağmen, Hayreddin için Türklerin çektiği küçük çektiri çok daha etkili bir savaş makinesiydi.” (Bradford, 2021, s. 108).

“Barbaros gibi bir akıncının amacı, her şeyden önce, hasmını batırmak değil, içindeki mürettebat ve yüklerle birlikte ele geçirmektir. O nedenle kendi teknesini hasım tekneyle borda bordaya getiriyor ve güverteye atlayıp ele geçiriyordu. Gemiler borda bordaya geldiği anda kürekleri bırakıp savaşa katılan kürekçilere sahip olmak da büyük bir avantajdı. Bunun dışında dayanıklı Türkler tam da bu işe göreydi” (Bradford, 2021, s. 108).

“Barbaros'un çoktandır başına bela olan kaleyi ele geçirdikten sonraki ilk işi buranın yerle bir edilmesini emretmek oldu. Ardından, esirleri çalıştırarak, kaleden ve civardaki taşocaklarından getirdiği taşlarla adayı Cezayir anakarasına bağlayan bir dalgakıran yaptırdı. Kalenin yardımına gelen, asker ve mühimmat yüklü birkaç nakliye gemisi hiçbir şeyden kuşkulandıktan kıyıya doğru yaklaştığında, dalgakıran inşaatı yeni başlamıştı. Barbaros çektirilere saldırı emri verdi; onlar da avın üzerine atmaca gibi atılıp, '2700 adam ile hatırı sayılır miktarda silah ve erzak' ele geçirdiler (de la Gravier'e göre)” (Bradford, 2021, s. 134).

“Barbaros'un maaşının o sırada Ege'nin en önemli üç adasından alınması ve Barbaros'un doğum yeri Midilli'nin de bunların arasında olması ilginçtir.”

“Chesneau, Türk donanmasının Barbaros’un ıslahatından önceki durumunu açıklamaya devam eder:

“Barbaros başa geçmeden önce, bazı korsanlar dışında Türkler denizcilik sanatı hakkında bir şey bilmiyorlardı. Bir filo için tayfaya ihtiyaç duyduklarında, Yunanistan ve Anadolu dağlarına gidip topladıkları çobanları kadırgaların küreklerine oturtur ve diğer gemilerin güvertelerinde görevlendirirlerdi. Bu hiçbir işe yaramazdı; zira ne denizcilikten anlıyor ne de kürek çekmeyi biliyorlardı, hatta denizde ayakta bile duramıyorlardı. Bu yüzden Türkler denizde herhangi bir varlık gösteremediler. Ama Barbaros bir anda bütün sistemi değiştirdi.’ Yukarıdaki açıklamayı yorumlayan amiral Jurien de la Graviere bu değişimi doğrular: Öylesine değiştirdi ki birkaç yıl içinde yenilmez unvanını aldılar”(Bradford, 2021, s. 145).

“Hayrettin Büyük ölçekli bir saldırıya karşı koyacak kadar askere ve yeterince tahkim edilmiş bir kente sahip olmadığının farkındaydı. 1535 baharının başında 15 büyük çektirisini, Tunus ile Cezayir’in neredeyse tam ortasında bulunan küçük ve korunaklı Bone limanına gönderdi. Gemilerin üstün bir filo tarafından limana hapsedilmesinin ne denli ölümcül olduğunu geçmişteki deneyimlerinden biliyordu. Kıyılarıdaki üstünlüğünü Deniz gücü sayesinde elde etmişti. Tunus'un düşmesi durumunda esas silahını kaybetmek niyetinde değildi” (Bradford, 2021, s. 161).

“Kaptanları ve destekçileri arasında ödleleri dikkate almayıp derhal imparatora karşı şiddetli bir savaş başlattı. Yaşamında birçok kez olduğu gibi, Barbaros usta bir stratejist ve taktikçinin tüm niteliklerini sergiledi. Sıkça Kendi isteğiyle "daha ileri hamleler için geri çekilmekten" çekinmedi. Düşmanın onu geri çekilmek zorunda bıraktığı o sırada, bunun yeni bir saldırı başlatmak için kullanılacağını kimse tahmin edemezdi. Kaptanlarına “soru sorma zahmetine katlanmadan” peşine takılmalarını emreden Barbaros hemen denize açıldı. V. Karl’ın kıyı boyunca saldırıya geçip “Türk korsanın” işini bitirmeye karar verme ihtimaline karşı, Barbaros'un şehri tahkim etmek için Cezayir’in yolunu tutması beklenirdi. Ama bunu yapmadı; amiral gemisi Akdeniz’de kuzeybatıya dümen kırdı” (Bradford, 2021, s. 166).

“...ama kendisine karşı gelen komutanlarını dizginlemede Barbaros pek de başarılı olmadı. İkinci gün, 26 Eylül’de Murad Reis komutasında bir yeniçeri birliğinin Preveze’de karaya çıkmasına ikna edildi. Dar bir boğazdan geçen birlik, İspanyolların ve İtalyanların müttefik filosunun tam karşısındaki sahile indi. Tam da Hayreddin’in öngördüğü oldu. Birlikler sahilde siper alır almaz kadırgaların ve kalyonların top ateşi başladı. Bir katliam oldu. Kalyonların top ateşi daha önce çok az türkün gördüğü bir şeydi. Barbaros'un kendisi de böyle bir şeyle karşılaşmamıştı (ateş gücünü ve isabetini duymuş olmasına rağmen).” (Bradford, 2021, s. 193).

“Muhtemelen Murad ve Sinan gibi denizcilerin Avrupalıların gemilerine bu kadar ağır top koyabileceklerinden haberdar olmamaları bu bozguna yol açtı. Siperlere yerleşemeyen, top ateşiyle perişan olan yeniçeriler Murad Reis komutasında, dağınık bir biçimde geri çekilmek zorunda kaldılar. Arkalarında, top ateşiyle delik deşik olmuş kumların üzerinde çok sayıda ölü bıraktılar.” (Bradford, 2021, s. 193-195).

“Barbaros'un görüşü, bunca insan kaybıyla, hazin bir biçimde de olsa doğrulandı. Artık kararları tartışılmadan uygulanacaktı. Komutanlar yaşayarak öğrenmişti. İster karada ister denizde olsun, savaşla ilgili konularda, ömrünü savaşlarda geçirmiş ve bulunduğu yere yeteneği ile gelmiş bir adamın nasihatlerinin bir kenara atılmaması gerektiğini de öğrenmişlerdi” (Bradford, 2021, s.195).

## SONUÇ

Denizcilik liderliği alanında Barbaros Hayrettin Paşa, önemli şahsiyetlerden biridir. Bu çalışmada liderlik ve denizcilik liderliği kavram ve kapsamı olarak ele alınmış, Barbaros Hayrettin Paşa’nın liderlik özellikleri incelenmiştir.

Bu çalışmada Barbaros Hayrettin Paşa'nın denizcilik alanındaki liderliği, Bradford'un (2021) "Padişahın Amiralî Barbaros Hayreddin Korsan ve İmparatorluk Kurucusu" kitabının doküman analizi tekniğiyle incelenmesiyle ortaya konulmuştur.

Bradford'un (2021) kitabı incelendiğinde, Barbaros Hayreddin Paşa'nın, denizlerin hâkimi olarak iyi bir komutan ve tecrübeli bir savaşçı olduğu anlaşılmaktadır. Siyasette ve devlet adamlığında başarılı bir yönetim tarzı sergilemiştir. Savaş taktiklerinde son derece vizyoner davrandığı, stratejik hareket ettiği görülmektedir.

Barbaros Hayreddin Paşa'nın liderlik profili, günümüz denizcilik liderliği literatüründe vurgulanan kritik özelliklerle bir uyum içindedir. Bradford'un (2021) çalışmasının analizi, onun sadece "denizlerin hâkimi" bir komutan değil, aynı zamanda vizyoner stratejileriyle bir dönüşümcü lider, siyasetteki başarısı ve farklı kökenden gelen denizcileri yönetmedeki maharetiyle de ilişki odaklı bir yönetici olduğunu ortaya koyar. Bu özellikler, modern araştırmalarda iş performansı ve örgütsel bağlılıkla doğrudan ilişkilendirilen dönüşümcü ve ilişki odaklı liderlik tanımlarıyla örtüşmektedir (Öter & Ayan, 2021; Yorulmaz, 2022).

Ayrıca, Hayreddin Paşa'nın operasyonel başarısı ve yönetim becerisi, denizcilik kazalarının temelinde yatan liderlik ve yönetim eksikliklerine (Kim, 2020) karşı etkili bir özellik olarak yorumlanabilir. Güçlü bir güvenlik kültürü oluşturması ve nitelikli insan kaynağını etkin kullanarak bir donanma inşa etmesi, günümüzün demografik değişim ve nitelikli personel sorunlarına (Lutzkanova, 2019) ışık tutacak derinliktedir. Sonuç olarak, Barbaros Hayreddin Paşa'nın liderliği, teknolojik gelişmelere rağmen denizcilikte insani ve stratejik becerilerin kalıcı önemini kanıtlayan evrensel bir model sunmaktadır.

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## SOSYAL MEDYA KULLANIMININ TOPLUMSAL KÜLTÜRE ETKİLERİ

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### ÖZET

Bilişim çağında sosyal medya kullanımı dünyada gittikçe yaygınlaşmaktadır. Kültürel değerleri, inançları, davranışları birbirinden farklı olan insanların bu mecrada karşılaşmaları çok daha kolay hale gelmekte ve birbirlerinden daha kolay etkilenebilmektedir. Bu etkilenebilirlik ise bir takım olumlu ve olumsuz sonuçları beraberinde getirmektedir. Bu çalışmada sosyal medyanın toplumsal kültüre etkilerinin incelenmesi amaçlanmaktadır.

Sosyal medyanın toplumsal kültür üzerinde olumlu etkiler kapsamında bir kültürel değer farklı şekillerde yeniden üretilmesini, evrensel boyutlarda hızla yayılmasını, anonim hale gelmesini sağlayabilmektedir. Yine sosyal medya kullanımı, kültürler arası etkileşimi artırarak, farklı kültürler hakkında bilgili, farkındalığı gelişmiş, özgüvenli ve esnek olmayı sağlamaktadır.

Sosyal medyanın toplumsal kültür üzerinde olumsuz etkiler bakımından sosyal medya bağımlılığına, kimi zaman içeriklerin sahte üretilip yayılmasına, kültürel kodlar veya simgeler yoluyla din, ahlak, cinsiyet, ekonomi, cinsel içerik yoluyla kültürün olumsuz etkilenmesine yol açabilmektedir. Sosyal medyada bireyler veya gruplar arasında söz konusu olan ayrımlaşma veya nefret söylemleri, farklı kültürden bireyler arasında yanlış bilgilendirme yanlış tutum ve potansiyel çatışma kaynağı olabilmektedir.

Sosyal medyanın doğru kullanımı için kısıtlama yerine sanal topluma ilişkin sanal kimliklerin oluşturulması, kültürel değerlerimizin dijitalleştirilerek Türkçe kodlarla evrensel olarak yaygınlaştırılmasının önemi büyüktür. Sosyal medyanın kültüre uyarlanması gerekmektedir.

**Anahtar Kelimeler:** Sosyal medya, sosyal medya kullanımı, kültür

### ABSTRACT

In the information age, social media use is becoming increasingly widespread worldwide. It has become much easier for people with different cultural values, beliefs, and behaviors to encounter one another on this platform, and they can be more easily influenced by one another. This influence brings with it a number of positive and negative consequences. This study aims to examine the impact of social media on social culture.

In terms of the positive effects of social media on social culture, it can enable the reproduction of a cultural value in different ways, its rapid spread on a universal scale, and its anonymization. Furthermore, social media use increases intercultural interaction, fostering knowledge, increased awareness, self-confidence, and flexibility about different cultures.

In terms of negative effects on social culture, social media can lead to social media addiction, sometimes the production and dissemination of fake content, and the negative impact of culture through cultural codes or symbols, including religious, moral, gender, economic, and sexual content. Discrimination or hate speech between individuals or groups on social media can be a source of misinformation, misconceptions, and potential conflict between individuals from different cultures.

Rather than restricting social media's proper use, it's crucial to create virtual identities for the virtual community and digitize our cultural values, universally disseminating them in Turkish. Social media needs to be adapted to our culture.

**Key Words:** Social media, social media use, culture

## GİRİŞ

Günümüzde gittikçe yoğun şekilde kullanılmaya devam eden teknoloji, beraberinde sosyal medyanın yoğun şekilde kullanımına aracılık etmiştir. 1990'lı yıllardan sonra internet ve bilgisayar kullanımının yaygınlaşması, 2000'li yıllardan sonra da cep telefonlarının yaygınlaşması, iletişimde yeni bir döneme girilip sosyal medya kullanımına katkı sağlamıştır (Uluç ve Yarcı, 2017, s.89).

Farklı kültürel değerlerdeki bireylerin, geleneksel iletişim yollarından, sosyal mecra yoluyla karşılaşma ihtimalleri daha fazla yükselmektedir. Bu etkileşim ise farklılıkların birbirlerini olumlu veya olumsuz etkilemesi sonucunu doğurmaktadır.

Küresel ekonomilerden önce geleneksel kültürlerin muhafaza edilmesi, geleceğe taşınması ve toplumsal kültür haline gelmesi daha kolaydı. Küreselleşmeyle birlikte yerel kültür ile küresel kültür iç içe geçerek daha karmaşık bir hal almıştır (Aytekin ve Ateş, 2023, s.8276).

### 1.Sosyal Medya Kavramı ve Kapsamı

Sosyal medya, bireylerin kolayca erişim sağlayabildiği, gündelik yaşamda rahatlıkla kullanılabilen ve bireyin sosyal, kültürel, ekonomik, siyasal ilişkilerine etki edebilen bir yapıya sahiptir (Babacan, 2016, s.7). Bireyin iletişime direkt katılabilme, içerik üretebilme özelliği nedeniyle diğer dijital platformlardan çok daha yoğun kullanımını sağlamış; geniş çapta ilişkiler kurabilme, sosyal medyanın hızla yayılmasında önemli bir etken olmuştur (Uluç ve Yarcı, 2017, s.88).

Sosyal medya olarak; Facebook, Twitter, Instagram, LinkedIn, Youtube gibi uygulamalar en yaygın kullanılan sosyal medya platformlarıdır. Bu platformlar kısaca şu şekilde açıklanabilir (Uluç ve Yarcı, 2017, s.89-90):

“Facebook, 2004 yılında Mark Zuckerberg tarafından kurulmuş platformdur. Twitter, 2006 yılında Jack Dorsey ve 13 arkadaşı tarafından da kurulan en fazla 140 karakterden oluşan metinlerin paylaşılmasını sağlayan platformdur. Youtube, 2007 yılında İngiltere’de kullanılmaya başlanan, video paylaşımına ve izlemesine imkân veren platformdur. LinkedIn: 2003’de profesyonel iletişim ağı şeklinde kurulan platformdur. Instagram: 2010’da Kevin Systrom ve Mike Krieger tarafından kurulan bir platformdur.”

Sosyal medyayı anlatabilmek için Şekil 1’deki İspanyol ressam Diego Rodríguez de Silva y Velázquez’un 1656 yılında resmettiği, Las Meninas tablosunu örnek vermek yerinde olacaktır. Bu tabloda, bazı karakterler; IV. Felipe’nin beş yaşındaki kızı İspanya prensesi Margarita; resmin arka duvarında asılı şekildeki aynada görülen figürler ise Kral IV. Felipe ve ikinci eşi Kraliçe María Ana olarak tasvir edilmektedir (Çetin Eylek ve Bilir Ataseven, 2023, s.494-496).



**Şekil 1.** Diego Rodríguez de Silva y Velázquez, “Las Meninas” (1656)

**Kaynak:** Museo Del Prado (t.y.).

Bu tablo esasen herkesin herkesi takip edip izleyebildiği sosyal medyaya benzemektedir. Nitekim ressam da olmak üzere resimdeki tüm figürler birbirini izlemektedir. Esasen ressam aynada yansımaları gözükken İspanya Kralı IV. Felipe ile eşi Mariana’yı resmetmektedir. Sosyal medyanın bu yönü “omnipticon” olarak insanların birbirini izlediği bir yapıya dönüşmüştür (Uluç ve Yarcı, 2017, s.89-90).

## 2. Sosyal Medya Kullanımı

Küresel topluma günümüzde matematikçiler, “siberkültür” ismini vermişlerdir. “Kontrol bilimi olan siberetikle kültür kelimelerinden oluşmaktadır (Uluç ve Yarcı, 2017, s.93).

Sosyal medyanın dört kullanım alanı bulunmaktadır (Babacan, 2016, s.7-17):

Bireyin kendini bireysel ve özgür hissetmesinde (özne-özgürlük),

Geleneksel medyadan farklı bir yol bulmasında (alternatif mecra),

Demokrasi kültürünü içselleştirilmesinde (demokrasi kültürü) ve

Sosyalleşme, yalnızlık hissinden kurtulma, eğlenme gibi psikolojik ihtiyaçların giderilmesinde (psikolojik tatmin) sosyal medya kullanılabilir.

Sosyal medyanın yaygın kullanımı, yerel kültür küresele; küresel kültür yerele olmak üzere; çift taraflı olarak küreselleşmeye katkı sağlamaktadır. Öyle ki farklı ve uzaktaki kültürün insanları yaşam tarzı olarak birbirlerine benzemeye başlamış; tavır, davranış, giyim, yemek vb. alanlarda farklılıklar ortadan kalmış; benzer bir tarz oluşmuştur (Uluç ve Yarcı, 2017, s.92-93).

Medyanın bireylerin algılarına etki ederler. Bu etkileme, bireylerin duygularını, düşüncelerini ve zihinlerini bilinçsiz bir şekilde ele geçirerek yeni bir gerçeklik oluşturabilmektedir (Aytekin ve Ateş, 2023, s.8278).

## 3.Sosyal Medyanın Toplumsal Kültüre Olumlu Etkileri

Sosyal medya, küresel iletişimi yeniden şekillendirerek toplumsal kültür üzerinde derin ve çoğunlukla olumlu etkiler yaratmıştır. Platformlar, kültürler arası etkileşimi teşvik ederek karşılıklı anlayışın

gelişmesine katkıda bulunurken (Chandra vd., 2024; Tang & Chan, 2020), aynı zamanda yerel kültürlerin korunması ve yeniden üretimi için yeni imkanlar sunmaktadır (Arslan, 2017, s. 31).

Sosyal medyanın en belirgin olumlu katkılarından biri, kültürlerarası diyalogu ve anlayışı güçlendirmesidir. Uluslararası öğrenciler üzerine yapılan bir araştırma, sosyal medyanın farklı kültürler hakkında bilgi edinmeyi ve farkındalık kazanmayı kolaylaştırdığını, bireylere farklı kültürlerle karşı daha özgüvenli ve esnek olma becerisi kazandırdığını ortaya koymaktadır (Aksoy, 2020, s. 126). Bu durum, kültürler arası arkadaşlıkları teşvik ederek küresel bir kültürel yakınlaşmaya zemin hazırlamaktadır.

İkinci olarak, sosyal medya kültürel mirasın korunması ve dönüşümünde etkin bir rol oynar. Teknolojik zemin, kültürel eserlerin farklı biçimlerde şekillenmesine, yeniden üretilmesine ve yeni anlamlar kazanmasına olanak tanımaktadır (Arslan, 2017, s. 31). Yerel kültürler, internet kanalıyla evrensel bir nitelik kazanarak sürdürülebilirlik şansı bulmakta (Arslan, 2017, s. 31) ve kuşaklar arası kültürel aktarım, özellikle genç kullanıcılar nezdinde güçlenebilmektedir (Kizgin vd., 2018; Rawat vd., 2025). Ayrıca, içeriklerin anonimleşerek yeniden üretilmesi, kültürel katılımı demokratikleştirmektedir (Arslan, 2017, s. 31).

Üçüncü bir olumlu etki, topluluk oluşturma ve sosyal sermayeyi güçlendirmesidir. Sosyal medya, bireylerin güçlü topluluk bağları kurmasına ve dayanışma ağları geliştirmesine imkan vererek sosyal sermayeyi artırmakta (Azzaakiyyah, 2023), aynı zamanda bireylere ün kazanma ve görünür olma fırsatı tanıyarak sosyal mobilitayı desteklemektedir (Karaduman, 2017, s. 8).

Dördüncü olarak, sosyal medya bireysel kimlik gelişimine ve eleştirel düşünceye katkı sağlayabilmektedir. Kullanıcıların dijital kimliklerini oluşturma süreci, öz farkındalığı artırabilmekte ve kimlik keşfi için yeni alanlar yaratmaktadır (Yadav, 2025). Platformlar, mevcut kültürel normları sorgulamaya teşvik eden içerikler sayesinde kültürel değişim ve yenilik için bir katalizör görevi görebilmektedir (Guftométros vd., 2021; Hsu vd., 2021). Son olarak, bilginin tekel olmaktan çıkması, yanlış haber veya bilginin daha kolay tespit edilip çürütülebilmesine zemin hazırlayarak kolektif bir eleştirel bilinç oluşumuna katkıda bulunabilmektedir (Aytekin & Ateş, 2023, s. 8280).

Sonuç olarak, sosyal medya toplumsal kültürü kültürlerarası diyalogu güçlendirerek, kültürel mirası dönüştürerek ve koruyarak, topluluk bağlarını pekiştirerek ve bireysel gelişime alan açarak çok yönlü şekilde olumlu etkilemektedir. Bu potansiyelin gerçekleşebilmesi, platformların demokratik, kapsayıcı ve şeffaf bir şekilde kullanılmasına bağlıdır.

#### 4. Sosyal Medyanın Toplumsal Kültüre Olumsuz Etkileri

Sosyal medyanın yaygınlaşması, toplumsal kültür üzerinde küresel ölçekte önemli dönüşümlere yol açarken, beraberinde bir dizi olumsuz etkiyi de getirmiştir. Küresel platformların hakimiyeti, yerel kültürlerin aşınması ve kültürel homojenleşme riskini artırmakta (Tang & Chan, 2020; Yadav, 2025), aynı zamanda bireylerin benlik algıları, sosyal ilişkileri ve tüketim alışkanlıkları üzerinde derin etkiler yaratmaktadır.

Sosyal medyanın olumsuz kültürel etkileri öncelikle manipülasyon ve yanlış bilginin yayılımıyla kendini göstermektedir. Siyasi veya ideolojik amaçlarla üretilen sahte içerikler, kullanıcıları yanıltmak ve toplumu manipüle etmek amacıyla kullanılabilir (Arslan, 2017, s. 40; Aytekin & Ateş, 2023, s. 8276). Bu durum, sanal ortamda yaygınlaşan nefret söylemi ve ayrımcılıkla birleştiğinde, farklı kültürlerle yönelik doğru olmayan bilgilerin ve negatif tutumların yayılmasına, hatta toplumsal çatışma potansiyelinin artmasına neden olmaktadır (Aksoy, 2020, s. 126).

İkinci olarak, sosyal medya bireyin psikolojik ve sosyal sağlığı üzerinde zararlı sonuçlar doğurabilmektedir. Platformlarda sıklıkla maruz kalınan idealize edilmiş yaşam standartları ve beden imgeleri, bireylerde bu standartlara uyma baskısı oluşturmakta ve kaygı ile depresyon gibi olumsuz

psikolojik sonuçlara yol açabilmektedir (McComb vd., 2023; Yadav, 2025). Ayrıca, sosyal ilişkilerin sanal ortama kayması, yüzeysel etkileşimleri artırmakta ve bireyleri "yalnız olmadıkları yanılması" ile baş başa bırakarak sosyal izolasyon riskini beraberinde getirebilmektedir (Bhatiasevi, 2024; Uluç & Yarcı, 2017, s. 96; Yadav, 2025).

Üçüncü bir olumsuz etki, kültürel yapının ve değerlerin aşınmasına yöneliktir. Sosyal medya, din, ekonomi ve cinsiyet gibi temel kültürel kod ve simgeleri dönüştürebilmekte (Arslan, 2017, s. 42), metalaşmış ve yüzeysel bir kültürün yaygınlaşmasına aracılık edebilmektedir (Aytekin & Ateş, 2023, s. 8276). Özellikle "şöhret kültürünü" besleyen bu ortam, içerik üreticilerini, etik kurallar gözetilmediğinde inanç ve davranışlar üzerinde manipülatif bir güç kullanmaya yönlendirebilmektedir (Aytekin & Ateş, 2023, s. 8280; Karaduman, 2017, s. 23).

Son olarak, sosyal medya ekonomik ve tüketim alışkanlıklarındaki dönüşümle kültüre etki etmektedir. Geleneksel tüketim kalıplarını hızla değiştiren platformlar, tüketim odaklı bir kültürün yaygınlaşmasına neden olabilmekte (Rawat vd., 2025), aynı zamanda vergi denetiminden uzak bir ticari kapasite sunabilmektedir (Arslan, 2017, s. 49). Kullanım alışkanlıkları, bireycilik-toplulukçuluk gibi mevcut kültürel değerlerden etkilenmekte ve bu değerlerdeki dönüşüm toplumlar arasında iletişim tarzları ve çatışmalar yaratabilmektedir (AlSaleh vd., 2019; Dlelengana vd., 2024).

Sonuç olarak, sosyal medyanın toplumsal kültür üzerindeki olumsuz etkileri çok boyutludur. Yanlış bilgi yayılımı, psikolojik baskı, sosyal izolasyon, kültürel değerlerin aşınması ve tüketim odaklı bir yaşam tarzının yükselişi, bu etkilerin başlıcalarıdır. Bu olumsuzlukların hafifletilmesi, dijital okuryazarlığın yaygınlaştırılması, platformların etik açıdan sorumlu davranmaya teşvik edilmesi ve kullanıcıların eleştirel medya okuryazarlığı becerileriyle donatılmasını zorunlu kılmaktadır.

## SONUÇ VE TARTIŞMA

Yapılan bu değerlendirme, sosyal medya kullanımının toplumsal kültür üzerinde çift yönlü ve derin etkileri olduğunu açıkça ortaya koymaktadır. Sosyal medya, bir yandan kültürel değerlerin dönüştürülerek küresel ölçekte yayılmasına, kültürler arası iletişim ve etkileşimin artmasına olanak tanımakta; bireylere farklı kültürler hakkında doğru bilgi edinme, farkındalık kazanma, özgüven ve esneklik becerileri geliştirme imkanı sunmaktadır. Kültürel mirasın anonimleşerek yeniden üretilmesi ve dijitalleştirilerek canlandırılması, bu olumlu etkilerin somut örneklerini oluşturmaktadır (Arslan, 2017).

Diğer yandan, sosyal medyanın olumsuz etkileri göz ardı edilemeyecek boyuttadır. Platformlar, bağımlılık yapıcı potansiyelinin yanı sıra, gerçek dışı ve ideolojik amaçlı içeriklerle toplumsal değerlere, ahlaki, dini ve ekonomik yapıya zarar verebilmekte; gruplar arası ayrışma, nefret söylemi ve kültürel çatışma riskini artırabilmektedir. Bu durum, farklı kültürlerle yönelik yanlış bilgileneleme ve olumsuz tutumların pekişmesine neden olmaktadır.

Ancak, bu olumsuzluklara karşı sosyal medyanın engellenmesi veya yasaklanması etkili ve sürdürülebilir bir çözüm olarak görünmemektedir. Bunun yerine, sanal kimliklerin ve sanal toplum dinamiklerinin gerçekliğini kabul eden, dijital okuryazarlığı merkeze alan çözümler geliştirilmesi elzemdir (Arslan, 2017, s. 42).

Kültürel değerlerin korunabilmesi ve olumlu etkilerden azami ölçüde faydalanılabilmesi için, içerik üretiminden platform yönetimine kadar tüm süreçlerde etik ilkelerin titizlikle gözetilmesi gerekmektedir. Somut bir adım olarak, geleneksel masal kahramanları gibi kültürel öğelerin dijital ortamlara kreatif bir şekilde aktarılması, kültürel sürekliliği sağlamak için etkili bir yöntem olarak öne çıkmaktadır (Arslan, 2017, s. 48).

Sonuç olarak, sosyal medyanın kültür üzerindeki net etkisi, onu nasıl yönettiğimize bağlıdır. Dijital platformlar, kontrolsüz bırakıldığında kültürel aşınmaya ve toplumsal parçalanmaya yol açabilecek

riskler barındırmakla birlikte; eleştirel bir bilinçle, etik değerler ışığında ve yaratıcı bir yaklaşımla kullanıldığında, kültürel diyalogu, dayanışmayı ve zenginleşmeyi destekleyen güçlü bir araç dönüşebilir. Gelecekteki politikaların ve eğitim programlarının, bu dengeli ve yapıcı perspektifi merkeze alması büyük önem taşımaktadır.

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## REZERVUAR ÖLÇEĞİNDE MANYETİK ARAŞTIRMALAR ÜZERİNE JEOMANYETİK DEĞİŞKENLİĞİN ETKİLERİ

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### ÖZET

Bu araştırma, güneş kaynaklı manyetik fırtınaların elektromıknatıs çekirdeğinin boşluğunda gerçekleştirilen manyetik alan ölçümlerinin hassasiyeti üzerindeki etkilerini incelemektedir. Sonuçlar, jeomanyetik bozulmalar sırasında kaydedilen değerlerin gerçek manyetik alan şiddetinden önemli ölçüde sapabileceğini göstermektedir. Bu tür tutarsızlıklar, güneş patlamaları tarafından tetiklenen Dünya'nın manyetik ortamındaki dalgalanmalardan kaynaklanmakta ve ölçüm sisteminin kararlılığını ve doğruluğunu zayıflatmaktadır. Laboratuvar ölçümlerinin ötesinde, bu durumun daha geniş kapsamlı etkileri bulunmaktadır. Jeomanyetik koşullardaki değişimlerin ekosistemleri etkilediği, bitkilerin büyüme döngülerini, hayvanların yön bulma ve davranışlarını, hatta insanın fizyolojik ve psikolojik sağlığını dahi etkilediği iyi bilinmektedir. Bu geniş etkiler, uzay havası olaylarının anlaşılması ve izlenmesinin önemini vurgulamaktadır. Petrol mühendisliğinde ise doğru manyetik alan ölçümleri, rezervuar karakterizasyonu, kuyu güzergâhı tasarımı, jeoyönlendirme (geosteering) ve saha geliştirme ile geliştirilmiş petrol geri kazanımı (EOR) operasyonlarının izlenmesi için kritik öneme sahiptir. Jeomanyetik bozulmalar, manyetik verileri bozarak enjeksiyon stratejilerinin, sondaj yollarının ve üretim yönetimi kararlarının hatalı alınmasına yol açabilir. Bu etkiler dikkate alınmadığında, verimsiz geri kazanım ve operasyonel gecikme riskleri artmaktadır. Bu çalışma, petrol arama ve geliştirme süreçlerine uzay havası farkındalığının entegre edilmesinin gerekliliğini vurgulamaktadır. Düzeltme algoritmaları, gerçek zamanlı jeomanyetik izleme ve uzay havası tahminlerinin rezervuar yönetimine entegrasyonu gibi önlemler, veri güvenilirliğini sağlamak açısından büyük önem taşımaktadır. Güneş kaynaklı jeomanyetik değişkenliği EOR ve saha operasyonlarındaki pratik zorluklarla ilişkilendirerek, bu araştırma üretim verimliliğini artırmaya, riskleri azaltmaya ve rezervuar yönetimini optimize etmeye yönelik uygulanabilir içgörüler sunmaktadır.

**Anahtar kelimeler:** Jeomanyetik aktivite, petrol endüstrisi uygulamaları, saha geliştirme, rezervuar, hidrokarbon

## GEOMAGNETIC VARIABILITY EFFECTS ON RESERVOIR-SCALE MAGNETIC INVESTIGATIONS

### ABSTRACT

This research investigates the effects of solar-induced magnetic storms on the precision of magnetic field measurements taken within the gap of an electromagnet core. The results demonstrate that during geomagnetic disturbances, recorded values can deviate considerably from the actual magnetic field intensity. Such discrepancies stem from perturbations in the Earth's magnetic environment, generated by solar flare activity, which disrupt the stability and accuracy of the measurement system. The implications extend beyond laboratory measurements. Variations in geomagnetic conditions are well-documented to influence natural ecosystems, affecting the growth cycles of plants, the navigation and behavior of animals and even human physiological and psychological well-being. These broader impacts emphasize the significance of understanding and monitoring space-weather effects. In petroleum engineering, accurate magnetic field measurements are crucial for reservoir characterization, well trajectory design, geosteering, and monitoring during field development and enhanced oil recovery (EOR) operations. Geomagnetic disturbances can distort magnetic data, potentially leading to errors in determining optimal injection strategies, drilling paths and production management decisions. Without accounting for such influences, risks of inefficient recovery and operational delays increase. This study highlights the necessity of incorporating space-weather awareness into petroleum exploration and development workflows. Mitigation strategies, such as correction algorithms, real-time geomagnetic monitoring and integration of space-weather forecasting into reservoir management are essential for ensuring data reliability. By linking solar-driven geomagnetic variability to practical challenges in EOR and field operations, the research provides actionable insights for enhancing production efficiency, reducing risks and optimizing reservoir management.

**Keywords:** Geomagnetic activity, petroleum industry applications, field development, reservoir, hydrocarbon.

### 1. INTRODUCTION

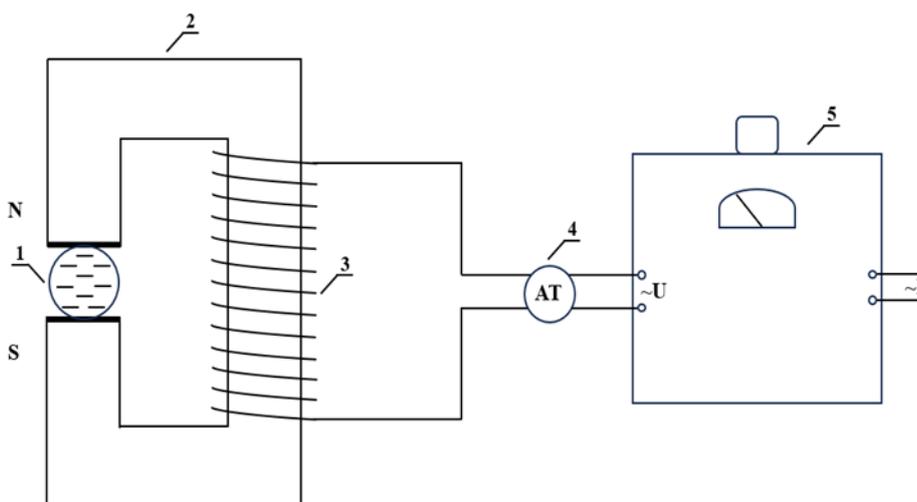
When conducting experimental studies that involve measuring the magnetic field of an “open” system, meaning a setup that is not magnetically shielded by impermeable materials, the reliability of the measurements can be affected by the superposition of external magnetic influences. These disturbances may arise from various sources, including natural variations in the Earth's geomagnetic field, localized anthropogenic electromagnetic fields, and large-scale solar-induced magnetic storms. Such external contributions can lead to deviations between the measured and the actual values of the investigated magnetic field, complicating both the interpretation of results and the reproducibility of experiments (Yang, Zhou & Blunt, 2021; Alvarado & Manrique, 2010).

In this context, the present article focuses on the effect of a solar-generated magnetic storm on magnetic field measurements performed within the gap of an electromagnet core. The chosen object of study is particularly relevant because an electromagnet with an open measurement gap is sensitive to fluctuations in the surrounding magnetic environment. During geomagnetic disturbances, the intensity and orientation of the Earth's magnetic field undergo rapid changes, which in turn can distort the electromagnetic conditions inside the measurement zone. These distortions may manifest as shifts in field strength, fluctuations in stability, or increased noise in the recorded data (Mirzajanzade, Iskandarov, Abdullayev, Agayev, Aliyev, Amirov & Gasimov, 1960).

## 2. METHODOLOGY

To illustrate the experimental configuration, the schematic diagram of the electromagnet core with its measurement gap is presented in Figure 1. This setup enables a detailed examination of how external solar-induced perturbations interact with the controlled magnetic field of the system. By analyzing the deviations observed during periods of magnetic storm activity, the study aims to quantify the degree of influence such cosmic phenomena exert on laboratory-scale measurements. The findings are significant not only for improving the accuracy of magnetic field investigations in unshielded environments but also for developing strategies to mitigate the impact of space weather on sensitive experimental systems (Mammadzade, 2021; Safarov, Vezhnin & Vulfovich, 2020).

In addition, the setup allows for a precise evaluation of electromagnetic interference mechanisms that occur when geomagnetic perturbations overlap with the applied laboratory field. Such disturbances may induce transient fluctuations in voltage, resistance, and magnetic flux density within the measurement gap, thereby influencing the stability and repeatability of recorded data. By quantifying these deviations, it becomes possible to determine the threshold levels at which external space weather effects begin to distort experimental measurements. This insight is crucial for improving instrumentation sensitivity, calibrating magnetically controlled systems, and designing effective shielding strategies for advanced reservoir and laboratory-scale investigations.



1 – object under study, 2 – electromagnetic coil core, 3 – ammeter, 4 – alternating current to direct current converter.

**Figure 1.** Schematic diagram of the experimental setup.

Measurements on the setup for treating the studied object (1) with a magnetic field are carried out as follows. A direct electric field voltage  $U$  is set at the output of the AC-to-DC converter (4). Using a magnetometer, the magnetic field strength  $H$ , located in the middle of the electromagnetic coil core (2) is determined. The obtained values are recorded in a table, based on which the dependence of  $H$  on  $U$  is plotted, see Figure 2.

The date of the experiment was determined from Table 1, which indicates the days of geomagnetic disturbances in November 2024 in the city of Baku, published on the internet.

In addition, it should be noted that magnetic storms are natural phenomena arising from disturbances in the Earth's geomagnetic field and occur quite frequently. These disturbances can have a serious impact on electromagnets, other systems operating on the basis of electromagnetic fields, and

sensitive experimental devices. Variations in the geomagnetic field lead to local instabilities in the electromagnetic field, which in turn may cause measurement errors or operational inconsistencies in electromagnetic-based equipment, especially in instruments requiring high precision. Such effects may reduce the accuracy of experimental results and lead to data distortion.

For the month of November, Table 1, which reflects the intensity of magnetic storms in Baku, provides essential information for assessing their potential impact on laboratory experiments. The intensity levels presented in the table quantitatively evaluate the strength of disturbances in the planet's magnetic field and allow researchers to identify the most suitable days for conducting laboratory experiments. The intensity levels of magnetic storms (expressed on a scale from 1 to 8, as shown at the bottom of the table) indicate different degrees of geomagnetic activity. Experiments were conducted on days when the scale indicated "minor disturbances," ensuring stability and correctness of the results. These conditions minimized the influence of geomagnetic activity and created favorable conditions for obtaining more accurate and reliable experimental analyses (Mammadzade & Alizade, 2025; Alizade, 2025).

Moreover, the careful scheduling of experiments based on geomagnetic indices is consistent with international scientific practice, where space-weather data are often incorporated into experimental design to ensure reproducibility. In particular, avoiding periods of high geomagnetic activity not only improves the quality of measurements but also contributes to reducing uncertainty in the interpretation of observed physical phenomena. By integrating geomagnetic monitoring into the planning stage, researchers strengthen the credibility of their results and ensure that any observed effects can be attributed to controlled experimental variables rather than external natural disturbances.

Furthermore, it is worth mentioning that for each day of laboratory experiments involving the use of magnets, real-time geomagnetic activity indicators were monitored, and any sudden changes were recorded and considered during the interpretation of results. In practice, this meant continuous observation of geomagnetic indices from specialized monitoring centers, with data cross-checked against independent international observatories. This additional verification step reduced the possibility of overlooking short-lived geomagnetic fluctuations that could affect sensitive instruments.

This approach made it possible not only to account for the general level of magnetic storms but also to minimize the effects of local and short-term geomagnetic deviations. As a result, external geomagnetic influences on experimental outcomes were reduced to a minimum, ensuring high accuracy and reliability of the measurements, while at the same time confirming that careful selection of experimental periods and continuous monitoring of geomagnetic conditions are essential prerequisites for obtaining reproducible and scientifically valid results.

In this context, the integration of geomagnetic monitoring into experimental methodology also serves as a valuable reference framework for future research. By documenting both baseline and disturbed geomagnetic conditions alongside laboratory observations, a comprehensive dataset is created that can be compared across different studies and geographic regions. Such systematic documentation facilitates meta-analyses and long-term evaluations of space-weather impacts on laboratory-scale magnetic investigations, ultimately contributing to the establishment of standardized practices in experimental geophysics and magnetically assisted technologies.

**Table 1.** Indicators of magnetic storm activity levels observed in Baku during the month of November (Internet material)

Dates	Time Frames							
	00:00	03:00	06:00	09:00	12:00	15:00	18:00	21:00
01.10.2024	1	1	1	1	1	1	1	1
02.10.2024	1	1	1	1	1	1	1	1
03.10.2024	1	1	1	1	4	5	3	3
04.10.2024	4	4	6	6	6	4	5	5
05.10.2024	3	4	4	6	6	7	7	6
06.10.2024	5	5	4	4	4	5	5	4
07.10.2024	4	4	3	3	3	3	4	5
08.10.2024	5	3	3	3	3	3	3	3
09.10.2024	2	2	1	1	1	1	1	2
10.10.2024	5	7	7	8	8	7	7	8
11.10.2024	7	6	6	6	6	5	4	5
12.10.2024	4	4	3	3	3	4	3	2
13.10.2024	2	2	1	2	2	3	3	3
14.10.2024	2	2	1	1	2	2	2	2
15.10.2024	2	1	1	2	3	4	4	3
16.10.2024	3	3	3	4	4	3	2	2
17.10.2024	2	1	2	2	2	3	2	3
18.10.2024	2	2	3	3	3	4	4	3
19.10.2024	3	2	2	2	2	3	3	3
20.10.2024	3	3	2	2	1	1	1	1
21.10.2024	1	1	1	1	1	1	4	2
22.10.2024	2	2	2	2	2	2	2	2
23.10.2024	2	2	2	2	2	2	2	2
24.10.2024	2	2	2	2	2	3	3	4
25.10.2024	3	2	2	2	2	2	4	4
26.10.2024	3	3	3	2	2	2	3	3
27.10.2024	3	3	2	2	1	2	3	5
28.10.2024	5	5	5	4	4	4	4	3
29.10.2024	3	3	3	2	2	2	3	2
30.10.2024	2	2	2	2	2	2	1	1
31.10.2024	1	1	1	1	1	1	2	2

The numbers indicated in the table's scale correspond to the following conditions:

1 - No significant disturbances, 2 - Minor disturbances, 3 - Weak geomagnetic storm, 4 - Minor geomagnetic storm, 5 - Moderate geomagnetic storm, 6 - Strong geomagnetic storm, 7 - Severe geomagnetic storm, 8 - Extreme geomagnetic storm.

### 3. CONCLUSION AND DISCUSSION

The experiments were carried out in accordance with the established methodology under both high and low geomagnetic activity conditions. During the tests, the oil volume, water volume, electrical resistance, and potential difference were measured and the corresponding results were incorporated into Table 2. As can be seen from the data, when the experiments coincided with periods of high geomagnetic activity, the obtained values of the investigated parameters, as well as their overall efficiency, were noticeably lower. In contrast, under conditions of low geomagnetic activity, the measured oil and water volumes, together with the resistance and potential difference, showed a significant increase, reflecting an improvement in efficiency. This comparison clearly demonstrates

that geomagnetic activity exerts a considerable influence on the system, where reduced activity creates more favorable conditions for fluid displacement and electrokinetic behavior in the porous medium.

**Table 2.** The results of experiments conducted at low (1st) and high (2nd) geomagnetic activity conditions.

t, min	P, atm	Voil, mL		$\eta_{oil}$ , %		Vwat, mL		$\eta_{wat}$ , %		R, kOm		U, mV	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
5	1.6	0	0.0	0.00	0.00	0	0	0.00	0.00	140	140	57.8	58.1
10	3.2	1	0.5	0.29	0.21	0	0	0.00	0.00	130	140	52.2	52.8
15	4.8	2	1.0	0.59	0.42	0	0	0.00	0.00	130	150	48.7	49.8
20	6.4	3	2.0	0.88	0.64	0	0	0.00	0.00	135	140	51.4	51.8
25	8.0	4	3.0	1.18	0.97	0	0	0.00	0.00	135	140	53.1	53.7
30	9.6	5	4.0	1.47	1.22	0	1	0.00	0.12	135	130	54.6	54.1
35	11.2	8	6.0	2.35	1.98	3	3	0.38	0.38	130	140	50.3	51.2
40	12.8	12	10.0	3.53	3.15	5	5	0.63	0.63	130	150	53.8	55.4
45	14.4	15	12.0	4.41	4.05	8	7	1.00	0.98	130	140	52.1	53.4
50	16.0	25	20.0	7.35	5.81	13	14	1.63	1.65	130	140	54.1	55.1
55	17.6	40	34.0	11.76	6.93	18	17	2.25	2.21	120	150	48.1	50.1
60	19.2	60	53.0	17.65	15.67	25	26	3.13	3.16	130	140	50.6	51.3
65	20.8	85	77.0	25.00	20.05	40	43	5.00	5.21	120	130	46.8	47.7
70	22.4	100	92.0	29.41	25.15	65	67	8.13	8.20	120	140	44.2	45.9
75	24.0	120	109.0	35.29	31.23	100	107	12.50	13.42	120	140	47.5	48.6
80	25.6	135	124.0	39.70	36.61	140	145	17.50	19.41	120	140	50.2	51.2
85	27.2	150	141.0	44.12	38.83	180	190	22.50	23.39	120	130	49.6	50.4
90	28.8	165	154.0	48.53	42.25	225	235	28.13	30.04	110	130	53.5	55.2
95	30.4	180	170.0	52.94	46.78	260	270	32.50	33.27	110	120	49.3	50.5
100	32.0	185	176.0	54.41	50.05	300	310	37.50	38.32	100	120	45.9	46.1
105	33.6	190	181.0	55.88	51.12	350	365	43.75	44.65	100	130	43.6	45.3
110	35.2	199	185.0	58.53	53.28	408	420	51.00	54.11	100	120	45.4	46.3

According to research findings the following results are concluded:

1. Geomagnetic activity has a measurable impact on experimental outcomes. The comparison of results under high and low geomagnetic activity demonstrates that magnetic storms reduce the efficiency of oil and water displacement, as well as lower the values of resistance and potential difference. This confirms that external geomagnetic disturbances directly interfere with the accuracy and stability of magnetic field-dependent measurements.
2. Low geomagnetic activity provides more favorable conditions for EOR-related processes. Experiments carried out during low geomagnetic activity exhibited higher oil and water recovery volumes, along with improved resistance and potential difference values. These results indicate that reduced geomagnetic disturbance enhances electrokinetic effects in porous media, leading to more efficient displacement behavior.
3. Accounting for space-weather effects is critical for petroleum operations. The findings emphasize that solar-induced geomagnetic disturbances can influence both laboratory experiments and field-scale applications, including reservoir monitoring, well placement, and EOR optimization. Careful timing of experiments and continuous monitoring of geomagnetic conditions are therefore necessary to ensure reliable measurements, minimize operational risks, and improve overall recovery efficiency.

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## THE EFFECT OF PERCEIVED SOCIAL SUPPORT AND LOCUS OF CONTROL ON MOBBING AND VICTIMIZATION

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### ABSTRACT

In today's increasingly globalized and competitive work environment, organizations and employees are exposed to heightened performance expectations, constant change, and growing external pressures. These dynamics often give rise to interpersonal tensions, conflicts, and various forms of unethical or counterproductive workplace behavior. Among these, mobbing—commonly referred to as workplace bullying—has gained attention as a critical organizational issue due to its detrimental effects on both individual well-being and institutional functioning. The present study aims to explore how two key psychosocial factors—social support and locus of control—influence employees' perceptions of mobbing and victimization. Drawing on data collected through a structured survey, the research employs structural equation modeling (SEM) to test the proposed relationships. The results indicate that employees who perceive high levels of social support from colleagues and supervisors are less likely to report experiences of mobbing or feel victimized within the workplace. Conversely, individuals with a strong external locus of control, who attribute outcomes to forces beyond their personal influence, tend to perceive higher levels of mobbing and victimization. Additionally, the findings reveal a significant interaction between perceived social support and locus of control on mobbing, suggesting that supportive organizational environments can buffer the negative effects of external control orientations. However, this moderating effect was not observed for victimization, implying that feelings of being targeted may be shaped by additional contextual or psychological factors. Overall, this research contributes to the limited empirical literature on mobbing, particularly within academic settings, and underscores the value of integrating interpersonal and dispositional variables in understanding workplace bullying. The study also extends the methodological use of SEM in examining complex psychosocial dynamics in organizational behavior.

### 1. INTRODUCTION

Acceleration of globalization since the 1980's has been causing organizations to perform their businesses in a highly competitive environment. Organizations continuously try to reach and sustain competitive advantage both in their local and global environments. These attempts have some reflections on employees. New competitive working environment, which requires continuous change forces members of the organizations to work harder and meet new terms such as restructuring, reengineering and downsizing. Employees focus on their career and success more than ever to be able to protect their jobs, and it gives raise in conflicts and unethical behaviors in the work places. Sabotage, theft, aggression, labor unrest and strikes become common counterproductive work place behaviors. Mobbing is one of the phenomenons related to these counterproductive behaviors in the workplaces.

Mobbing is a relatively new concept in OB literature. It was first suggested by Leymann in the late 1980's (Leymann, 1996) and attracted attention in the mid 1990's in countries other than Sweden (Einarsen et al., 2003). In Turkey, the first study on mobbing was a narrative study held by Yuceturk

in 2002. It has been more than 20 years since the introduction of term, but is still an under investigated subject. Previous studies held in Turkey has generally focused on the most frequent negative behaviors related to mobbing, differences in the degree of mobbing in terms of age, gender, education, experience, and such kind of demographic information.

The aim of this proposed research is to broaden our understanding on the effect of mobbing for individuals. More specifically, the concern is about how the relationship between mobbing and victimization would change according to individual's perceptions about controlling events and in the presence of social support.

## LITERATURE REVIEW

### 1.1.1. Mobbing Defined

According to Leymann (1996:168) mobbing means hostile and unethical communication, which is directed in a systematic way by one or a few individuals mainly towards one individual who, due to mobbing, is pushed into a helpless and defenseless position. Björkqvist et al. (1994:173) define it as repeated activities, with the aim of bringing mental (but sometimes also physical) pain, and directed toward one or more individuals who, for one reason or another, are not able to defend themselves. As to Namie (2003:1) it is a "status-blind" interpersonal hostility that is deliberate, repeated and sufficiently severe as to harm the targeted person's health or economic status. These examples demonstrate that mobbing indicates an unethical communication style, hostility and repeated activities. It is not a concrete and observable variable, thus, in order to understand the construct of mobbing, some behaviors should be attached. There are five core themes underlie these and other definitions: negative behaviors, negative consequences on the individual exposed to these negative behaviors, power inequality between sides, frequency, and longevity.

Mobbing is often made reference to negative behaviors. But what are these frequently mentioned mobbing behaviors? Those negative and aggressive behaviors include a wide range of actions from giving a person too simple tasks to physically hurt someone, and actually have no distinguishing characteristics indicating mobbing. Normal behaviors that can be confronted by everyone in every work place commence to carry different meanings in the mobbing process. The focus is on frequency and duration of these behaviors rather than what is done or how it is done (Leymann, 1996). Most of the researchers include physical aggression to the extent of mobbing behaviors even if they agree that concept is more related to psychological aggression (Keashly, 1998; Leymann, 1996; Zapf et al., 1996).

It is also essential for the domain specification to differentiate mobbing from similar concepts such as conflict, work stress, maltreatment of manager, and bad working conditions since some people who have suffered from these concepts see themselves as victims of mobbing. In every work place conflict can occur, but conflicts may result in positive outcomes if they are managed appropriately. Besides, organizational climate becomes foggy, communication ambiguous and the interaction between people is hostile, in mobbing situations (Cassito, 2003). Mobbing is an extreme source of stress (Zapf, 1999), but stress is different than mobbing since normal social stressors affect almost everybody in a department, whereas mobbing is targeted at particular individuals and may not affect the other members of the organization at all (Einarsen et al., 2003). Also, managers can treat badly to their subordinates but if anger is not directed only one or a few individuals, and if the manager does not manipulate the weaknesses of people, we cannot call it mobbing. In addition, bad working conditions such as poor lightning, heavy workload, lack of necessary equipment cannot be named as mobbing unless they are intentionally set to make some individuals uncomfortable (Minibas-Poussard and Idig-Camuroglu, 2009).

In the current study, mobbing is defined as repeated and long-lasting negative behaviors targeted to few individuals, which have negative consequences on the target and make the target somehow less powerless than the perpetrator. Not all targets feel and affected in the same way even they face the same negative behaviors in the same work places. There are some other factors changing the degree of their affection resulting from mobbing. Some of them can continue their lives as if nothing important is happening, while some of them are really affected and victimized.

### **1.1.2. The Role of Social Support**

Social support is the actual or perceived availability of social resources that can be used for comfort or aid, particularly in times of stress. Social support helps people to reduce the negative effects of stressors and enhance their physical and psychological health (Lepore, 2012: 493). There are several studies examining the effect of social support on job stress. Having social support from their surroundings, reduces the job stress of employees experienced directly, or reduces the effects of psychological problems they experience due to job stress indirectly. Health problems arising from stress can be reduced or eliminated with social support, while people who do not get any support suffer from serious health problems (LaRocco et al., 1980; Fenlason and Beehr, 1994). Source of support is also important. Support from work environment, supervisors and colleagues are more effective than the support from family and friends (Fenlason and Beehr, 1994). Some studies prove that support from co-workers significantly helps more to reduce the job stress, emotional exhaustion and related health problems and increase the feeling of personal achievement (LaRocco et al., 1980; El-Bassel et al., 1998).

Mobbing is seen as a source of job stress (Spector, 2008) since it includes systematically repeated negative behaviors. Zapf et al. (1996) emphasizes that mobbing is an extreme source of job stressor. It is claimed to be a more important job stressor, which causes physical and psychological health problems (Hauge et al., 2010). Thus, social support may also ease the discomfort arising from mobbing as one of the work stressors. Employees who have high perception of social support feel less vulnerable when they experience mobbing. Also, harmful health effects of mobbing are reduced by social support (Einarsen, 2000). Zapf et al. (1996) found that mobbing targets who perceive more social support from their superiors and colleagues were exposed less to some aggressive behaviors. In addition, Bilgel et al. (2006) found out those targets with high perception of social support experienced less psychological problems than the others. Therefore, this study assumes that perceived social support from colleagues in the mobbing process will have a positive effect on the perception of experienced negative behaviors and attitudes, and affection resulting from mobbing, thus the first hypothesis is:

Hypothesis 1: Perceived high social support will decrease (a) the perception of mobbing and (b) victimization.

### **1.1.3. The Role of Work Locus of Control**

There is a controversy as to whether individual dispositions and personal characteristics affect being a victim in mobbing process. Some researchers argue that individual dispositions are antecedents of mobbing (Coyne et al., 2000); while some of them argue that victims cannot be hold responsible for their sufferings, and the difference between those dispositions may arise from the mobbing itself (Leymann, 1996, Persson et al., 2009). Individual dispositions may or may not be the cause of exposure to mobbing, but they affect the appraisal and coping processes, and individual consequences of mobbing (Hogh et al., 2011: 119). Previous studies have found that mobbing is significantly related to some personal characteristics such as neuroticism, self-esteem, assertiveness, social anxiety, positive and negative affect, and sense of coherence (Vartia, 1996; Moreno-Jimenez et al. 2007;

Nielsen et al., 2008). Another personality trait that can be related to mobbing is locus of control (LOC). Locus of control refers to whether or not people believe they are in control of reinforcements in life. People who believe that they control reinforcements are termed internals; people who believe that fate, luck, or powerful others control reinforcements are termed externals (Spector, 2008: 236).

There are some studies examining the relationship between work locus of control and job-related variables, and comparing the characteristics of people with internal and external locus of control at work. Judge and Bono (2001) found out that job satisfaction and performance is related to WLOC. Spector et al. (2002) examined the relationship between WLOC and well-being at work in 24 different countries and concluded that job satisfaction and psychological well-being are significantly related to WLOC, globally. Furnham and Drakeley (1993) found that internal LOC is related to a positive perception of organizational climate, particularly commitment and morale. Mohan (2010) concludes that people scored high on internal locus of control have more job satisfaction and can cope better with high work stress. Study results of a meta-analysis research held by Ng et al. (2006) yielded that internal LOC positively related to mental well-being, life satisfaction, physical health, global job satisfaction, satisfaction with pay, promotion, supervisors and co-workers, organizational commitment, number of hours worked, attendance, intrinsic task motivation, job involvement, self-development, self-efficacy, psychological empowerment, and negatively related to turnover intention, role overload, role ambiguity, role conflict, work-family conflict, job stress, burnout, emotion-focused coping. In light of these prior findings:

Hypothesis 2: Having high external locus of control will increase (a) the perception of mobbing, and (b) victimization.

Ng et al. (2006) also found significant positive relationships between internal locus of control and greater social support received, greater social integration at work, better relationship with supervisors, and problem-focused coping, so there has to be some interaction effect with LOC and perceived social support on victimization of mobbing. Therefore, it is expected that:

Hypothesis 3: Perceived high social support and low levels of external locus of control (internal LOC) will decrease (a) the perception of mobbing and (b) victimization.

## **2. RESEARCH**

### **2.1. Design and Participants**

The analyses were based on data collected from academicians work in Turkish universities. SPSS and AMOS 21.0 statistical packages were used in the process. Explanatory and confirmatory factor analyses, reliability analyses were conducted to assess the construct validity of the scales. In order to test the given hypotheses, structural equation modeling and regression analysis were conducted. Also, one-way ANOVA, t-tests, and correlations were used to have a better understanding about mobbing concept. The findings of all these analyses were presented in the following sections.

Convenience sampling was employed while designing the study. The concept of grey numbers was developed to express the characteristic behaviors of grey systems (Deng, 1985). Grey system theory can assist in solving problems related to uncertainty and incomplete information in cases of discrete data (Ju-Long, 1982; Julong, 1989). One of the primary advantages of this theory is its ability to handle limited data under uncertainty, making it particularly suitable for small samples (Liu and Qiao, 2014). This theory can be easily integrated with other decision-making processes to enhance the accuracy of judgments (Tseng, 2009).

### **2.2. Measures**

Main instruments that were used to collect data for this study designed to measure four constructs: mobbing, victimization, social support, and locus of control. Also, coping mechanisms and witnessing to mobbing were evaluated by using previously developed scales. At first, all items related to main constructs were evaluated by explanatory factor analysis. None of the items cross-loaded with another construct's item. Thus, it demonstrated a support for the discriminant validity of the measures. Then, all scales were factor analyzed separately to understand the underlying dimension structure. Also, confirmatory factor analyses were conducted to assess the convergent validity of the measures. Results for the relevant scales will be discussed in the following section.

### 2.2.1. Locus of Control Scale

The selected measure for locus of control was Work Locus of Control (WLOC) Scale, which was developed by Spector (1988) to evaluate people's locus structure about work related situations. It included 16 questions: 8 refer to internal and 8 refer to external locus of control. Respondents were asked to indicate how much they agree with the given statements on a 5-point Likert scale. High values indicated high external locus of control. Turkish translated version of WLOC (Minibas-Poussard and Idig-Camuroglu, 2009) was used for this study. Internally worded items were deleted since they reduced the reliability of the scale, and inconsistent EFA and unsatisfactory CFA results. After the elimination, CFA was run again. For this study, this scale proved to be statistically convergent valid [ $\chi^2(17) = 101,65$ ;  $p = 0,00$ ; CFI = 0,95; NFI = 0,94; IFI = 0,95], and internally consistent (Cronbach  $\alpha = 0,87$ ).

### 2.2.2. Victimization Scale

This was measured by "Bergen Bullying Index" developed by Einarsen et al. (1994) to assess the degree to which mobbing is perceived to be a problem at one's workplace and for oneself personally. It is a global measurement of potential individual and organizational consequences of mobbing and indicates in what degree an individual see himself/herself as "victim" of mobbing. It consisted 5 items each scored on a 5-point Likert scale. Turkish translated version of victimization scale was used in the current study (Minibas-Poussard and Idig-Camuroglu, 2009). It showed high internal consistency (Cronbach  $\alpha = 0,94$ ), and CFA yielded good fit [ $\chi^2(5) = 69,98$ ;  $p = 0,00$ ; CFI = 0,95; NFI = 0,95].

### 2.2.3. Social Support Scale

The selected measure to assess the degree of perceived social support developed originally by Schwarzer and Schulz (2000), and adapted by Minibas-Poussard and Idig-Camuroglu (2009). 5 items evaluate how much people are cared and supported in the mobbing process. 5-point Likert scale was used ranging from 1 (never) to 5 (all the time). Respondents were asked to evaluate the degree of their perceived support at work. Given scores to each item were then summed to have a total score of social support for each individual. Present study yielded a high Cronbach  $\alpha$  value (0,94), and a good fit [ $\chi^2(5) = 53,62$ ;  $p = 0,00$ ; CFI = 0,97; NFI = 0,96; IFI = 0,97].

### 2.2.4. Negative Acts Scale

Items to assess mobbing related negative behaviors and their frequency were inspired from NAQ-R developed by Einarsen et al. (2009) and WAR-Q developed by Neuman and Keashly (2004). In the final version, respondents were asked to rate how often they experience the given 35 behaviors in the last six months from the choices "never", "occasionally", "once a month", "once a week", "everyday", and the position of perpetrator. As shown in the below table, four factors were labeled as

threats to professional status, threats to personal status, direct threats to professional integrity, and physical/verbal abuse. Four-factor solution from EFA was also supported with CFA. CFA provided empirical proof for convergent validity of the developed scale [ $\chi^2(2) = 1,62$ ;  $p = 0,45$ ; CFI = 1,00; NFI = 0,99; RMSEA = 0,00].

**Table 1. Factor Loadings and Reliability Statistics of Mobbing Scale**

	Factor Loadings	Explained Variance (%)	Cronbach $\alpha$
Factor 1: Threats to Professional Status		22,33	0,91
28. Your requests for assistance are refused to leave you in a tight spot.	0,78		
29. Your works are delayed intentionally.	0,72		
30. Your contributions are ignored.	0,71		
31. You are not defended when explaining your plans and ideas.	0,7		
27. Your work is either not considered or evaluated unfairly.	0,69		
1. You are not given the necessary information that affects your performance.	0,66		
11. Your key responsibilities are removed or replaced with more trivial tasks.	0,65		
4. Your opinions are ignored.	0,54		
14. You are not given the chance to talk at the meetings.	0,53		
17. Your telephone calls, messages, or e-mails are not returned intentionally.	0,43		
Factor 2: Threats to Personal Status		18,37	0,8
18. You are insulted or offended about your personality, attitudes or your private life.	0,75		
25. There are attempts to turn other employees against you.	0,74		
20. Your errors/mistakes are constantly reminded and criticized.	0,67		
32. You are shouted at or being the target of spontaneous anger.	0,66		
23. You are subjected to false allegations.	0,64		
Factor 3: Direct Threats to Professional Integrity		12,58	0,76
5. You are given unreasonable workloads/deadlines.			
2. You are given tasks that are below your qualifications.	0,69		
12. You are given meaningless jobs to carry out.	0,67		

3. You are given tasks that are beyond your qualifications.	0,61		
6. Your work is excessively monitored.	0,5		
Factor 4: Physical/Verbal Abuse		8,48	0,42
35. Physical violence or threats of physical violence are made.	0,75		
10. You are being humiliated and ridiculed in connection to your work.	0,66		
34. Your way is blocked to intimidate you.	0,56		
KMO = 0,95			
Bartlett significance = 0,00		61,76	0,93

#### 4. RESULTS

Table 2 shows the intercorrelations among variables. Consistent with the previous research and expectations, mobbing, victimization, and locus of control were significantly and positively related with each other, while significantly and negatively correlated with social support and locus. This preliminary analysis indicated that high social support and low external control decreases the perception of mobbing and negative effects of mobbing in one's live.

**Table 2. Intercorrelations among the study variables**

Variable name	1	2	3	4
1. Mobbing	-			
2. Victimization	0,62*	-		
3. Social support	-0,27*	-0,22*	-	
4. Locus of control	0,36*	0,23*	-0,26*	-

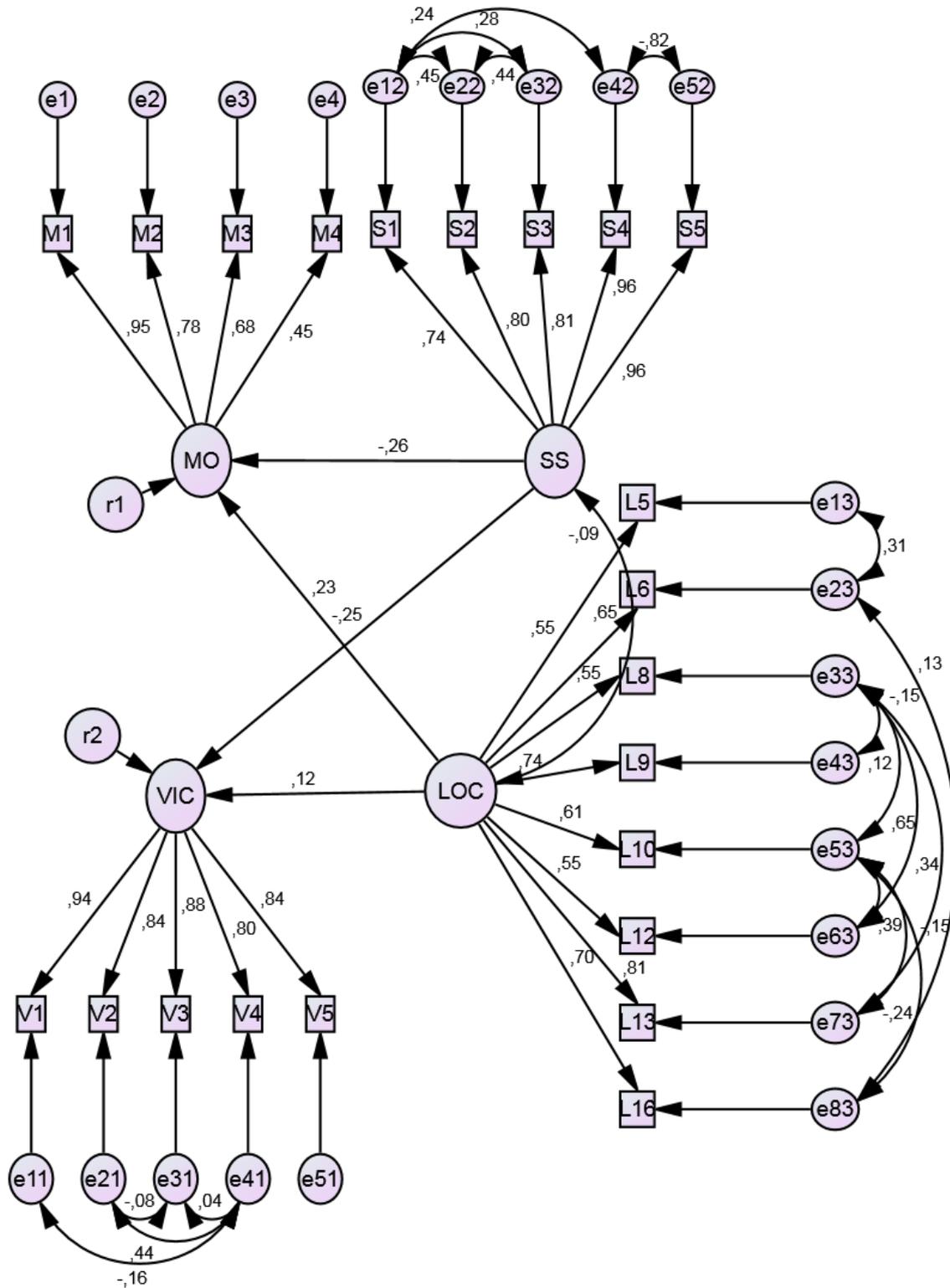
Note: \*  $p < 0.01$

Structural equation modeling was used to test H1 and H2, the effect of social support and locus of control on perceptions of mobbing and victimization. Maximum Likelihood Estimation was preferred to assess the model. Results showed that regression weights of the given paths were significant at 0.5 significance level, but model did not achieve an acceptable level of fit [ $\chi^2(204) = 968,66$ ;  $p = 0,00$ ; CFI = 0,89; NFI = 0,87; RMSEA = 0,09]. Thus, modification indices were used to respecify the model and several covariance paths were added.

After the model was modified, analysis was run again. Figure 1 demonstrates the final model. Although chi-square value was quite large and significant, hypothesized model fitted the sample data perfectly considering fit statistics [ $\chi^2(186) = 379,35$ ;  $p = 0,00$ ; CFI = 0,97; TLI = 0,97; NFI = 0,95; RMSEA = 0,05]. The paths from social support to mobbing ( $B = -2,57$ ;  $\beta = -0,26$ ;  $p < 0,01$ ), social support to victimization ( $B = -0,32$ ;  $\beta = -0,25$ ;  $p < 0,01$ ), locus of control to mobbing ( $B = 2,75$ ;  $\beta = 0,23$ ;  $p < 0,01$ ), and locus of control to victimization ( $B = 0,18$ ;  $\beta = 0,12$ ;  $p < 0,05$ ) were statistically significant, indicating that all the regression coefficients in this model were significantly different from zero beyond 0.5 significance level; thus providing support for H1a, H1b, H2a, H2b. Taken together, results indicated that tested model is theoretically meaningful and provides adequate fit to

the data. Further, these coefficients indicated that social support had more explanatory power of mobbing and victimization than locus of control.

Figure 1: Final Model with Standardized Estimates



In order to eliminate alternative explanations, separate regression analyses were conducted for mobbing and victimization, while controlling for the effects of age, gender, institution type,

experience, and position. Results suggested that both locus of control and social support significantly affected mobbing and victimization even after controlling for the effects of given variables (See Table 3).

**Table 3. Regression summary for H1 and H2 with control variables**

Dep. Var.	Ind. Var.	B	S.E.	$\beta$
Mobbing	Age	-2,35	1,48	-0,13
	Gender	-0,59	1,76	-0,02
	Institution	-1,56	2,04	-0,05
	Experience	3,78	1,3	0,20**
	Position	0,62	2,61	0,02
	LOC	0,37	0,13	0,16**
	Social support	-0,64	0,15	-0,23**
Victimization	Age	0,34	0,55	0,05
	Gender	-1,52	0,65	-0,13*
	Institution	-0,83	0,75	-0,07
	Experience	0,33	0,48	0,05
	Position	-0,87	0,96	-0,07
	LOC	0,11	0,05	0,13*
	Social support	-0,19	0,06	-0,19**

While testing hypothesis 3, multiple regression analyses were conducted by using centered product terms due to possible multicollinearity problem. Results showed that perceived high social support decrease the perception of mobbing and victimization, while higher levels of external locus of control increases the perception of mobbing and victimization, parallel with SEM results. As shown in Table 4, interaction effect of victimization and locus of control significantly effected mobbing ( $B = -0,06$ ;  $\beta = -0,14$ ;  $p = 0,02$ ), but not victimization ( $B = -0,01$ ;  $\beta = -0,07$ ;  $p = 0,24$ ). Thus, hypothesis 3 was partially supported. People who perceive high social support and have low levels of external locus of control were affected less from the negative acts they have experienced. But the interaction of high social support and low levels of external locus of control did not buffer individual effects of harmful negative acts.

**Table 4. Regression results of H3**

		Unstandardized coefficients		Standardized coefficients			R <sup>2</sup>	Adj. R <sup>2</sup>	F	p (F)
Dep. Var.	Ind. Var.	B	S.E.	$\beta$	t	p				
Mobbing	(Constant)	43,36	0,86		50,71	0	0,11	0,1	12,42	0
	LOC	0,38	0,13	0,16	2,87	0				
	SS	-0,61	0,15	-0,22	-4,03	0				

	LOC*SS	-0,06	0,02	-0,14	-2,46	0,02			
Victimization (Constant)		18,59	0,32		58,9	0			
	LOC	0,1	0,05	0,11	1,99	0,04			
	SS	-0,19	0,06	-0,19	-3,34	0	0,06	0,05	31,17
	LOC*SS	-0,01	0,01	-0,07	-1,18	0,24			

Group of respondents who reported less than 1 year of exposure to negative acts had the lower scores of mobbing ( $\mu=36,26$ ) and victimization ( $\mu=16,08$ ). According to one-way ANOVA results, the longer the experience, the higher the perception of mobbing ( $F = 9,80, p \leq 0,01$ ) and the higher the perception of victimization ( $F = 6,99, p \leq 0,01$ ).

## 5. DISCUSSION

This study provides insights about mobbing processes and victimization of individuals. The role of social support and locus of control on the perceptions of mobbing and victimization were investigated. Social support from colleagues and work context is important to handle with mobbing which is an extreme source of work stress. In this study, results suggested that perceived social support decrease the perception of mobbing and its detrimental effects for an individual. Employees who didn't get social support from colleagues were affected more from negative acts that they have experienced and victimized more. Parallel with the supported hypothesis 1, Zapf et al. (1996) found that employees who get social support from work were experienced some negative acts less than the others. The study of Bilgel et al. (2006) also showed that employees with a high perception of social support reported less mobbing, and suffered less from anxiety and depression, felt less work stress, and satisfied more from their jobs. Social support might have prevented the targets' from feeling alone, desperate and powerless. Individuals who took advices and support from their surroundings might have tried to change the situation according to the advice they were given.

Another important result is that individual dispositions play an important role in perceptions of mobbing and affection from mobbing. When the level of external locus of control increases, the perception on mobbing and victimization increases. Bowling et al. (2010) and Altinkurt's (2012) studies further supported these findings. Having thought that experiences in life are controlled by external forces might have made externally motivated employees to do nothing against the negative acts they have experienced. On the other hand, internally motivated employees might have found the courage and strengths to change the situation. Considering that highly externally controlled respondents reported more emotion focused coping mechanisms such as feeling powerless and do nothing, waiting for a miracle, and avoiding from the perpetrator, above inference seems appropriate.

Besides the above findings related to main hypotheses in the research, it was found that most reported negative acts were work related, while the least reported ones were about physical threats. These findings are consistent with several study results from different countries (Hoel and Cooper, 2000; Salin, 2001; Pranjić et al., 2006; Tanoglu et al., 2007; Koc and Urasoglu-Bulut, 2009; Yelgecen-Tigrel and Kokalan, 2009). Hierarchical position of the perpetrator was mostly a superior; this result is also consistent with the results from several studies worldwide (Einarsen et al., 1994; Rayner, 1997; WBI, 2007; Gunel, 2010).

This study is not without limits. Survey method was chosen for the study, and only predetermined behaviors and attitudes were stated and asked respondents to evaluate their experiences in this framework. But this method may not be sufficient to explain mobbing, which is a complicated process. In further studies interviews, critical incidents, and focus groups will yield a deeper, clearer and comprehensive understanding about the phenomenon. Besides, feedbacks from academicians showed that there is certainly a need to develop a mobbing scale measure for academicians.

Academicians do not work as regular employees, and interactions between people are more discrete than having set the response choices as “every day”, “once a week” was not appropriate. Chosen negative behaviors might not also fit with their actual problems.

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## **PROCEDURAL JUSTICE AND WORKPLACE EMOTIONS: THE MEDIATING ROLE OF AFFECTIVE COMMITMENT**

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### **ABSTRACT**

This study investigates how procedural justice influences employees' emotions through the mediating role of affective commitment. Based on organizational justice and Affective Events theories (Colquitt, 2001; Weiss & Cropanzano, 1996), we argue that employees' perceptions of fair procedures influence their emotional reactions at work by strengthening their affective commitment to the organization. Using survey data from private banks (N = 182) in Istanbul, Türkiye, we examined a mediation model in which affective commitment explained the relationship between procedural justice and both negative and positive emotions. The findings revealed a differential pattern: affective commitment fully mediated the link between procedural justice and negative emotions, whereas it partially mediated the relationship between procedural justice and positive emotions. These findings show that procedural justice does not affect positive and negative emotions in a symmetrical way. While fair procedures reduce negative emotions mainly by fostering affective commitment to the organization, they also enhance positive emotions both directly and indirectly. Theoretical and practical implications are discussed.

### **1. INTRODUCTION**

Procedural justice, defined as employees' perceptions of fairness in organizational decision-making processes, has been recognized as a key factor influencing workplace attitudes and behaviors (Colquitt, 2001). Barsky and Kaplan (2007) showed positive/negative affectivity in linkage with procedural justice, which works with outcomes tending to producing diverse emotional states. While the link between procedural justice and affective outcomes has been explored in prior research, the underlying mechanisms through which justice perceptions translate into emotions remain under-examined with affective commitment.

Affective commitment, the emotional attachment of employees to their organization (Meyer & Allen, 1997), represents a potential mediating pathway. Employees who perceive fair treatment are more likely to develop a strong sense of belonging and loyalty, which in turn may influence their emotional responses to workplace events. Understanding this mediating role is crucial for both theory and practice, as emotions significantly affect job performance, well-being, and turnover intentions.

This study aims to investigate how procedural justice relates to positive and negative emotions, with a particular focus on affective commitment as a mediator. Specifically, we examine whether affective

commitment mediates these relationships, providing a nuanced understanding of how justice perceptions shape emotional experiences at work.

## **2. THEORETICAL BACKGROUND**

### **2.1 Procedural Justice and Workplace Emotions**

Procedural justice refers to the perceived fairness of organizational processes, including consistency, transparency, and voice (Thibaut & Walker, 1975; Colquitt, 2001). In their meta-analysis, Colquitt et al. (2013) included a consideration of the links between measures of affect and organizational justice. Fair procedures have been shown to reduce negative emotions such as frustration, anger, and anxiety, while enhancing positive emotions such as enthusiasm, pride, and satisfaction.

The Affective Events Theory is used as theoretical framework of this study (Weiss & Cropanzano, 1996). Affective Events Theory proposes that affective experiences are important antecedents of work-related attitudes and behaviors. Several studies underlined the link between emotions and justice perception (Barsky & Kaplan, 2007; Barclay et al. 2005; Krehbiel & Cropanzano, 2000; Minibas-Poussard et al, 2023 ; Robbins et al. , 2012; Tabibnia et al., 2008).

### **2.2 Affective Commitment as a Mediator**

Affective commitment is defined by Allen and Meyer (1996, p. 253) as “identification with, involvement in and emotional attachment to organization”. Meyer and Allen (1997, p:42-46) underlined the factors influencing affective organizational commitment: organizational characteristics, personal characteristics, and work experiences. Prior research suggests that employees perceiving higher procedural justice are more likely to develop stronger affective commitment. Several studies have confirmed positive links between organizational commitment and organizational justice (Cohen-Charash & Spector, 2001; Cohen & Veled-Hecht, 2010; Colquitt et al., 2013; Ohana, 2014) more specifically with procedural justice (Gopinath & Becker, 2000; Masterson et al., 2000; Mossholder et al., 1998).

Therefore, Hypothesis 1 and 2 are formulated.

H1: Affective commitment mediates the relationship between procedural justice and negative emotions.

H2: Affective commitment mediates the relationship between procedural justice and positive emotions.

## **3. METHOD**

### **3.1 Sample and Procedure**

The study was conducted among employees working in private banking industry. Participants were invited to complete an online survey before pandemic period. A total of N = 182 employees participated, representing diverse roles (executives, executive-assistants and clerical workers) and tenure within the organization. The average age is 30 years, 51% of the participants were female and 49% were male. 85% of them had a university degree. Participation was voluntary, and responses were kept confidential. Explicit consent was obtained.

### 3.2. Measurement

Research instruments used in the study were translated into Turkish language, and then back translated to the original by two bilingual scholars, following the guidelines provided by Brislin (1986). We obtained satisfactory psychometric properties in this study (see below for each scale).

**Procedural Justice:** Measurement is constructed by Naumann and Benett (2000) (adapted from Moorman, 1991) and the scale ranges from 1 (strongly disagree) to 5 (strongly agree). Sample items: 'Decisions made by our supervisor's respect coherent rules and procedures', 'Our supervisors ask our opinion before making decisions', (Cronbach's  $\alpha = .70$ ). This scale was originally used in several scientific studies in Turkey (Minibas-Poussard et al., 2017, Minibas-Poussard et al., 2023).

**Affective Commitment:** Assessed with the scale of Allen and Meyer (1996) is used. 6 items ranging from 1 (strongly disagree) to 5 (strongly agree) were used (Cronbach's  $\alpha = .84$ ). Sample items: "I would be very happy to spend the rest of my career in this organization", "I do not feel a strong sense of belonging to this organization".

**Positive/Negative emotions:** The Job-Related Affective Well-being Scale (Spector, 1998) was used, with 10 items for positive emotions and 10 items for negative emotions, with Likert-type scales ranging from 1 to 5. Sample items for positive emotions: *My job made me feel content; my job made me feel calm*. Sample items for negative emotions: *My job made me feel angry; my job made me feel discouraged*. Satisfactory psychometric properties were obtained (Cronbach's  $\alpha = .94$  for positive emotions Cronbach's  $\alpha = .94$  for negative emotions and factor load  $>.40$  for both).

Harman's single-factor test was conducted to evaluate the potential influence of common technique bias. An unrotated exploratory factor analysis encompassing all items indicated that the first factor represented 16.38% of the total variance, well below the suggested 50% threshold. This finding suggests that common technique bias is improbable to pose a substantial risk to the validity of the results.

## 4. RESULTS

### 4.1 Descriptive Statistics and Correlations

Descriptive statistics including means, standard deviations, and correlations among procedural justice, affective commitment, and positive/negative emotions were computed to provide an overview of the data. These preliminary analyses ensured that the variables were suitable for mediation testing (Table 1).

**Table 1.** Means, Standard Deviations and Correlation Coefficients

	M	SD	1	2	3
1. Negative emotions	25.87	8.85			
2. Positive emotions	29.48	8.18	-.47**		
3. Procedural justice	31.24	6.85	-.20**	.53**	
4. Affective commitment	23.09	4.68	-.40**	.67**	.62**

\*\* Correlation is significant at the 0.01 level (2-tailed)

\*Correlation is significant at the 0.05 level (2-tailed)

## 4.2 Mediation Analyses

To test the hypothesized mediation model, we employed PROCESS macro (Hayes, 2017) in SPSS 22, examining whether affective commitment mediates the relationships between procedural justice and both positive and negative emotions. Bootstrap confidence intervals with 5,000 resamples were used to assess the significance of indirect effects.

According to H1, affective commitment fully mediated the relationship between procedural justice and negative emotions ( $R = .40$ ,  $R^2 = .16$ ,  $F = 17.33$ ,  $p \leq .001$ ). There was no direct effect (Effect = .0817,  $t = .72$ ,  $p > .05$ ) but the indirect effect was confirmed (Effect = -.3507, BootSE = .0833, BootLLCI = -.5204, BootULCI = -.1915).

According to H1, affective commitment partially mediated the relationship between procedural justice and positive emotions ( $R = .70$ ,  $R^2 = .49$ ,  $F = 87.05$ ,  $p \leq .001$ ). There was direct effect (Effect = .2711,  $t = 3.44$ ,  $p \leq .01$ ) but also the indirect effect was confirmed (Effect = .3840, BootSE = .0669, BootLLCI = .2555, BootULCI = .5216).

## 5. DISCUSSION

This study aimed to investigate the mediating role of affective commitment in the relationship between procedural justice and employees' emotions. By testing a serial mediation model, the research provides a framework for understanding how perceptions of fair procedures may shape both positive and negative emotional experiences at work.

From a theoretical perspective, the model highlights the importance of considering affective commitment as a potential pathway through which procedural justice influences emotions. Employees who perceive fair treatment are more likely to develop strong emotional attachment to the organization, which in turn may affect their emotional experiences (Meyer & Allen, 1997; Colquitt, 2001). This approach integrates organizational justice theory with affective and attitudinal constructs, offering a more nuanced understanding of the mechanisms linking fair treatment and employee well-being (Weiss & Cropanzano, 1996).

The differentiation between positive and negative emotions is particularly relevant. Treating these emotional dimensions separately allows researchers to explore whether they respond differently to organizational justice perceptions and organizational attachment, suggesting that interventions might need to be tailored according to the type of emotion targeted. Previous research (Minibas-Poussard et al., 2023) indicate the buffering effect of organization-based self-esteem, work self-efficacy and work locus of control on the interlinkages between negative emotions and procedural justice, but the moderating role of these variables is not confirmed for the relationship between procedural justice and positive emotions.

Well-being and organizational justice are fundamental components of organizational sustainability. Di Fabio (2017) asserts that the psychology of sustainability and sustainable development enhances the primary preventative strategy and promotes well-being throughout the organization at all levels. Well-being is a significant concern for International Labor Organization (2020), which highlights various stressors faced by workers in financial services, including time pressure, ergonomic issues, and conflicts with clients, leading to increased stress and violence (Giga & Hoel, 2003). Studies indicate a rise in stress-related mental health issues in banking (Giorgi et al., 2017).

### 5.1. Practical Implications

For practitioners, the model underscores the significance of fostering fair procedures not only to promote organizational commitment but also to influence the emotional climate of the workplace. By

understanding the potential mediating role of affective commitment, managers and HR professionals can design policies and practices that strengthen employees' emotional engagement, regulate negative emotions, and enhance overall well-being.

## 5.2. Limitations and Future Research

While the study provides a conceptual framework and methodological approach, future research could extend the findings by exploring additional mediators or moderators, different cultural contexts, and longitudinal designs to capture the dynamic nature of justice, commitment, and emotions.

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## COMSOL İLE TASARLANAN VE SLA İLE ÜRETİLEN NEGATİF EĞRİLİKLİ FİBERLERİN İNCELENMESİ

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### ÖZET

Bu çalışma, terahertz uygulamaları için negatif eğrilikli fiberlerin (NCF) tasarımını, sayısal analizini ve katmanlı imalatını sunmaktadır. Negatif eğrilikli fiberler, anti-rezonanslı kılavuzluk mekanizması sayesinde elektromanyetik dalgaları düşük sıkıştırma kayıplarıyla yönlendirme yetenekleri nedeniyle önemli ilgi görmektedir. Bu çalışmada, COMSOL Multiphysics kullanılarak üç farklı geometrik konfigürasyon tasarlanmıştır: iki halkalı yapı, dört halkalı yapı ve içerisine ek bir halka yerleştirilmiş modifiye dört halkalı yapı. Bu tasarımların modal özellikleri, mod dağılımı ve sıkıştırma karakteristiklerine odaklanılarak terahertz frekans aralığında özmod simülasyonları ile analiz edilmiştir. Simülasyon sonuçları, önerilen geometriler arasında belirgin farklılıklar ortaya koymuştur. İki halkalı tasarım temel kılavuzluk sağlamış ancak nispeten daha yüksek sızıntı göstermiştir. Dört halkalı konfigürasyon ise artan anti-rezonans katmanları sayesinde mod sıkışmasını iyileştirmiştir. Ayrıca, içerisine ek halka yerleştirilmiş dört halkalı yapı, sıkıştırma kaybının azaltılabileceğini ve pratik terahertz dalga kılavuzluğunda performansın artırılabilirliğini gösteren gelişmiş mod lokalizasyonu sergilemiştir. Simülasyon aşamasının ardından tasarlanan yapılar, yüksek çözünürlüklü polimer tabanlı fiber prototiplerinin üretilmesine imkân tanıyan stereolitografi (SLA) yöntemiyle üretilmiştir. Bu yapıların başarıyla gerçekleştirilmesi, geleneksel üretim yöntemleriyle üretilmesi zor olan karmaşık fiber geometrileri için 3B baskı teknolojilerinin uygulanabilirliğini ortaya koymaktadır. Bu çalışmanın sonuçları, negatif eğrilikli fiberlerde geometri ve modal özellikler arasındaki etkileşime dair değerli içgörüler sunmakta ve 3B baskı ile üretilmiş terahertz dalga kılavuzlarının gelecekteki deneysel doğrulaması, kayıp karakterizasyonu ve optimizasyonu için bir temel oluşturmaktadır.

**Anahtar Kelimeler:** Negatif eğrilikli fiber, COMSOL, özmod analizi, SLA, 3B baskı, terahertz dalga kılavuzları

## INVESTIGATION OF NEGATIVE CURVATURE FIBERS DESIGNED BY COMSOL AND FABRICATED VIA SLA

### ABSTRACT

This study presents the design, numerical analysis, and additive manufacturing of negative curvature fibers (NCFs) for terahertz applications. Negative curvature fibers have attracted significant attention due to their ability to guide electromagnetic waves with low confinement losses by utilizing an anti-resonant guiding mechanism. In this work, three different geometrical configurations were designed using COMSOL Multiphysics: a two-ring structure, a four-ring structure, and a modified four-ring structure with an additional inner ring. The modal properties of these designs were analyzed through eigenmode simulations in the terahertz frequency range, focusing primarily on mode distribution and confinement characteristics. The simulation results demonstrate clear differences between the proposed geometries. The two-ring design provided basic guidance but with relatively higher leakage, while the four-ring configuration improved mode confinement due to the increased number of anti-resonant layers. Furthermore, the four-ring structure with an inserted inner ring exhibited enhanced mode localization, indicating the potential for reduced confinement loss and improved performance in practical terahertz wave guidance. Following the simulation stage, the designed structures were fabricated using stereolithography (SLA), which enables high-resolution polymer-based fiber prototypes. The successful realization of these structures highlights the feasibility of employing 3D printing technologies for complex fiber geometries that are challenging to produce through conventional fabrication methods. The results of this study provide valuable insight into the interplay between geometry and modal properties in negative curvature fibers, and they pave the way for future experimental validation, loss characterization, and optimization of 3D-printed terahertz waveguides.

**Keywords:** Negative curvature fiber, COMSOL, eigenmode analysis, SLA, 3D printing, terahertz waveguides, confinement

### Introduction

Terahertz (THz) radiation spans frequencies roughly from 0.1 to 10 THz, corresponding to wavelengths on the order of millimeters to sub-millimeters. In this spectral range, waveguiding is challenging because many conventional materials (e.g. polymers, glasses) exhibit high absorption loss, and free-space propagation suffers from strong attenuation due to water vapor in air (Ankan et al., 2020; Cruz et al., 2015). Consequently, there is significant interest in developing specialized fiber-optic waveguides for THz transmission that confine electromagnetic energy predominantly in air-filled regions to minimize material absorption (Lu et al., 2008; Cruz et al., 2015). Hollow-core fibers, where the THz wave is guided in an air-filled core, are particularly attractive for low-loss THz guidance. Early demonstrations of THz hollow fibers included microstructured polymer fibers and tube lattice fibers which guided THz waves with reduced loss and dispersion compared to bulk media (Lu et al., 2008). These waveguides not only facilitate low-loss transmission but also enable integration of THz systems by routing THz signals between components, an important step beyond free-space optics. Within the class of hollow-core fibers, negative curvature fibers (NCFs) have emerged as a promising design for low-loss guidance. In an NCF, the boundary of the hollow core is formed by a cladding structure that curves inward (concave toward the core), contrary to the convex curvature of a simple circular core boundary (Wei et al., 2017). This negative curvature of the core-cladding interface leads to an inhibited coupling mechanism: the fundamental core mode has poor overlap with cladding modes, greatly reducing leakage of energy into the cladding (Wei et al., 2017). In practice, NCF designs often consist of a hollow core surrounded by a ring of thin-walled capillaries or tubes, creating an anti-resonant reflective cladding. When the capillary walls are of appropriate

thickness relative to the wavelength, the antiresonant effect further prevents the THz field from penetrating into the lossy support material, confining it to the air core (Cruz et al., 2015; Wei et al., 2017). The combination of inhibited coupling and antiresonant reflection can yield very low propagation losses and single-mode guidance over a broad bandwidth in NCFs (Wei et al., 2017). Moreover, the simplicity of the hollow-tube cladding structure (compared to photonic crystal lattices or Bragg mirrors) makes NCFs attractive to fabricate and scale. Negative curvature hollow-core fibers are highly relevant for THz transmission and sensing applications. By guiding THz waves in an air core, these fibers mitigate absorption in polymers or other solid media, enabling low-loss THz links for communications or spectroscopy (Cruz et al., 2015; Ankan et al., 2020). For example, Cruz et al. (2015) demonstrated THz propagation up to 1.1 THz in a polymer NCF fabricated by 3D printing, covering a spectral band where solid-core materials exhibit extremely high loss. Such fibers can serve as THz transmitters or jumpers, transporting THz signals with less power attenuation than free-space paths of equivalent length (especially in humid environments). In addition, hollow-core NCFs provide a convenient platform for THz sensing: the large fraction of power in the air core can interact with samples or analytes introduced into the hollow region. This property has been leveraged for chemical and biomedical sensing, where characteristic THz absorption features of gases or liquids can be measured by filling the fiber core with the substance of interest (Ankan et al., 2020). For instance, Ankan et al. (2020) proposed a six-tube NCF for THz chemical sensing and showed that filling its core with various liquids yields strong spectral responses, highlighting the fiber's utility as a THz sensor. Similarly, NCF-based fiber probes have been used in THz spectroscopy and imaging – Lu and Argyros (2014) demonstrated that a flexible hollow fiber with a tube lattice cladding could be employed to deliver THz radiation to a target and collect the response, enabling near-field imaging and sensing with minimal loss. These examples underscore the broad applicability of NCFs in scenarios where THz waves must be guided, whether for efficient power delivery or for enhancing interactions with materials in sensing. Despite their benefits, fabricating THz NCFs with precision can be non-trivial using traditional fiber-drawing techniques, especially given the comparatively large cross-sectional dimensions (on the order of millimeters) required for THz wavelengths. Additive manufacturing, particularly stereolithography (SLA) 3D printing, offers a compelling solution to prototype and realize these complex fiber structures (Cruz et al., 2018). Recent advances in high-resolution 3D printing have enabled the creation of hollow-core fiber geometries that would be difficult to achieve by extrusion or capillary-stacking methods, such as intricate anti-resonant structures and nested capillary designs (Cruz et al., 2018; Armas et al., 2023). In the context of THz fibers, SLA-printed designs benefit from the relatively large feature sizes (hundreds of micrometers to millimeters) and the availability of low-loss polymer resins at THz frequencies. Armas et al. (2023) demonstrated the feasibility of using UV-curable resin printers to fabricate NCFs with multiple nested tubes, achieving functional THz waveguides and confirming that increasing the number of capillary rings can adjust the modal properties (e.g., higher mode counts for multi-ring fibers). These studies pave the way for rapid design iterations and customization of THz fiber designs for specific applications, using simulation tools to optimize the fiber geometry and 3D printing to quickly realize prototypes. In this paper, we investigate the design, simulation, and fabrication of negative curvature fibers for THz guidance. Three NCF geometries were designed using COMSOL Multiphysics (a finite-element electromagnetic solver) to study their fundamental mode characteristics: (1) a two-ring structure, (2) a four-ring structure, and (3) a four-ring structure with an additional inner ring. Ring here refers to the number of thin-walled capillary tubes placed around the hollow core in the fiber cross-section. By comparing these designs, we aim to understand how increasing the number of supporting capillaries and introducing a nested inner ring affect the fundamental mode confinement and symmetry. All designs were conceived with dimensions suitable for THz operation (on the order of millimeters) and were subsequently fabricated using SLA 3D printing to demonstrate practical feasibility. The following sections detail the fiber geometries and fabrication process (Materials and Methods), present the simulated mode profiles for each design (Results and Discussion), and conclude

with insights on the viability of SLA-fabricated NCFs for future THz transmission and sensing applications.

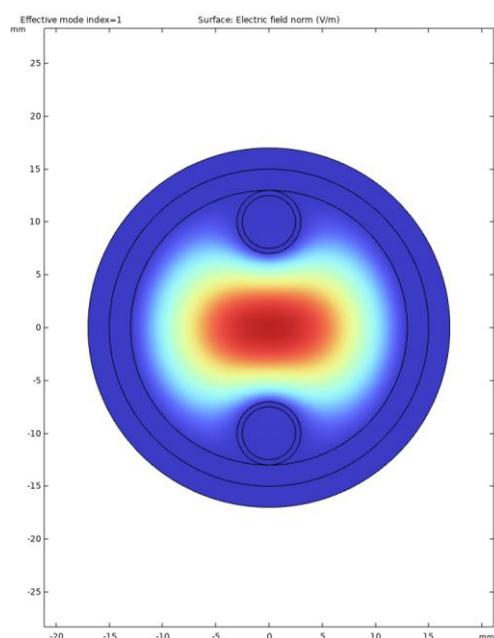
## Materials and Methods

Three negative curvature fiber geometries were modeled, each having a large air core and a ring of thin-walled capillaries in the cladding. The overall outer diameter of each fiber design is 30 mm, which includes a solid outer wall of thickness 2 mm encircling the structure for mechanical support. The central hollow core diameter is 14 mm in all cases, providing a sizable air channel for THz wave propagation. Around this core, a number of circular capillaries (hollow tubes) are arranged symmetrically. Each capillary has an outer diameter of 5 mm and a wall thickness of 0.5 mm, resulting in a thin-walled tube that can act as an anti-resonant element. For the first design – the two-ring structure – two capillaries are positioned on opposite sides of the core (180° apart). In the four-ring structure, four identical capillaries are evenly spaced (90° apart) around the core, roughly at the cardinal directions. In both cases, the capillaries are placed such that their inner edges are adjacent to the core boundary, creating a negative-curvature interface between the core and each capillary (i.e. the core boundary between capillaries bulges inward toward the core). The third design builds upon the four-ring structure by adding an inner ring: a thin circular ring-shaped wall that surrounds the core. This inner ring has an outer diameter of 14 mm (matching the core diameter) and a wall thickness of 0.5 mm, effectively forming a secondary hollow ring just at the core boundary. The four capillaries in this design remain in the same positions as in the four-ring case (outside the inner ring), so the inner ring is concentric with the core and lies between the core and the capillaries. The inclusion of this inner ring creates a “nested” anti-resonant structure – an approach known to enhance mode confinement by providing an additional reflecting interface for the guided field (Wei et al., 2017). All geometric parameters were chosen to be realistic for fabrication while ensuring that the capillary wall thicknesses (~0.5 mm) are in the suitable range for antiresonant guidance at THz frequencies (Cruz et al., 2015). The fiber cross-sections were modeled in COMSOL Multiphysics to analyze their modal properties. The simulations assumed the fiber is surrounded by air (refractive index ~1) and that the fiber material is a polymer (with refractive index typically around 1.4–1.5 in THz, though material absorption was not the focus here). A frequency in the lower THz range (on the order of 0.1–0.3 THz) was used for solving the eigenmodes, consistent with the fiber dimensions. Perfectly matched layers (PML) or absorbing boundary conditions were applied at the outer perimeter to mimic an isolated fiber in free space. For each design, the solver computed the fundamental mode – the mode with the lowest effective index (closest to the index of air, ~1) – which corresponds to the primary mode that would propagate in hollow-core fibers. The electric field magnitude distribution  $|E(x,y)|$  of this fundamental mode was recorded for analysis. We specifically examined how the mode is distributed in the core and cladding for the different geometries, to assess mode confinement and symmetry. No additional perturbations or material losses were introduced in the simulations, since our focus is on the qualitative mode profiles and basic guidance characteristics (confinement loss calculations and higher-order modes are beyond our scope in this study). To validate the designs experimentally, we fabricated sample fibers using stereolithography (SLA) 3D printing. A Formlabs Form 3L printer was employed, which uses a 405 nm laser to selectively cure photopolymer resin layer-by-layer, achieving high resolution in the printed parts. Two types of resin were used for fabrication: Formlabs Rigid 10K Resin and Formlabs Clear Resin. The Rigid 10K is a glass-filled photopolymer known for its high stiffness and minimal thermal expansion, which is advantageous for maintaining dimensional accuracy in the thin walls of the fiber structures. The Clear Resin is a standard acrylic-based formulation that cures to a translucent plastic; it was selected to allow visual inspection of the internal features and also to evaluate a material with different mechanical properties and possibly different THz absorption characteristics. The fibers were printed in sections (given the 30 mm diameter) with the hollow features oriented vertically to ensure that capillary walls and the inner ring were properly formed without support material blocking the voids. After printing, the parts were washed in isopropanol to remove excess resin and post-cured under UV light to fully harden the material. The

final printed fiber samples accurately reproduced the designed geometries, including the 14 mm hollow core, the thin-walled capillaries, and the inner ring in the third design. The use of SLA demonstrates the feasibility of fabricating complex NCF structures: even large diameter fibers with millimeter-scale features can be realized with good fidelity. In the following section, we discuss the simulated mode profiles of these designs, which reflect the guiding behavior one can expect in the fabricated fibers.

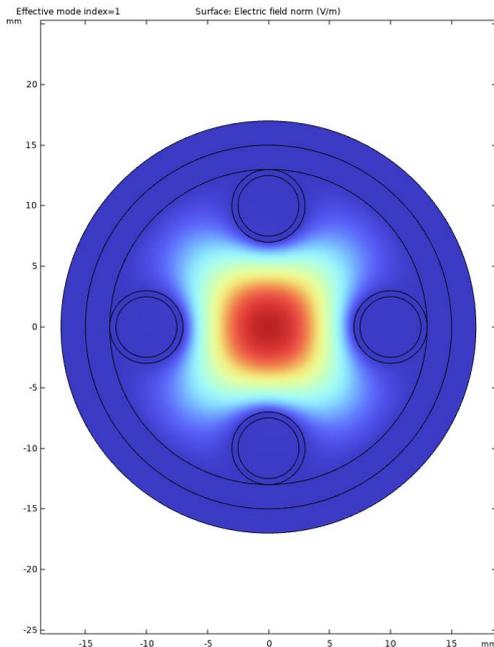
## Results and Discussion

To evaluate the THz guiding performance of the proposed fiber designs, we examine the simulated electric field distribution of the fundamental mode for each structure. Figures 1–3 present the cross-sectional field magnitude  $|E|$  for the two-ring, four-ring, and four-ring + inner ring fibers, respectively. These field maps illustrate how the electromagnetic energy is distributed between the hollow core and the cladding for each geometry, revealing the mode confinement and symmetry.



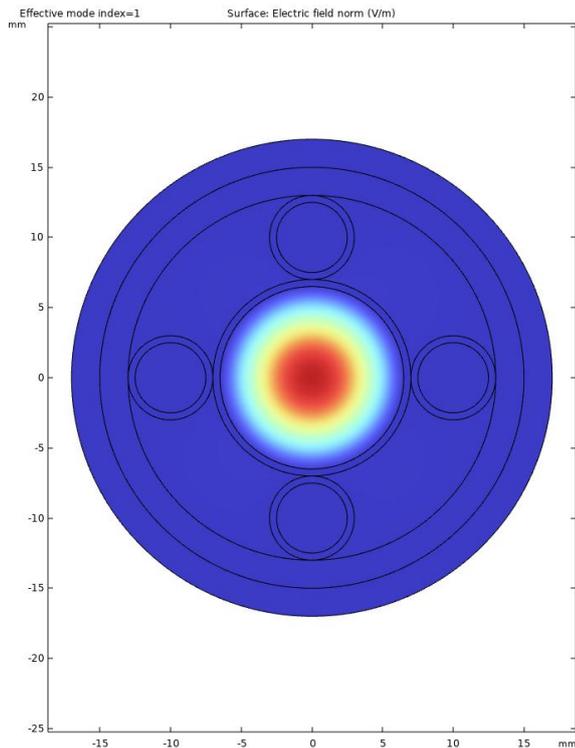
**Figure 1:** COMSOL mode analysis result of the negative curvature fiber (NCF) structure with two circular capillaries.

Simulated electric field magnitude ( $|E|$ ) of the fundamental mode in the two-ring NCF design. The fiber's cross-section features two diametrically opposed capillaries (small circular voids) forming a minimal negative-curvature cladding structure. The resulting fundamental mode is clearly formed within the central air core: the highest field intensity (red/yellow regions) is concentrated in the core region directly between the two capillaries. The mode exhibits a slight elongation along the axis connecting the two capillaries, indicating that the presence of only two support tubes leads to some asymmetry in the field distribution. Nevertheless, the majority of the electric field remains confined to the hollow core, with relatively low field intensity extending into the surrounding polymer cladding. This confirms that even a two-capillary NCF is capable of guiding a fundamental THz mode through the antiresonant effect and inhibited coupling mechanism. The guided mode in this case is essentially the fundamental  $HE_{11}$ -like mode, though with an elliptical profile reflecting the structure's two-fold symmetry.



**Figure 2:** COMSOL mode analysis result of the negative curvature fiber (NCF) structure with four circular capillaries.

Electric field magnitude of the fundamental mode in the four-ring NCF design (four capillaries around the core). With four capillaries symmetrically spaced around the hollow core, the fundamental mode is more uniformly confined and symmetric. As seen in the figure, the highest field intensities (red) form a nearly circular shape in the core center, surrounded by lower intensities (green/blue) near the core boundary. The mode is better centered compared to the two-ring case, with the four capillaries providing a more even confinement from all sides. Each capillary acts as an antiresonant barrier, and the field tends to avoid entering the capillary walls (notice the field is low within the capillary regions). The symmetry of the four-fold cladding yields a fundamental mode that has nearly equal extension in all directions, reducing the elongation or distortion observed in the two-capillary design. In essence, the mode confinement is improved – more of the THz field is kept within the core and less leaks into the polymer – and the mode's shape approximates a circular Gaussian-like profile. This improved confinement and symmetry with four capillaries is a desirable feature for maintaining low loss and consistent mode quality in THz transmission.



**Figure 3.** COMSOL mode analysis result of the negative curvature fiber (NCF) structure consisting of four circular capillaries surrounding an additional central ring.

Electric field magnitude of the fundamental mode in the four-ring + inner ring NCF design. This design includes a thin inner ring surrounding the core in addition to four outer capillaries. The fundamental mode is highly confined and centrally peaked in this configuration. The field intensity in the core (bright red region at the center) is stronger and more localized than in the previous designs, indicating that the addition of the inner ring provides an extra waveguiding barrier. The inner ring effectively creates a double-layer cladding: the THz field sees a smaller aperture (the inner ring's hollow center, ~13 mm diameter) as the immediate core, with the ring's thin wall acting as the first antiresonant interface, and the outer capillaries acting as a second layer of confinement. As a result, the mode in Figure 3 is tightly centered — virtually no high-intensity field reaches the vicinity of the outer capillaries. The mode profile remains fundamentally single-lobed and resembles the  $HE_{11}$  mode but with even lower field penetration into the cladding than seen in Figure 2. The near-perfect circular symmetry and strong core localization suggest that this design will guide the THz fundamental mode very robustly. These observations align with known trends in NCF design: introducing a nested or secondary ring in the cladding can significantly enhance mode confinement (Wei et al., 2017). By effectively increasing the negative curvature complexity, the four-ring + inner ring fiber minimizes the coupling of the core mode to any cladding modes, ensuring that the fundamental mode stays well-confined to the air core.

Comparing the three field distributions (Figures 1–3), we clearly see a progression in mode confinement and symmetry as the cladding structure becomes more elaborate. The basic two-ring fiber (Figure 1) does guide a fundamental mode in its large air core, but the field is somewhat less constrained, extending toward the sparse cladding and exhibiting an asymmetric shape. When the number of capillaries is increased to four (Figure 2), the mode becomes more symmetric and tightly confined, thanks to the more uniform surrounding structure. Finally, adding the inner ring (Figure 3) yields the most confined mode, with the field almost entirely isolated in the central core region. In all cases, the existence of a well-defined fundamental mode with the majority of its energy in the hollow core demonstrates effective guidance via the antiresonant inhibited-coupling mechanism. None of the

designs show the fundamental mode coupling strongly into the polymer regions; instead, the mode avoids the high-index material, consistent with the antiresonant behavior of the capillary walls (Cruz et al., 2015). We also note that higher-order modes were found to be present in simulations (especially for the four-ring designs which can support more modes due to the larger core and multi-fold symmetry), but those are not the focus here. In practice, slight imperfections in fabrication or bending might suppress higher-order modes, and the fundamental mode would dominate transmission – a beneficial scenario for low-loss single-mode THz guidance.

From a fabrication standpoint, the simulation results provide confidence that all three designs should guide THz waves, though their performance may differ. The two-ring fiber is the simplest to fabricate (only two capillaries) but may exhibit more coupling of light into imperfect cladding modes or higher loss due to its less constrained field. The four-ring fiber strikes a balance, offering good confinement with a still relatively simple structure. The nested-ring fiber (four + inner ring) is the most complex to build but promises the best mode confinement; our successful printing of this geometry in resin is an encouraging indication that even complex NCF designs can be realized with SLA. Importantly, the printed fibers allow experimental verification in future work – for example, coupling a THz source into the fabricated fiber to observe the transmitted mode profile and loss. The strong core confinement seen in Figure 3 suggests that this design would deliver the highest power throughput and possibly the lowest loss among the three, as less energy interacts with the absorptive polymer. While quantitative metrics like attenuation or bandwidth were not measured here, the mode profiles alone confirm fundamental mode guidance in each structure, which is the first and crucial step in establishing the viability of these fibers for THz transport.

In summary, the COMSOL simulations of the electric field distribution substantiate the design rationale: increasing the number of capillaries and adding nested structures in an NCF leads to improved mode confinement and symmetry. These findings mirror observations in other studies that found multi-ring or nested antiresonant fibers can outperform simpler hollow cores in containing the guided mode (Wei et al., 2017; Armas et al., 2023). For applications like sensing, a more confined mode (as in the four+inner design) can increase interaction with any sample in the core while still minimizing loss, whereas for short-range THz links a simpler design might suffice if low fabrication complexity is desired. The fundamental THz mode in all three designs is well-supported, indicating that even relatively large, millimeter-scale NCF structures fabricated by 3D printing can function as effective THz waveguides.

## Conclusions

We have designed, simulated, and fabricated several negative curvature hollow-core fiber structures optimized for THz wave guidance. Through COMSOL modeling, we examined a two-capillary NCF, a four-capillary NCF, and a four-capillary NCF with an added inner ring, all with a large 14 mm air core and thin supporting walls. The introduction of negative curvature cladding structures (capillary rings and a nested inner ring) proved effective in guiding the fundamental THz mode in all cases. Our results showed that even the simplest two-ring fiber can support a core-guided mode, while more complex designs (four rings, and especially the nested inner ring design) yield progressively better mode confinement and symmetry. Notably, the four-ring fiber with an inner ring produced a highly centered and tightly confined fundamental mode, highlighting the benefit of nested antiresonant features for robust single-mode guidance.

Using a stereolithography 3D printer (Formlabs Form 3L), we successfully fabricated the designed fiber geometries in photopolymer resin, demonstrating the feasibility of realizing these THz fiber designs physically. The fabricated fibers, made from both a rigid composite resin and a standard clear resin, confirm that modern SLA techniques can achieve the necessary resolution and accuracy for millimeter-scale hollow-core structures with sub-millimeter wall thicknesses. This approach opens

the door to rapid prototyping of custom THz fibers that were previously difficult to fabricate with conventional methods.

In conclusion, the combination of simulation-driven design and additive manufacturing enables a new platform for THz waveguides. The negative curvature fibers investigated in this work show effective guidance of the fundamental THz mode, making them promising candidates for low-loss THz transmission lines. Moreover, their hollow cores and configurable structures make them attractive for THz sensing applications – for instance, guiding THz radiation through samples or creating fiber-integrated sensors for spectroscopy. Future work will involve experimental characterization of the printed fibers, including measuring attenuation across the THz band and testing sensing performance with various analytes. We envision that the continued development of NCF designs (such as additional nested rings or different capillary arrangements) combined with high-precision 3D printing will further improve THz fiber performance. Such fibers could play a key role in next-generation THz systems, enabling flexible, low-loss terahertz transmission links and compact fiber-based terahertz sensors for medical, industrial, or communication applications.

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## DOLULUK ORANINA GÖRE SLA İLE ÜRETİLMİŞ POLİMER YAPILARIN THZ-TDS İLE TERAHERTZ ÖZELLİKLERİNİN İNCELENMESİ

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### ÖZET

Bu çalışma, farklı doluluk oranlarına sahip stereolitografi (SLA) yöntemiyle üretilmiş polimer yapıların terahertz (THz) iletim özelliklerini, terahertz zaman-alan spektroskopisi (THz-TDS) sistemi kullanarak incelemektedir. Katmanlı imalat teknikleri, özellikle SLA, iç mimarisi kontrol edilebilen karmaşık polimer geometrilerinin üretimi için benzersiz fırsatlar sunmakta ve bu durum, yapıların THz rejimindeki elektromanyetik performanslarını doğrudan etkilemektedir. Bu çalışmada, iç gözeneklilik ve malzeme yoğunluğunun temel optik parametreler üzerindeki etkisini sistematik olarak incelemek amacıyla %20, %40, %60 ve %80 olmak üzere dört farklı doluluk oranı seçilmiştir. 0.1–2 THz frekans aralığında gerçekleştirilen ölçümler, kırılma indisi, permitivite, soğurma katsayısı ve kayıp tanjantı değerlerinin elde edilmesine odaklanmıştır. Deneysel sonuçlar, doluluk oranının artmasıyla birlikte etkin kırılma indisi ve permitivite değerlerinde kademeli bir artış olduğunu ortaya koymakta, bu da daha yoğun yapılarda daha güçlü elektromanyetik sıkışmayı işaret etmektedir. Buna karşılık, düşük doluluk oranına sahip numunelerde soğurma ve kayıp tanjantı değerlerinin azaldığı gözlemlenmiş ve bu da onları hafif ve düşük kayıplı THz bileşenleri için uygun hale getirmiştir. Bu bulgular, SLA ile üretilen polimerlerde doluluk oranının ayarlanmasının, polimer tabanlı cihazların THz optik özelliklerini şekillendirmek için basit fakat etkili bir yol sunduğunu göstermektedir. Elde edilen sonuçlar, malzeme özelliklerinin temel polimer kimyası değiştirilmeden katmanlı imalat yoluyla mühendislik edilebildiği mercekleme, dalga kılavuzları ve algılama platformları gibi fonksiyonel THz bileşenlerinin tasarımı ve optimizasyonu açısından büyük önem taşımaktadır.

**Anahtar Kelimeler:** Terahertz, SLA, 3B baskı, polimer yapılar, doluluk oranı, THz-TDS, kırılma indisi, permitivite, soğurma, kayıp tanjant

## INVESTIGATION OF TERAHERTZ PROPERTIES OF SLA-PRINTED POLYMER STRUCTURES BASED ON INFILL RATIO USING THz-TDS

### ABSTRACT

This study investigates the terahertz (THz) transmission properties of stereolithography (SLA)-printed polymer structures with varying infill ratios, using a terahertz time-domain spectroscopy (THz-TDS) system. Additive manufacturing techniques, particularly SLA, provide unique opportunities to fabricate complex polymer geometries with controllable internal architectures, which directly influence their electromagnetic performance in the THz regime. In this work, four distinct infill ratios 20%, 40%, 60%, and 80% were selected to systematically examine the effect of internal porosity and material density on key optical parameters. Measurements were conducted in the frequency range of 0.1–2 THz, focusing on the extraction of refractive index, permittivity, absorption coefficient, and loss tangent values. The experimental results reveal that increasing the infill ratio leads to a gradual enhancement of the effective refractive index and permittivity, indicating stronger electromagnetic confinement within denser structures. Conversely, lower infill ratios exhibited reduced absorption and loss tangent values, highlighting their potential for lightweight, low-loss THz components. These findings demonstrate that tuning the infill ratio of SLA-printed polymers offers a simple yet effective route to tailor the THz optical properties of polymer-based devices. The results are of significant importance for the design and optimization of functional THz components, such as lenses, waveguides, and sensing platforms, where material properties can be engineered through additive manufacturing without altering the base polymer chemistry.

**Keywords:** Terahertz, SLA, 3D printing, polymer structures, infill ratio, THz-TDS, refractive index, permittivity, absorption, loss tangent

### Introduction

The terahertz (THz) region of the electromagnetic spectrum, typically defined as the frequency range between 0.1 and 10 THz, has garnered significant scientific and technological interest over the past two decades. Positioned between the microwave and infrared bands, THz radiation possesses unique properties, including non-ionizing photon energies, the ability to penetrate a wide range of dielectric materials, and a strong sensitivity to molecular vibrations and rotations (Anitha et al., 2023). These characteristics have paved the way for a diverse array of promising applications, such as security screening, non-destructive quality control, biomedical imaging, and next-generation high-speed wireless communications (Siegel, 2004). However, the widespread adoption of THz technologies has been historically hindered by a lack of efficient and low-cost components, a challenge often referred to as the "THz gap." The realization of these promising applications is contingent upon the availability of high-performance and cost-effective THz components, including lenses, waveguides, filters, and antennas. The performance of these devices is fundamentally dictated by the optical properties of their constituent materials. Ideal materials for THz applications should exhibit a low absorption coefficient and a controllable refractive index (Majeed et al., 2019). While traditional materials like high-resistivity silicon, quartz, and polytetrafluoroethylene (PTFE) have been used, they often suffer from limitations such as high cost, complex fabrication processes, or a lack of design flexibility. Therefore, the exploration of new materials and fabrication strategies is crucial for advancing THz technology. In recent years, additive manufacturing (AM), colloquially known as 3D printing, has emerged as a disruptive technology for the rapid prototyping and fabrication of complex electromagnetic devices (Ian et al., 2015). AM techniques allow for the creation of intricate, three-dimensional structures directly from a digital model, offering unparalleled design freedom and reducing both manufacturing time and cost. Among various AM methods, stereolithography (SLA) is particularly attractive for optical applications due to its high resolution and excellent surface finish, which are critical for minimizing scattering losses at THz frequencies. The use of 3D printing has

already enabled the fabrication of novel THz components, such as hollow-core waveguides and custom-shaped lenses, demonstrating its potential to overcome the limitations of conventional manufacturing (Cruz et al., 2015). Beyond the fabrication of complex macro-geometries, AM offers unprecedented control over the internal microstructure of a printed object. One of the most fundamental yet powerful parameters in this context is the infill ratio, which defines the density of the internal lattice structure. By varying the amount of material within the object's interior, a composite structure of polymer and air is created. According to effective medium theory, the macroscopic electromagnetic properties of such a composite can be tuned by adjusting the volume fraction of its constituents (Choy, 2015). This suggests that by systematically varying the infill ratio, the effective refractive index and permittivity of a 3D-printed part can be precisely tailored using a single base material. This approach offers a powerful route to creating custom dielectrics on-demand.

In this study, we present a systematic investigation into the THz properties of polymer structures fabricated via SLA as a function of their internal infill ratio. Utilizing a terahertz time-domain spectroscopy (THz-TDS) system, we extract and analyze the frequency-dependent refractive index ( $n$ ), permittivity ( $\epsilon_r$ ), absorption coefficient ( $\alpha$ ), and loss tangent ( $\tan\delta$ ) for samples with infill ratios of 20%, 40%, 60%, and 80%. The primary objective is to demonstrate that manipulating the infill ratio provides a straightforward yet powerful method for engineering the dielectric properties of THz components, thereby enabling the design and optimization of functional devices without altering the base material chemistry.

## Materials and Methods

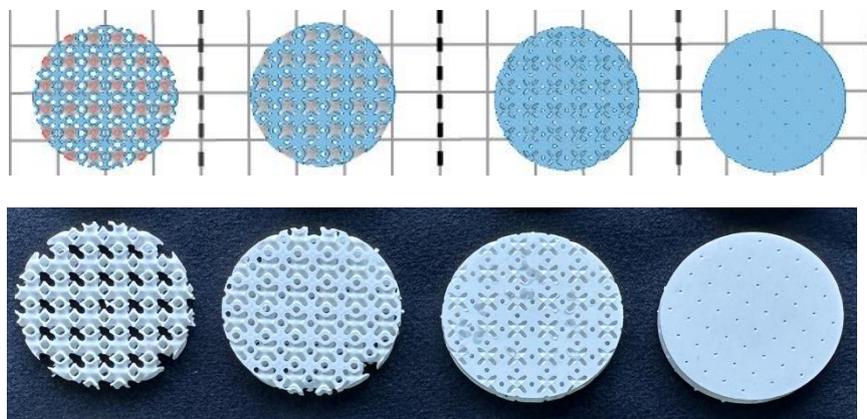
This section details the experimental procedures employed in this study, from the digital design and fabrication of the polymer structures to their characterization using terahertz time-domain spectroscopy (THz-TDS) and the subsequent data analysis.

## Sample Design and Fabrication

The design and fabrication process involved three key stages; digital modeling, additive manufacturing, and post-processing. The designed SLA-printed polymer structures with varying infill ratios are illustrated in Figure 1. The CAD models (top row) and their corresponding fabricated samples (bottom row) clearly demonstrate the gradual transition from highly porous to denser architectures as the infill ratio increases from 20% to 80%.

The geometric designs for the periodic lattice structures were generated using the MSLattice software package. This tool enabled precise control over the design parameters, allowing for the definition of the unit cell topology and the systematic variation of the internal porosity. Four distinct designs were created, corresponding to infill ratios of 20%, 40%, 60%, and 80%. The final designs were exported as standard tessellation language (.STL) files, which are directly compatible with additive manufacturing systems. All samples were designed as square slabs with lateral dimensions of 30 mm x 30 mm and a uniform thickness of 3 mm to ensure consistency during THz measurements. It is important to note that no electromagnetic simulations were performed prior to fabrication; the properties were determined purely through experimental characterization. The fabrication of the samples was carried out using a Stereolithography (SLA) 3D printer (Formlabs Form 3L). SLA was specifically chosen for its ability to achieve micron-level resolution and produce smooth surfaces, which are critical for minimizing scattering losses and ensuring geometric fidelity at THz frequencies. The high resolution of the Form 3L printer enabled the accurate realization of the slender struts and complex periodic architecture of the designed lattices. The base material selected for this study was Rigid 10K Resin (Formlabs Inc.), a commercial photopolymer known for its high stiffness, mechanical stability, and favorable dielectric properties in the THz range. Following the SLA printing

process, the fabricated structures underwent a two-step post-processing procedure. First, the samples were thoroughly washed in a bath of isopropyl alcohol (IPA) for 15 minutes to remove any uncured resin from their surfaces and internal voids. Second, the cleaned samples were subjected to ultraviolet (UV) curing for 90 minutes at 60 °C to ensure complete polymerization, thereby achieving their final mechanical and dielectric properties.



**Figure 1.** Designed SLA-printed polymer structures with different infill ratios (top: CAD models, bottom: fabricated samples).

### Terahertz Time-Domain Spectroscopy (THz-TDS) Characterization

The optical properties of the fabricated polymer structures were characterized using a conventional terahertz time-domain spectroscopy (THz-TDS) system operating in a transmission configuration. The THz pulses were generated using a photoconductive antenna (PCA) excited by a femtosecond laser and coherently detected by an identical PCA. To mitigate absorption by atmospheric water vapor, which can obscure material properties in the THz range, the entire beam path was enclosed and purged with dry air, maintaining a relative humidity below 2%.

For each measurement, two time-domain waveforms were recorded over a 100 ps window. First, a reference signal  $E_{ref}(t)$ , was acquired with the THz pulse propagating through the purged air path. Subsequently, a sample signal  $E_{sam}(t)$ , was acquired by placing one of the fabricated polymer structures at the focal point of the THz beam, normal to its direction of propagation. This procedure was repeated for each sample corresponding to the different infill ratios.

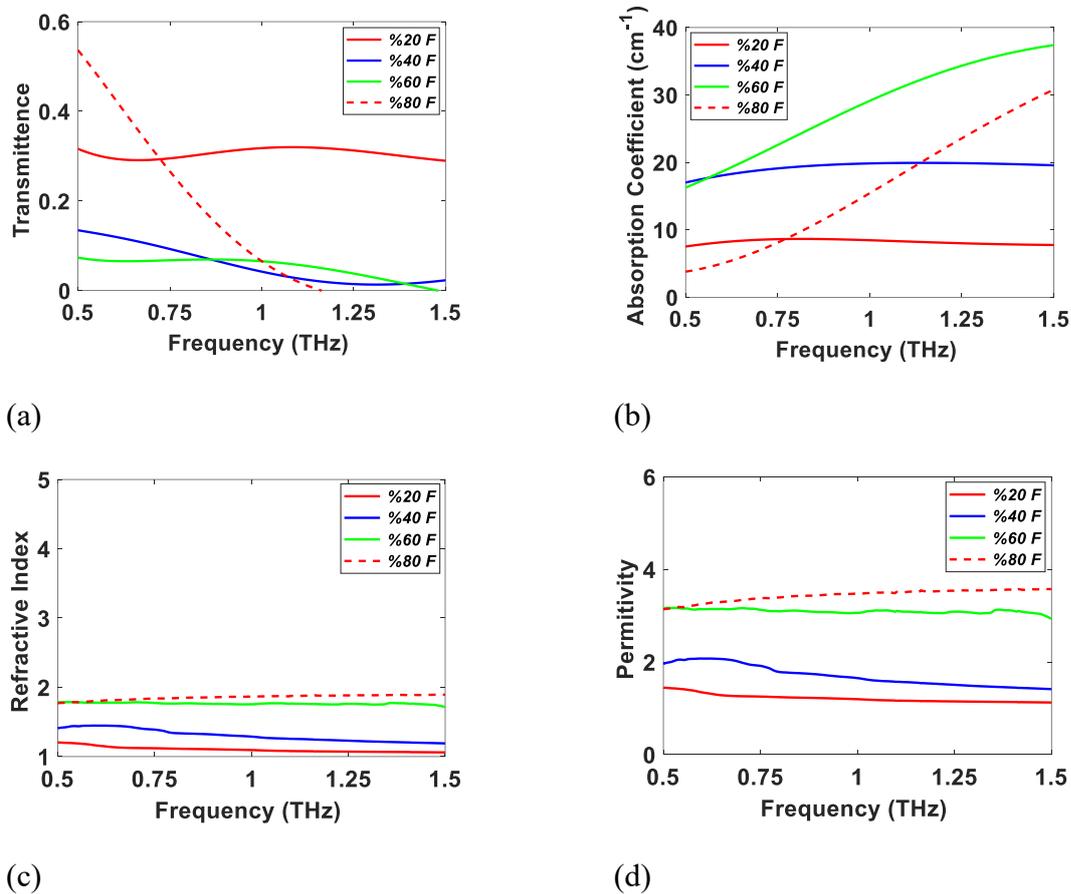
### Results and Discussion

The measured spectral response of the IWP lattice in the 0.5–1.5 THz band is presented in Figure 2. The structure displays distinctive spectral features, particularly in transmission, with clear variations emerging as the filling ratio increases. As illustrated in Figure 2 (a), the 20% filling case exhibits relatively stable transmittance across the band, starting at  $\approx 0.3$  and gradually decreasing to  $\approx 0.28$  by 1.5 THz. For 40% and 60% filling, transmission levels remain significantly lower throughout the band, ranging between  $\approx 0.05$  and  $\approx 0.15$ . In sharp contrast, the 80% filling case demonstrates the highest transmission at low frequencies, peaking at  $\approx 0.55$  in the 0.5–0.75 THz region, but it collapses sharply beyond 1 THz to values near zero, indicating a dramatic suppression of propagation. This phenomenon suggests strong resonance-like boundary effects associated with high infill levels. The absorption coefficient ( $\alpha$ ), shown in Figure 2 (b), exhibits a clear, filling-ratio-dependent trend. It remains lowest and stable for 20% filling  $\approx 10 \text{ cm}^{-1}$  across the band. It increases moderately for 40% filling reaching  $\approx 20 \text{ cm}^{-1}$  and steeply for 60% filling, which shows a near-linear increase to  $\approx 37 \text{ cm}^{-1}$

at 1.5 THz. The 80% filling case, however, displays a unique behavior: it starts with the lowest absorption  $\approx 5 \text{ cm}^{-1}$  at 0.5 THz but then rises sharply and non-linearly to reach  $\approx 30 \text{ cm}^{-1}$  at 1.5 THz. This steep rise in absorption coincides with the transmission collapse observed in Figure 6 (a), strongly suggesting resonance-induced losses dominate at higher frequencies for the 80% case.

The refractive index results in Figure 2 (c) show that  $n$  values generally increase with the filling ratio, ranging from  $n \approx 1.3$  for 20% filling. The 60% and 80% cases settle around  $n \approx 1.8$ , while the 80% case exhibits the highest values, peaking at  $n \approx 1.9$  across the band. The permittivity response is presented in Figure 2 (d). The real part  $\epsilon'$  generally increases with the filling ratio. It rises from  $\approx 1.7$  at 20% filling. The 80% filling case shows the highest values  $\epsilon' \approx 3.5$ , closely followed by the 60% filling case  $\epsilon' \approx 3.25$  to 3.5. The 40% filling case shows a distinct separation, remaining stable around  $\epsilon' \approx 2.0$ . A weakly decreasing trend with frequency is also observed, consistent with typical dielectric dispersion.

Overall, the IWP lattice is characterized by its high low-frequency transmission observed in both the 20% and 80% filling cases. The 80% filling case, in particular, demonstrates a pronounced switching behavior around 1 THz, transitioning from high transparency to high loss and suppression, suggesting its potential for narrowband switching or band-limiting applications. The high absorption and permittivity values at high frequencies for the 80% and 60% cases confirm that a denser dielectric profile with significant resonance-related losses governs the response in this regime.



**Figure 2.** Dielectric properties of the IWP lattice (F) (a) transmittance (b) absorption coefficient (c) refractive index and (d) permittivity

## Conclusions

In this study, the terahertz properties of stereolithography (SLA)-printed polymer structures were systematically investigated as a function of their internal infill ratio. Using a THz-TDS system, we characterized samples with infill ratios of 20%, 40%, 60%, and 80% over a frequency range of 0.5–1.5 THz and extracted their effective refractive index, permittivity, absorption coefficient, and loss tangent. The experimental results conclusively demonstrate that the infill ratio is a powerful and effective parameter for tuning the electromagnetic properties of additively manufactured dielectrics. It was found that the effective refractive index and permittivity increase systematically and predictably with an increase in the infill ratio, a direct consequence of the higher volume fraction of the polymer material. Conversely, the absorption coefficient and loss tangent were found to decrease significantly at lower infill ratios, as the higher proportion of air within the structure reduces the overall material loss. These findings have significant implications for the future of THz technology. They establish a simple, cost-effective, and highly flexible method for engineering bespoke dielectric materials on-demand using a single base resin. This approach eliminates the need for developing new polymer chemistries, instead leveraging geometric control at the microstructural level. The ability to precisely tailor the dielectric constant and loss provides a new degree of freedom for the design and optimization of advanced THz components, including gradient-index (GRIN) lenses, low-loss substrates, custom waveguides, and sensing platforms. This work bridges the gap between advanced manufacturing and THz science, paving the way for the rapid prototyping and fabrication of next-generation functional THz devices.

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## DERİN ÖĞRENME ALGORİTMALARI VE BÜYÜK VERİ ARAÇLARI KULLANILARAK SAKARYA VE ŞAM ŞEHİRLERİNDE KÜRESEL YATAY IŞINIMIN TAHMİNİ

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### ÖZET

Küresel Yatay Işınım (GHI) tahmini, Güneş Enerjisinin elektrik şebekesine entegre edilmesini sağlar. GHI, aralıklı bir yapıya sahip dalgalanan bir parametredir ve bu da tahmini zorlu bir görev haline getirir. Çeşitli araştırmacılar, tahmin doğruluğunu artırmak ve mevcut makine öğrenimi modellerinin sınırlamalarını hafifletmek için derin öğrenme modelleri önermiştir. Bu araştırmada, Ocak 2022 ile Ocak 2025 arasında Sakarya (Türkiye) ve Şam'daki (Suriye) csv veri kümeleri için gerçek zamanlı akış hattı oluşturmak amacıyla Apache Kafka ve Spark gibi büyük veri araçları kullanılmıştır. GHI değerleri 0 olduğu için gece saatleri filtrelenmiş ve yalnızca gündüz saatleri kullanılmıştır. Aykırı değerlerle başa çıkmak için IQR yöntemi uygulanmıştır. Hiperparametre ayarı, aşağıdaki sıralı modeller için KerasTuner kullanılarak yapılmıştır: LSTM, CNN, LSTM yığılmış CNN (LSTM-SCNN), CNN-SLSTM, SGRU-SCNN, CNN-GRU, SLSTM ve SGRU. Derin öğrenme modelleri, en iyi hiperparametre ayarlarına göre 5 saat ileriye dönük tahmin yapmak üzere eğitilmiştir. Sonuçlar, hem Şam hem de Sakarya için LSTM-yığılmış CNN modelinin diğer kıyaslama modellerinden daha iyi performans gösterdiğini ortaya koymaktadır. Şam için R<sup>2</sup>: 0.990, MAE: 0.0172, MSE: 0.0009 ve RMSE: 0.03; Sakarya için ise R<sup>2</sup>: 0.96, MAE: 0.0368 MSE: 0.0046 ve RMSE: 0.07 değerleri elde edilmiştir. Bu araştırma makalesi, hibrit derin öğrenme modellerinin bağımsız modellere göre güçlü yönlerini ortaya koyarak literatürü desteklemekte ve büyük veri araçlarıyla GHI'nin çok değişkenli zaman serisi tahminini geliştirebilecek yeni bir hibrit model mimarisi sunmaktadır.

**Anahtar Kelimeler:** Küresel Yatay Işınım (GHI), Yenilenebilir Enerji, Derin Öğrenme, Apache Spark, Apache Kafka, Çok değişkenli Zaman Serisi Tahmini

## FORECASTING GLOBAL HORIZONTAL IRRADIANCE IN SAKARYA AND DAMASCUS CITIES USING DEEP LEARNING ALGORITHMS AND BIG DATA TOOLS

### ABSTRACT

Forecasting Global Horizontal Irradiance (GHI) enables the integration of Solar Energy to the power grid. GHI is a fluctuating parameter with an intermittent nature that makes forecasting a challenging task. Various researchers have proposed deep learning models to improve forecast accuracy and mitigate the limitations of existing machine learning models. In this research, big data tools such as Apache Kafka and Spark are utilized to build real time streaming pipeline for csv datasets in Sakarya (Türkiye) and Damascus (Syria) from January 2022 to January 2025. Night time hours were filtered because GHI values are 0 hence only morning times were utilized. IQR method was used to deal with the outliers. Hyperparameter tuning is done using KerasTuner for the following sequential models: LSTM, CNN, CNN-SLSTM, LSTM stacked CNN, SGRU-SCNN, CNN-GRU, Stacked LSTM and Stacked GRU. Deep learning models were trained for 5 hours ahead forecasting according to the best hypertuned parameters. The results show that for both cities Damascus and Sakarya, LSTM- stacked CNN model outperformed the rest of the benchmark models with  $R^2$  of 0.990, MAE of 0.0172, MSE of 0.0009 and RMSE of 0.03 for Damascus city and for Sakarya city the LSTM-stacked CNN resulted in  $R^2$  of 0.962, MAE: 0.0368, MSE of 0.0046 and RMSE of 0.07. This research paper supports the literature in demonstrating the strengths of hybrid Deep learning models over standalone models and it presented a novel architecture of hybrid model that may improve multivariate time series forecasting of GHI according to big data tools.

**Keywords:** Global Horizontal Irradiance, Renewable energy, Deep learning, Apache Spark, Apache Kafka, multivariate Time Series Forecasting

### 1. INTRODUCTION

Many solar energy applications are based on knowledge of global horizontal irradiance (GHI) [(Zhou et al., 2021)], which is the total amount of solar radiation received on photovoltaic (PV) panels. GHI is the type of radiation that PV panel cells are most frequently projected to receive. Accurate forecasting of GHI enables a smoother integration of renewable energy sources into the power grid by providing grid operators and energy providers with the ability to anticipate changes in solar energy production because it largely impacts the operation and construction of Systems for Solar Energy conversion. In addition, forecasting GHI improves the calculations of beam/direct horizontal irradiance( $H_b$ ), diffuse horizontal irradiance( $H_d$ ) and tilted surface irradiance( $H_t$ ), because forecasting GHI enables accurate decomposition into direct and diffuse components, supporting precise modeling of solar irradiance on tilted surfaces and enhancing the overall accuracy of solar energy systems simulation and forecasting. Furthermore, GHI significantly affects future energy legislation and investments.

Additionally Solar Irradiance forecasting are used in load distribution planning, renewable energy system optimization, electricity market trading, power grid planning, supply-demand balancing, and facility development[(Mostafavi et al., 2013)]. However, due to the complex natural causes that affect solar irradiance and sometimes make it impossible to predict, the development of solar energy is significantly constrained[(Perez et al., 2014)]. When coupled with large-scale PV generation, this fluctuation can significantly affect the security of the power grid. As a result, creating precise short-term solar irradiance forecasting models is essential to guaranteeing the best possible power system management and dispatch, especially as PV power generation becomes more widely used.

Due to their excellent capability of extracting nonlinear features from complex data, deep learning techniques have become the preferred choice in time series forecasting applications (Zang et al., 2020;

Srivastava & Lessmann, 2018; Qing & Niu, 2018; Moncada et al., 2018; Lago et al., 2018). In particular, models such as recurrent neural networks (RNNs)—including Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU) networks—are widely used because of their ability to model temporal dependencies effectively (Zarzycki & Ławryńczuk, 2022). Specifically, the LSTM network—an advanced form of RNN—addresses the vanishing gradient problem common in traditional RNNs by incorporating a memory cell and three gates: input, forget, and output. This allows it to retain relevant long-term information and discard irrelevant data, facilitating the learning of complex time-series patterns (Liu et al., 2021).

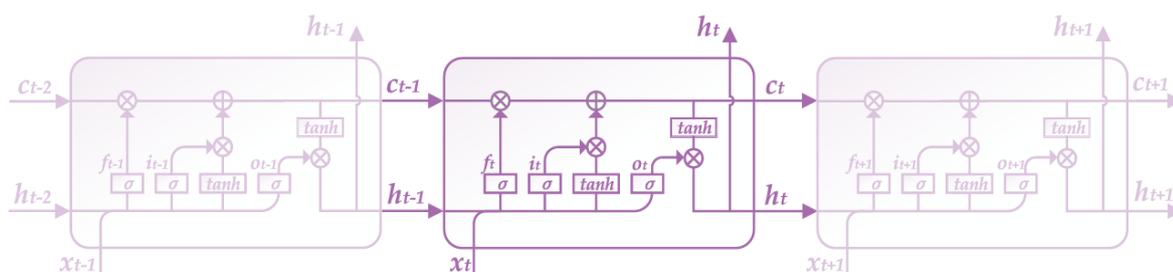


Figure 1. Architecture of LSTM algorithm (Zang et al., 2020)

In contrast, a Convolutional Neural Network (CNN) is a feedforward architecture composed of convolutional layers, pooling layers, and fully connected layers. It extracts hierarchical features by applying a series of filters and pooling operations, making it highly effective for spatial data analysis (Li et al., 2020).

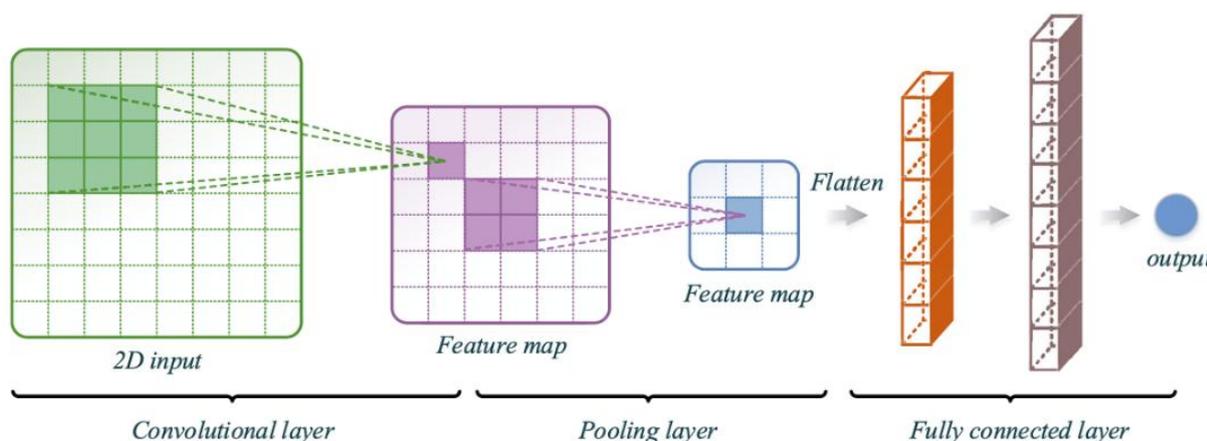


Figure 2. Schematic showing CNN architecture (Zang et al., 2020)

In addition, recently Gated recurrent unit network or GRU shortly has received popularity in time series forecasting. Basically it's a simple version of LSTM network that uses two gates known as update gate and recent gate. The Figure below shows its structure.

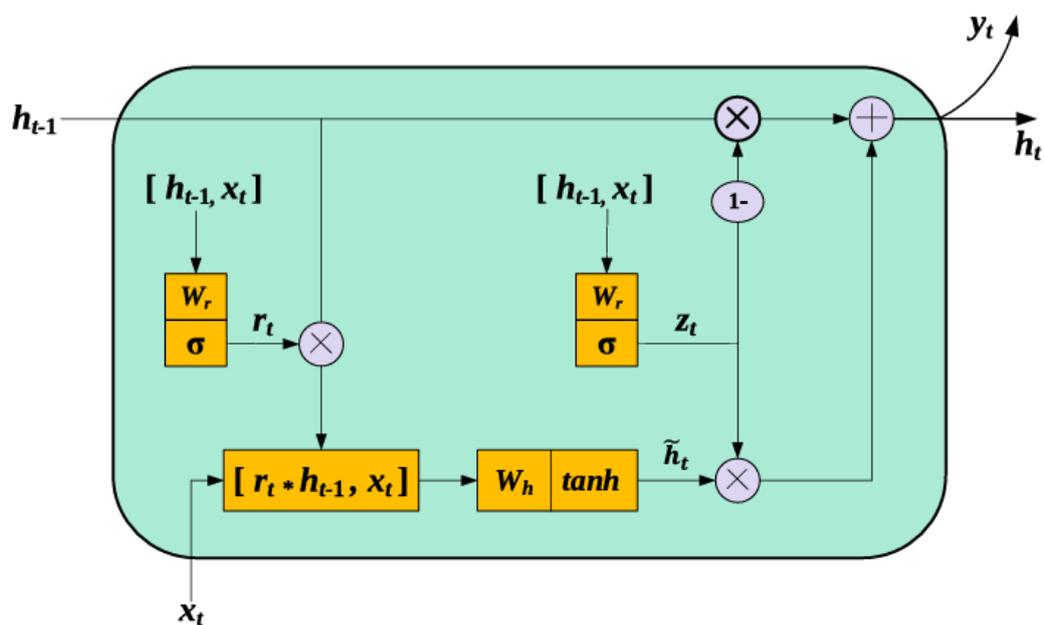


Fig.3. GRU cell structure(Xu et al., 2024)

Compared to LSTM, GRU network is feasible to implement, simpler and needs less computation power. GRU overcome short-term memory challenges of RNN because it retain past information more effectively, hence this makes it a suitable choice for long term forecasting.

## 2. RESEARCH AND FINDINGS

### 2.1. RESEARCH WORKFLOW

This research paper aims to fill the research gap in utilizing big data tools to design a novel architecture that predicts GHI accurately in two different locations to enhance the generalizability of the algorithms and evaluate their performance and explore new architectures of deep learning algorithms to provide more contemporary analysis and enhance the predictive performance. The research workflow began by collecting hourly data from Meteoblue website in csv format for years in the range of 01/2022 until 01/2025. Then the data is processed real-time using Apache Kafka and Spark, the exploratory data analysis (EDA) was done to understand the nature of the data, which mainly includes plotting boxplots and histograms to visualize the general patterns throughout the data and to detect the features that are affected by outliers, then feature engineering process was implemented to detect hidden properties of the data features by creating various external features to enhance the models' performance. Then outliers were detected and removed from the data. The deep learning models were trained for short term horizon of 5 hours because according to California independent system operators (CAISO) real time market forecasting requirements, hourly forecasts for a five hour period ought to be repeated every hour to adhere to the actual rolling update rate of CAISO(Yang et al.,2019). Furthermore, hyperparameter tuning was done to choose the best parameters for every model trained. Figure 4 below shows the processes followed in the research.

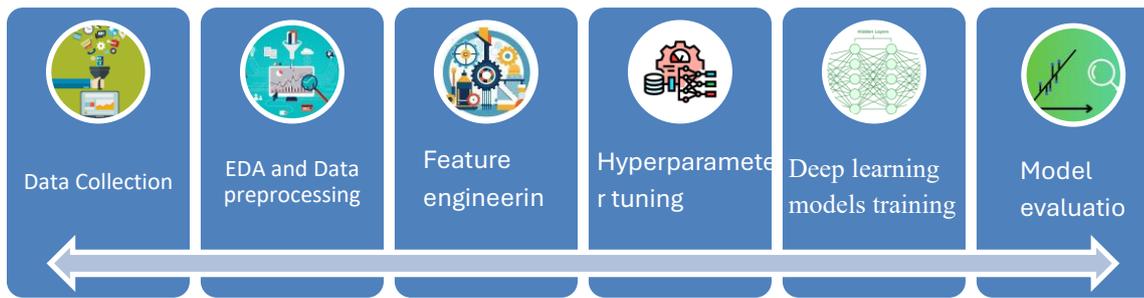


Fig.4. Research workflow processes

## 2.2. DATA COLLECTION

Meteoblue website is utilized to collect comma separated values (csv) data for Sakarya and Damascus cities from January 2022 to January 2025. The csv datasets chosen for this study is based on NOAA Environment Monitoring System (NEMS) model with high resolution dataset for years beginning from 2008. Kafka producer and Apache Spark consumer are utilized to stream the input csv datasets. The extra introductory records that has different schema from the schema defined in the Spark consumer were discarded, this step is necessary otherwise Spark consumer will read all of the streaming producer data as NULL values. Before operating Kafka, Apache Zookeeper should be initialized because zookeeper has role of centralized service that basically tracks the status of partitions, topics, brokers and etc. Furthermore, Zookeeper maintains consistency and checks that Kafka cluster nodes agree on configuration details, which is imperative for functioning of reliable distributed systems. The features of the csv dataset include: timestamp, temperature, sunshine hours, Shortwave Radiation (also known as GHI in Meteoblue website), Direct Shortwave Radiation, Diffuse Shortwave Radiation, precipitation, Relative Humidity, total cloud coverage, mean sea level pressure, wind speed at 10m and wind direction at 10m. After connecting to Zookeeper, python producer API is used to send messages to Kafka producer, it does this by firstly creating a producer object, Furthermore the kafka producer has three obligatory properties: bootstrap\_server, key\_serializer and value\_serializer. The bootstrap server includes broker pairs that producer utilizes to establish connection with kafka cluster. Key serializer is the class name that serializes the records' keys that will be produced to Kafka. Value serializer serializes the records' values. A ProducerRecord should be created that includes the topic name along with the related keys and values of the records. Then the key and value objects should be serialized to Byte Arrays so the network can receive them (Nerkehde et al.,(2017). *Kafka the definitive guide*. O'Reilly)). The data will then be sent to the partitioner, if the partition isn't mentioned in the Producer Record then the partitioner will select a partition based on the ProducerRecord key. A response will be sent in the form of Record meta data once the broker successfully receives the messages. Consumer role is to read data from Kafka by subscribing to Kafka topics and receiving topics' messages. Apache Spark is chosen as the consumer via Python API Pyspark. Sink mode is utilized from the writeStream option in the memory format and append output mode so that Spark consumer can push all the streaming data to one area to ease the rest of preprocessing steps.

## 2.3. EDA AND DATA PREPROCESSING

After initializing the Kafka producer, spark session was built by setting the master to local mode as the research work is based on local resources. Then readStream option of Spark was set by choosing kafka format and subscribing to kafka producer topic initially created. JavaScript Object Notation (Json) schema was created so that the producer JSON data get parsed according to the schema columns. Then pyspark write stream was initialized to write the resultant topic to a new kafka topic

and read from it. The streaming Kafka data can't be used for building deep learning models so it was converted to memory format, this way we could handle the streaming data by storing it in-memory sink. The memory sink is suitable for small to medium dataset sizes and its purpose is to run experiments and debug any errors. The timeseries subplot patterns of the input features is shown below for Sakarya and Damascus datasets. Figure 5 and figure 6 shows the timeseries subplots for dataset features of Sakarya and Damascus datasets respectively.

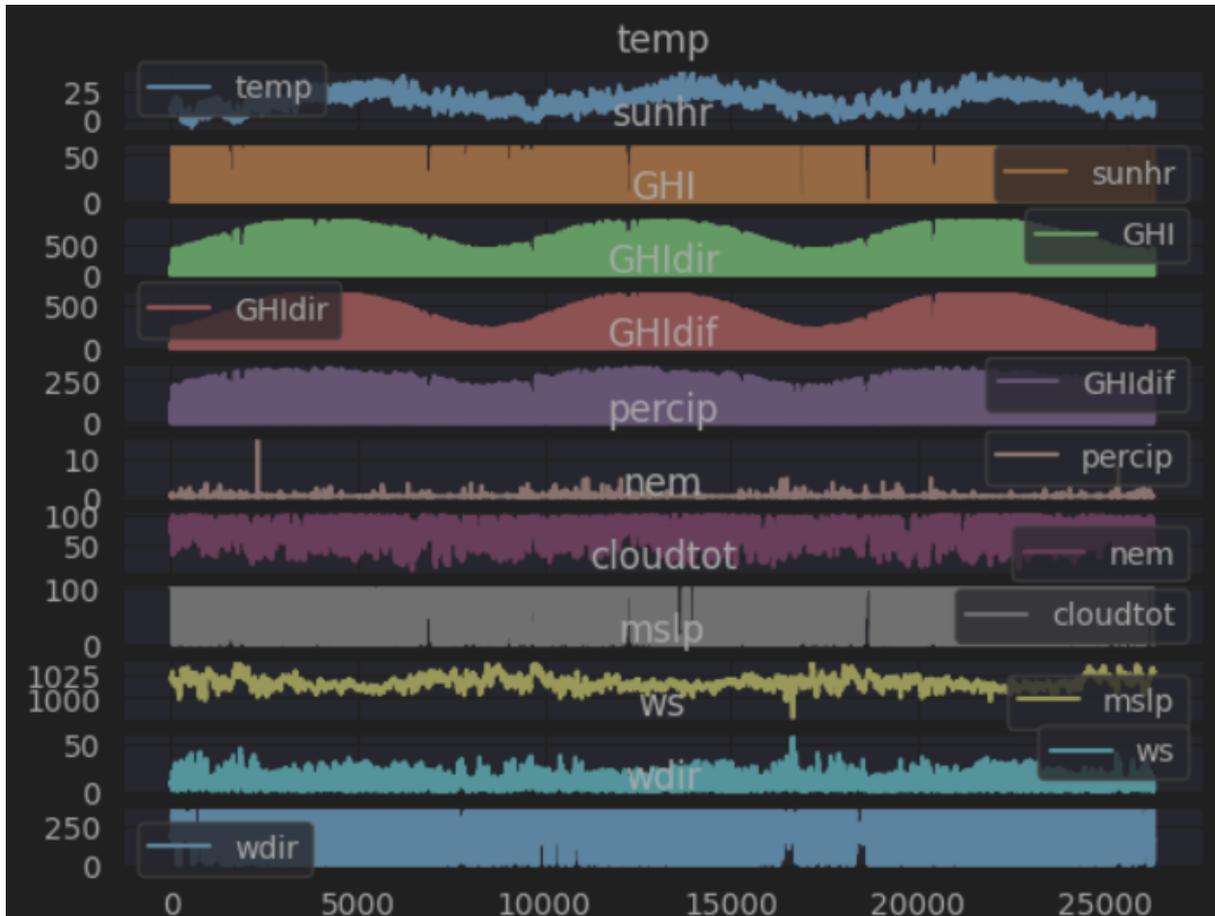


Fig.5. Timeseries subplot figures for Sakarya dataset features from Jan/2022 to Jan/2025

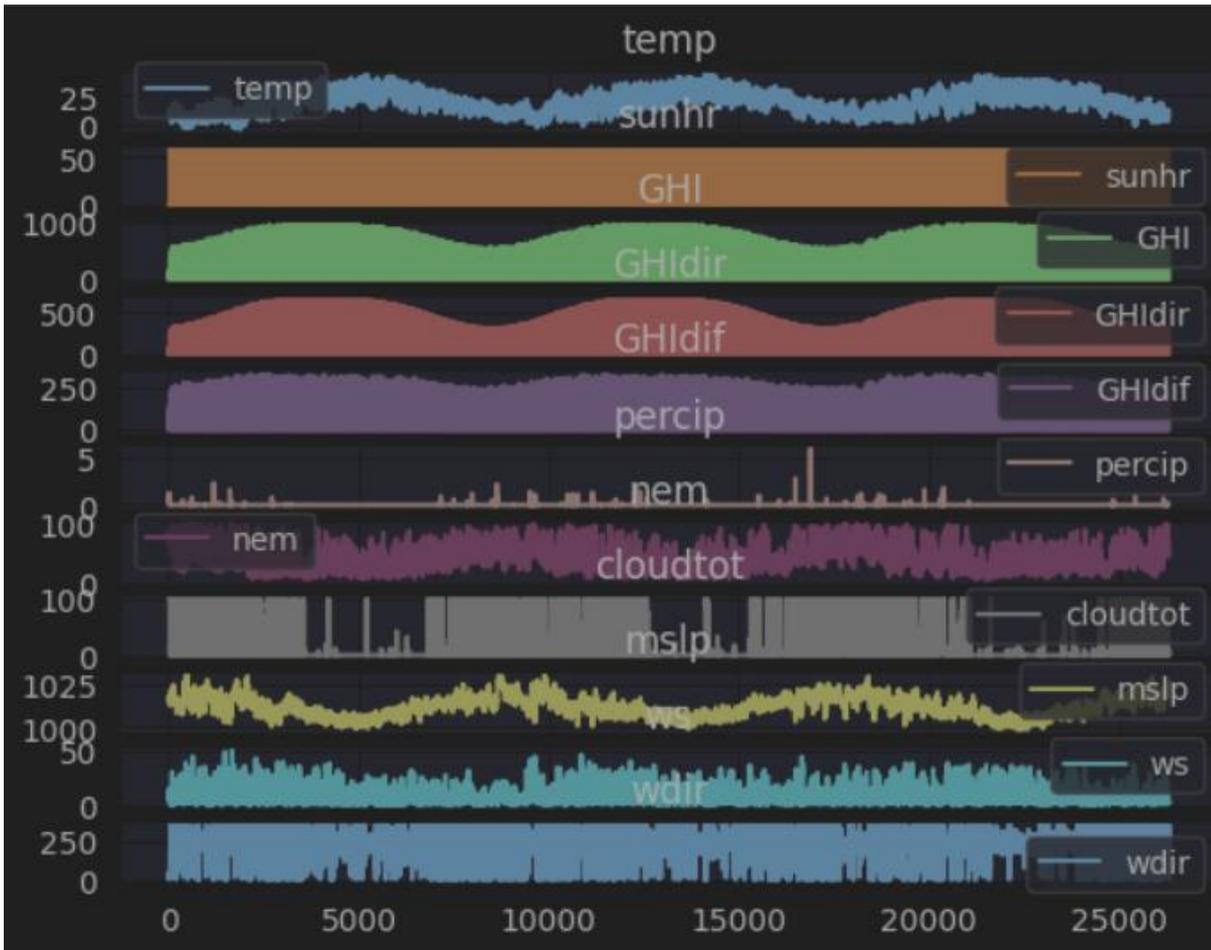


Fig.6. Timeseries subplot figures for Sakarya dataset features from Jan/2022 to Jan/2025

EDA includes Data cleaning which involves detecting and dealing with nan or null values in the dataset. For Sakarya dataset Nan values were present in 35 records for all features except the timestamp feature, whereas for Damascus dataset 18 records with nan values were found in diffuse Solar radiation feature and 35 records with nan values were found in the remaining features except for timestamp feature. The nan values for both datasets were filled using linear interpolation method as this method was previously utilized by researchers to deal with time series datasets[Xu et al.,2024].

Then the outliers were identified and detected using boxplot and IQR method because these methods are the common techniques used to deal with outliers[He et al., 2024].

The IQR method is based on the following formula:

$$x_0 \in \begin{cases} x > Q_U + 1.5IQR, \\ x < Q_L - 1.5IQR. \end{cases} \quad (1)$$

In the above formula  $x_0$  represent the dataset's outliers,  $x$  represent the data point undergoing IQR analysis process,  $Q_U$  demonstrates the upper quartile,  $Q_L$  represents the lower quartile and IQR represents the quartile ranges. In this study, the outlier points were handled using the capping technique, in which points that fall under the lower quartile are substituted with the lower quartile

and same concept is applied for the upper quartile. Capping method is a common technique in data science that's utilized to deal with time series related outliers[He et al., 2024].

## 2.4. FEATURE ENGINEERING

In order to generate accurate models with good generalization ability, the selection process of critical features and generation of more valuable features, becomes very important in any deep learning project.

Pearson correlation was implemented to improve the efficiency of features' selection. Pearson correlation is suitable for time series data to assess the linear relationship between the input features and target variable. The mathematical formula behind Pearson correlation is stated below:

$$r_{x y} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^n (y_i - \bar{y})^2}} \quad (2)$$

Here  $r_{x y}$  is the Pearson coefficient between x and y,  $\bar{x}$  and  $\bar{y}$  are the mean for x and y respectively. Pearson coefficient values lies between the range of -1 and 1. The cases were dataset has highly correlated features are linked with unreliability and increased variance. Hence a threshold of 85% for both datasets were employed to exclude features that are highly correlated and exceed the specified threshold. This step is necessary to reduce variance and unreliability (Abumohsen et al.,2024).

The heatmap figures based on Pearson correlation for input features are shown below for Sakarya and Damascus datasets respectively in Figure 7 and 8:

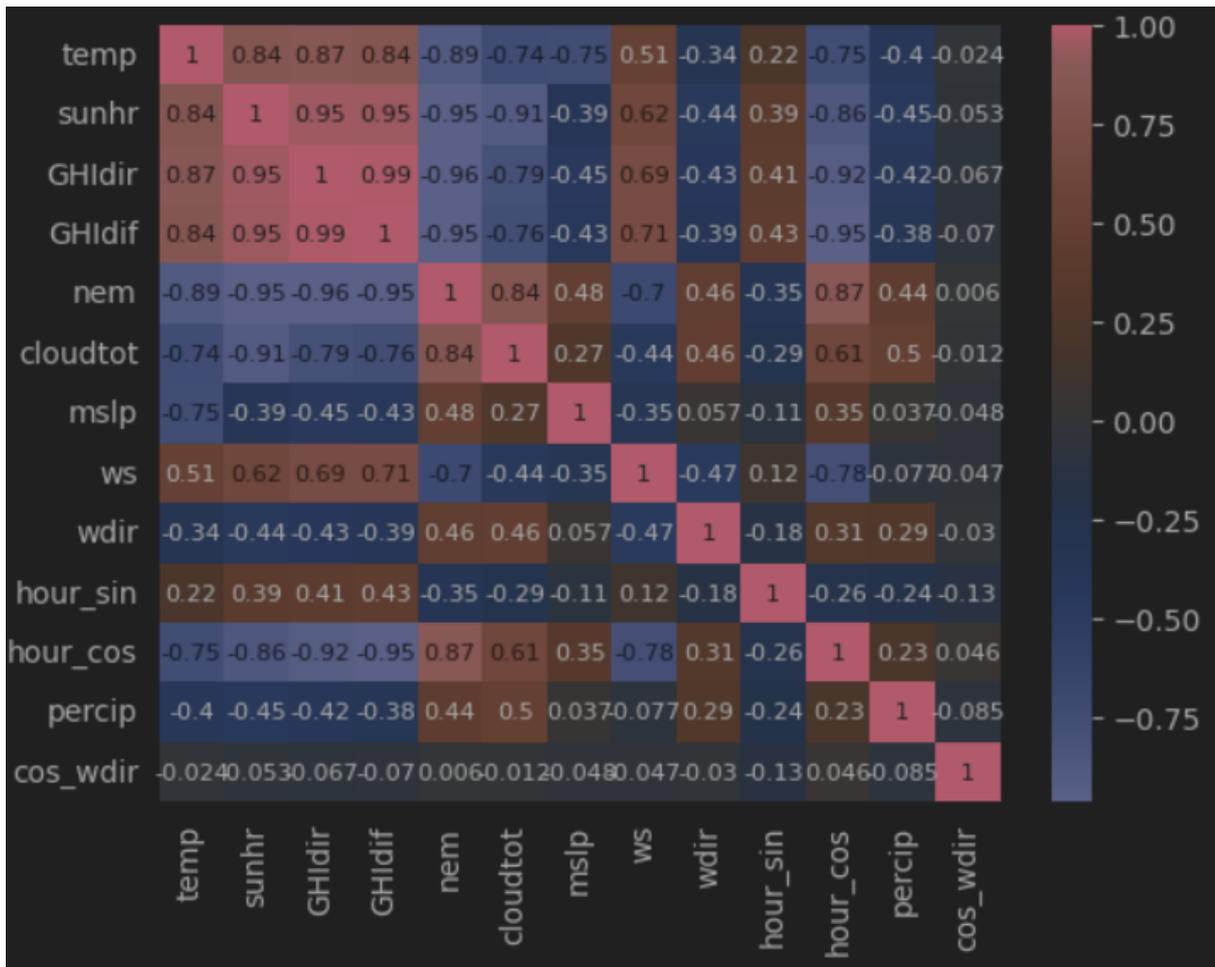


Fig.7. Sakarya heatmap showing correlation between input features.

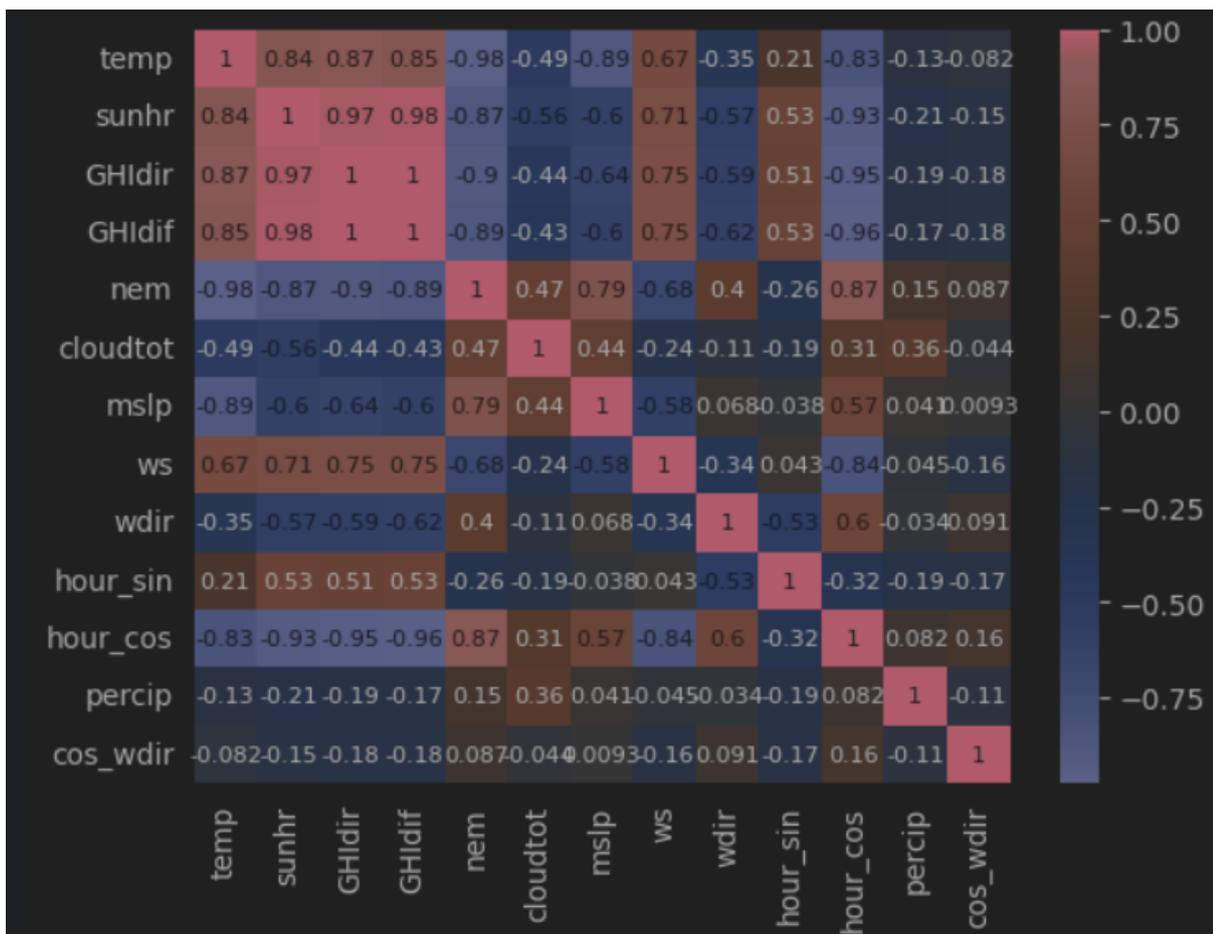


Fig.8. Sakarya heatmap showing correlation between input features.

Various external features were generated to uncover the hidden characteristics of the data and improve the overall accuracy of the forecasting models(Xu et al.,2024). The newly generated features for both datasets include the following:

Hour of the day: This feature was generated after separating the timestamp components. Since this feature is a cyclic feature then sin and cos related to this feature reveal important cyclic patterns

Wind direction: This feature is also a cyclic feature because it demonstrates the wind speed' projection angle at a specific direction. So its related cos and sin values are important input features that are employed for training the models.

The last step of feature engineering includes data normalization because the models' accuracy gets affected when each of its input feature has different ranges. Hence, Minmax normalization was applied to result in a unified scale that ranges from 0 to 1 according to the following formula:

$$\chi_i = \frac{\chi_i - \chi_{min}}{\chi_{max} - \chi_{min}}$$

Minmax normalization is a common approach for normalizing data features used by various researchers in the domain of Solar Irradiance forecasting [Hou et al, 2023b; Mittal & Sangwan, 2020; Abumohsen et al, 2024].

## 2.5. HYPERPARAMETER TUNING

Model training was done for 5hr interval because CAISO real-time market operates on rolling forecasts updated every hour, with forecast horizons typically spanning around 5 hours ahead to support dispatch and balancing decisions. The model training step was done after Hyperparameter tuning using KerasTuner. The models trained included LSTM, CNN, CNN-LSTM, LSTM stacked CNN (LSTM-SCNN), GRU-CNN, stacked CNN-GRU, Stacked LSTM (SLTM) and Stacked GRU (SGRU). Hyperband algorithm was chosen to hypertune the deep learning models due to its utilization of early stopping and adaptive resource allocation to increase speed of its random search. In addition, filtering night time hours is a critical step that many experts in the domain of Solar Irradiance forecasting recommend. Furthermore, short term forecasting spans from half an hour up to around 3 days so five hour ahead forecasting fits the criteria for short term forecasting. Table 1 below shows the hyperparameters tuned for both Sakarya and Damascus datasets using Hyperband algorithm in KerasTuner.

Deep learning model	hyperparameters optimization
LSTM	Dropout rate: 0.1, 0.2,0.3, Adam optimizer Learning rate: 0.001 and 0.0001
CNN	Filters: 64, 128, kernel size: 3,4; Dense layer units: 128,256 Adam optimizer Learning rate: 0.001 and 0.0001
CNN-SLSTM	1 <sup>st</sup> CNN layer: filters: 64,128; kernel size: 3,4; LSTM 1 <sup>st</sup> and 2 <sup>nd</sup> layers: units: 32,64; Dense layer units: 64,128; Dropout layer: 0.1,0.3,0.5, Adam optimizer learning rate: 0.001 and 0.0001
LSTM-SCNN	LSTM units: 32,64, 1 <sup>st</sup> and 2 <sup>nd</sup> 1d CNN layers: filters: 64,128; kernel size: 3,4; Dense layer: units: 64,128;Adam optimizer learning rate: 0.001 and 0.0001; Dropout layer: 0.1,0.3,0.5
SGRU-SCNN	1 <sup>st</sup> and 2 <sup>nd</sup> GRU layers: units: 64,128; 1 <sup>st</sup> and 2 <sup>nd</sup> 1d CNN layers: filters: 64,128 ; kernel size: 3,4; Dense layer units: 64,128; Dropout layer: 0.1,0.3,0.5, Adam optimizer learning rate: 0.001 and 0.0001;
CNN-GRU	1d CNN layer: filters: 64,128; kernel size: 3; GRU layer: units: 32,64; Dense layer: units:32,64; Adam optimizer learning rate: 0.001, 0.0001; Dropout layer: 0.1,0.3,0.5
SLSTM	LSTM 1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> layers: units: 64,128; dropout rate:0.1,0.3,0.5; Dense layer units: 64,128; Adam optimizer learning rate: 0.001 and 0.0001
SGRU	GRU 1 <sup>st</sup> , 2 <sup>nd</sup> and 3 <sup>rd</sup> layers: units: 64,128; dropout rate:0.1,0.3,0.5; Dense layer units: 64,128,256; Adam optimizer learning rate: 0.0001 and 0.00001

Table 1. Hyperparameter optimization in KerasTuner using Hyperband Algorithm.

## 2.6. DEEP LEARNING MODELS TRAINING

The models trained in this research paper included the following : LSTM, CNN, CNN-SLSTM, LSTM-SCNN, GRU-CNN, SCNN-SGRU, Stacked LSTM (SLTM) and Stacked GRU (SGRU). The

model training was done using TensorFlow library according to the hyperparameters' values chosen by the Hyperband algorithm with 35 epochs for training the models, this number is chosen to adapt with memory sink and to not cause driver overload, the architecture of the models will be described in this section. The data was divided into train, validation and test sets with a 70%-10%-20% split respectively.

Since the choices for hyperparameter tuning optimization is already mentioned in the last section, they won't be discussed here. This section explains the optimal hyperparameters chosen by Hyperband algorithm for Sakarya and Damascus datasets. The LSTM model was constructed using 1 layer of LSTM network with 64 units, followed by a dense layer of 128 units, a final dense layer with 1 variable as output. The dropout rate was 0.2 for Sakarya's dataset and 0.1 dropout rate was for Damascus dataset, the learning rate is 0.001, for all deep learning models the model optimizer chosen is Adam optimizer. Regarding 1d CNN model, the CNN network was designed with 128 filters for Sakarya and Damascus datasets, kernel size of 3 was chosen for Sakarya dataset whereas kernel size of 4 was chosen for Damascus dataset, followed by 2 dense layers, for both datasets the first dense layer was chosen as 128 units and the second layer had 1 unit, the learning rate for the optimizer was chosen as 0.001. The LSTM-SCNN for Sakarya dataset was designed with the LSTM of 32 units, with 128 filters and kernel size of 4 for both CNN layers, followed by 1d global max pooling layer with its default parameters, then a dense layer with 128 units followed by dropout of 0.3 rate then a final dense layer with 1 unit, however for Damascus city, LSTM had 64 units with two CNN layers each has 64 filters and kernel size of 4, then a dense layer with 64 units followed by dropout of 0.1 rate then a final dense layer with 1 unit, the optimizer learning rate for both datasets of this model is 0.001. The CNN-GRU model was designed using 128 filters for 1d CNN, kernel size of 4, GRU of 32 units, followed by dense layer of 64 units and dropout rate of 0.3 then final dense layer of 1 unit, the optimizer learning rate is 0.001; Regarding Damascus the CNN-GRU model was trained same filter number and kernel size as Sakarya model ,however the GRU had 64 units and the same dropout layer of 0.3 but with 0.0001 learning rate . The SGRU-SCNN was designed by stacking two GRU layers followed by two stacked 1d CNN layers, between 1d CNN layers was a 1d maxpooling layer, after the CNN layers another 1d maxpooling layer was added followed by a 1d global average pooling layer, then 2 dense layers were inserted in which a dropout layer was added between them, for Sakarya's dataset 128 units was utilized for both layers of GRU, but for Damascus's dataset 64 units of GRU were utilized, then CNN layers for both datasets had 64 filters and kernel size of 4 , the 1d maxpooling 1d global average pooling layers had default settings , the dropout rate was 0.3 for Sakarya and 0.1 for Damascus dataset, for both datasets the units for the first dense layer was chosen as 64 units and the last dense had 1 unit for the final output , the optimizer learning rate is 0.001. The CNN-SLTSM model was designed by inserting 1 CNN network followed by 1d maxpooling layer then 2 layers of LSTM networks were added, after which 2 dense layers were added, in which the final output had 1 unit to output the final result. For Sakarya's dataset 128 filters and kernel size of 4 were chosen, whereas 64 filters and 3 kernel size were chosen for Damascus dataset, the 1d maxpooling layer had default settings, the stacked LSTM networks for both Sakarya and Damascus had 128 unit, the dense layer was chosen as 128 units for Sakarya dataset and for Damascus dataset it was chosen as 64 units , the optimizer learning rate was chosen as 0.001 for both datasets. For Sakarya and Damascus SLTSM model, the architecture consisted of 3 LSTM layers with 64 units in each layer, a dropout layer for regularization was added after the 2<sup>nd</sup> LSTM but its value was chosen as 0.3 for Sakarya and 0.1 for Damascus, then for Sakarya SLTMS a dense layer of 64 units was added, followed by a dropout layer of 0.3 and finally one unit of dense layer, but for Damascus after adding 3 LSTM layers, the dense layer of 128 units was inserted, followed by 0.1 as dropout layer then dense layer with 1 unit was added, the learning rate was 0.001 for both datasets. For Sakarya and Damascus SGRU model, the three GRU layers had 128 layers, the architecture design was similar to SLSTM model, there were two stacked GRU layers after which a dropout layer (rate was 0.1 for Sakarya dataset and 0.3 for Damascus dataset) then GRU layer, followed by two dense layers, the

first layer had 64 units for Sakarya dataset and 256 for Damascus dataset and the last dense layer consisted of 1 unit for the final regression output. The optimizer learning rate was 0.001 for both datasets.

## 2.7. MODEL EVALUATION

To measure statistically the data performance, various metrics can be utilized (Plevris et al., 2022). Metrics such as root mean square error (RMSE), mean square error (MSE), mean absolute error (MAE), and coefficient of determination ( $R^2$ ) are used in this paper for the evaluation of GHI prediction models.

$$\text{RMSE} = \sqrt{\frac{1}{N} \sum_{i=1}^N (y_i - \hat{y}_i)^2} \quad (3)$$

$$\text{MSE} = \frac{1}{N} \sum_{i=1}^N (y_i - \hat{y}_i)^2 \quad (4)$$

$$\text{MAE} = \frac{1}{N} \sum_{i=1}^N |y_i - \hat{y}_i| \quad (5)$$

$$R^2 = \left(1 - \frac{\sum (\hat{y}_i - y_i)^2}{\sum (\bar{y}_i - y_i)^2}\right) \times 100 \quad (6)$$

## 3. RESULTS AND DISCUSSION

LSTM-SCNN outperformed the benchmark models in both datasets with  $R^2$  of 0.962, MAE: 0.0368, MSE: 0.0046 and RMSE: 0.07 for Sakarya dataset. For Damascus dataset LSTM-SCNN had  $R^2$  of 0.990, MAE of 0.0172, MSE of 0.0009 and RMSE of 0.03. The results for the deep learning models in Sakarya and Damascus datasets are shown in table 2 and 3 respectively. This interesting outcome shed light into an important concept in deep learning, i.e., using stacked layers increases the network's depth that makes the model train more efficiently and this step is known as representational optimization. In fact, (Pascanu et al, 2013) stated that Deep learning is based on the hypothesis that a hierarchical deeper model can be more exponentially efficient at demonstrating some functions compared to a shallow network.

Furthermore (Mariappan et al., 2025) research demonstrated the outperformance of CNN-SLTSM in predicting daily average GHI compared to LSTM, GRU, LSTM-CNN, SLTSM and other regression machine learning models, this reveals the efficacy of stacked hybrid deep learning models in learning non-linear relationships with higher accuracy.

On the other hand, 1D CNN and LSTM networks had a very good performance and their evaluation outcome are close to the best performing model. This is an interesting outcome because (Alkhatib et al 2024) study explored the univariate and multivariate techniques that predict hourly GHI in 3 cities of USA and found that LSTM and CNN algorithms had the best performance compared to the benchmark models. However, their study didn't investigate using stacked hybrid deep learning models.

In addition, hybrid deep learning models fuse the merits of deep learning models to yield improved performance and higher accuracy. Stacked deep learning models offer more depth and may detect

sophisticated non-linear relationships better than unstacked models in some cases, that's why in literature stacked deep learning models are more preferred than unstacked deep learning models for models training. Furthermore, hybrid models can be implemented in smart grids, which constitute an imperative role at the fourth industrial revolution, because it optimizes energy utilization by effectively integrating energy source. While basic models are simpler and easier to use, hybrid models are particularly suitable for smart grid applications due to their ability to optimize energy use by enabling efficient integration of renewable energy sources into the electrical grid (Park et al., 2023; Karout et al., 2023; Li et al., 2024; Bhutta et al., 2024).

Deep learning models	Short term interval Sakarya: 5hr
<b>LSTM</b>	MAE: 0.0417, MSE : 0.0052, RMSE : 0.072, R2 : 0.957
<b>CNN</b>	MAE: 0.0408 ,MSE : 0.0051, RMSE : 0.0714, R2 : 0.958
<b>LSTM-SCNN</b>	MAE: 0.0414, MSE : 0.0050, RMSE : 0.0704 ,R2 : 0.960
<b>CNN-GRU</b>	MAE: 0.0595, MSE : 0.0080, RMSE : 0.0894, R2 : 0.934
<b>CNN-SLSTM</b>	MAE: 0.0463, MSE : 0.0055, RMSE : 0.0741, R2 : 0.955
<b>SGRU-SCNN</b>	MAE: 0.0458, MSE : 0.0054, RMSE : 0.0737, R2 : 0.955
<b>SGRU</b>	MAE: 0.0469, MSE : 0.0054, RMSE : 0.0734, R2 : 0.955
<b>SLTSM</b>	MAE: 0.0456, MSE : 0.0053, RMSE : 0.0723, R2 : 0.956

Table 2. Results of evaluation metrics for multivariate time series data in Sakarya dataset.

Deep learning model	Short term interval Damascus: 5hr
<b>LSTM</b>	MAE: 0.0182, MSE : 0.0010, RMSE : 0.032 ,R2 : 0.988
<b>CNN</b>	MAE: 0.0220, MSE : 0.0011, RMSE : 0.033, R2 : 0.972
<b>CNN-SLSTM</b>	MAE: 0.0225, MSE : 0.0012, RMSE : 0.034, R2 : 0.986
<b>LSTM-SCNN</b>	MAE: 0.0140, MSE : 0.0008, RMSE : 0.0281, R2 : 0.990
<b>SGRU-SCNN</b>	MAE: 0.0179, MSE : 0.0010, RMSE : 0.031, R2 : 0.989
<b>CNN-GRU</b>	MAE: 0.0282, MSE : 0.0016, RMSE : 0.0405, R2 : 0.981
<b>SLSTM</b>	MAE: 0.0344, MSE : 0.0020, RMSE : 0.0447, R2 : 0.977
<b>SGRU</b>	MAE: 0.0313, MSE : 0.0017, RMSE : 0.042, R2 : 0.980

Table 3. Results of evaluation metrics for multivariate time series data in Damascus dataset.

#### 4. CONCLUSIONS

According to the results of multivariate time-series forecasting, LSTM- stacked CNN model outperformed the rest of the benchmark models for both datasets. The main contributions of this study is utilizing Kafka- Spark pipeline to reach the objective of designing deep learning models in a parallel processing environment, designing a novel architecture (LSTM-SCNN) that generates higher accuracy and better performance, improving the forecasting accuracy of deep learning models by generating new features via feature engineering techniques and exploring various hybrid deep learning algorithms to perform comparative analysis. However, there are few limitations in this study, the overall time to train an individual model was between 7-12 minutes. Future work can focus on integration of ensemble methods with Hybrid deep learning algorithms to decrease the training time, incorporation of wider data sources based on more locations, further investigations should be done to integrate cloud data into prediction models to enhance the overall accuracy. The study emphasizes the critical role of persistent innovation in deep learning techniques and big data technologies to meet up with the growing needs of the Solar energy sector driven by the rising demand of renewable energy sources.

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## **DIGITAL TWIN MODELING OF TRANSMISSION LINES FOR DYNAMIC LINE RATING (DLR) APPLICATIONS: CLIMATE-DRIVEN THERMAL MONITORING AND CAPACITY ENHANCEMENT**

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### **ABSTRACT**

The global energy transition and the high integration of renewable energy sources into the grid have significantly increased power flow density on existing High-Voltage Transmission Lines. Concurrently, extreme temperatures and volatile weather conditions induced by climate change are pushing the thermal stress on these lines to critical levels. Conventional Static Line Rating (SLR) operational approaches restrict the line's real-time potential, reducing grid flexibility and often hindering optimal RES curtailment.

This study presents an innovative approach that combines Advanced Sensor Technologies (fiber-optic temperature sensing, remote sensing) with a Digital Twin model to overcome these operational challenges. The proposed Digital Twin architecture continuously collects environmental data, such as conductor temperature, wind speed, and solar irradiance, to simulate the line's physical and thermal equilibrium equations in real-time. This methodology allows for the highly accurate calculation of the Dynamic Line Rating (DLR), which is the instantaneous safe maximum current carrying capacity of the line.

Case study simulations demonstrate that DLR implementation provides a safe capacity increase of up to 27% during peak load periods or favorable climatic conditions, compared to the rigid SLR method. Furthermore, this continuous monitoring system based on the Digital Twin proactively identifies potential high-stress points, significantly optimizing predictive maintenance strategies. The proposed methodology enhances the operational efficiency and reliability of power systems, playing a critical role in assisting grid operators to meet renewable energy integration targets.

**Keywords:** Dynamic Line Rating (DLR), Digital Twin, High Voltage Transmission Lines, Renewable Energy Integration, Thermal Monitoring

### **1. INTRODUCTION**

Our energy sector is undergoing a major transformation driven by the fight against climate change and increasing electrification demands. Central to this transition is the integration of variable renewable energy sources (RES), such as wind and solar, into the grid. However, the fluctuating and uncertain generation profiles of RES can lead to congestion on transmission lines, resulting in the curtailment of these resources. Traditionally, the current carrying capacity (ampacity) of transmission lines is determined by Static Line Rating (SLR) values, which are highly conservative and based on worst-case scenarios. This approach causes a large portion of the line's true potential to remain unused (Baharvandi & Nguyen, 2024).

Dynamic Line Rating (DLR) was developed as a solution to this problem. DLR determines the instantaneous current carrying capacity of lines based on real-time weather conditions in their corridor. DLR typically reveals an additional capacity of to 25% compared to SLR, enabling more

efficient utilization of existing infrastructure (McCall & Servatius, 2016; Douglass et al., 2019). Nevertheless, DLR itself involves challenges such as forecasting difficulties, variability, and the critical identification of the least-cooled sections along a wide corridor (Karimi et al., 2018).

This is where the Digital Twin (DT), a foundational technology of Industry 4.0, comes into play. A Digital Twin creates a virtual copy of a physical asset or system, continuously updating this virtual model with real-time data from sensors to simulate the system's behavior with high fidelity. Digital Twin modeling of transmission lines has the potential to elevate DLR applications to the next level (Paldino et al., 2022). This model not only reflects the instantaneous status but also enables predictive analysis by forecasting future states using Machine Learning (ML) and Artificial Intelligence (AI) algorithms (Martinez et al., 2024; Song et al., 2023; Das et al., 2024).

This article comprehensively examines the theoretical foundation, application areas, benefits, and challenges of Digital Twin modeling for DLR applications in transmission lines. We detail how physics-based and data-driven models are combined within a hybrid approach (Paldino et al., 2022), how the need for sensors can be reduced through innovative methods like Transfer Learning (TL) (Paldino et al., 2024), and how this technology enables climate-impacted thermal monitoring and capacity enhancement.

## 2. METHODOLOGY (MATERIALS AND METHODS)

### 2.1. Dynamic Line Rating (DLR) Technology: Fundamentals and Methods

DLR is based on the principle that a transmission line's ampacity is determined dynamically according to the real-time meteorological conditions in the corridor it passes through (Karimi et al., 2018). This approach aims to maximize the utilization of existing infrastructure as long as the line's safe operational limits (maximum conductor temperature and minimum ground clearance) are not exceeded.

#### 2.1.1. Core Principle: The Heat Balance

The basis of DLR calculations lies in the heat balance on the conductor. This principle expresses the equilibrium between the heat gained (due to Joule heating from current flow and solar heat gain from solar radiation) and the heat lost (via convection from wind cooling and radiation). Standards such as IEEE 738 and CIGRE provide detailed formulations for modeling this dynamic thermal equilibrium (Douglass et al., 2019). This balance is mathematically represented as:

$$Q_{konveksiyon} + Q_{radyasyon} = Q_{güneş} + I^2R(T, \theta)$$

Wind speed and direction are the factors that most significantly affect convective cooling and play a critical role in determining the line's capacity. Ambient temperature, solar radiation, and the physical properties of the line (emissivity, absorptivity) are also important parameters used in calculating the instantaneous thermal state.

#### 2.1.2. DLR Determination Methods

DLR systems are primarily classified into two types based on data collection and capacity calculation methods (Morozovska & Hilber, 2017):

**Indirect Methods:** In this approach, the line rating is calculated using theoretical thermal models based on meteorological data collected from weather sensors (anemometers, thermometers, pyranometers) or data obtained from Numerical Weather Prediction (NWP) models. These methods have lower installation costs but carry the risk of not fully representing the worst-case conditions across the entire line.

**Direct Methods:** In this approach, the physical properties of the line are measured directly, including conductor temperature, sag, mechanical tension, or clearance above ground. For example, temperature sensors mounted on the conductor, load cells measuring tension, or vibration sensors measuring sag fall into this category. These methods typically yield more accurate results but require higher installation and maintenance costs.

Both methods have advantages and disadvantages. Indirect methods are more cost-effective and applicable over large areas, while direct methods provide higher accuracy at critical points. Digital Twin technology has the potential to combine these two approaches, offering a more holistic and reliable solution (Do Nascimento et al., 2024).

## **2.2. Digital Twin Modeling for DLR: The Fusion of Physics and Data**

The Digital Twin of a transmission line is more than just a physical copy; it is a dynamic model that continuously reflects its behaviors, status, and performance in a virtual environment (Thwe et al., 2025; Song et al., 2023). In the context of DLR, this means simulating the thermal and mechanical behavior of all segments of the line in real-time.

### **2.2.1. Hybrid Model Architecture: Physics-Based and Data-Driven Approaches**

An effective DLR Digital Twin utilizes a hybrid architecture that combines physics-based and data-driven approaches, rather than relying on a single model (Paldino et al., 2022).

**Physics-Based Core:** The foundation of the model consists of the heat balance and the mechanical behavior (sag-tension) formulations defined in standards such as IEEE 738 and CIGRE. These engineering equations describe the fundamental physical behavior of the system.

**Data-Driven Layer:** This layer includes Machine Learning (ML) and Artificial Intelligence (AI) algorithms. ML models, trained using real-time sensor data and historical operational data, undertake various functions:

**Model Calibration and Error Correction:** ML models learn the discrepancy between the predictions of the physical model (e.g., IEEE 738) and real-world measurements, continuously correcting the physical model's output. This approach is known as "grey-box" modeling and significantly improves prediction accuracy (Martinez et al., 2024).

**Surrogate Models:** Faster, ML-based surrogate models that mimic the input-output relationship of complex and computationally intensive physical simulations can be used in their place (Chakraborty et al., 2020). This is critical for real-time "what-if" scenario analysis.

**Sensorless Approaches:** An ML model trained with sufficient historical data can estimate conditions across the entire line or in non-sensored areas using data from a limited number of sensors (Martinez et al., 2024). This helps reduce sensor installation costs.

### **2.2.2. Data Efficiency with Transfer Learning (TL)**

Establishing a comprehensive sensor network and collecting sufficient data for every transmission line is costly and time-consuming. Transfer Learning (TL) offers an innovative solution to this

problem (Paldino et al., 2024). In this technique, knowledge and model parameters acquired from a "source" line, which is well-modeled with extensive sensor data, are transferred to a "target" line with less data. This allows a high-accuracy model for the target line to be created with significantly less data and in a shorter time. This translates into a scalable and cost-effective Digital Twin deployment, especially for Transmission System Operators (TSOs) with large transmission networks.

### 2.2.3. Dynamic Modeling and Real-Time Simulation

The Digital Twin is not a static model; dynamic geometric models created using platforms like Unity3D can visualize the physical movements of the line, such as sag and oscillation (Yang et al., 2023). Time series segmentation algorithms combine analytical solutions with real-time sensor data by assuming the line's status (tension, calculated clearance, etc.) is constant over short time intervals. This ensures the model is continuously updated and accurately reflects the line's instantaneous dynamic behavior.

### 2.2.4. DLR Calculation

The DLR value is determined by solving the thermal equilibrium relationship for the current, assuming the conductor is operating at its maximum safe operating temperature ( $T_{c,max}$ ). The result, which indicates the maximum safe current the line can carry under the measured real-time meteorological conditions, is calculated using the derived form of the heat balance equation:

$$DLR = \sqrt{\frac{(T_{c,max} - \theta)}{R(\theta, t, max)}}$$

## 3. RESULTS AND DISCUSSION

### 3.1. Application Areas and Benefits Provided

A DLR-focused Digital Twin developed for transmission lines offers numerous operational and strategic benefits to Transmission System Operators (TSOs) and Distribution System Operators (DSOs):

**Real-Time Thermal Monitoring and Safety Enhancement:** The Digital Twin continuously monitors the conductor temperature and ground clearance at all critical sections of the line. This prevents minimum clearance violations, which are critical for public safety, and slows down the thermal aging (annealing) process that shortens the conductor's lifespan due to overheating. The system can proactively warn operators when a potential violation risk arises.

**Maximization of Transmission Capacity:** The most fundamental benefit of DLR is providing significant additional capacity compared to SLR, especially in cold and windy weather. The Digital Twin delivers this capacity reliably and predictably, enabling more efficient use of existing lines and potentially deferring or eliminating the need for costly new line investments. Studies show this increase averages between .

**Facilitation of Renewable Energy Integration:** High wind energy generation times often coincide with high wind speeds, which increases the line's cooling capacity. The Digital Twin captures this positive correlation, preventing the curtailment of energy from wind farms and allowing for maximum grid integration.

**Reduction of Grid Congestion and Economic Benefits:** The capacity increased by DLR reduces congestion on transmission lines. This allows for the more efficient dispatch of cheaper generation resources, which lowers overall system operation costs and, ultimately, consumer bills.

**Predictive Maintenance and Asset Management:** The Digital Twin records the operational history of the line (such as the duration of exposure to high temperatures), estimating the thermal aging rate and remaining lifespan of the conductor. This allows maintenance and repair activities to be proactive and planned rather than reactive, thus mitigating the risk of failures and extending asset life.

### 3.2. Challenges and Future Perspectives

While Digital Twin modeling for DLR offers great potential, there are some technical and operational challenges hindering its widespread adoption:

Table 1. Core Challenges of DLR Digital Twin Implementation

Challenge Area	Description
<b>Data Management and Quality</b>	Collection, cleaning, and real-time integration of sensor, SCADA, and NWP data in heterogeneous formats. (Data Federation is key).
<b>Model Accuracy and Calibration</b>	Continuous correction of physics-based model deviations using ML and ensuring model reliability under extreme conditions.
<b>Computational Load and Real-Time Operation</b>	The substantial computational power required for the real-time operation of a high-fidelity model. (Use of Model Order Reduction (MOR) techniques is necessary).
<b>Cybersecurity</b>	Vulnerabilities to cyberattacks arising in sensor and communication layers due to increased interconnectivity.
<b>Standardization and Interoperability</b>	The need for common standards and protocols to ensure compatibility among different vendor platforms and models.

In the future, this technology is expected to expand beyond transmission lines to include other grid components such as transformers and circuit breakers. Furthermore, creating "federated digital twins" among different TSOs to achieve broader system-wide optimization and resilience will be a significant area of research.

## 4. CONCLUSION (CONCLUSIONS)

Dynamic Line Rating (DLR) applications for transmission lines have become an indispensable tool for maximizing the potential of existing energy infrastructure. As examined in this article, Digital Twin technology takes the implementation of DLR a step further, transforming it from merely a reactive monitoring tool into a proactive and predictive management platform.

From an electrical engineer's perspective, this technology combines the best engineering solutions by offering a hybrid approach that merges the robustness of theoretical models with the flexibility of machine learning. The physics-based heat balance principles form the backbone of the model, while data-driven algorithms, fed by real-time data, continuously calibrate and refine this model. Advanced techniques like Transfer Learning ensure that this technology is economically viable even in large-scale networks.

In conclusion, the Digital Twin modeling of transmission lines offers a holistic solution to the most fundamental challenges of the contemporary energy sector: capacity enhancement, renewable energy integration, grid safety, and asset management. By overcoming challenges in data management, cybersecurity, and standardization, Digital Twins will serve as a foundational building block for the smart, flexible, and resilient power systems of the future.

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## DEPOZİTO İADE SİSTEMLERİNDE KULLANILAN CAM KIRMA BIÇAKLARININ TRIBOLOJİK PERFORMANSININ MALZEME VE YÜZEY İŞLEMLERİNE BAĞLI OLARAK İNCELENMESİ

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### ÖZET

Depozito iade sistemleri, cam ambalajların geri dönüşümünde kritik bir rol oynamakta olup, bu süreçte kullanılan cam kırma bıçaklarının tribolojik performansı sistemin verimliliğini doğrudan etkilemektedir. Camın yüksek sertlik ve gevrekliği, bıçaklarda şiddetli abrazyon, darbe ve mikro-çatlak oluşumuna neden olmakta, bu da hızlı malzeme kaybı ve kısa servis ömrüyle sonuçlanmaktadır. Bu çalışmada, söz konusu bıçakların aşınma davranışını iyileştirmek amacıyla farklı malzemeler ve yüzey mühendisliği yöntemlerinin etkinliği deneysel olarak araştırılmıştır. Deneysel çalışmada düşük karbonlu St37 ve alaşımlı 4140 çelikleri seçilmiş, St37 üzerine sementasyon ve plazma nitrüleme işlemleri, 4140 üzerine ise plazma nitrüleme uygulanmıştır. Aşınma testleri için cam parçacıkları ile gerçek çalışma koşullarını simüle eden özgün bir deney düzeneği tasarlanmış ve numuneler farklı sürelerde (15–75 dakika) test edilmiştir. Elde edilen sonuçlar, yüzey işlemi uygulanmayan 4140 çeliği, St37'ye kıyasla daha yüksek aşınma eğilimi göstermiştir; yani alaşım içeriği tek başına üstünlük sağlamadığını göstermiştir. St37'nin sementasyonu, neredeyse tüm zaman adımlarında yüzey işlemi uygulanmayan St37'ye göre daha düşük kümülatif aşınma kaybı üretmiş ve net bir iyileşme sunmuştur (başlangıçtaki kısa “alışma” evresi hariç). St37'nin plazma nitrülenmesi ise uzun sürelerde belirgin aşınma artışıyla en olumsuz performansı sergilemiş; bu durum düşük karbonlu altlıkta oluşan kırılabilir bileşik tabakanın cam parçacığı darbeleri altında mikro-çentiklenmeye yatkın olmasına bağlanabilir. Buna karşılık 4140 çeliğinin plazma nitrülenmesi açık ara en iyi sonuçları üretmiş, zamanla artışı çok sınırlı kalan en düşük aşınma eğrisi elde edilmiştir. Muhtemel neden, 4140'ın alaşım elementleriyle desteklenen daha derin/kararlı difüzyon tabakasının yük taşıma kapasitesini artırması ve mikro-çatlak ilerlemesini baskılamasıdır. Sonuç olarak, en uygun seçenek 4140 + plazma nitrüleme kombinasyonudur. St37 kullanılacaksa sementasyon tercih edilmeli, St37'de plazma nitrüleme yönteminin bu uygulama için uygun olmadığı dikkate alınmalıdır. Bulgular, bıçak tasarımı ve bakım stratejileri için doğrudan yönlendirici niteliktedir.

**Anahtar kelimeler:** Depozito iade sistemleri, cam kırma bıçakları, St37 çeliği, 4140 çeliği, yüzey serleştirme, aşınma davranışı

## INVESTIGATION OF THE TRIBOLOGICAL PERFORMANCE OF GLASS CRUSHING BLADES USED IN DEPOSIT RETURN SYSTEMS IN RELATION TO MATERIAL AND SURFACE TREATMENTS

### ABSTRACT

Deposit return systems play a critical role in the recycling of glass packaging, and the tribological performance of glass crushing blades used in these systems directly affects overall efficiency. The high hardness and brittleness of glass expose the blades to severe abrasion, impact, and micro-crack formation, leading to rapid material loss and a shortened service life. In this study, the effectiveness of different materials and surface engineering methods was experimentally investigated to improve the wear behavior of these blades. Low-carbon St37 steel and alloyed AISI 4140 steel were selected as base materials; carburizing and plasma nitriding were applied to St37, while plasma nitriding was applied to 4140. A custom-designed test rig simulating real operating conditions with glass particles was used, and the specimens were tested at different durations (15–75 minutes). The results showed that untreated 4140 exhibited higher wear compared to St37, indicating that alloying alone does not ensure superior performance. Carburized St37 produced consistently lower cumulative wear losses than untreated St37, providing a clear improvement (except for a short initial “running-in” stage). Plasma-nitrided St37, however, displayed the poorest performance at longer test durations, with significantly increased wear attributed to the formation of a brittle compound layer on the low-carbon substrate that was prone to micro-chipping under glass particle impacts. In contrast, plasma-nitrided 4140 yielded by far the best results, with the lowest wear curve and only minimal increases over time. This can be explained by the deeper and more stable diffusion layer supported by the alloying elements of 4140, which enhanced load-bearing capacity and suppressed micro-crack propagation. In conclusion, the optimal option is the 4140 + plasma nitriding combination. If St37 is to be used, carburizing should be preferred, whereas plasma nitriding is not suitable for this steel in such applications. These findings provide direct guidance for blade design and maintenance strategies in deposit return systems.

**Keywords:** Deposit return systems, glass crushing blades, St37 steel, 4140 steel, surface hardening, wear behavior

### 1. GİRİŞ

Cam ambalajların geri dönüşüm sürecinde depozito iade sistemleri, dögüsel ekonominin en önemli bileşenlerinden biri olarak öne çıkmaktadır. Bu sistemlerde toplanan cam ürünlerin yeniden ergitilmeden önce hacimlerinin azaltılması amacıyla kırılması, hem lojistik verimliliği artırmakta hem de geri dönüşüm sürecinde enerji tüketimini minimize etmektedir [1-3]. Özellikle camın yoğunluğu ve hacimsel ağırlığı dikkate alındığında, kırma yoluyla gerçekleştirilen hacim küçültme işlemi, depolama ve taşıma maliyetlerini düşürmekte ve camın kapalı döngü geri dönüşüm sistemlerinde etkin biçimde yeniden kazanılmasına katkı sağlamaktadır [4,5]. Ancak camın yüksek sertlik ve gevrekliği, kırma işlemini gerçekleştiren bıçaklarda oldukça zorlayıcı koşullar oluşturmaktadır. Cam parçacıklarıyla sürekli temas eden bu bıçaklar, yüksek darbe, sürtünme ve abrazif yükler altında çalışmakta; bunun sonucunda kırıcı yüzeylerde hızlı malzeme kaybı, yüzey pürüzlülüğünde artış, mikro-çatlak oluşumu ve kesme performansında düşüş meydana gelmektedir [6-8]. Literatürde, cam kırıcı uygulamalarda aşınmanın esas olarak parçacık aracılı aşınma, darbe kaynaklı mikro-çentiklenme ve gevrek çatlak ilerlemesi ile karakterize olduğu bildirilmektedir [9-12]. Bu bağlamda, malzemenin mikroyapısal özellikleri, yüzey sertliği ve tokluğu, tribolojik performans üzerinde belirleyici parametreler olarak öne çıkmaktadır [13].

Yapılan çalışmalarda düşük karbonlu çeliklerin bu tür koşullar altında sınırlı performans sergilediği; alaşımli çeliklerin ise özellikle uygun yüzey mühendisliği yöntemleriyle (ör. sementasyon, plazma nitrüleme, difüzyon temelli yüzey modifikasyonları) desteklendiğinde aşınma direncinde belirgin iyileşmeler sağladığı vurgulanmaktadır [14–17]. Nitekim yüzey sertleştirme tekniklerinin abrazyon aşınmayı azalttığı, mikro-çatlak ilerlemesini yavaşlattığı ve bileşenlerin servis ömrünü uzattığı çeşitli triboloji çalışmalarında ortaya konmuştur.

Bununla birlikte, literatürde cam kırma bıçaklarının aşınma davranışına yönelik doğrudan araştırmalar oldukça sınırlı olup, mevcut çalışmaların çoğu genel tribolojik değerlendirmeler veya farklı endüstriyel uygulamalar üzerine yoğunlaşmaktadır [18,19]. Bu eksiklik, depozito iade makinelerinde kullanılan cam kırma bıçaklarının malzeme seçimi ve yüzey mühendisliği uygulamaları açısından sistematik olarak incelenmesini gerekli kılmaktadır. Bu çalışma, farklı çelik malzemeler (St37 ve 4140) ve yüzey modifikasyonlarının (sementasyon ve plazma işlemleri) cam kırma koşullarındaki aşınma davranışı üzerindeki etkisini deneysel olarak ortaya koyarak, hem literatürdeki boşluğu doldurmayı hem de endüstriyel uygulamalar için yol gösterici bulgular sunmayı amaçlamaktadır.

## 2. DENEYSEL ÇALIŞMALAR

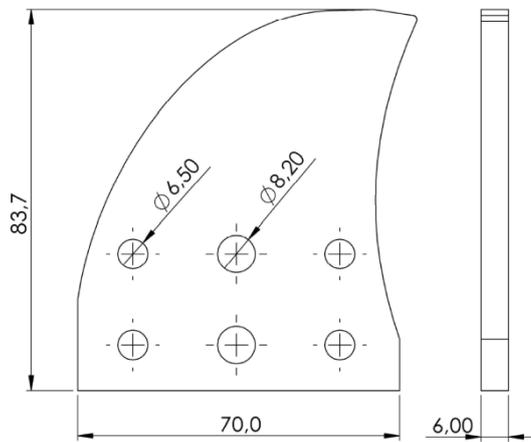
Deneyler için iki farklı çelik malzeme seçilmiştir: düşük karbonlu yapı çeliği St37 ve alaşımli çelik AISI 4140. Bu malzemelerin kimyasal bileşimleri ve mekanik özellikleri sırasıyla Tablo 1 ve Tablo 2’de sunulmaktadır. Deneysel aşınma testlerinde kullanılan cam kırma bıçaklarının boyutları ve görüntüsü de Şekil 1’de verilmiştir.

Tablo 1. St37 ve 4140 çeliklerinin kimyasal bileşimleri (ağırlıkça %).

Malzeme	C	Mn	Si	P	S	Cr	Mo	Ni	Fe
St37	0.12-0.20	0.40-1.00	≤ 0.30	≤ 0.045	≤ 0.045	–	–	–	Kalan
4140	0.38-0.43	0.75-1.00	0.15-0.35	≤ 0.035	≤ 0.040	0.90-1.20	0.15-0.25	≤ 0.25	Kalan

Tablo 2. St37 ve 4140 çeliklerinin mekanik özellikleri.

Malzeme	Akma Dayanımı (MPa)	Çekme Dayanımı (MPa)	Sertlik (HB)	Uzama (%)
St37	~235	360-510	120–180	26–28
4140	655-950	850-1000	200–300	12–20



a)



b)

## Şekil 1. Aşınma deneylerinde kullanılan cam kırma bıçağının boyutları (a) ve görüntüsü (b)

Çalışmada, cam kırma bıçaklarının aşınma performansını artırmak amacıyla farklı yüzey sertleştirme yöntemleri uygulanmıştır. Düşük karbonlu St37 çeliğine, hem sementasyon hem de plazma nitrürleme işlemleri uygulanmıştır. St37 çeliğine sementasyon işlemi, 940 °C sıcaklıkta 3 saat süre ile karbon potansiyeli 1,2 olan ortamda gerçekleştirilerek yüzeyde karbon difüzyonu sağlanmış ve ardından yağ banyosunda hızlı soğutulmuştur. Ardından 940 °C'de 75 dk süresince menevişleme işlemine tabi tutulmuştur. Plazma nitrürleme işlemi ise hem St37 hem de 4140 çeliklerine uygulanmıştır. İşlem, 450 °C sıcaklıkta azot-hidrojen gaz karışımı atmosferinde 12 saat süre ile gerçekleştirilmiştir. Plazma ortamında azot iyonlarının yüzeye difüzyonu ile sert nitrür tabakası oluşmuş, bu sayede yüzey sertliği ve aşınma direnci artırılmıştır. 4140 çeliğine sementasyon uygulanmamıştır, çünkü bu malzeme zaten orta karbonlu ve alaşımlı yapısı nedeniyle doğrudan ısıl işlem ve nitrürleme yöntemleriyle daha etkin sonuçlar vermektedir. Bu nedenle 4140 üzerinde yalnızca plazma nitrürleme değerlendirilmiştir. Bu çalışmada kullanılan deney grupları ve uygulanan yüzey modifikasyonları Tablo 3'de verilmiştir.

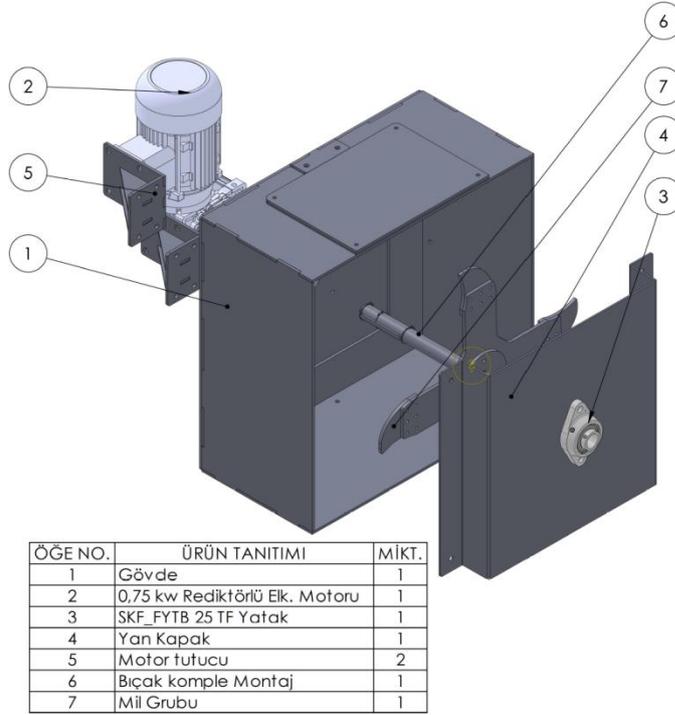
Tablo 3. Deney grupları ve uygulanan yüzey modifikasyonları.

Numune Kodu	Yüzey Modifikasyonu	Açıklama
St37	–	İşlemsiz referans numunesi
St37-S	Sementasyon	940 °C'de sementasyon + yağda sertleştirme + 180 °C'de menevişleme
St37-PN	Plazma nitrürleme	450 °C, 12 saat, N <sub>2</sub> -H <sub>2</sub> atmosferinde
4140	–	İşlemsiz referans numunesi
4140-PN	Plazma nitrürleme	450 °C, 12 saat, N <sub>2</sub> -H <sub>2</sub> atmosferinde

Aşınma davranışının değerlendirilmesinde malzemelerin sertlik özellikleri kritik rol oynamaktadır. Bu nedenle tüm numunelerde aşınma testleri öncesinde Vickers mikrosertlik ölçümleri gerçekleştirilmiştir. Referans numunelerinde sertlik yüzeyden alınmış olup, her numune için en az 10 tekrar alınarak ortalama değerler hesaplanmıştır. Yüzey modifikasyonu uygulanmış numunelerde sertlik dağılımının derinlik boyunca değişimini belirlemek için bıçak numuneleri hassas metalografik kesme cihazı ile kesit alınacak şekilde kesilmiş, ardından standart metalografik yöntemlerle zımparalama ve parlatma işlemleri uygulanarak ölçüme uygun yüzeyler elde edilmiştir. Bu kapsamda, sementasyon ve plazma nitrürleme uygulanmış numunelerde, yüzeyden itibaren 40 µm aralıklarla derinlik boyunca ölçümler alınmıştır. Tüm sertlik ölçümleri 25 g yük ve 10 sn bekleme süresi ile yapılmıştır.

Çalışmada, cam kırma bıçaklarının gerçek çalışma koşullarını tribolojik açıdan simüle edebilmek amacıyla özel bir deney düzeneği tasarlanmış ve imal edilmiştir. Düzeneğin tasarımında, depozito iade makinelerinde kullanılan kırıcı sistemlerin temel aşınma koşulları dikkate alınmıştır. Tasarlanan cihaz, cam parçacıkları ile sürekli temas halinde olan numune yüzeyine darbeli yükler ve sürtünme hareketi uygulayacak şekilde geliştirilmiş olup, bu sayede bıçakların maruz kaldığı abrazyon, darbe kaynaklı mikro-çentiklenme ve çatlak ilerlemesi gibi aşınma mekanizmaları laboratuvar ortamında simüle edilmiştir. Tasarlanan ve üretilen deney cihazı Şekil 2'de verilmiştir. Düzeneğin en önemli özelliklerinden biri, test süresi ve çevrim sayısının elektronik bir kontrol ünitesi aracılığıyla hassas bir şekilde kontrol edilebilmesidir. Ayrıca, literatürde cam kırma bıçakları üzerine doğrudan deneysel sistemlerin sınırlı olması nedeniyle bu düzenek, özgün bir katkı sunmaktadır. Gerçek sistemlerin tribolojik koşullarını laboratuvar ortamına ölçekleyerek tekrarlanabilir ve kontrollü aşınma testleri yapılmasına imkân sağlamaktadır. Deney düzeneği aynı anda dört bıçak numunesinin test edilmesine

olanak tanımaktadır. Numuneler, belirli büyüklükte ve miktarda cam parçacıkları içerisinde (115 adet cam şişenin kırığı), test esnasında 110 dev/dak hızla döndürülmüştür. Her test başında cam parçacıkları değiştirilerek deneylerin tekrarlanabilirliği artırılmıştır. Deneyler, 15, 30, 45, 60 ve 75 dakika sürelerle gerçekleştirilmiş; her süre sonunda numuneler çıkarılarak kütle kaybı ölçülmüştür. Ölçüm öncesinde tüm numuneler ultrasonik banyo ile temizlenmiş ve  $10^{-4}$  g hassasiyetine sahip terazide tartılarak aşınma kayıpları belirlenmiştir. Numunelerin aşınma kayıplarının belirlenmesinde 3 numunenin ortalaması alınmıştır.



Şekil 2. Cam kırma bıçaklarının aşınma testleri için tasarlanan deney düzeneği.

### 3. SONUÇLAR VE TARTIŞMA

Çalışmada, ST37 ve 4140 çelikleri, sementasyon ve plazma nitrürleme işlemlerinin yüzey sertliği üzerindeki etkileri açısından karşılaştırılmıştır. İşlem uygulanmamış numunelerde ortalama sertlik değerleri ST37 için 174,5 HV<sub>0.05</sub>, 4140 için 203,2 HV<sub>0.05</sub> olarak belirlenmiştir. 4140 çeliğinde bulunan Cr ve Mo alaşım elementleri, çekirdek sertliğini ST37'ye göre yaklaşık %16 oranında artırmıştır.

Tablo 4. St37 ve 4140 çeliklerinin Vickers sertlik ölçüm sonuçları.

Ölçüm No	ST37 Sertlik (HV0.05)	4140 Sertlik (HV0.05)
1	207,4	188,1
2	193,0	183,4
3	183,2	188,8
4	123,8	194,2
5	140,0	223,6
6	164,3	202,0
7	174,5	217,5
8	182,2	239,9

Ölçüm No	ST37 Sertlik (HV0.05)	4140 Sertlik (HV0.05)
9	185,7	216,0
10	190,5	178,9
<b>Ortalama</b>	<b>174,5</b>	<b>203,2</b>

St37 çeliğinde sementasyon sonrası yüzey sertliği 626,8 HV<sub>0.05</sub>'e ulaşmış, bu değer çekirdek sertliğinin yaklaşık 3,5 katı seviyesindedir (Tablo 5 ve Şekil 3). Sertlik profili, 2,0 mm derinlik civarına kadar belirgin bir azalma eğilimi göstermekte olup, bu bölge etkin karbon difüzyon derinliği olarak tanımlanabilir. 2,0 mm derinliğin altında sertlik değerleri 300 HV civarında sabitlenmiştir. Sementasyon prosesi sonrası uygulanan yağda su verme işlemi, çekirdek bölgesinde martenzitik dönüşümün gerçekleşmesini de sağlayarak çekirdek sertliğinde belirgin bir artışa neden olmuştur. St37'nin plazma nitrüleme sonrası yüzey sertliği ise 267 HV<sub>0.05</sub> olarak ölçülmüş, bu değer sementasyonlu numunelere göre oldukça düşüktür (Tablo 6 ve Şekil 4). Bu durum, ST37 çeliğinde nitrür oluşumunu stabilize eden uygun alaşım elementlerinin (örn. Cr, Mo, Al, V) bulunmaması ile ilişkilidir. Yaklaşık 200–300 µm derinliğe kadar sertlik değerleri 220 HV<sub>0.05</sub> civarında kalmış, ardından çekirdek bölgede 160–180 HV<sub>0.05</sub> seviyelerine düşmüştür. Sonuçlar, plazma nitrüleme işleminin ST37 gibi düşük karbonlu çeliklerde sınırlı yüzey sertliği artışı sağladığını göstermiştir.

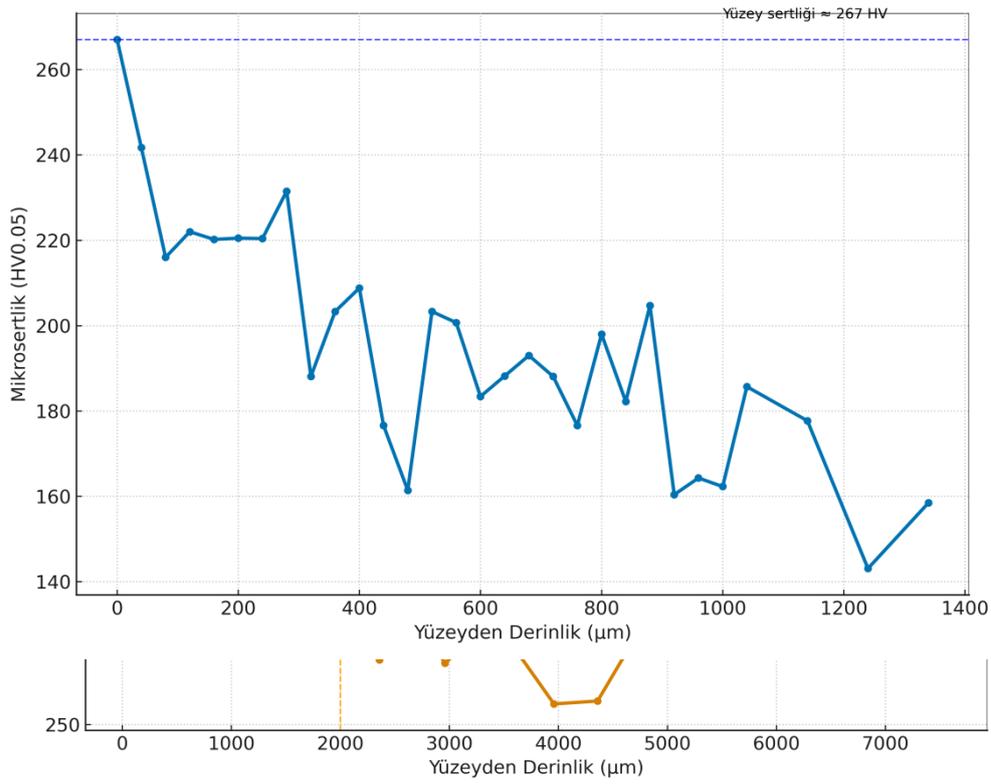
Tablo 5. Sementasyon uygulanmış ST37 çeliğinde derinliğe bağlı mikrosertlik dağılımı.

Ölçüm Derinliği (µm)	Sertlik (HV <sub>0.05</sub> )
40	626,8
80	497,8
120	519,1
160	572,3
260	559,8
360	541,8
460	519,1
560	605,5
660	578,8
760	497,8
860	487,8
960	477,8
1060	473,0
1160	432,8
1260	459,0
1360	468,3
1460	376,3
1560	428,6
1660	424,5
1760	420,5
1860	393,8
1960	356,7
2160	404,9
2360	294,3

Ölçüm Derinliği ( $\mu\text{m}$ )	Sertlik ( $\text{HV}_{0.05}$ )
2560	341,6
2760	316,8
2960	292,0
3160	306,4
3360	308,9
3560	306,4
3960	264,1
4360	266,1
4760	316,6
5160	330,1
5760	308,9

Şekil 3. Sementasyon derinliğe bağlı mikrosertlik

uygulanmış ST37 çeliğinde profili.



Şekil 4. Plazma nitrürleme uygulanmış ST37 çeliğinde derinliğe bağlı mikrosertlik profili.

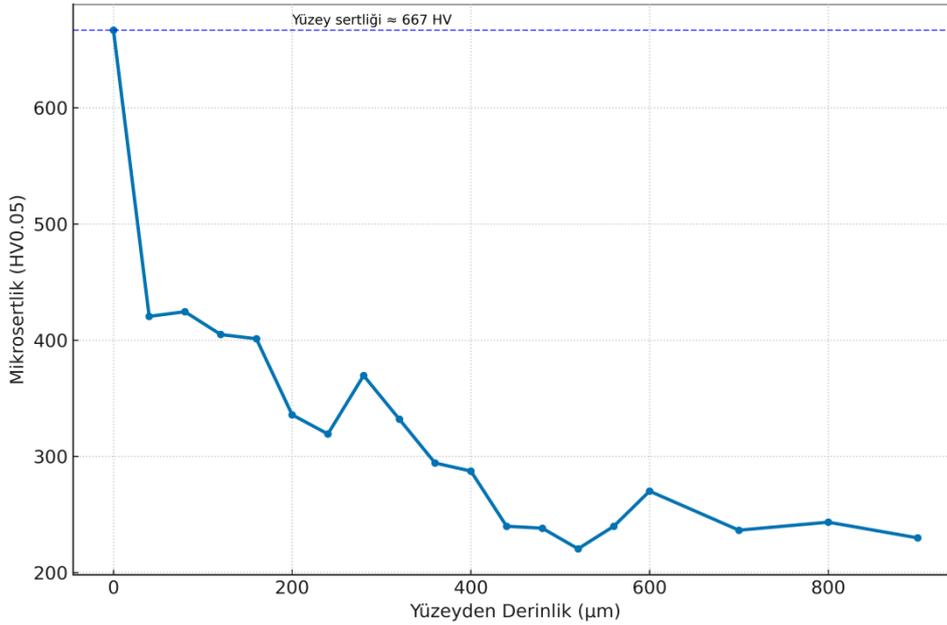
Tablo 6. Plazma nitrürleme uygulanmış ST37 çeliğinde derinliğe bağlı mikrosertlik dağılımı.

Ölçüm Derinliği ( $\mu\text{m}$ )	Sertlik ( $\text{HV}_{0.05}$ )
0	267,0
40	241,7
80	216,0
120	222,0
160	220,2
200	220,5
240	220,4
280	231,5
320	188,1
360	203,3
400	208,8
440	176,6
480	161,4
520	203,3
560	200,7
600	183,4
640	188,2
680	193,0
720	188,1
760	176,6
800	198,0
840	182,2
880	204,7
920	160,4
960	164,3
1000	162,3
1040	185,7
1140	177,7
1240	143,1
1340	158,5

4140 çeliğinde plazma nitrürleme sonrası yüzey sertliği 666,8 HV değerine ulaşmıştır (Tablo 7 ve Şekil 5). Bu oldukça yüksek sertlik, yüzeyde  $\text{Fe}_{2-3}\text{N}$  ( $\epsilon$ - $\gamma'$ ) bileşik tabakası oluşumuna işaret etmektedir. Difüzyon bölgesinde sertlik kademeli olarak azalarak 0,5 mm derinliğin ötesinde 230–250  $\text{HV}_{0,05}$  seviyelerine düşmüştür. 4140 çeliğinin Cr, Mo ve V içeriği, azotla birleşerek yüksek sertlikte nitrür fazlarının oluşumunu teşvik etmiş; bu sayede yüzeyde yüksek aşınma direnci, çekirdekte ise tokluk korunmuştur. St37 çeliğinde sementasyon işlemi, 4140 çeliğinde ise plazma nitrürleme işlemi etkin yüzey sertleştirme yöntemleri olarak belirlenmiştir. Alaşımli 4140 çeliğinin nitrürleme sonrası gösterdiği yüksek sertlik, alaşım elementlerinin azotla oluşturduğu kararlı fazların sertlik performansını belirgin biçimde artırdığını ortaya koymuştur.

Tablo 7. Plazma nitrürleme uygulanmış 4140 çeliğinde derinliğe bağlı mikrosertlik dağılımı.

Ölçüm Derinliği ( $\mu\text{m}$ )	Sertlik (HV <sub>0.05</sub> )
0	666,8
40	420,5
80	424,5
120	404,9
160	401,2
200	335,8
240	319,3
280	369,6
320	332,0
360	294,3
400	287,4
440	239,9
480	238,2
520	220,5
560	239,9
600	270,1
700	236,5
800	243,4
900	229,9



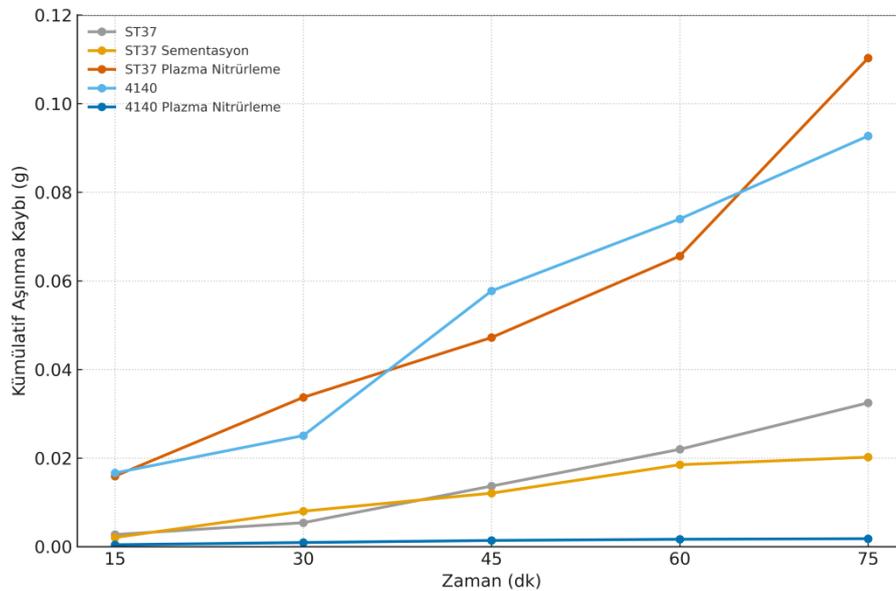
Şekil 5. Plazma nitrürleme uygulanmış 4140 çeliğinde derinliğe bağlı mikrosertlik profili.

Yapılan karşılaştırmalı aşınma testleri sonucunda, yüzey işlemi uygulanmamış 4140 çeliğinin St37'ye kıyasla daha yüksek kümülatif aşınma kaybı sergilediği belirlenmiştir (Tablo 8 ve Şekil 6). Bu durum, 4140 çeliğinin alaşım elementi içeriğinin tek başına aşınma direnci açısından belirleyici olmadığını

göstermiştir. St37 çeliğinin sementasyon işlemi yüzey işlemi uygulanmamış St37'ye göre daha düşük kümülatif aşınma değerleri üretmiştir. Bu iyileşme, sementasyon ile yüzeyde oluşan yüksek karbonlu martenzitik fazın aşınma direncini artırması ve yüzey sertliğinin çekirdek bölgeye göre yaklaşık 3,5 kat yükselmesiyle ilişkilidir. Ancak, testin başlangıcındaki kısa "alışma" evresinde sementasyon tabakasında hafif bir aşınma artışı gözlenmiştir; bu durum, yeni oluşmuş tabakanın pürüzlü yüzeyinin oturmasıyla ilişkilendirilebilir. Plazma nitrüleme işlemi uygulanmış St37 numunesi, test süresi boyunca belirgin şekilde yüksek aşınma değerleri göstermiştir. Özellikle 45. dakikadan itibaren eğrinin eğimi artmış, bu da düşük karbonlu altlık üzerinde oluşan kırılğan bileşik tabakanın cam partiküllerinin darbe etkileri altında mikro-çatlak ve mikro-çentiklenmeye karşı düşük direnç sergilemesiyle açıklanabilir. Ayrıca, St37 çeliğinde nitrülenmeyi stabilize edecek Cr, Mo, Al, V gibi alaşım elementlerinin bulunmaması, hem azot difüzyon derinliğini sınırlamış hem de oluşan fazların süreksiz ve gevrek bir karakter kazanmasına neden olmuştur. Buna karşılık, 4140 çeliğinin plazma nitrülenmesi açık ara en düşük kümülatif aşınma kaybını üretmiştir. Bu üstün performans, 4140 çeliğinin içerdiği alaşım elementleri (özellikle Cr, Mo) sayesinde oluşan daha kalın, kararlı ve sert nitrür difüzyon tabakasının aşınma yüklerini taşıyabilmesi ve mikro-çatlak ilerlemesini engellemesiyle ilişkilidir. Cam parçacıklı tribolojik yükleme koşullarında en uygun yüzey modifikasyonu 4140 + plazma nitrüleme kombinasyonu olarak belirlenmiştir. Düşük karbonlu St37 çeliği kullanılacaksa sementasyon işlemi, aşınma direncinde anlamlı iyileşme sağladığından tercih edilmelidir. Buna karşın, plazma nitrüleme işlemi St37 için uygun değildir, çünkü düşük alaşım içeriği bu proseste hedeflenen yüzey sertliği ve difüzyon derinliğinin oluşmasına izin vermemektedir.

Tablo 8. Yüzey işlemi uygulanmış ve uygulanmamış St37 ile 4140 çeliklerinde zamana bağlı kümülatif aşınma kaybı değerleri.

Zaman (dk)	ST37	ST37 Sementasyon	ST37 Plazma Nitrüleme	4140	4140 Plazma Nitrüleme
15	0,00273	0,00207	0,01593	0,01663	0,00043
30	0,00540	0,00800	0,03370	0,02507	0,00093
45	0,01367	0,01207	0,04720	0,05773	0,00140
60	0,02197	0,01850	0,06560	0,07397	0,00167
75	0,03247	0,02020	0,11027	0,09270	0,00180



Şekil 6. Yüzey işlemi uygulanmış ve uygulanmamış St37 ile 4140 çeliklerinde zamana bağlı kümülatif aşınma kaybı değişimi.

#### 4. SONUÇLAR

Bu çalışmada, depozito iade sistemlerinde kullanılan cam kırma bıçaklarının tribolojik performansını iyileştirmek amacıyla St37 ve 4140 çeliklerine uygulanan yüzey sertleştirme işlemlerinin etkileri incelenmiştir. Deneysel bulgular aşağıda özetlenmiştir:

Alaşımli 4140 çeliği, işlem görmemiş durumda St37'ye kıyasla daha yüksek sertliğe sahip olmasına rağmen, cam parçacıklı aşınma testlerinde daha yüksek kütle kaybı sergilemiştir. Bu durum, aşım elementlerinin varlığının tek başına aşınma direncini garanti etmediğini göstermiştir.

Sementasyon işlemi, St37 çeliğinde yüzey sertliğini yaklaşık 3,5 kat artırarak 626,8 HV<sub>0.05</sub> seviyesine yükseltmiştir. Karbon difüzyonu sonucu oluşan yüksek karbonlu martenzitik yüzey tabakası, 2 mm derinliğe kadar etkin bir sertlik gradyanı sağlamış ve mevcut tribo-sistemde aşınma direncini artırmıştır.

Plazma nitrüleme sonrası St37 çeliğinde yüzey sertliği 267 HV<sub>0.05</sub> civarında kalmış, bu da sementasyonlu numuneye göre oldukça düşüktür. Azotla kararlı bileşik fazlar oluşturacak Cr, Mo, Al, V gibi elementlerin eksikliği nedeniyle nitrür tabakası ince ve kırılabilir bir yapı sergilemiştir. Bu yapı cam parçacıklarıyla etkileşimde mikro-çentiklenme ve tabaka kopmasıyla hızla aşınmıştır. Dolayısıyla düşük karbonlu St37 için plazma nitrüleme uygun bir yöntem değildir.

4140 çeliğinde plazma nitrüleme sonrası yüzey sertliği 666,8 HV<sub>0.05</sub> seviyesine ulaşmıştır. Aşım elementlerinin (Cr, Mo) azotla kararlı nitrür fazları oluşturması sayesinde daha kalın ve dayanıklı bir difüzyon tabakası meydana gelmiş, aşınma testlerinde açık ara en düşük kümülatif kütle kaybı bu numunede elde edilmiştir.

Tüm test sonuçları, 4140 + plazma nitrüleme kombinasyonunun en yüksek aşınma direncini sağladığını göstermiştir. St37 çeliği kullanılacaksa sementasyon işlemi tercih edilmelidir. Plazma nitrüleme işlemi düşük karbonlu çeliklerde sınırlı sertlik artışı ve kırılabilir tabaka oluşumu nedeniyle uygun değildir.

4140 çeliğine uygulanan plazma nitrüleme işlemi, cam parçacıklı tribolojik koşullarda en üstün performansı sunmuş; bu kombinasyonun cam kırma bıçaklarının servis ömrünü uzatmak ve bakım sıklığını azaltmak açısından en uygun çözüm olduğu belirlenmiştir.

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## DEPOLITICIZED DEMOCRACY: ELECTORAL INVINCIBILITY AND THE EROSION OF ACCOUNTABILITY IN ALBANIA (2013–2025)

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### Abstract

This paper explores the phenomenon of depoliticization in Albania's political sphere, focusing on the period marked by the unbroken dominance of the ruling Socialist Party from 2013 to 2025. Drawing conceptually on Pierre Manent's reflections on modern democracy and political representation, the study argues that Albania exhibits a form of systemic depoliticization, wherein the mechanisms of political competition no longer produce real alternatives or accountability. The ruling party appears electorally invincible, transforming elections into ritualistic confirmations rather than genuine contests of power. Consequently, it bears little to no accountability to the electorate. Simultaneously, the opposition, chronically fragmented and electorally ineffective, also escapes democratic responsibility, as it is not perceived as a credible governing alternative. This mutual detachment from electoral accountability produces a hollowing out of the political field, where democratic forms persist but the substance of political contestation erodes. The paper situates this Albanian experience within broader concerns about the decline of political life in contemporary democracies, as theorized by Manent, and calls for a critical reassessment of institutional incentives that perpetuate this political stagnation.

**Keywords:** Albania, Depoliticization, Democratic accountability, Electoral dominance, Political opposition, Political representation, Party system stagnation

### 1. Introduction

The period 2013–2025 in Albania represents a paradigmatic case of what contemporary scholars describe as the erosion of democratic substance behind the façade of procedural continuity. The uninterrupted rule of the Socialist Party of Albania (SPA) under Prime Minister Edi Rama has not been accompanied by democratic deepening, but rather by the weakening of alternation, political accountability, and representational pluralism. The aim of this paper is to analyze this condition as a form of systemic depoliticization, whereby democracy persists as a *form*, but political contestation—the lifeblood of democratic *substance*—is effectively suspended.

Drawing from the political philosophy of Pierre Manent, and engaging with theories of post-democracy (Crouch, 2004), depoliticization (Flinders & Buller, 2006), and competitive authoritarianism (Levitsky & Way, 2010), this paper argues that Albania exemplifies a regime form in which elections become ritualized, the ruling elite is entrenched, and the opposition disarticulated. As elections cease to offer real alternatives, and managerial logic replaces ideological conflict, the citizen is transformed from a political subject into a passive observer.

### 2. Theoretical Framework: Manent, Representation, and the Disappearance of Politics

Pierre Manent (2006) insists that the essence of democracy lies in representation—not merely as a mechanism of delegation, but as a political form that enables society to govern itself through the

articulation of competing worldviews. Representation requires real alternatives, meaningful choice, and ideological distance between parties.

Depoliticization, by contrast, is the *erosion of those distinctions*. According to Flinders and Buller (2006), depoliticization occurs when policy issues are transferred away from democratic arenas to insulated bodies, often in the name of neutrality or expertise. Similarly, Crouch (2004) defines post-democracy as a condition in which the institutions of democracy remain, but where elite dominance, technocratic governance, and citizen disengagement prevail.

These theories converge on four core indicators:

Electoral ritualism – elections exist but are hollowed of alternation.

Elite entrenchment – incumbents monopolize access to state resources.

Opposition disarticulation – alternative parties are fragmented or delegitimized.

Managerial substitution – ideology gives way to technocratic or aesthetic governance.

### **3. The Dominance of the Socialist Party: From Contestation to Confirmation**

From 2013 to 2025, the Socialist Party won three successive parliamentary elections (2013, 2017, 2021), each time consolidating its grip on the state. The 2017 victory gave the SPA a rare single-party majority, a feat repeated in 2021 despite the introduction of open lists and changes to the electoral code (European Commission, 2021).

Multiple mechanisms enabled this dominance:

State patronage: Public sector jobs, procurement contracts, and local investments were frequently politicized to benefit SPA supporters (Freedom House, 2023).

Media manipulation: Most national media outlets were either owned by SPA-affiliated figures or influenced through state advertising (Reporters Without Borders, 2022).

Electoral engineering: In 2020, SPA altered the electoral system unilaterally, weakening coalition mechanisms and increasing disproportionality (OSCE/ODIHR, 2021).

These conditions produced electoral invincibility—a condition in which elections no longer serve to replace governments, but to confirm them.

### **4. The Opposition Crisis: Fragmentation and Institutional Abdication**

Parallel to the SPA's rise, the Democratic Party (PD)—once the main vehicle for alternation—underwent institutional collapse. Following the 2019 boycott of parliament and local elections, the PD effectively abandoned the formal arena of politics (Balkan Insight, 2020). The 2021 internal split between Lulzim Basha and Sali Berisha further fractured the party, resulting in two rival factions each claiming legitimacy (Erebara, 2022).

This fragmentation had three critical consequences:

Loss of coherence: Competing narratives within the PD created confusion and weakened public identification.

Organizational decay: Local structures deteriorated, especially after the withdrawal from the 2019 local elections.

Absence of platform: The PD failed to articulate a credible policy alternative to the SPA, relying instead on anti-corruption rhetoric and populist appeals.

As Sartori (1976) warned, a system without a viable opposition risks becoming *hegemonic pluralism*—a form where elections exist, but political alternation is functionally blocked.

## 5. International Actors and the Proceduralization of Democracy

Albania's path toward EU accession has brought intense international involvement in domestic reforms. The 2016–2020 Justice Reform, supported by the EU and U.S. government, sought to vet judges and prosecutors and create a more independent judiciary (Krasniqi & Elbasani, 2021). However, the process also outsourced democratic responsibility to unelected bodies and bypassed the need for political consensus.

Election monitoring reports by OSCE/ODIHR (2021) repeatedly emphasize procedural compliance—voter registration, campaign finance, ballot secrecy—while largely ignoring systemic imbalances in access to media or state resources.

This form of external proceduralism contributes to depoliticization by shifting legitimacy from internal accountability to international validation. As Manent (2006) argues, when democracy becomes a series of technical procedures divorced from national self-government, it loses its political vitality.

A defining feature of Edi Rama's leadership has been the transformation of political discourse from ideological engagement to managerial modernism. Initiatives such as e-Albania, the “Rilindja Urbane” projects, and digitalization of public services are promoted as symbols of progress, modernization, and aesthetics rather than political choices.

Rama's rhetoric often frames politics as an obstacle to governance, and his persona blurs the line between leader, artist, and brand (Mërtiri, 2021). In this vision:

Citizens become consumers, evaluating performance rather than engaging in deliberation.

Policy becomes administration, not contestation.

Politics becomes aestheticized, with grand urban projects serving as the regime's symbolic legitimacy.

This is consistent with Bernard Manin's (1997) notion of *audience democracy*, where political performance replaces representative government.

## 6. Findings

The analysis of Albania's political trajectory between 2013 and 2025 reveals a clear pattern of systemic depoliticization, unfolding across four interrelated dimensions: electoral dominance, opposition fragmentation, international proceduralism, and the substitution of ideological discourse with managerial governance. These findings demonstrate that while the formal structures of democracy remain intact, the substantive content—representation, contestation, and participation—has been severely eroded.

### 6.1 Electoral Dominance as Political Ritual

Across three successive electoral cycles (2013, 2017, 2021), the Socialist Party (SPA) has maintained parliamentary majorities and formed single-party governments, an exceptional pattern in the post-communist region. Rather than signaling democratic vitality, these repeated victories reflect:

Instrumental use of state resources in electoral campaigns, including public employment, procurement contracts, and selective enforcement of judicial investigations (Freedom House, 2023);

Manipulation of the electoral framework, particularly the 2020 constitutional amendments, which were enacted unilaterally by the ruling majority and weakened coalition-building mechanisms (European Commission, 2021);

International legitimation through procedural assessments, which emphasized technical correctness while neglecting structural inequalities in access to media and public funding (OSCE/ODIHR, 2021).

The result is a context in which elections no longer serve their primary democratic function of power rotation, but operate instead as rituals of reaffirmation.

## **6.2 Opposition Disintegration and the Collapse of Representation**

Rather than providing a viable democratic alternative, the opposition—chiefly the Democratic Party (DP)—underwent an institutional and moral breakdown. Key findings include:

Institutional self-exclusion, most notably the 2019 parliamentary and local election boycotts, which effectively ceded institutional space to the SPA (Balkan Insight, 2020);

Leadership fragmentation, with the 2021 split between Sali Berisha and Lulzim Basha resulting in parallel structures and legal disputes over party legitimacy (Erebara, 2022);

Lack of a substantive policy platform, which weakened the party's ability to distinguish itself from the governing majority and reduced its credibility as an alternative governing force.

This disintegration has led to a quasi-monistic political environment, where no actor credibly performs the function of opposition or institutional counterweight.

## **6.3 International Proceduralism and the Displacement of Domestic Legitimacy**

A striking finding is the extent to which key institutional reforms—particularly the Justice Reform (2016–2020)—were designed and implemented under the auspices of international actors, primarily the European Union and the United States (Krasniqi & Elbasani, 2021). This external guidance produced several dynamics:

Substitution of domestic consensus with conditionality, sidelining public debate and political negotiation;

Formalistic assessment of reforms, privileging checklists over democratic depth;

Concentration of power in the executive, through ad hoc institutional arrangements outside the normal constitutional framework.

This process has led to what Manent (2006) would describe as democracy without a demos—a regime where international approval substitutes for national self-government.

## **6.4 Managerial Governance and the Aestheticization of Power**

Under Prime Minister Edi Rama, governance has shifted from ideological contestation to aesthetic and managerial performance. Public initiatives such as urban regeneration (“Rilindja Urbane”), digital governance (e-Albania), and administrative streamlining are framed not as political choices but as apolitical modernization.

Findings indicate that:

Government rhetoric consistently favors technical solutions over ideological deliberation, portraying politics as inefficient or obsolete;

Urban and digital projects serve as legitimacy symbols, reinforcing the image of progress while depoliticizing governance;

The absence of political alternatives has transformed the public sphere into a monologue of power, where dissent is often pathologized or ridiculed.

This managerial discourse replaces pluralist politics with technocratic administration, marginalizing conflict and rendering political engagement unnecessary or illegitimate.

Here we have a table that helps us better understand the relationship of this phenomenon to our country.

Country	Alternation (2010–2024)	Opposition Coherence	Electoral Integrity	Depoliticization Level
<b>Albania</b>	No (2013–2025)	Weak / Fragmented	Formally Valid	High
<b>North Macedonia</b>	Yes	Moderate	Improving	Medium
<b>Serbia</b>	No	Marginalized	Compromised	High (Authoritarian)
<b>Hungary</b>	No	Suppressed	Low	High (Authoritarian)
<b>Romania</b>	Yes	Strong	Competitive	Low

This comparative table shows that while Albania avoids overt authoritarianism, it suffers from post-democratic stagnation. The democratic form persists, but the substance—ideological competition, alternation, and representation—is eroded.

## 7. Discussion

The findings presented above underscore a profound transformation in Albania's democratic architecture during the period 2013–2025—a transformation not toward authoritarianism per se, but toward depoliticized democracy, in which the rituals and forms of democratic governance are preserved while their political content is emptied. Drawing on Pierre Manent's theory of political representation and the broader literature on post-democracy, this discussion section integrates the four dimensions of depoliticization into a coherent diagnosis of Albania's political condition.

### 7.1 From Competitive Elections to Ritual Acclamation

The first and perhaps most visible expression of depoliticization is the conversion of elections from instruments of alternation into mechanisms of confirmation. While Albania continues to hold regular elections, the repeated and increasingly uncompetitive victories of the Socialist Party point to a deeper erosion of the democratic principle of uncertainty in outcomes. As Manin (1997) and Przeworski (1991) argue, democracy presupposes that incumbents can lose; when this principle is no longer operational, the electoral process shifts from contestation to ritual.

This transformation has not occurred through overt repression or vote rigging, but rather through structural asymmetries in state access, media control, and electoral engineering. These asymmetries are then legitimized by international actors, who treat procedural correctness as a sufficient condition for democratic legitimacy, thereby enabling what Levitsky and Way (2010) would call *competitive authoritarian equilibrium*—except that in the Albanian case, the competition is formally allowed but substantively defunct.

## 7.2 The Crisis of Representation and the Vacant Opposition

Closely tied to the ritualization of elections is the collapse of representational pluralism. As the findings indicate, the opposition's inability to sustain institutional presence, articulate ideological positions, and project leadership legitimacy has created a vacuum in the political field. In Manent's terms, the dialectic of representation—the encounter between competing visions of the common good—has been severed, leaving a political space that is formally pluralistic but materially monistic.

This has major implications for accountability. Without a credible opposition, the ruling party is liberated not only from the pressure of alternation but from the necessity of self-restraint, programmatic renewal, or responsiveness to criticism. The opposition's retreat into populist rhetoric and internal conflict reinforces the dominant narrative that no viable alternative exists, further entrenching the status quo.

## 7.3 The Externalization of Legitimacy and the Procedural State

Another key element in Albania's depoliticization is what may be termed the externalization of legitimacy—a process in which the authority and credibility of domestic institutions are increasingly derived from international endorsement rather than internal contestation or citizen trust. The Justice Reform is paradigmatic in this respect. While successful in many of its technical goals, it was imposed through external conditionality, bypassing deliberative politics and further weakening the legitimacy of domestic actors (Krasniqi & Elbasani, 2021).

This phenomenon aligns with what Flinders and Buller (2006) describe as the depoliticized state—a regime that governs through technocratic insulation rather than democratic engagement. In the Albanian context, this dynamic has been compounded by EU conditionality, OSCE assessments, and bilateral diplomatic pressure, all of which promote stability and reform at the expense of pluralism and representation.

## 7.4 Managerialism, Aesthetic Governance, and the Silencing of Politics

Finally, the findings confirm the emergence of a distinctly managerial and aesthetic mode of governance, which replaces political deliberation with branding, efficiency narratives, and symbolic modernization. Edi Rama's leadership style—combining executive control with artistic presentation and digitalization—exemplifies what Manent (2006) would call the eclipse of the political in favor of administration.

This form of rule is not simply non-ideological; it is anti-political in the sense that it delegitimizes dissent as irrational, backward, or obstructive. By monopolizing both the symbols of modernization and the tools of administration, the SPA has created a regime in which contestation is pathologized, opposition is aestheticized as chaos, and the citizen is reduced to a client of services rather than a co-author of laws.

## 7.5 The Albanian Case in Comparative Perspective

While these developments have unique local features, they resonate with broader patterns in post-communist Europe. In contrast to cases like Hungary or Serbia, where depoliticization has occurred alongside authoritarian centralization, Albania represents a more subtle case of technocratic hegemony within democratic form. As shown in the comparative table, Albania lacks the overt suppression seen elsewhere, yet it exhibits an equally robust depoliticization through elite entrenchment, opposition collapse, and international proceduralism.

What distinguishes Albania, therefore, is not the presence of authoritarian tools, but the absence of political alternatives. It is a democracy in which pluralism is legally permitted but socially and institutionally defunct.

## 8. Re-Politicizing Albanian Democracy: Strategic Proposals

Reversing depoliticization requires the revitalization of the political field:

Opposition renewal: Through ideological clarity, leadership legitimacy, and grassroots engagement.

Media pluralism: Policies to counteract media oligopoly and strengthen independent journalism.

Deliberative participation: Creation of citizens' assemblies, participatory budgeting, and consultative processes.

Civic education: Reinforcing the role of political literacy in schools and public discourse.

Re-nationalization of democracy: Shifting the source of legitimacy from international actors back to domestic political engagement.

As Manent (2006) argues, democracy cannot survive without a *demos* that governs itself.

## 9. Conclusion

This study has argued that Albania, between 2013 and 2025, has undergone a subtle but profound transformation: from a fragile post-communist democracy into a depoliticized political system. While the country has avoided the formal slide into authoritarianism seen in other parts of the region, it has not consolidated as a representative democracy in the substantive sense. Instead, what has emerged is a regime form in which elections persist, institutions function procedurally, and reforms are implemented—yet the core of democratic life, namely political contestation, representation, and accountability, has been hollowed out.

At the heart of this transformation is the electoral invincibility of the Socialist Party, which has successfully transformed elections into mechanisms of symbolic ratification rather than genuine choice. Simultaneously, the opposition has failed to offer a credible alternative, either programmatically or organizationally, collapsing into internal conflict and institutional withdrawal. The result is a system where power is no longer meaningfully constrained by political competition.

Compounding this dynamic is the externalization of democratic legitimacy, whereby international actors play a central role in defining and endorsing domestic political outcomes. This process of proceduralization, while intended to support democratic consolidation, has in fact depoliticized reform by removing it from the realm of representative contestation and public deliberation.

Most critically, the regime has shifted toward a managerial and aesthetic mode of governance, where political language is displaced by the vocabulary of efficiency, digitalization, and modernization. As Manent (2006) warns, democracy without conflict, without ideological diversity, and without representative mediation ceases to be a form of self-government and becomes a technocratic shell.

In light of these findings, the Albanian case should not be understood as an outlier, but as a symptom of a broader condition afflicting many post-transition democracies: the retreat of politics under the guise of procedural order. Albania's future as a democratic polity depends not merely on holding regular elections or meeting EU benchmarks, but on repoliticizing public life—restoring ideological conflict, strengthening opposition, enabling real alternatives, and reestablishing democratic representation as a lived, contested process.

The challenge ahead is not only institutional, but philosophical. It requires a renewed understanding of the citizen not as a client of services or a consumer of state products, but as a participant in collective self-rule. Only by recovering the political dimension of democracy—its antagonism, its deliberation, its plurality—can Albania escape the quiet erosion of its democratic promise.

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## **CLAUDIA SHEINBAUM PARDO: ANÁLISIS JURÍDICO Y DE GENERO SOBRE EL LIDERAZGO DE LA PRIMERA PRESIDENTA DE MEXICO.**

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### **Abstract**

This article examines the political leadership of Claudia Sheinbaum Pardo as the first female president of Mexico, from a legal and gender perspective. The analysis focuses on the national and international normative obligations that commit the Mexican State to guarantee substantive equality, as well as the structural challenges that persist in political violence and women's access to justice. The role of the Supreme Court's jurisprudence and international treaties in building a solid legal framework is discussed, while highlighting the gap that remains between law and reality.

### **Introducción**

El ascenso de Claudia Sheinbaum Pardo a la presidencia de México marca un hito histórico en la vida política del país. No obstante, este acontecimiento obliga a repensar críticamente el alcance real de la igualdad de género en la esfera pública. México ha suscrito tratados internacionales como la CEDAW (1979) y la Convención de Belém do Pará (1994), que imponen obligaciones específicas en materia de igualdad sustantiva y erradicación de la violencia contra las mujeres. Sin embargo, la persistencia de fenómenos como la violencia política de género, la subrepresentación en espacios de toma de decisiones y la desigualdad en el acceso a la justicia revelan las tensiones entre norma y práctica. Este artículo propone un análisis jurídico-crítico que, más allá de reconocer avances, evidencia las limitaciones estructurales que enfrenta la democracia mexicana.

### **Planteamiento del problema**

El problema central que orienta este trabajo es la contradicción entre el marco jurídico robusto en materia de igualdad de género y la persistencia de desigualdades estructurales que limitan el ejercicio pleno de los derechos políticos de las mujeres en México. El artículo 1º de la Constitución prohíbe toda forma de discriminación; el artículo 4º reconoce la igualdad entre mujeres y hombres; y el artículo 41 establece la paridad en candidaturas. Además, la jurisprudencia de la Suprema Corte (Tesis 21/2018) consolidó el principio de 'paridad en todo'. Pese a ello, los informes del INE (2024) y de la CNDH evidencian que las mujeres siguen enfrentando violencia política, particularmente en entidades como Oaxaca y Chiapas. Esta brecha normativa plantea el desafío de evaluar en qué medida la llegada de una mujer a la presidencia transformará realmente las condiciones estructurales de desigualdad.

## Estado del arte

Diversos estudios académicos han analizado la participación política de las mujeres en América Latina. Autoras como Marcela Lagarde (2005) han señalado que la democracia paritaria exige transformar las estructuras patriarcales de poder, mientras que Nancy Fraser (2013) advierte sobre la necesidad de articular reconocimiento e igualdad material. En México, investigadores como María de los Ángeles Peschard (2019) y Flavia Freidenberg (2021) han documentado tanto avances normativos como resistencias prácticas en la implementación de la paridad. Por su parte, Biroli y Caminotti (2020) han destacado que el acceso de mujeres a la presidencia en América Latina no siempre se traduce en transformaciones sustantivas para todas las mujeres, debido a la persistencia de sesgos institucionales y culturales. Este estado del arte evidencia que el caso de Sheinbaum debe analizarse críticamente, sin caer en triunfalismos ni reduccionismos.

## Metodología

La metodología utilizada en este artículo combina un enfoque cualitativo con análisis jurídico y politológico. En primer lugar, se realiza una revisión documental de la Constitución mexicana, leyes nacionales y tratados internacionales vinculantes para el Estado mexicano. En segundo lugar, se recurre a la jurisprudencia de la Suprema Corte de Justicia de la Nación y a informes oficiales del INE y la CNDH para identificar brechas en la implementación del principio de igualdad. En tercer lugar, se utilizan aportes teóricos del feminismo jurídico y la ciencia política comparada. Esta metodología permite vincular el plano normativo con la práctica política. No obstante, se reconoce como limitación la falta de acceso a entrevistas directas con actoras políticas, lo cual podría enriquecer el análisis empírico. Se propone que investigaciones futuras incorporen estudios de caso a nivel local.

## Análisis crítico: luces y sombras

Entre los logros, destaca que México es uno de los pocos países del mundo en alcanzar la paridad legislativa y en elegir a una presidenta mujer. La existencia de un marco normativo sólido ofrece una base importante para consolidar la igualdad sustantiva. Sin embargo, persisten sombras: la violencia política de género documentada por el INE, los casos de acoso y hostigamiento en campañas locales, así como los índices de feminicidio que, según el Secretariado Ejecutivo del Sistema Nacional de Seguridad Pública (SESNSP, 2024), se mantienen elevados. Estos hechos cuestionan hasta qué punto el liderazgo de una mujer en la presidencia puede transformar por sí solo las estructuras patriarcales del Estado mexicano.

## Aportación de la mujer hoy en día en México

La participación de la mujer en la vida pública mexicana ha experimentado un cambio sustancial en las últimas décadas. En el ámbito político, la reforma de paridad en todo (2019) obligó a los partidos a garantizar la igualdad en candidaturas, logrando que hoy el Congreso de la Unión cuente con un 50% de representación femenina. A nivel local, diversas entidades han registrado gobernadoras, presidentas municipales y legisladoras que han transformado la agenda pública, priorizando temas como la seguridad de las mujeres, el combate a la violencia política de género y la redistribución de los cuidados.

En el ámbito jurídico, la presencia de ministras en la Suprema Corte de Justicia de la Nación ha sido decisiva en fallos históricos sobre derechos reproductivos, paridad de género y violencia de género.

Ejemplo de ello es la jurisprudencia que despenalizó el aborto a nivel federal, reconociendo el derecho a decidir como parte de los derechos humanos de las mujeres.

En el plano económico y social, las mujeres se han consolidado como líderes en universidades, centros de investigación y empresas, así como en organizaciones de la sociedad civil que luchan contra la violencia feminicida y por el reconocimiento del trabajo doméstico y de cuidados. Sin embargo, persisten brechas significativas en materia salarial, acceso a puestos directivos y redistribución equitativa de las responsabilidades familiares.

Estas aportaciones evidencian que el liderazgo de Claudia Sheinbaum no debe analizarse de forma aislada, sino como parte de un proceso histórico de avance de los derechos de las mujeres en México. El reto consiste en lograr que estos avances no se queden en figuras individuales, sino que permeen de manera estructural en todos los niveles de la vida política, jurídica y social del país.

### **La mujer en la política:**

Hoy en día la participación de las mujeres, es un derecho humano , reconocido en los tratados Internacionales y en la legislación Nacional , es por ello que la CEDAW, en su artículo 7 impone a los Estados la obligación de eliminar la discriminación en la vida política, garantizando el derecho a votar , el ser elegidas y participar en la formulación de políticas públicas, por otra parte la Convención de Belem do Para , por su parte , establece que la violencia política por razón de genero constituye una forma de violencia debe prevenirse , sancionarse y erradicarse.

La lucha por la representación política femenina comenzó a institucionalizarse con la reforma de 1993, el COFIPE, (Código Federal de Instituciones , procedimientos Electorales) fue el primero que introdujo las primeras acciones afirmativas a través de cuotas de género, es por ello por lo que la reforma constitucional de 2019 consagro el principio de paridad en todo, extendiéndolo a los tres poderes del Estado, organismos autónomos y ayuntamientos.

A pesar de estos avances, persisten obstáculos para acceder a cargos ejecutivos , en el 2015, solo el 16% de las presidencias municipales estaban ocupadas por mujeres; en 2018 la cifra logro aumentar a un 31.2 % y en 2021 alcanzo un 37.9 %, por lo que este crecimiento ha sido alentador, pero es evidente aun que la igualdad formal no siempre se traduce en igualdad real.

### **Mexico en el porvenir:**

Por otra parte, los testimonios de las mujeres abogadas, activistas nos reflejan expectativas encontradas, ya que unas valoran el avance simbólico que representa su elección, mientras otras cuestionan si su liderazgo cumplirá con los compromisos internacionales asumidos por México

Es por ello por lo que el reto que tiene Sheimbaum será el de ejercer un gobierno paritario lo cual integre las perspectivas de género en todas la políticas públicas, cumpliendo con las obligaciones derivadas de la CEDAW, la convención de Belem do Para y la jurisprudencia de la Suprema Corte de Justicia de la Nación que ha reconocido que la paridad y la igualdad son elementos fundamentales y esenciales de la democracia constitucional.

### **Comparación internacional: avances y desafíos de las mujeres en México frente al contexto global**

La situación de las mujeres en México debe analizarse también a la luz de la experiencia internacional. Si bien nuestro país ha alcanzado avances significativos en materia de paridad política, convirtiéndose

en un referente en América Latina, estos logros contrastan con la persistencia de altos índices de feminicidio y violencia política en razón de género.

En España, por ejemplo, la Ley Orgánica de Igualdad Efectiva entre Mujeres y Hombres (2007) consolidó un marco normativo fuerte, complementado por políticas públicas como el Ministerio de Igualdad, aunque enfrenta desafíos en el ámbito laboral y la violencia machista. Argentina, por su parte, marcó un hito en 2020 al legalizar el aborto, impulsada por el movimiento Ni Una Menos, que visibilizó la violencia feminicida. En contraste, Suecia representa un modelo avanzado de igualdad sustantiva, con políticas de redistribución de cuidados y paridad en ministerios, aunque aún existen críticas sobre la inclusión de mujeres migrantes.

México, frente a este panorama, muestra una dualidad: por un lado, liderazgo normativo en materia de paridad; por el otro, un déficit grave en la protección de la vida y seguridad de las mujeres. Este contraste evidencia que el reto no es solo normativo, sino estructural y cultural, pues las reformas legales deben acompañarse de políticas públicas eficaces y cambios sociales profundos.

## Conclusiones

El liderazgo de Claudia Sheinbaum representa un parteaguas en la historia democrática de México y un paso importante hacia la igualdad política. Su elección como la primera presidenta del país no debe interpretarse únicamente como un logro simbólico, sino como un punto de inflexión que plantea nuevas exigencias en la consolidación de los derechos de las mujeres. La igualdad formal que proclaman la Constitución y los tratados internacionales aún no se refleja en la práctica diaria, donde persisten obstáculos que limitan la participación efectiva de las mujeres en los espacios de poder.

El reto para este gobierno será demostrar que la presencia femenina en la Presidencia trasciende la representación y se traduce en acciones concretas. Para ello, se requieren políticas públicas que combatan la violencia política de género, fortalezcan el acceso a la justicia y promuevan cambios estructurales en partidos e instituciones que todavía reproducen patrones patriarcales. La capacidad de transformar estas estructuras será la medida real del alcance de su liderazgo.

No menos importante será valorar la coherencia entre discurso y acción. La figura de una mujer en el más alto cargo del país no basta si no logra incidir en la redistribución equitativa de recursos, en la participación equilibrada en todos los niveles de decisión y en la eliminación de prácticas que perpetúan la exclusión. La ciudadanía espera que este gobierno no solo sea eficaz, sino también justo e incluyente.

Futuras investigaciones deberán analizar la relación entre este liderazgo femenino y los cambios palpables en materia de igualdad sustantiva: desde la representación política en los ámbitos locales hasta la reducción de la violencia y la consolidación de un sistema de justicia sensible al género. La democracia mexicana podrá considerarse realmente incluyente únicamente cuando las mujeres, más allá de la figura presidencial, cuenten con condiciones reales de igualdad en todos los espacios de poder. El verdadero legado de Claudia Sheinbaum se medirá no solo por ser la primera presidenta, sino por su capacidad de abrir un camino duradero hacia una transformación cultural y política que garantice la participación plena de las mujeres en la vida pública.

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## ECONOMIC GROWTH: A COMPARATIVE ANALYSIS BETWEEN ALBANIA AND THE NORTH MACEDONIA

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### ABSTRACT

The topic of economic growth is important and has been studied by many economists as it relates to the growth of well-being and development of a country. Economic growth models help us understand the rate of economic growth as well as the differences between different countries. Economic growth has been a topic of scientific research for David Ricardo, Schumpeter, Harrod, Domar, Solow, Swan, Romer, Lucas, etc. Economic growth models can be divided into two main categories: neoclassical growth theory, according to which the factors that affect economic growth are treated as external, and new growth theory, which deals with internal factors of economic growth.

The aim of this paper is to distinguish the economic growth models of Albania and North Macedonia, by presenting a statistical model for each country. Both countries have similar characteristics as they are Western Balkan states with similar historical backgrounds, transitional economies and EU integration aspirations. However, both of the countries face challenges ahead in terms of structural and institutional reforms. Albania has shown faster GDP growth but North Macedonia shows better FDI quality and institutional indicators. Albania's economy is a more service-oriented economy with a considerable impact from tourism and remittances. Whereas, North Macedonia's economy is more focused towards manufacturing and industry (particularly automotive and metallurgy), and has higher industrial output per capita.

**Keywords:** Albania, North Macedonia, economic growth, econometric model, time series data.

### INTRODUCTION

Economic growth is expressed as the percentage increase in real gross domestic product (GDP). In the middle of the 1990s, economic growth took off, at least in the English-speaking countries of the United States, Canada, and the United Kingdom, in large part because of advances in computer and information technology, including the Internet. Yet this period of rapid growth was then offset by the financial crisis and deep recession in 2008-2009.

As has been shown (Warner & Sachs, 1970 to 1989) among developed nations, open economies grew at 2.3 percent yearly, whereas the closed economies show a growth rate of 0.7 percent annually. Data for developing nations reveal that open economies grew at 4.5 percent annually; those for the closed economies suggest a 0.7 percent annual growth.

Frankel and Romer conclude that "a rise of one percentage point in the ratio of trade to GDP increases income per person by at least one-half percentage point. Trade seems to raise income by prompting the accumulation of human and physical capital and by increasing output for given levels of capital."

Adam Smith stated that openness to international trade is good for economic growth.

The endogenous growth theory rejects the Solow model's assumption of exogenous technological change. In the endogenous growth model, saving and investment can lead to continuous growth. Indeed, the increasing pace of scientific and technological innovation over the past few centuries has led some economists to argue that there are increasing returns to knowledge. If the view that knowledge is a type of capital is accepted, then the endogenous growth model becomes a description of long-run economic growth with the assumption of constant returns to capital.

One line of endogenous growth theory, pioneered by economists Philippe Aghion and Peter Howitt, builds on Schumpeter's insights by modeling technological advance as a process of entrepreneurial innovation and creative destruction.

The Solow growth model cannot explain the persistent growth in living standards that are observed in most countries.

There are four hypotheses which explain the fall in productivity growth:

Measurements Problems

Oil Prices

Worker Quality

The Depletion of Ideas

Whereas, GDP can be defined as the market value of all officially recognized final goods and services produced within a country in a single year.

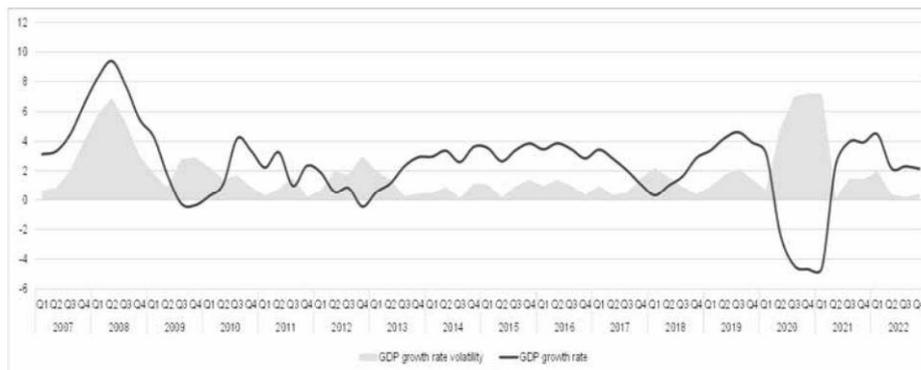
Capital, labor, and technology are the key determinants of a nation's production of goods and services. The determinants of technological progress are not well understood.

Such variables as saving, population growth, and human capital determine in turn the world economies' steady states. According to a hypothesis an efficient economy may encourage capital accumulation.

Maddison (2006) posited that among transition economies, Albania's growth experience during the transition has been a success story. Growth performance has been impressive with a stable growth rate of 6.6% per year from 1992 to 1997 when there was the crisis of economic activity because of the collapse of the pyramid saving schemes. Annual real GDP growth rises to 7 percent among 1998-2006. This economic growth has been due mainly to reduction in deficit financing, low inflation, increase in total factor productivity and consumption sustained by remittances.

Since the 2008–09 global financial crisis, economic growth in Albania has remained subdued. After a precrisis decade of a 6 percent average growth rate, growth fell to 3.3 percent in 2009. The crisis led to lower remittances and exports, which in turn contributed to lower growth and fiscal revenues. GDP increased by 3.5 percent in 2010 and 3 percent in 2011, supported mainly by services and industry. Albania's growth for 2012 has weakened substantially due mainly to the continued deterioration of the external environment. Third quarter GDP data for 2012 showed a pick-up in economic activity, with the real growth rate reaching 2.7 percent (year-on-year) from 2.1 percent in the second quarter. Agriculture grew at 5.6 percent, boosting overall growth by 1 percentage point. Other services (which include private education) have also grown at an elevated rate of 9 percent, contributing 2.3 percentage points in total growth.

Real GDP of North Macedonia has increased with about 55% over a decade. The highest economic growth period was from 2006 to 2008 with 5% and after that a negative growth period followed. This was in the years 2009 – 2012, period when the global economic crisis took place. Since then, a stabilization and a positive growth of GDP can be seen. The most important factor of economic growth in the Republic of North Macedonia is the physical capital.

**Figure 1.** The growth path of North Macedonia from Q1 2007 to Q4 2022 (in %)

Source: Lazarov, D., Simeonovski, K. (2023).

The research question in this work is to try to give an answer if the selected variables influence in a meaningful way the economic growth of each country taken into consideration, that is the following hypothesis is presented:

H<sub>0</sub>: Model is not right

H<sub>A</sub>: Model is right

In this paper, it has been focused on the macroeconomic level, that is factors that affect the economic growth for the selected period. The rest of the paper examines the methodology taken into account, a specific econometric model for each country, then we pass to the third part, where the results are discussed and in the last part the conclusions of this analysis are presented.

## MATERIAL AND METHODS

Data for both countries are collected for the interval from 1990 to 2023. For these 34 observations the properties and further explanations are given in the appendix of this paper.

A model estimating the variability in GDP change has been predicted as follows:

$$EG = \alpha + \beta C + \beta GEXP + \varepsilon,$$

where EG stands for economic growth, C for consumption and GEXP for government expenditure and  $\varepsilon$  for the error term.

It tries to give an explanation on how the independent variables included in this linear regression model, which are consumption, government expenditure have an impact on Albania's economic growth.

For the Republic of North Macedonia the model has been extended with one more variable named trade openness, which gives a more meaningful aspect for the regression model. In addition to, the other variable is foreign direct investments of North Macedonia, where the effects of it are explained in the next section.

$$EG = \alpha + \beta C + \beta FDI + \beta TO + \varepsilon,$$

where EG again is the economic growth, C is consumption, FDI is foreign direct investment and TO is trade openness for North Macedonia.

### 3.RESULTS AND DISCUSSION

Results were obtained from the IBM SPSS Statistics software. They are presented for both Albania and North Macedonia including the following test statistics for each model.

Firstly, we discuss the model significance by interpreting the values of R square:

$$R^2 = 0.498; R^2 = 0.339$$

Approximately forty nine percent of the variation in the GDP growth rate can be explained by the explanatory variables for Albania. Whereas, thirty four percent is the value for North Macedonia.

The values of adjusted R square obtained from the regression analysis for the first and the second model are:

$$\text{Adjusted } R^2 = 0.466; \text{ Adjusted } R^2 = 0.263$$

Secondly, in analysing the next step, that is the hypothesis test, since  $F_{\text{Statistic}} > F_{\text{Table}}$ ,  $15.372 > 0.000$ , than it can be concluded that the null hypothesis is rejected and  $H_A$  is accepted, meaning that the model is right for Albania. In addition to, if we are willing to accept this model the error percentage that we are doing is 0 %, meaning that there is less than a 5% probability of observing a result as extreme as that observed solely due to chance, then the association between the GDP growth, consumption and government expenditure is considered statistically significant. The same holds for North Macedonia (0.012), which is a value under the 5% confidence interval.

The Durbin – Watson values computed from our regression analysis are 1.695, which is inside the boundaries of 1.5 and 2.5. Hence, we conclude that there is no proper autocorrelation in our Albania's model. Whereas, for the North Macedonia the DW has a value of 2.063, which infers that there is no serious autocorrelation for the second model.

Next, we look at the t values computed by the statistical software we can see that only one value exceeds 0.05 (0.001; 0.000; 0.130 respectively for each independent variable). These values imply that the estimates of our model are significant, or otherwise stated the percentage increases in any of the independent variables, for example such as the government expenditure, can effect the percentage change in GDP growth negatively. Related to the North Macedonia the t values are 0.004; 0.003; 0.421 and 0.020, meaning that the above explanation holds for this country's model except for the coefficient of FDI.

In analyzing the last step of our regression model, where we check for multicollinearity for the linear regression model of Albania, we can see that the values of tolerance for all the independent variables are bigger than 0.2. It can be concluded that there is not a multicollinearity problem among our chosen independent variables. The values of VIF are low, not exceeding the values of 5 or 10, meaning that the standard errors of the independent variables are not high. The same results hold for the North Macedonia.

### 4.CONCLUSIONS

Countries that save and invest a high fraction of their output are richer than countries that save and invest a smaller fraction, and countries with high rates of population growth are poorer than countries with low rates of population growth.

Governments should provide a “helping hand” to the market system by protecting property rights, enforcing contracts, promoting competition, prosecuting fraud, and so on. Anyway, they do not do so, by deferring from this ideal. Empirical studies have shown that the extent of corruption in a nation is indeed a significant determinant of economic growth.

In this paper a clear definition on what economic growth is, has been given. The application has been made over the country of Albania and North Macedonia. For this a model that would best explain GDP growth changes has been predicted, by trying to estimate the value of the independent variables coefficients. In order to achieve this, a set of data for the time interval 1990 – 2023 has been gathered and the results have been obtained from the SPSS Statistics software.

In the results part an explanation for the most critical statistical determinants;  $R^2$ , adjusted  $R^2$ , hypothesis test, Durbin – Watson, t test and multicollinearity has been given. The results suggested that the model is correct and can be used for further analysis.

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**APPENDIX**

The following are data collected for Albania from the World Bank website. There are in total 34 observations starting from the year 1990 to 2023. The variables taken into analysis for the first model are GDP growth (which serves as the dependent variable), household final consumption expenditure and government expenditure.

**Table 1. GDP Growth**

<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>
-9.58	-28.00	-7.19	9.56	8.30	13.32	9.10	-10.92	8.83	12.89
<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>
6.95	8.29	4.54	5.53	5.51	5.53	5.90	5.98	7.50	3.35
<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>
3.71	2.55	1.42	1.00	1.77	2.22	3.32	3.80	4.02	2.09
<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>						
-3.30	8.91	4.86	3.40						

**Table 2. Household Final Consumption Expenditure including NPISHs**

<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>
62.68	94.22	165.50	123.85	101.18	91.59	94.14	97.92	94.62	86.54
<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>
82.73	78.21	80.03	80.33	77.21	76.95	77.62	81.77	83.09	80.82
<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>
78.11	78.30	77.97	80.03	80.79	80.69	80.96	79.61	79.11	79.90
<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>						
82.87	71.36	70.21	70.21						

**Table 3. Government Expenditure**

<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>
19.20	22.90	21.40	14.60	14.60	13.80	9.50	10.40	10.80	11.10
<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>
9.70	10.60	11.30	11.10	11.20	11.00	10.50	10.50	10.40	11.10
<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>
11.20	11.00	10.80	11.00	11.50	11.10	11.30	11.50	11.90	12.70
<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>						
13.70	12.80	12.00	12.00						

Data for the Republic of North Macedonia are as follows, where we have collected again time series data for GDP growth, household final consumption expenditure, foreign direct investments and the trade openness:

**Table 4. GDP Growth**

<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>
	-6.2	-6.6	-7.5	-1.8	-1.1	1.2	1.4	3.4	4.3
<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>
4.5	-3.1	1.5	2.2	4.7	4.7	5.1	6.5	5.5	-0.4
<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>
3.4	2.3	-0.5	2.9	3.6	3.9	2.8	1.1	2.9	3.9
<b>2020</b>	<b>2021</b>		<b>2022</b>			<b>2023</b>			
-4.7	4.5		2.8			2.1			

**Table 5. Household Final Consumption Expenditure including NPISHs**

<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>
63.77	62.03	66.46	67.99	71.98	66.95	74.05	81.23	84.70	83.32
<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>
75.46	71.89	77.35	79.75	81.01	80.20	79.05	77.34	78.61	76.75
<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>
75.54	73.91	73.89	71.75	69.80	68.84	66.92	66.65	65.85	65.50
<b>2020</b>	<b>2021</b>		<b>2022</b>			<b>2023</b>			
66.37	69.54		69.53			72.87			

**Table 6. FDI, net inflows (% of GDP)**

<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>
				0.7	0.2	0.2	0.4	4	2.4
<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>
5.8	12.7	2.8	2.4	5.4	2.3	6.2	8.8	6.2	2.8
<b>2010</b>	<b>2011</b>	<b>2012</b>	<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>
3.2	4.8	3.5	3.7	0.5	2.9	5.1	3.4	5.1	4.4
<b>2020</b>	<b>2021</b>		<b>2022</b>			<b>2023</b>			
0.1	5		6.1			4.1			

**Table 7. Trade Openness**

<b>1990</b>	<b>1991</b>	<b>1992</b>	<b>1993</b>	<b>1994</b>	<b>1995</b>	<b>1996</b>	<b>1997</b>	<b>1998</b>	<b>1999</b>
59	46	102	96	82	72	58	72	77	73
<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>	<b>2005</b>	<b>2006</b>	<b>2007</b>	<b>2008</b>	<b>2009</b>

80	71	72	71	81	86	93	106	112	87
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2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
98	113	112	105	113	114	116	124	133	139

2020	2021	2022	2023
128	147	166	149

## DIVORCE INVOLVING PERSONS LACKING LEGAL CAPACITY UNDER VIETNAMESE LAW

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### Özet

Makale, özellikle eşlerden birinin bilişsel ve davranışsal yetilerini kaybettiği ve aynı zamanda aile içi şiddetin mağduru olduğu durumlarda, 2014 tarihli Evlilik ve Aile Hukuku kapsamında anne, baba veya diğer yakın akrabaların boşanma talebinde bulunma hakkını analiz etmeye odaklanmaktadır. Uygulamadaki mahkeme kararlarının incelenmesi yoluyla, yazar bazı sorunlara işaret etmektedir: hukuki düzenlemelerin genel ve belirsiz olması, boşanma talebinin hangi koşullarda ortaya çıkabileceğine ilişkin rehberliğin eksikliği; medeni ehliyetsizliği kanıtlayan delillerin belirlenmesinde tutarsızlıklar; ehliyetsizlik kararı verilmediği durumlarda ortaya çıkan hukuki boşluklar; ve mahkemelerin hukuki gerekçelendirmelerindeki sınırlılıklar. Bu temelde, makale hukuk sisteminin geliştirilmesi ve uygulanabilirliğinin artırılması için bazı öneriler sunmaktadır. Bunlar arasında: kanunlarda veya ikincil düzenlemelerde açık kriterlerin eklenmesi; delillere ilişkin kuralların birleştirilmesi; özel durumlar için hızlandırılmış usullerin oluşturulması; içtihat veya yönlendirici kararların yayımlanması; ve kişisel hakların korunması ilkesinin güvence altına alınması yer almaktadır.

**Anahtar Kelimeler:** Boşanma, Evlilik, Medeni ehliyet, Aile içi şiddet, Vietnam Hukuku.

### Abstract

This article analyzes the right to request divorce granted to parents or other relatives under the 2014 Law on Marriage and Family of Vietnam, particularly in cases where one spouse has lost cognitive and behavioral capacity and is simultaneously a victim of domestic violence. By examining selected court judgments, the study identifies several shortcomings: the law remains overly general and lacks clear guidance on the conditions for exercising this right; inconsistencies exist in determining acceptable evidence of loss of legal capacity; legal gaps appear when no court decision declaring incapacity has been issued; and judicial reasoning in some cases remains limited. Based on these findings, the article proposes solutions to improve legislation and judicial practice, including: clarifying criteria in statutes or guiding documents; unifying rules on admissible evidence; adopting simplified procedures for special cases; issuing precedents or guiding resolutions; and ensuring the protection of personal rights of the incapacitated spouse.

**Keywords:** divorce, marriage, legal capacity, domestic violence, Vietnamese law.

## 1. INTRODUCTION

Marriage establishes a legal marital relationship, while divorce is the legal process for its dissolution. When one spouse loses legal capacity due to mental illness or other causes, divorce cases become legally and ethically complex. The Law on Marriage and Family 2014 allows a spouse, and in certain cases parents or close relatives, to request divorce on behalf of the incapacitated spouse. However, legal conditions and procedural requirements remain unclear, leading to inconsistent judicial practice.

This paper examines relevant laws and judicial decisions, focusing on the conditions, evidence, and reasoning applied in such cases. Based on this analysis, the study proposes recommendations to clarify legal provisions and improve judicial consistency in protecting the rights of persons who have lost legal capacity.

## 2. MATERIAL AND METHODS

To complete this paper, the author employed the following materials and research methods:

**Materials:** This study is based on the following sources: (1) Theoretical issues concerning divorce involving a person who has lost legal capacity; (2) Provisions of Vietnamese law on divorce involving a person who has lost legal capacity; (3) Selected judgments of Vietnamese courts on divorce cases involving a person who has lost legal capacity.

**Methods:** The study applies both methodological and specific research methods. It is grounded in the methodology of dialectical materialism and historical materialism of Marxism–Leninism. Specific methods include the statutory analysis method, the historical method, and the practical summary method.

**Statutory Analysis Method:** This method is mainly used to analyze and clarify theoretical issues, the current state of legal regulations, and their application, thereby providing conclusions and evaluations.

**Historical Method:** This method is employed to clarify the historical aspects of legal regulations on divorce involving persons who have lost legal capacity, thereby illustrating the inheritance and development trends of such provisions in Vietnamese law.

**Practical Summary Method:** This method is used to examine and assess the practical application of the law based on Vietnamese court judgments, in order to gain a deeper understanding of disputes related to divorce involving persons who have lost legal capacity.

## 3. RESULTS AND DISCUSSION

Marriage serves as the legal basis for establishing a marital relationship, while divorce constitutes the legal ground for its termination. Divorce is a legal process that brings an end to the marital bond between husband and wife. However, when one spouse loses legal capacity due to illness or other objective reasons, the resolution of divorce becomes complex, both from a legal and an ethical perspective. In such cases, several questions arise: Who has the right to initiate divorce proceedings? How should the procedure be conducted? And what factors influence the court's decision? This section will analyze the current legal provisions and judicial practice concerning situations where one spouse is declared legally incapacitated.

### 3.1. Divorce Petition Filed by a Spouse Against an Incapacitated Partner:

In practice, it is not uncommon for one spouse to lose legal capacity. In such circumstances, the other spouse may petition the court for divorce. Pursuant to Article 51 of the 2014 Law on Marriage and Family of Vietnam, which regulates the right to request divorce and limitations thereto, a spouse retains the right to initiate divorce proceedings even when the other party has been declared legally incapacitated. Under the provisions of civil procedure law, however, an individual who has lost legal capacity is not deemed to possess procedural capacity in civil proceedings<sup>1</sup>. Therefore, in cases where one spouse has lost civil act capacity and the other petitions the Court for divorce, pursuant to the

<sup>1</sup> Clause 4, Article 69 of the 2015 Civil Procedure Code of Vietnam.

provisions on guardianship under the Civil Code, the Court shall appoint a legal representative for the incapacitated person in order to proceed with the divorce proceedings<sup>2</sup>. Thus, under the current legal framework, when a spouse has been declared legally incapacitated, the other spouse still retains the right to petition for divorce, and such cases fall under divorce at the request of one party. In Judgment No. 03/2020/HNGĐ-ST dated January 16, 2020 of the People's Court of Phu Ly City, Ha Nam Province (hereinafter referred to as "the first case"), Mr. Le Thanh B and Ms. Do Thi H had a legally registered marriage in 2003. After the marriage, they lived together harmoniously until 2012, when marital conflicts arose, and Ms. H left the family home; the couple had been completely separated since then. Following the separation, Mr. B developed a mental illness and was declared legally incapacitated under Decision No. 01/2015 dated December 10, 2015, issued by the People's Court of Phu Ly City, Ha Nam Province. Subsequently, Ms. H filed a petition for divorce against Mr. B. Since Mr. B lacked procedural legal capacity, the Court carried out the necessary procedures in accordance with the law to appoint his lawful representative, Mr. Le Dinh K (his biological father). The petition for divorce filed by Ms. H therefore falls under divorce at the request of one party as provided in Clause 1, Article 56 of the 2014 Law on Marriage and Family. Accordingly, the legal grounds for divorce in this case are that either spouse commits acts of domestic violence or seriously violates the rights and obligations of husband and wife, leading to a seriously deteriorated marital relationship, the impossibility of maintaining a shared life, and the failure to achieve the objectives of marriage<sup>3</sup>. In the above case, the Trial Panel observed that "the marital conflict had become irreconcilable, the common life had ceased to exist for a long time, and the purpose of the marriage was no longer attainable. Therefore, the plaintiff's petition for divorce filed by Ms. Đỗ Thị H is accepted by the Court in accordance with Articles 51 and 56 of the 2014 Law on Marriage and Family." The Court's approach and resolution of Ms. H's petition for divorce in circumstances where Mr. B had been declared legally incapacitated are entirely convincing and consistent with the current legal framework. In judicial practice, there are numerous cases with similar characteristics that have been adjudicated by the courts<sup>4</sup>. The cases discussed above share a common feature: one spouse petitions for divorce from the other spouse who has already been declared legally incapacitated by a court decision. However, a more complex question arises when one spouse seeks divorce while the other suffers from a mental illness or other condition impairing cognitive capacity but has not yet been declared legally incapacitated by a judicial decision. The 2014 Law on Marriage and Family and its implementing guidelines provide no direct answer to this situation. From the judicial practice perspective, the Supreme People's Court, in its Official Letter No. 01/2017/GĐ-TANDTC providing guidance on certain professional matters, expressed the following view: "When a party claims that a litigant in a case has lost civil act capacity, the Court must provide instructions and guidance for them to exercise their right to request a judicial declaration of such incapacity in accordance with the law. If such a request is filed and accepted by the Court, the Court shall apply Point (d), Clause 1, Article 214 of the 2015 Civil Procedure Code to suspend the trial of the civil case. If no such request is made, the Court shall proceed with the civil case under general procedures."

This guidance indicates that if a spouse petitions for divorce while the other suffers from a mental disorder or other condition impairing cognition but has not yet been judicially declared legally incapacitated, the Court must instruct the petitioner to initiate separate proceedings requesting such a declaration. If the petitioner submits such a request and the Court accepts it, the divorce proceedings will be suspended until resolution of the capacity issue. Conversely, if the petitioner does not request a declaration of incapacity, the Court will proceed with the divorce case under general procedures.

<sup>2</sup> Clause 3, Article 24 of the 2014 Law on Marriage and Family of Vietnam.

<sup>3</sup> Clause 1, Article 56 of the 2014 Law on Marriage and Family of Vietnam.

<sup>4</sup> See also People's Court of Ứng Hòa District (Hanoi), Judgment No. 57/2019/HNGĐ-ST, October 29, 2019.

### 3.2. Divorce initiated on behalf of a spouse who has been declared legally incapacitated

In addition to cases where one spouse seeks divorce from the other who has lost civil act capacity, as discussed above, judicial practice has also encountered situations in which the spouse who becomes incapacitated due to illness may need to be divorced from the other spouse. To address this legitimate need and to respond to the practical demands of such cases, the 2014 Law on Marriage and Family introduced an important innovation: it grants the right to request divorce to parents or other close relatives of the incapacitated spouse. Specifically, Clause 2, Article 51 of the 2014 Law on Marriage and Family stipulates: “Parents or other relatives have the right to request the Court to settle a divorce when one spouse, due to mental illness or another disease, is unable to perceive or control his/her behavior, and at the same time is a victim of domestic violence perpetrated by the other spouse, seriously affecting his/her life, health, or spirit.” This provision represents a new and progressive development compared to all previous Marriage and Family Laws, as it recognizes the right of close relatives to petition for divorce in addition to the spouses themselves. It has resolved many situations in which relatives sought divorce on behalf of an incapacitated family member but were previously barred from doing so, given that earlier laws restricted the right to request divorce solely to the spouses—despite the fact that the incapacitated person lacked procedural capacity to act in civil proceedings<sup>5</sup>. In essence, divorce is a personal right (*jus personae*), and therefore it must be exercised directly by the individual concerned. Even when a spouse has full civil act capacity, the law does not allow him or her to authorize another person to act as a representative in divorce proceedings, except for the specific case where divorce is requested by parents or other close relatives as discussed above. With this new provision, it can be seen that in addition to parents, other close relatives are now also entitled to petition the Court for divorce. Under the 2014 Law on Marriage and Family, “close relatives” are defined as “persons related by marriage, adoptive relationship, persons of the same direct blood line, and persons related within three generations”<sup>6</sup>. The above definition shows that the scope of “relatives” is quite broad, including: (i) persons having a marital relationship (husband and wife); (ii) persons having an adoptive relationship (adoptive parents and children); (iii) persons related by direct bloodline (those having a consanguineous relationship, in which one is born successively from the other); and (iv) persons related within three generations (those descended from the same origin, including parents as the first generation; siblings of the same parents, or of the same father but different mothers, or of the same mother but different fathers as the second generation; and cousins – children of uncles and aunts – as the third generation). Although current legislation provides for the right to request divorce by parents or other relatives, such a right only arises when certain conditions are met, including: (i) one spouse suffers from a mental illness or another disease that renders him/her incapable of perceiving or controlling his/her acts; and (ii) simultaneously, he/she is a victim of domestic violence committed by the husband or wife, which seriously affects his/her life, health, or mental state. If these conditions are not satisfied, the right of parents or other relatives to request divorce will not arise. However, in practice, it appears that in some cases the courts have not fully considered the above conditions when adjudicating requests for divorce filed by parents or other relatives.

In Judgment No. 82/2018/HNGĐ-ST dated July 10, 2018 of the People’s Court of Buôn Ma Thuột City, Đắk Lắk Province (hereinafter referred to as “the second case”), Mrs. H’D was in a lawful marriage with Mr. YB and had been declared legally incapacitated under Decision No. 02/2018/QĐST-DS dated January 18, 2018 of the same court. On March 6, 2018, Ms. H’N (the eldest daughter of Mrs. H’D and Mr. YB) filed a petition requesting the People’s Court of Buôn Ma Thuột City to grant a divorce between her mother, Mrs. H’D, and Mr. YB. Pursuant to the provisions of the

<sup>5</sup> Le, V. T., & Dinh, T. T. (2023). The right to request divorce under the 2014 Law on Marriage and Family: Issues and recommendations. *Tạp chí Tòa án*. Retrieved March 5, 2025, from <https://tapchitoaan.vn/quyen-yeu-cau-giai-quyet-ly-hon-theo-luat-hon-nhan-va-gia-dinh-nam-2014-vuong-mac-va-kien-nghi9614.html>

<sup>6</sup> Clause 19, Article 3 of the 2014 Law on Marriage and Family.

2014 Law on Marriage and Family, Ms. H’N was a relative of Mrs. H’D and therefore had the legal capacity to request a divorce on behalf of her mother, as well as to act as her representative. Nevertheless, the judgment did not clearly articulate the grounds for parents or relatives to request divorce under Clause 2, Article 51 of the 2014 Law on Marriage and Family, nor the legal basis for divorce at the request of parents or relatives provided in Clause 3, Article 56 of the same law. Specifically, the ground for divorce at the request of parents or relatives is “there is evidence that the husband or wife has committed domestic violence seriously affecting the life, health, or spirit of the other”. In its reasoning on the grounds for divorce in the above-mentioned case, the Court stated: *“During the course of the marriage, Mr. YB and Mrs. H’D often had conflicts and incidents of domestic violence. The local authorities attempted conciliation and intervention but were unable to resolve the situation. Since 2007, the couple has been living separately, with no mutual care or concern, and the purpose of the marriage has not been achieved. Therefore, the request for divorce filed by Mrs. H’D’s guardian is well-founded under Articles 51 and 56 of the Law on Marriage and Family”*. It appears that the Court’s reasoning was based on the ground for divorce at the request of one spouse under Clause 1, Article 56 of the 2014 Law on Marriage and Family, rather than on the grounds for divorce at the request of parents or other relatives<sup>7</sup>. For the reason that, in the judgment, there is no finding that Mr. YB committed acts of domestic violence against Mrs. H’D that seriously affected her life, health, or mental state. The Court only reasoned that Mr. YB had committed domestic violence which the local authorities attempted to reconcile and intervene in but without success, and that Mr. YB and Mrs. H’D had lived separately since 2007 until the time the Court adjudicated the case. If Mr. YB merely committed acts of domestic violence against Mrs. H’D without causing serious consequences to her life, health, or mental state, then such circumstances are insufficient to constitute grounds for divorce in this case. The fact that a spouse commits acts of domestic violence causing serious harm to the life, health, or mental state of the other is not only a ground for divorce at the request of the parents or other relatives but also the condition for such persons to have the right to request a divorce on behalf of the spouse under Article 51 of the 2014 Law on Marriage and Family. In other words, if Mrs. H’D was not a victim of domestic violence by Mr. YB that seriously affected her life, health, or mental state, then Ms. H’N would not have the right to request the Court to settle the divorce. For a Court to accept and adjudicate a civil case in general, and a marriage and family case in particular, the petitioner must have the right to institute proceedings. If the petitioner does not have such right, the Court will not accept the case and will return the petition<sup>8</sup>. Pursuant to Clause 2, Article 51 of the 2014 Law on Marriage and Family, when filing a petition for divorce at the request of the parents or other relatives, such persons are also required to provide documents and evidence proving their legal standing to request the divorce. For parents or other relatives to have the right to initiate divorce proceedings, two conditions must be satisfied: (i) the husband or wife suffers from a mental illness or another disease that renders them incapable of perceiving and controlling their own acts—this is the basis for requesting the Court to declare such person legally incapacitated<sup>9</sup>; (ii) the husband or wife is a victim of domestic violence committed by the other spouse, which seriously affects his or her life, health, or mental well-being. Accordingly, when parents or other relatives file a petition for divorce, they must provide documents and evidence proving that the husband or wife “suffers from a mental illness or another disease that renders them incapable of perceiving and controlling their acts” (the first condition). Regarding this condition, there are two different

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<sup>7</sup> Clause 1, Article 56 of the 2014 Law on Marriage and Family provides for the grounds for divorce at the request of one spouse as follows: *“There is evidence that a spouse has committed acts of domestic violence or has seriously violated the rights and obligations of husband and wife, causing the marriage to fall into a serious condition, the common life cannot be prolonged, and the purpose of the marriage is not achieved”*.

<sup>8</sup> Point a, Clause 1, Article 198 of the 2015 Civil Procedure Code.

<sup>9</sup> Clause 1, Article 22 of the 2015 Civil Code stipulates: *“When a person, due to mental illness or another disease, is unable to perceive and control his or her acts, the Court shall, at the request of a person with related rights and interests or of a relevant agency or organization, issue a decision declaring such person to have lost legal capacity on the basis of a psychiatric forensic examination”*.

interpretations. The first interpretation holds that it is sufficient to provide medical records certified by the hospital where the treatment took place, together with a forensic psychiatric examination report issued by a competent judicial expertise institution, confirming that the spouse suffers from a mental illness or another disease rendering them incapable of perceiving and controlling their acts. The second interpretation, however, maintains that a court decision declaring the spouse legally incapacitated is required<sup>10</sup>. It should be noted that Clause 2, Article 51 of the 2014 Law on Marriage and Family does not require a prior court declaration of legal incapacity for a spouse before parents or other relatives may file for divorce. The provision only requires proof that the spouse “suffers from a mental illness or another disease that renders them incapable of perceiving and controlling their acts.” Accordingly, in such cases, it is sufficient for the petitioner to provide medical or other evidentiary documents demonstrating the spouse’s condition, without the necessity of a judicial declaration of incapacity. In the second case under discussion, Ms. H’D had already been declared legally incapacitated before her daughter, Ms. H’N, requested the court to grant a divorce on her mother’s behalf. However, even without such a declaration, the first statutory condition would still be met if Ms. H’N could provide sufficient documentation proving that her mother suffered from a mental illness rendering her incapable of self-control. The second condition requires that parents or relatives submit evidence that the spouse is a victim of domestic violence perpetrated by the other spouse, with serious consequences for life, health, or mental well-being. The concept of *domestic violence* is broadly construed, encompassing not only acts such as abuse, mistreatment, and physical assault but also neglect, indifference, and the failure to provide care and support to dependents who are unable to look after themselves.

In the second case, the Court reasoned that Mr. YB committed acts of domestic violence against Ms. H’D. However, the judgment did not clarify whether such conduct caused “serious harm” to her life, health, or mental well-being. Only when this element is established—together with the first condition discussed above—would there be sufficient grounds for Ms. H’N to exercise the right to request a divorce under Clause 2, Article 51 and for the Court to grant the divorce under Clause 2, Article 56 of the 2014 Law on Marriage and Family. An analysis of the case shows that the People’s Court of Buôn Ma Thuột accepted the divorce petition filed by Ms. H’N on behalf of her mother, Ms. H’D, who had already been declared legally incapacitated. Nevertheless, the Court’s reasoning remains legally inconsistent. Specifically, the Court appeared to rely mainly on the general ground for unilateral divorce under Clause 1, Article 56, rather than the special provision for parents or other relatives under Clause 3 of the same article. It must be stressed that the right of relatives to petition for divorce, as prescribed in Clause 2, Article 51 and Clause 3, Article 56, is subject to stringent conditions: (i) the spouse suffers from a mental illness or another disease rendering them incapable of perceiving and controlling their acts; and (ii) the spouse is a victim of domestic violence causing serious harm to life, health, or mental well-being. Although the judgment acknowledged the existence of domestic violence and long-standing conflicts between Mr. YB and Ms. H’D, it failed to establish the requisite element of “serious harm” as required by law. By overlooking this condition, the Court’s reasoning lacked conformity with the statutory framework. Consequently, the judgment in this case does not fully align with the legislative intent of the 2014 Law on Marriage and Family, which clearly provides that the right of relatives to request divorce arises only in narrowly defined, exceptional circumstances, so as to safeguard the personal rights of the spouses to the greatest extent possible.

### 3.3. Limitations and Inconsistencies in Vietnamese Law on Divorce Involving Persons Declared Legally Incapacitated

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<sup>10</sup> Le, V. T., & Dinh, T. T. (2023). The right to request divorce under the 2014 Law on Marriage and Family: Issues and recommendations. *Tạp chí Tòa án*. Retrieved March 5, 2025, from <https://tapchitoaan.vn/quyen-yeu-cau-giai-quyet-ly-hon-theo-luat-hon-nhan-va-gia-dinh-nam-2014-vuong-mac-va-kien-nghi9614.html>

Although the 2014 Law on Marriage and Family represents a significant step forward by introducing the right of parents or other relatives to petition for divorce, several limitations remain:

**Lack of clarity regarding the conditions for relatives to petition for divorce.** The law sets out two conditions—(i) loss of cognitive capacity and (ii) being a victim of domestic violence—but fails to specify what constitutes “serious harm to life, health, or mental well-being.” This ambiguity has resulted in divergent interpretations and inconsistent application in judicial practice.

**Absence of uniform rules on evidence of incapacity.** Some opinions consider medical records and psychiatric assessments sufficient, while others insist on a formal court decision declaring the spouse legally incapacitated. Such inconsistency creates difficulties for both petitioners and courts in adjudicating cases.

**Legal gap where no declaration of incapacity has been issued.** In situations where a spouse suffers from mental illness but has not yet been formally declared legally incapacitated, divorce proceedings are often suspended pending an independent declaration procedure. This prolongs litigation and adversely affects the rights and interests of the parties involved.

**Weaknesses in judicial reasoning.** Case law indicates that some trial panels have not strictly applied the specific provisions of Articles 51 and 56 of the 2014 Law on Marriage and Family, but have instead relied on the general ground of unilateral divorce. This approach undermines the coherence and rigor of judicial reasoning and creates inconsistency in adjudication.

### **3.4. Recommendations for Improving the Legal Framework on Divorce Involving Persons Declared Legally Incapacitated**

To address the shortcomings identified above, several reforms are necessary:

**Clarify the criterion of “serious harm.”** The Law on Marriage and Family—or its guiding instruments—should expressly define what constitutes “serious harm to life, health, or mental well-being” in cases of domestic violence, thereby ensuring a clear threshold for relatives to exercise the right to petition for divorce.

**Unify evidentiary requirements for incapacity.** Legislation should specify the evidentiary value of medical records and psychiatric assessments alongside court decisions declaring incapacity. This would provide flexibility, reduce unnecessary procedural burdens, and facilitate access to justice.

**Introduce simplified procedures in cases of clear incapacity.** Where a spouse evidently suffers from mental illness or another condition impairing cognition, courts should be allowed to proceed under a streamlined procedure rather than suspending cases pending a separate incapacity declaration, thus avoiding undue delays.

**Issue authoritative judicial guidance.** The Supreme People’s Court should promulgate case law or a guiding resolution on the application of Articles 51 and 56 of the 2014 Law on Marriage and Family. Such guidance would promote uniformity and consistency across courts, reducing disparities in judicial practice.

**Safeguard the personal rights of spouses.** Any extension of standing to third parties in divorce proceedings must remain narrowly circumscribed to prevent abuse, while simultaneously ensuring that individuals lacking capacity are afforded effective legal protection in marriages that no longer serve their lawful purposes.

## **4. CONCLUSIONS**

The introduction of the right for parents or other relatives to petition for divorce under the 2014 Law on Marriage and Family constitutes an important legal and humanitarian advancement, reflecting a

commitment to safeguarding the personal rights of persons declared legally incapacitated. Nonetheless, significant gaps and ambiguities remain in the current legal framework, particularly regarding the criteria for “serious harm,” the evidentiary standards for incapacity, and the absence of unified procedural guidance. These shortcomings have resulted in inconsistent judicial interpretations and practices, thereby undermining legal certainty and access to justice.

To enhance the effectiveness of this special divorce mechanism, legislative reform should focus on clarifying substantive conditions, standardizing evidentiary requirements, introducing expedited procedures where appropriate, and providing authoritative judicial guidance. Such reforms would ensure both consistency in judicial practice and robust protection of the personal rights of vulnerable spouses, while preventing potential abuse of the mechanism. Ultimately, the development of a coherent, transparent, and well-guided legal framework would strengthen the rule of law in family matters and uphold the principles of fairness, dignity, and protection that underpin the modern Vietnamese legal system.

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## THE RETURN OF BRIDE PRICE IN VIETNAMESE FAMILY LAW: LEGAL FRAMEWORK AND JUDICIAL PRACTICE

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### Özet

Bu makale, Vietnam hukukunda evlilikte başlık parasının verilmesi ve geri alınmasına ilişkin hukuki sorunları incelemektedir. Başlık parası geleneksel bir adet olmakla birlikte, evlilik gerçekleşmediğinde veya boşanma durumunda sıklıkla uyuşmazlıklar ortaya çıkmaktadır. Güncel Vietnam mevzuatı bu konuyu doğrudan düzenlememekte, ancak feodal hukuk, sömürge dönemi hukuku ve 1972 Medeni Kanunu açık hükümler içermektedir. Vietnam'daki yargı uygulamaları farklı yaklaşımlar sergilemiştir: bazı mahkemeler başlık parasını şarta bağlı bağış sözleşmesi olarak değerlendirmiş, bazıları ise yalnızca geleneklere veya taraflar arasındaki anlaşmalara dayanmıştır. Esas mesele, bağışın şartının ne olduğunun (hukuken geçerli evlilik kaydı mı yoksa yalnızca düğün merasimi mi) ve şart gerçekleşmediğinde iade yükümlülüğünün kapsamının belirlenmesidir. Makale, başlık parasının şarta bağlı bağış sözleşmesi olarak kabul edilmesi gerektiğini, geçerli evliliğin bu sözleşmenin şartı olduğunu ileri sürmektedir. Evlilik gerçekleşmezse damat tarafı başlık parasını geri talep edebilir; ancak kusur damat tarafında ise yalnızca kısmi iade mümkündür. Çalışma, başlık parasına ilişkin hukuki temeli ve yargı uygulamasını açıklığa kavuşturmakta ve Vietnam aile hukukunun geliştirilmesine yönelik öneriler sunmaktadır.

**Anahtar Kelimeler:** Başlık parası, Evlilik, Şarta bağlı bağış sözleşmesi, Gelenek, Hukuki uyuşmazlık.

### Abstract

This article examines the legal issues surrounding the giving and reclaiming of bride price in marriage under Vietnamese law. Although bride price is a traditional custom, disputes often arise when the marriage does not take place or when the couple divorces. Current Vietnamese legislation does not provide direct provisions governing this matter, while historical laws—including feudal law, colonial law, and the 1972 Civil Code—contained explicit regulations. Judicial practice in Vietnam has revealed divergent approaches: some courts treat the bride price as a conditional gift contract, while others rely primarily on customs or private agreements. The key issue lies in determining the condition of the gift (whether a legally registered marriage or merely the wedding ceremony) and the scope of restitution when such condition is not fulfilled. This article argues that bride price should be classified as a conditional gift contract, with the establishment of a lawful marriage as the condition precedent. If the marriage does not occur, the groom's family has the right to reclaim the bride price, though only partial restitution should be permitted when the groom's side is at fault. The study clarifies the legal basis and judicial practice regarding bride price and proposes directions for improving Vietnamese family law.

**Keywords:** Bride price, Marriage, Conditional gift contract, Custom, Legal dispute.

## 1. INTRODUCTION

In traditional Vietnamese wedding ceremonies, it is customary for the groom's family to present the bride's family with various betrothal gifts such as gold jewelry, earrings, rings, silk, livestock, or cash in preparation for the marriage ceremony. This practice is considered a long-standing and meaningful tradition of the Vietnamese people and is also found in certain other cultures around the world<sup>1</sup>. However, in practice, two common situations often arise: (i) the bride's family has accepted the betrothal gifts but the marriage is not carried out; or (ii) the marriage ceremony has taken place, but the spouses subsequently divorce. In reality, there have been numerous cases where the groom's family initiated legal action demanding the return of the betrothal gifts, either because the marriage did not take place or because, after the marriage, one of the spouses petitioned for divorce. This gives rise to the central research question: Does the groom's family have the right to reclaim the betrothal gifts in the two scenarios: (1) when the marriage does not take place, and (2) when the marriage has taken place but the spouses later divorce?

## 2. MATERIAL AND METHODS

To accomplish this study, the author relied on the following sources and employed various research methods.

**Materials.** The paper is based on four main categories of materials: (1) theoretical studies on the nature of bride price and the practice of giving and receiving bride price; (2) the legal framework of Vietnam concerning bride price and related practices; (3) selected legal provisions of several foreign jurisdictions regarding bride price; and (4) judgments of Vietnamese courts relating to disputes over the return of bride price.

**Methods:** The study was conducted under the methodological foundation of dialectical and historical materialism. Several specific methods were applied:

**Legal analysis:** This is the primary method employed throughout the study, used to examine written legal provisions, clarify theoretical issues, and assess the current state of legislation and its application in practice, thereby providing evaluative conclusions.

**Comparative method:** This method was used to compare Vietnam's legal framework on bride price with that of selected foreign jurisdictions in order to identify similarities, differences, and potential lessons.

**Historical method:** This method was applied to explore the historical evolution of legal rules concerning bride price, highlighting both the continuity and the developmental trends of Vietnam's regulations.

**Case law analysis:** By reviewing and synthesizing relevant judgments of Vietnamese courts, this method provided insights into the practical application of law and the judicial handling of disputes concerning the return of bride price.

## 3. RESULTS AND DISCUSSION

### 3.1. Vietnamese legal regulations on the reclaiming of betrothal gifts

At present, Vietnamese law does not contain any specific provisions governing the reclaiming of betrothal gifts or the bride's family's obligation to return such gifts to the groom's family. Unlike the current legal framework, however, both the feudal laws of Vietnam and the laws enacted during the

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<sup>1</sup> Do, V. D., & Le, T. D. P. (2024). *Disputes over betrothal gifts when an engagement is canceled*. <https://s.net.vn/swfL> [Accessed November 2, 2024].

French colonial period did include certain rules concerning the giving and return of betrothal gifts in marriage procedures.

**Provisions in the Hồng Đức Code.** The feudal legal system regulated the giving and receiving of betrothal gifts prior to marriage, as reflected in several provisions of the Hồng Đức Code. Article 314 of the Code stipulates: “If a marriage is concluded without delivering sufficient betrothal gifts to the bride’s parents, then, if both parents are deceased, the gifts must be brought to the head of the clan or the village head to request approval. Should the marriage be conducted carelessly in such a situation, the parties shall be degraded one rank and, depending on their social status, be compelled to pay a fine”.

Furthermore, Article 315 provides: If, after accepting betrothal gifts (such as money, silk, gold, silver, pigs, wine), the bride’s family refuses to marry off their daughter, they shall be punished with eighty strokes of the cane. If they instead marry her to another man and the marriage is consummated, they shall be sentenced to penal servitude as laborers. Should the second husband knowingly accept this situation, he too shall be sentenced to penal servitude; if he was unaware, he shall not be punished. In such a case, the woman must be given in marriage to the first suitor; if the first suitor no longer wishes to marry, the bride’s family must compensate him by returning double the betrothal gifts, and the woman may then be married to the second suitor. Conversely, if the groom’s family, after delivering the betrothal gifts, refuses to proceed with the marriage, they shall be punished with eighty strokes of the cane and forfeit the gifts.

In addition, Article 322 provides for exceptional circumstances: If a woman is betrothed but the marriage has not yet taken place, and the man suffers from a serious illness or disability but has not committed a crime or dissipated his family property, the woman may petition the authorities to return the gifts. If the woman herself has a serious illness or has committed a crime, she shall not be required to return the gifts. Any violation of these provisions shall be punished with eighty strokes of the cane.

These provisions demonstrate that the Hồng Đức Code placed significant emphasis on the giving and return of betrothal gifts, as well as penalties for renegeing after having received such gifts. Specifically: (i) in marriage, the groom’s family was obliged to deliver sufficient betrothal gifts to the bride’s family, failing which they would be punished by demotion in rank and fines; (ii) if the bride’s family, after accepting the gifts, refused to marry off their daughter or married her to another man, they faced penal servitude and had to return double the value of the gifts; (iii) if the groom’s family, after giving the gifts, refused to proceed with the marriage, they were punished and forfeited the gifts. Importantly, the Hồng Đức Code was progressive in recognizing circumstances where the bride’s family could legitimately return the gifts without penalty—for example, if the groom suffered from a serious illness but had not committed crimes or squandered family assets, or if the bride herself suffered from a serious illness or had committed a crime, in which case the gifts did not have to be returned.

### **Provisions in the 1931 Northern Civil Code and the 1936 Central Civil Code:**

The issue of *betrothal gifts* was explicitly regulated in Articles 68–72 of the 1931 Northern Civil Code. Article 68 stipulated that the groom’s family must present *betrothal gifts* to the bride’s family, and such presentation had to be carried out in a formal manner in order to be legally valid. Article 71 of the same Code provided that: “*If either party breaks off the engagement without any justifiable reason or due to his or her own fault, that party shall be liable for damages. If the engagement is dissolved because one of the engaged parties dies, no compensation shall be required*”.

Similarly, the 1936 Central Civil Code regulated *betrothal gifts* in the provisions on the betrothal ceremony (Chapter I, Title V). According to Article 68, the engagement would only be valid if the groom’s family solemnly presented *betrothal gifts* to the bride’s family. Article 71 further stipulated that: “*If the bride or her parents cancel the engagement without any justifiable reason, they must*

*return the betrothal gifts or their monetary value, and in some cases also compensate the groom or his family for damages. Conversely, if the groom or his family cancels the engagement without any justifiable reason, they must forfeit the betrothal gifts and, in some cases, compensate the bride or her family for damages. If the cancellation is caused by the fault of either the groom or the bride, the party at fault must compensate the other. If the engagement is canceled because of the death of either the groom or the bride, no return or compensation is required”.*

The provisions of the 1936 Central Civil Code thus offered fairly detailed and specific rules regarding circumstances under which the groom’s family could reclaim the *betrothal gifts* or would lose them. They also clearly addressed the role of fault in causing the cancellation of the engagement and the related obligations to return or compensate for the *betrothal gifts*.

### **Provisions in the 1972 Civil Code (South Vietnam):**

In a manner similar to the 1931 Northern Civil Code and the 1936 Central Civil Code, the 1972 Civil Code also contained provisions on the giving of *betrothal gifts* and the obligations of return or compensation in the event of cancellation of the engagement (Articles 100–102). Accordingly, if the engagement was broken off without justifiable cause, the party responsible was required to compensate for damages, except in the case of consumable items<sup>2</sup>.

Previously, Resolution No. 01/1988 of the Judicial Council of the Supreme People’s Court, dated January 20, 1988, also contained provisions concerning the handling of jewelry given to the spouses on their wedding day in the event of divorce. According to this Resolution, “*Jewelry given separately to the bride or groom by their parents on the wedding day shall be regarded as personal property. However, if such items were given jointly to both spouses with the intention of establishing initial capital for the couple, they shall be deemed common property. When dividing common property, jewelry of relatively small value compared to the total common property shall be allocated to the spouse who is currently using it.*”. This regulation only addressed jewelry given to one or both spouses on the wedding day and classified it as either common or personal property, depending on the purpose of the gift. It did not, however, provide guidance on how to resolve issues related to betrothal gifts presented by the groom’s family to the bride’s family during the engagement ceremony. Nevertheless, the regulation introduced a rather persuasive principle for determining whether jewelry constitutes personal property, namely: “*jewelry of relatively small value compared to the common property shall be allocated to the spouse who is currently using it*”.

### **3.2. Application of Customary Practices in Resolving Disputes over Betrothal Gifts**

Disputes concerning the return of betrothal gifts occur quite frequently in practice and are often adjudicated by the courts. As noted above, the Law on Marriage and Family in particular, and civil law in general, do not currently provide specific provisions governing such disputes. This raises the legal question of whether customary practices may be applied to resolve these disputes when the parties cannot reach an agreement and the law contains no explicit regulation.

From a legal perspective, Article 5 of the 2015 Civil Code provides that in cases where the parties have no agreement and the law does not provide otherwise, customs may be applied, provided that such customs are not contrary to the fundamental principles of civil law set forth in Article 3 of the Civil Code. Similarly, Clause 1 of Article 45 of the 2015 Civil Procedure Code expressly recognizes

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<sup>2</sup> The term “*consumable items*” here corresponds to the modern legal concept of “*consumable property*.” Under Clause 1, Article 102 of the 2015 Civil Code of Vietnam, “*consumable property is property which, after being used once, ceases to exist or loses its original qualities, form, or utility.*”

the application of customs in dispute resolution when there is no agreement between the parties and no statutory provision.

The necessity of applying customary practices in resolving disputes over betrothal gifts is clearly illustrated in Judgment No. 283/2021/DS-PT dated December 9, 2021 of the People's Court of Tien Giang Province (hereinafter referred to as *Case One*), in which the Court held that “*when considering and resolving the case, it is necessary to apply Articles 3 and 5 of the Civil Code and Clause 1 of Article 45 of the Civil Procedure Code.*” Similarly, in Judgment No. 05/2018/HNGĐ-ST dated April 13, 2018 of the People's Court of Thach An District, Cao Bang Province (*Case Two*), and Judgment No. 07/2020/HNGĐ-ST dated August 18, 2020 of the People's Court of Binh Gia District, Lang Son Province (*Case Three*), the courts found that “*according to local customs, prior to the wedding ceremony, the groom's family must present the bride's family with a certain amount of money as agreed upon by both families*”; that “*the agreement on betrothal gifts is based on local custom, on the voluntary consent of the parties, does not violate prohibitions of the law, is not contrary to social morality, and is consistent with Articles 3, 4, 5, and 7 of the Civil Code*”; and that “*local customs do not provide that upon divorce, the bride's family must return the betrothal gifts or bride price to the groom's family.*” The courts' reliance on customary practices in these cases is legally and culturally persuasive, reflecting both the principles of civil law and the recognition of local traditions<sup>3</sup>.

### 3.3. The Giving and Receiving of Betrothal Gifts as a Conditional Gift Contract

As analyzed above, the Law on Marriage and Family does not contain any provisions governing the giving, receiving, or returning of betrothal gifts. However, from the perspective of civil transactions, the act of giving and receiving betrothal gifts may be regarded as a type of civil transaction. More specifically, it can be conceptualized as a *gift contract*, in which the groom's family acts as the donor and the bride's family as the donee.

In the four cases under discussion, the courts in *Case One* and *Case Three* identified the giving and receiving of betrothal gifts as a gift contract, while in *Case Two* and Judgment No. 43/2022/DS-ST dated August 4, 2022 of the People's Court of Mo Cay Bac District, Ben Tre Province (*Case Four*), the courts did not apply the provisions on gift contracts in resolving the dispute. This inconsistency demonstrates that, in practice, there is still no uniform approach to identifying the legal nature of disputes concerning the return of betrothal gifts. Nonetheless, the court's determination in *Case One* that the giving and receiving of betrothal gifts constitutes a conditional gift contract is entirely convincing.

Importantly, the giving of betrothal gifts should not be considered an ordinary gift, but rather a *conditional gift*, as explicitly stated by the court in *Case One*, which held that: “*This is a dispute in which Article 120 of the Civil Code on conditional civil transactions should be applied.*” Article 120 of the 2015 Civil Code provides that when the parties agree upon a condition that gives rise to or terminates a civil transaction, the transaction shall arise or be terminated upon the occurrence of that condition. Similarly, Clause 6 of Article 402 defines a conditional contract as one in which performance depends upon the occurrence, modification, or termination of a specified event.

In addition, the 2015 Civil Code contains explicit provisions on conditional gift contracts, under which the donor may require the donee to perform one or more obligations either before or after the gift is made. Thus, the law clearly recognizes conditional gift contracts, and judicial practice has

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<sup>3</sup> Article 457 of the 2015 Civil Code provides: “*A contract for the donation of property is an agreement between the parties whereby the donor delivers and transfers ownership of his or her property to the donee without requiring compensation, and the donee agrees to receive it.*”

shown that many courts consider the giving and receiving of betrothal gifts to fall within this category. What remains to be clarified, however, is the precise meaning of the *condition* in this context.

In *Case One*, the court reasoned that the condition attached to the giving of betrothal gifts was the “*celebration of marriage*.” In *Case Two*, the court did not clearly articulate the condition of the gift but merely noted that, in practice, “*the wife had already joined the groom’s family as a daughter-in-law*.” In *Case Three*, the court determined that the giving of betrothal gifts was *unconditional*. In yet another case, the court held that the relevant condition was that a “*wedding ceremony would be organized*”<sup>4</sup>. The question arises: how should the conditions such as “proceeding with the marriage,” “the wife has moved in with the husband’s family,” or “a wedding will be held” be understood? Is it sufficient that a wedding ceremony is conducted according to local customs for the condition of the gift to be satisfied, or must the marriage be formally registered (i.e., legally recognized) before the condition is fulfilled? In the judgments under review, there is no truly clear and consistent answer to this issue. The judgment of the Saigon Court of Appeal dated January 3, 1895, previously determined that the condition for the giving of betrothal gifts was the occurrence of marriage, meaning a marriage legally recognized by law<sup>5</sup>. The laws of England, Iceland, and Wales also recognize the giving and receiving of betrothal gifts as a conditional gift, with the specified condition being the occurrence of marriage<sup>6</sup>. In judicial practice in several U.S. states, such as Iowa, Kansas, Michigan, Minnesota, New Jersey, New Mexico, New York, and Pennsylvania, the courts have explicitly determined that the condition attached to the giving of betrothal gifts is marriage, rather than mere engagement<sup>7</sup>.

In practice, when the groom’s family brings betrothal gifts to the bride’s family, what they essentially aim at is that the couple will become husband and wife, that is, a marriage recognized by law. Therefore, it can be inferred that the implied (or suspensive) condition in this context is the conclusion of a lawful marriage. Consequently, if the couple merely holds a wedding ceremony without registering the marriage, the condition attached to the betrothal gift contract should be regarded as unfulfilled.

Determining the legality of the condition attached to betrothal gifts: In addition to provisions on conditional gift contracts, Article 462(1) of the 2015 Civil Code also sets out requirements for such conditions, stipulating that they must not contravene prohibitions of the law or social morals. In the second case, the Court reasoned that the giving of betrothal gifts was carried out ‘according to local customs, under which, before holding the wedding ceremony, the groom’s family must present the bride’s family with a certain sum of money as agreed upon by both families.’ In the third case, the Court likewise held that ‘the agreement on betrothal gifts was based on local customs and mutual consent, and did not violate any legal prohibitions or social morals, being consistent with Articles 3, 4, 5, and 7 of the Civil Code, and therefore should be legally recognized.’ It can thus be seen that the condition of ‘concluding a marriage’ attached to betrothal gift contracts is lawful and not contrary to social morals.

### 3.4. Cases where betrothal gifts may be reclaimed

As analyzed above, the giving and receiving of betrothal gifts has the legal nature of a conditional gift contract. In essence, if the condition attached to the gift has not been fulfilled, the donor is entitled to reclaim the property and claim damages. Accordingly, if the couple does not proceed to marriage, the bride’s family must return the betrothal gifts received from the groom’s family. In the first case,

<sup>4</sup> Judgment No. 42/2010/DS-ST dated June 15, 2010 of the People’s Court of Chau Thanh District, Long An Province.

<sup>5</sup> See *Journal judiciaire de la Cochinchine et du Cambodge* (1896), pp. 90–91.

<sup>6</sup> Section 3, arrangement of section, Family Law action; Section 3(2) Of The Law Reform (Miscellaneous Provisions) Act 1970.

<sup>7</sup> Do, V. D., & Le, T. D. P. (2024). *Disputes over betrothal gifts when an engagement is canceled*. <https://s.net.vn/swfL> [Accessed November 2, 2024].

the Court reasoned that since the marriage between Mr. Nguyễn Thành Đ1 and Ms. Thị Cẩm T was not carried out (i.e., the condition did not occur), Ms. Lê Thị Cẩm T was obliged to return to Mr. Nguyễn Văn Đ and Mrs. Huỳnh Thị Cẩm V the betrothal gifts consisting of: one ring weighing 6 phân 1 ly of 18-karat gold; one necklace weighing 4 chỉ of 24-karat gold; one bracelet weighing 2 chỉ of 24-karat gold; and one ring weighing 1 chỉ of 24-karat gold. The Court's decision requiring Ms. T to return the betrothal gifts after failing to marry Mr. Đ1 was entirely reasonable and well-founded. Similarly, in the fourth case, since the wedding between Mr. T and Ms. T3 was cancelled, the Court also ruled that Mr. T was entitled to recover part of the value of the betrothal gifts, amounting to VND 7,500,000 (including VND 2,500,000 for banquet expenses and VND 5,000,000 for make-up and gown rental on the wedding day). Article 1088 of the French Civil Code of 1804, as amended in 2016, likewise provides that 'any gifts made in contemplation of marriage shall be void if the marriage does not subsequently take place.' It is evident that with respect to betrothal gifts, French law contains clearer and more specific provisions than Vietnamese law.

### 3.5. Cases where betrothal gifts may not be reclaimed

If the condition of the betrothal gift contract has been fulfilled (i.e., marriage has taken place), the groom's family cannot reclaim the betrothal gifts. Once the conditional gift contract has taken effect, the parties are bound to respect and comply with the agreement already established. In the second case, the Court reasoned that the groom's family gave the betrothal money so that the bride's family could purchase personal belongings and household items (such as blankets, beds, wardrobes, pots, etc.) for the bride to bring to her husband's home. Since Ms. H had in fact moved in with Mr. T's family as his wife, the Court held that Mr. T's claim for the return of VND 30,000,000 as betrothal money lacked legal grounds. The condition attached to the gift was deemed fulfilled, as evidenced by the fact that 'Ms. H had become Mr. T's wife.' Similarly, in the third case, the Court determined that under the law, the giving of betrothal money constitutes a gift contract. The giving of money upon marriage was based on the voluntary agreement of the parties as to the amount and form of transfer, without any additional conditions, and was effective from the moment Ms. Hoàng Thị S received betrothal gifts—cash and other property valued at VND 25,000,000— from Mr. Hoàng Văn L, thereby acquiring ownership of the property in her own right. Furthermore, Official Letter No. 53/UBND dated August 15, 2020, from the People's Committee of Q Commune confirmed that there was no customary rule requiring the bride's family to return the betrothal money or bride price upon divorce. Consequently, Mr. L's claim for the return of the VND 25,000,000 in betrothal money was deemed unfounded and rightly rejected. Although the Court in the third case did not explicitly discuss the condition of the VND 25,000,000 gift from Mr. L to Ms. S, the decision to dismiss his claim was entirely persuasive, given that the couple had already celebrated their wedding and registered their marriage in accordance with the law.

In the fourth case, the Court did not apply the doctrine of conditional gifts, which resulted in inconsistency in handling the issue of returning betrothal gifts. Specifically, with respect to the VND 15,000,000 in cash given by Mr. T's family to Ms. T3 on the engagement day (including VND 5,000,000 for clothes to be used after marriage, VND 5,000,000 for make-up and gown rental on the wedding day, and VND 5,000,000 for banquet expenses), the Court ruled that Ms. T3 had to return only the VND 5,000,000 intended for make-up and gown rental. The VND 5,000,000 for clothes was not subject to return, while the VND 5,000,000 for banquet expenses was to be returned only in half, even though the wedding ceremony never took place. This reveals a certain inconsistency and hesitation on the part of the Court in determining the scope of restitution of betrothal gifts when marriage is not consummated.

### 3.6. Fault as a factor in the restitution of betrothal gifts

As analyzed above, where the condition attached to the giving of betrothal gifts does not occur, the groom's family has the right to reclaim the gifts. The question arises whether the bride's family must return all of the betrothal gifts even in cases where the groom is at fault for preventing the marriage from taking place. This issue arose in the first case, where the marriage between Mr. Đ1 and Ms. T did not proceed because Mr. Đ1 had repeatedly exchanged affectionate text messages with another woman and expressed his intention not to marry Ms. T. On October 1, 2020, at Ms. T's home, Mr. Đ1 admitted his relationship with this other woman and, in the presence of both families, demanded the cancellation of the marriage. On this basis, the Court found that Mr. Đ1 was at fault for the failure of the marriage and thus Ms. T was not required to return all of the betrothal gifts, but only part of them. Specifically, Ms. T was not obliged to return the pair of diamond earrings worth VND 21,678,550 that Mr. Đ1 had personally placed on her during the betrothal ceremony, nor the VND 10,000,000 given by Mr. Đ and Ms. V for Ms. T to purchase wedding clothes, since the wedding date had already been fixed and invitations issued. Ms. T was only required to return to Mr. Đ and Ms. V certain jewelry, namely: one ring weighing 6 phân 1 ly of 18K gold; one necklace weighing 4 chỉ of 24K gold; one bracelet weighing 2 chỉ of 24K gold; and one ring weighing 1 chỉ of 24K gold. This approach differed from that of the trial court, which had ordered Ms. T to return all of the betrothal gifts, including the diamond earrings and the VND 10,000,000. The trial court had failed to address Mr. Đ1's fault in preventing the marriage. The appellate court's decision was more persuasive, as it took into account Mr. Đ1's fault in causing the marriage to fall through, and used this as the basis for apportioning responsibility for the restitution of betrothal gifts. In the fourth case, the Court also held that Mr. T was at fault for the cancellation of the wedding, and therefore denied his claim for the return of VND 5,450,000, which represented part of the value of the wedding gold.

Unlike the approach of Vietnamese courts—as reflected in the first case under discussion—courts in several U.S. states generally do not consider fault in such disputes. That is, if the marriage does not take place, the recipient of betrothal gifts is obliged to return them regardless of who is at fault. This no-fault approach is often considered more consistent and reasonable. However, the Vietnamese approach—imposing responsibility on the party at fault for preventing the marriage—may be viewed as fostering a more civilized and responsible attitude among parties involved in such relationships.

### **7.7. Restitution of betrothal gifts that are consumables**

Betrothal gifts may consist of various items such as gold jewelry, earrings, wedding rings, cash, food, alcohol, and tea. A question arises as to whether, if the marriage is not solemnized, the party that received the betrothal gifts is required to return consumable items such as food, alcohol, or tea. This question was partly addressed in the third case, where the Court reasoned that 'the pork intended for the wedding feast was in fact consumed during the wedding preparations, as the groom's family also dined at the bride's family's house on the day of the wedding procession.' Consequently, the Court rejected Mr. Hoàng Văn L's claim for the return of pork worth VND 10,000,000, which his family had given to Ms. Hoàng Thị S's family as part of the betrothal gifts. From this reasoning, it can be inferred that betrothal gifts that are consumables are not subject to restitution, even if the marriage does not take place.

This principle was also expressly provided in the 1972 Civil Code, which specified that ceremonial gifts in the form of consumables need not be returned. This legislative approach is persuasive, as consumable betrothal gifts (such as alcohol, meat, tea, or fruit) are typically used by both families during the gathering to discuss the marriage, with the groom's family often partaking in their consumption at the bride's home

### **3.8. Shortcomings and limitations of current Vietnamese law concerning disputes over the restitution of betrothal gifts.**

At present, the Vietnamese legal system, including the 2014 Law on Marriage and Family, contains no specific provisions directly regulating betrothal gifts and their restitution. The settlement of disputes in this area largely relies on:

**Local customs** (pursuant to Article 5 of the 2015 Civil Code), which vary greatly from region to region, leading to a lack of consistency in application.

**Divergent judicial interpretations**, with some courts treating betrothal gifts as conditional gifts, while others interpret them as common or separate property, or as matters of customary practice.

As a result, cases of the same nature may be decided with different reasoning, legal bases, and outcomes. This undermines the predictability of the law and may give rise to a sense of unfairness among the parties. Furthermore, the absence of clear legal provisions on the restitution of betrothal gifts in cases where the marriage does not take place or is dissolved reduces the deterrent effect of the law and fails to provide effective guidance for parties engaged in marital relations.

### **3.9. Recommendations for improving Vietnamese law concerning disputes over the restitution of betrothal gifts**

To address the aforementioned shortcomings, it is advisable that the Law on Marriage and Family be supplemented with specific provisions on the giving and restitution of betrothal gifts, along the following lines:

**First**, clearly define the legal nature of betrothal gifts as conditional gifts, with the condition for their effectiveness being the lawful conclusion of marriage.

**Second**, stipulate the circumstances of restitution: where the marriage does not take place due to the fault of one party, that party must bear responsibility. If neither party is at fault (e.g., one party dies before the wedding), the betrothal gifts should be returned or handled according to mutual agreement. Consumable or already used items (such as food or wedding supplies) should not be subject to restitution.

**Third**, incorporate the element of fault to ensure fairness: if one party is at fault for the failure of the marriage, that party must forfeit or return the betrothal gifts, and may also bear liability for damages, if any.

Such clear provisions would contribute to greater transparency and consistency in judicial practice, while respecting the positive traditions and customs of the Vietnamese people and at the same time ensuring fairness and civility in legal relations

## **4. CONCLUSIONS**

Through the presentation and analysis of relevant legal provisions and judicial practice in several court judgments concerning disputes over the restitution of betrothal gifts, a number of observations may be drawn: (i) the current Law on Marriage and Family contains no provisions governing the giving and restitution of betrothal gifts, which constitutes a significant gap given that such disputes frequently arise in practice; (ii) due to the absence of explicit regulation, there is no consistency in how courts identify the legal nature of these disputes. Some judgments characterize them as disputes over conditional gifts, while others resolve the matter without reference to the doctrine of conditional gifts. As a result, cases with essentially similar circumstances may be adjudicated differently; and (iii) it should be emphasized that, in essence, the giving and receipt of betrothal gifts should be recognized

as a conditional civil transaction (a conditional gift contract). Under the current legal framework, courts should apply the rules governing conditional transactions when resolving such disputes, so as to ensure the legitimate rights and interests of the parties involved are adequately protected.

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## **VIOLENCIA CONTRA LA MUJER EN LA MUJER EN LA ÉPOCA ACTUAL, CAUSAS Y REALIDADES CONTEMPORÁNEAS.**

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### **Resumen**

La violencia contra las mujeres sigue siendo una de las manifestaciones más persistentes de desigualdad en América Latina. Aunque en las últimas décadas se han firmado tratados internacionales y aprobado leyes nacionales que reconocen el derecho a vivir libres de violencia, la experiencia cotidiana demuestra que esos avances no han logrado frenar la impunidad ni transformar prácticas institucionales. La persistencia de feminicidios, agresiones en el ámbito doméstico y nuevas formas de hostigamiento en espacios digitales evidencia que la brecha entre norma y realidad continúa abierta.

Este trabajo examina la evolución del marco jurídico internacional y regional, con énfasis en la **CEDAW (1979)** y la **Convención de Belém do Pará (1994)**, así como las respuestas nacionales en México, Argentina y Chile. Se analizan también las causas estructurales que reproducen la violencia, entre ellas la desigualdad económica, la persistencia de estereotipos de género y la falta de voluntad política para aplicar la ley.

El artículo sostiene que la sanción penal, aunque necesaria, resulta insuficiente si no se acompaña de educación con perspectiva de género, empoderamiento económico y políticas de protección frente a la violencia digital. Reconocer la violencia contra las mujeres como una violación a los derechos humanos implica que los Estados no solo proclamen la igualdad, sino que la conviertan en una experiencia concreta y cotidiana para todas las mujeres.

**Palabras clave:** violencia de género; derechos humanos; impunidad; igualdad sustantiva; América Latina.

## **VIOLENCE AGAINST WOMEN IN THE PRESENT ERA: CAUSES AND CONTEMPORARY REALITIES.**

### **Abstract**

Violence against women remains one of the most persistent manifestations of inequality in Latin America. Although international treaties and national laws recognizing the right to live free from violence have been signed in recent decades, daily experience shows that these advances have failed

to curb impunity or transform institutional practices. The persistence of femicides, domestic violence, and new forms of harassment in digital spaces demonstrates that the gap between law and reality remains wide open.

This article examines the evolution of the international and regional legal framework, with an emphasis on the CEDAW (1979) and the Convention of Belém do Pará (1994), as well as national responses in Mexico, Argentina, and Chile. It also analyzes the structural causes that reproduce violence, including economic inequality, the persistence of gender stereotypes, and the lack of political will to enforce the law.

The article argues that criminal sanctions, although necessary, are insufficient if not accompanied by gender-sensitive education, economic empowerment, and policies to protect against digital violence. Recognizing violence against women as a human rights violation requires States not only to proclaim equality, but also to make it a concrete and everyday experience for all women.

**Keywords:** gender violence; human rights; impunity; substantive equality; Latin America.

## 1.- INTRODUCCIÓN:

La violencia contra las mujeres no es un fenómeno nuevo ni excepcional; es una realidad que atraviesa generaciones y contextos sociales, dejando huellas en la vida cotidiana y en las instituciones. En los últimos años, este problema se ha situado en el centro de la agenda de derechos humanos, no solo por la gravedad de sus manifestaciones, sino porque expone la capacidad —o incapacidad— de los Estados para garantizar igualdad y justicia. Pese a la existencia de constituciones, leyes específicas y tratados internacionales, los niveles de violencia siguen siendo elevados, lo que revela una profunda distancia entre la letra de la norma y la experiencia de las mujeres.

El marco jurídico internacional ha sido fundamental para visibilizar esta situación. La **CEDAW (1979)** y la **Convención de Belém do Pará (1994)** establecieron obligaciones claras para prevenir y sancionar la violencia de género. No obstante, en países como México, las estadísticas oficiales continúan registrando cifras alarmantes de feminicidios y agresiones en el ámbito familiar (SESNP, 2023). Este contraste muestra que los avances legales, aunque imprescindibles, resultan insuficientes si no se traducen en acciones eficaces y sostenidas.

Desde la teoría feminista y la crítica jurídica, la violencia se explica como parte de estructuras históricas de dominación y no como hechos aislados. Autoras como **Lagarde (1990)** y **Segato (2003)** han señalado que estas prácticas cumplen la función de mantener a las mujeres en condiciones de subordinación, lo que explica la resistencia institucional a aplicar plenamente la perspectiva de género. Muchas veces, los mismos operadores jurídicos reproducen los estereotipos que deberían erradicar, lo que debilita la eficacia de las leyes.

El objetivo de este artículo es examinar cómo los compromisos internacionales y regionales han influido en la legislación nacional, identificar las raíces estructurales de la violencia y valorar las estrategias de prevención y respuesta más efectivas. El análisis se centra en América Latina y parte de una lectura crítica: la violencia contra las mujeres no puede seguir tratándose como un asunto privado, sino que debe entenderse como una violación sistemática de derechos humanos que exige voluntad política, recursos adecuados y transformaciones profundas en las instituciones.

## 2.- MARCO HISTÓRICO Y NORMATIVO INTERNACIONAL

El derecho internacional, en sus primeras etapas, no prestó atención real a las condiciones de las mujeres. La prioridad eran la paz y la cooperación entre Estados, y en ese marco las desigualdades de género quedaban relegadas. Esta omisión permitió que prácticas discriminatorias se mantuvieran

justificadas como costumbres legítimas, invisibilizando las múltiples formas de violencia que atravesaban la vida cotidiana de las mujeres (Cook, 1994).

Los primeros instrumentos universales incluyeron referencias a la igualdad, pero con un carácter más simbólico que práctico. La **Carta de la ONU (1945)** habló de la igualdad entre hombres y mujeres, y la **Declaración Universal de Derechos Humanos (1948)** reiteró ese principio. Sin embargo, ambos textos carecieron de mecanismos eficaces para obligar a los Estados a modificar leyes o costumbres que mantenían la subordinación femenina (Facio & Fries, 2005).

Un cambio significativo se dio con la **Convención sobre la Eliminación de Todas las Formas de Discriminación contra la Mujer (CEDAW, 1979)**. Este tratado obligó a los Estados a no limitarse a reconocer derechos en el papel, sino a transformar patrones socioculturales que reproducen subordinación. Sus **Recomendaciones Generales núm. 19 (1992) y 35 (2017)** marcaron un paso decisivo al afirmar que la violencia de género constituye una forma de discriminación y, por ende, una violación de los derechos humanos.

En el plano regional, la **Convención de Belém do Pará (1994)** representó un avance histórico: definió la violencia contra las mujeres como una violación de derechos humanos y estableció la responsabilidad directa de los Estados de prevenir, sancionar y erradicarla. A partir de este instrumento, la **Corte Interamericana de Derechos Humanos** empezó a construir una línea jurisprudencial clave. En el caso *Fernández Ortega y otros vs. México* (2010), por ejemplo, el tribunal sostuvo que la violencia sexual cometida por agentes estatales y la falta de investigación adecuada constituyen violaciones graves al derecho internacional.

A pesar de estos avances normativos, la violencia persiste. El problema no está en la falta de tratados, sino en la distancia entre las normas y su implementación. Nuevas realidades como la violencia digital y la trata de mujeres muestran que los textos adoptados en el siglo pasado no alcanzan a responder por sí mismos. Como señala Bodelón (2014), el derecho se vuelve inoperante cuando los Estados carecen de voluntad política y de instituciones que hagan cumplir lo que ya está escrito.

### 3.- CONCEPTUALIZACIÓN Y TIPOLOGÍAS DE LA VIOLENCIA CONTRA LA MUJER

Cuando se habla de violencia contra las mujeres, no basta con describir un hecho concreto de agresión. El concepto remite a cualquier acción u omisión que, por motivos de género, limite derechos, afecte la integridad física, psicológica o sexual, o reduzca la libertad de decisión de las mujeres. La **Declaración de la ONU de 1993** ofreció una definición formal, pero más allá del texto lo relevante es reconocer que se trata de una práctica estructural que se repite en distintos ámbitos: el hogar, la comunidad, el trabajo o incluso frente a instituciones estatales.

Para fines de análisis jurídico y social, se han identificado varias formas de violencia. Entre ellas destacan las agresiones físicas, las limitaciones económicas y patrimoniales, las conductas que buscan someter a través del miedo o del daño emocional, la violencia sexual en sus diversas expresiones, y, de manera más reciente, los ataques digitales como el hostigamiento en redes o la difusión no consentida de imágenes íntimas. Estas categorías son útiles para visibilizar la amplitud del fenómeno, aunque en la vida real suelen combinarse en un mismo caso.

Las tipologías reconocidas permiten dimensionar la complejidad del fenómeno.

**Violencia física** comprende todo acto que cause daño corporal mediante golpes, quemaduras o cualquier forma de agresión material.

**violencia sexual**, por su parte, incluye violación, acoso, explotación y cualquier práctica que vulnere la autonomía sexual de la mujer.

**violencia psicológica** se manifiesta en insultos, humillaciones, amenazas y control emocional, cuya gravedad muchas veces pasa inadvertida en los sistemas judiciales

**violencia digital** como una modalidad emergente. El acoso en redes sociales, la difusión no consentida de imágenes íntimas y el espionaje mediante dispositivos tecnológicos representan un nuevo escenario de vulneración de derechos, que exige respuestas normativas específicas (EIGE, 2022). Este tipo de violencia resulta especialmente grave porque trasciende fronteras y expone a las víctimas a una revictimización constante.

Una lectura crítica exige reconocer que las categorías jurídicas de violencia, aunque necesarias para ordenar el fenómeno y darle contenido normativo, no siempre captan la complejidad de la experiencia de las mujeres. En la realidad, las agresiones rara vez se presentan de manera aislada: la mujer que sufre golpes suele estar sometida, al mismo tiempo, a chantajes emocionales o al control de sus ingresos; quien es víctima de acoso psicológico puede serlo también de amenazas sexuales; y los ataques en entornos digitales suelen prolongar o intensificar relaciones abusivas que comenzaron en el espacio privado.

Esta superposición evidencia que la violencia de género no puede entenderse como un conjunto de hechos fragmentados, sino como un entramado estructural que responde a patrones de dominación históricamente arraigados. El riesgo de limitar el análisis a un catálogo rígido de tipologías es que la respuesta del Estado se reduzca a un formalismo, incapaz de atender la verdadera magnitud del problema.

El desafío, por tanto, consiste en que los marcos normativos y las políticas públicas asuman esta complejidad. Reconocer la interacción entre las distintas formas de violencia permite diseñar estrategias de prevención y de reparación que respondan a la realidad de las víctimas y no solo a categorías abstractas. La ley, en este sentido, debe ser una herramienta dinámica que se actualice frente a las nuevas manifestaciones de violencia, y no un esquema estático que termine reproduciendo las mismas limitaciones que pretende superar.

#### 4.- CAUSAS ESTRUCTURALES DE LA VIOLENCIA CONTRA LA MUJER

La violencia contra las mujeres no puede reducirse a un listado de incidentes ni atribuirse únicamente a la conducta de ciertos agresores. Es un fenómeno de raíz estructural, vinculado a la manera en que las sociedades han distribuido el poder y lo han legitimado a través de instituciones, costumbres y marcos jurídicos que, durante siglos, reforzaron la subordinación femenina.

Uno de los pilares de esa estructura es el **patriarcado**. No se trata solo de una ideología, sino de un sistema social que concentra en los varones el poder político, económico y simbólico, relegando a las mujeres a roles de dependencia y obediencia. Como advierte **Lagarde (1990)**, la violencia funciona aquí como un mecanismo disciplinador: mantiene a las mujeres bajo control y asegura la continuidad de ese orden desigual.

Otra raíz profunda es la **impunidad institucional**. En gran parte de América Latina, la falta de investigaciones serias y la revictimización durante los procesos judiciales crean un entorno donde la violencia no solo ocurre, sino que se normaliza. **Monárrez (2009)** lo documentó en Ciudad Juárez: la ausencia de justicia frente a los feminicidios transformó a las mujeres en blancos sistemáticos, mostrando cómo la indiferencia estatal alimenta la repetición de los crímenes.

La **socialización de género** completa este entramado. Desde la infancia, niños reciben mensajes diferenciados: a ellos se les asocia con la autoridad y la fuerza, a ellas con el cuidado y la sumisión. Estos aprendizajes tempranos consolidan prácticas que legitiman el control masculino y naturalizan la violencia como parte de las relaciones cotidianas. Tal como señala **Segato (2003)**, la violencia de género se sostiene porque se transmite y se reproduce de generación en generación.

La **desigualdad económica** constituye otro pilar. La feminización de la pobreza, documentada por la CEPAL (2021), muestra que las mujeres tienen menos acceso a empleos dignos, crédito y tierra. Esta precariedad económica limita sus opciones de independencia y las obliga, en muchos casos, a permanecer en relaciones violentas.

Finalmente, los **factores culturales y religiosos** en ciertas comunidades han legitimado prácticas que restringen derechos fundamentales. Bajo la idea de tradición o moral, se justifican conductas como el control del cuerpo femenino, la negación de derechos reproductivos o la subordinación en la vida familiar. Estas visiones, cuando no se cuestionan, refuerzan la violencia como una práctica aceptada socialmente.

Lo que muestran los testimonios y expedientes judiciales es que las mujeres no enfrentan una sola forma de violencia, sino varias a la vez. Un golpe puede ir acompañado de chantaje económico, de insultos constantes o de amenazas en línea. Por eso, más que entender la violencia como un listado de tipos, conviene verla como un entramado complejo que reproduce desigualdades históricas y que exige respuestas estatales integrales.

## 5.- MARCO TEÓRICO

Para comprender la violencia contra las mujeres es necesario situarla en un marco teórico que vaya más allá de la descripción de hechos y permita identificar los elementos estructurales que la reproducen. Desde el derecho y las ciencias sociales, se han desarrollado diversos enfoques que resultan esenciales para este análisis.

Uno de los aportes más relevantes proviene de la **teoría feminista del derecho**, que cuestiona la aparente neutralidad jurídica. Autoras como Catharine MacKinnon (1989) sostienen que el derecho ha sido históricamente diseñado desde una perspectiva masculina y, en consecuencia, ha legitimado la subordinación de las mujeres. En América Latina, Marcela Lagarde (1990) advierte que la violencia no es un fenómeno marginal, sino un mecanismo que asegura el control social sobre las mujeres, limitando su autonomía.

Otro enfoque fundamental es la **teoría ecológica**, planteada por Lori Heise (1998), que analiza la violencia desde distintos niveles: individual, relacional, comunitario y estructural. Esta mirada permite explicar por qué los factores económicos, la cultura patriarcal y la debilidad institucional interactúan para perpetuar la violencia. Estudios recientes en la región, como los de Monárrez Frago (2009) sobre el feminicidio en Ciudad Juárez, confirman que las condiciones sociales y culturales son determinantes en la reproducción de la violencia extrema.

La **interseccionalidad**, introducida por Kimberlé Crenshaw (1989), aporta otra herramienta clave. Esta perspectiva señala que las mujeres no enfrentan la violencia de manera homogénea, pues las condiciones de clase, etnia, edad, orientación sexual o discapacidad crean experiencias diferenciadas. En América Latina, esto se refleja en la situación de mujeres indígenas y migrantes, quienes padecen una doble vulnerabilidad: por género y por discriminación estructural (Pautassi, 2007).

Finalmente, la **teoría crítica del derecho** recuerda que los sistemas jurídicos no son neutrales y que, en muchos casos, reproducen las desigualdades que dicen combatir. Como señala Bodelón (2014), la mera promulgación de leyes no garantiza la erradicación de la violencia; lo determinante es la voluntad política y la capacidad de transformar prácticas institucionales.

Este conjunto de enfoques teóricos permite entender que la violencia contra las mujeres no es un accidente ni un problema privado, sino una construcción social e histórica que requiere respuestas jurídicas integrales. El marco teórico, por tanto, no solo explica el fenómeno, sino que orienta el diseño de estrategias para su prevención y erradicación.

## 6.- MARCO JURÍDICO REGIONAL Y NACIONAL (MÉXICO Y AMÉRICA LATINA)

En México, el marco jurídico en materia de igualdad y no discriminación tiene bases constitucionales claras. El artículo 1º de la **Constitución Política de los Estados Unidos Mexicanos** prohíbe toda forma de discriminación y obliga a todas las autoridades a garantizar los derechos humanos. El artículo 4º, por su parte, reconoce expresamente la igualdad entre mujeres y hombres. Estos mandatos, en teoría, obligan al Estado a diseñar políticas públicas que hagan realidad la igualdad sustantiva.

Un paso decisivo en el plano legislativo fue la promulgación de la **Ley General de Acceso de las Mujeres a una Vida Libre de Violencia (2007)**. Esta ley definió los distintos tipos de violencia — física, psicológica, sexual, económica y patrimonial y creó mecanismos de coordinación institucional para prevenir, sancionar y erradicarla. Sin embargo, como advierte Bodelón (2014), la eficacia del derecho no depende únicamente de su diseño normativo, sino de la voluntad política para aplicarlo. En México, los altos índices de feminicidio muestran que la implementación de esta ley sigue siendo limitada.

En el ámbito regional, **Argentina** ha tenido avances significativos con la Ley 26.485 de 2009, que amplió las categorías de violencia para incluir formas simbólicas y mediáticas. Esta legislación es relevante porque reconoce que la violencia no siempre se manifiesta de manera física, sino también a través de representaciones culturales y discursos que refuerzan la subordinación de las mujeres (Pautassi, 2007). Sin embargo, a pesar de la amplitud normativa, los femicidios continúan siendo un fenómeno alarmante, lo que refleja que la norma por sí sola no basta.

En **Chile**, la Ley 21.484 de 2022 marcó un punto de inflexión al transitar de un marco centrado en la violencia intrafamiliar hacia un enfoque integral que reconoce distintas expresiones de violencia de género. El desafío chileno, como señala Fernández (2022), es lograr que la cultura judicial incorpore una perspectiva de género real y deje de minimizar los testimonios de las víctimas.

La comparación entre México, Argentina y Chile muestra un patrón común: **marcos normativos progresistas frente a instituciones débiles**. En todos los casos, se han dado pasos importantes en el plano legal, pero los obstáculos estructurales impunidad, falta de recursos, prejuicios culturales impiden que los derechos reconocidos se conviertan en realidades tangibles. El reto, por tanto, no está en la falta de normas, sino en la construcción de instituciones eficaces y en la transformación cultural necesaria para que la igualdad sustantiva deje de ser una promesa.

## 7.- ESTRATEGIAS DE PREVENCIÓN Y RESPUESTA

La prevención de la violencia contra las mujeres exige un cambio estructural que combine acciones jurídicas, educativas, económicas y tecnológicas. No basta con sancionar al agresor una vez cometido el delito; la verdadera transformación requiere anticiparse y construir condiciones que reduzcan la vulnerabilidad de las mujeres y fortalezcan sus derechos.

Un primer eje indispensable es la **educación con perspectiva de género**. La experiencia demuestra que los estereotipos de género se transmiten desde la infancia y normalizan la desigualdad. Iniciativas como la Educación Sexual Integral en Argentina han mostrado que incluir contenidos sobre respeto, igualdad y diversidad desde etapas tempranas contribuye a reducir la tolerancia social hacia la violencia (Dides, 2019). En México, la Secretaría de Educación Pública ha impulsado lineamientos en esta materia, aunque de manera fragmentada y sin continuidad.

El **sistema de justicia** representa otro ámbito decisivo. Los protocolos especializados y la capacitación de operadores jurídicos han sido avances relevantes, pero insuficientes. La persistencia de prácticas discriminatorias y la revictimización demuestran que se necesita una transformación cultural profunda dentro de ministerios públicos y tribunales (Bodelón, 2014). La jurisprudencia de

la Corte Interamericana, como en el caso *Fernández Ortega y otros vs. México* (2010), confirma que la falta de debida diligencia estatal constituye en sí misma una forma de violencia institucional.

El **empoderamiento económico** de las mujeres también es esencial. La CEPAL (2021) ha documentado que la feminización de la pobreza incrementa la exposición a la violencia y limita las posibilidades de independencia. Políticas de acceso al empleo digno, al crédito y a la seguridad social no son medidas accesorias, sino condiciones necesarias para garantizar una vida libre de violencia.

Finalmente, la **protección digital** se ha convertido en un reto contemporáneo. La violencia en línea que incluye desde el acoso en redes sociales hasta la difusión no consentida de imágenes íntimas ha mostrado un crecimiento acelerado. ONU Mujeres (2020) advierte que esta modalidad reproduce los mismos patrones de control y dominación que la violencia física, pero en un espacio donde la respuesta institucional es aún incipiente. Los Estados deben actualizar su legislación y generar mecanismos de acompañamiento y reparación adaptados a este ámbito.

En conjunto, estas estrategias reflejan que la prevención y la respuesta no pueden fragmentarse. Educación, justicia, economía y tecnología deben abordarse como pilares interdependientes. Solo así será posible que los marcos normativos se traduzcan en experiencias reales de igualdad y en una disminución efectiva de la violencia contra las mujeres.

## 8.- DISCUSIÓN Y RESULTADOS

Cuando se habla de violencia contra las mujeres, no basta con describir un hecho concreto de agresión. El concepto remite a cualquier acción u omisión que, por motivos de género, limite derechos, afecte la integridad física, psicológica o sexual, o reduzca la libertad de decisión de las mujeres. La **Declaración de la ONU de 1993** ofreció una definición formal, pero más allá del texto lo relevante es reconocer que se trata de una práctica estructural que se repite en distintos ámbitos: el hogar, la comunidad, el trabajo o incluso frente a instituciones estatales.

Para fines de análisis jurídico y social, se han identificado varias formas de violencia. Entre ellas destacan las agresiones físicas, las limitaciones económicas y patrimoniales, las conductas que buscan someter a través del miedo o del daño emocional, la violencia sexual en sus diversas expresiones, y, de manera más reciente, los ataques digitales como el hostigamiento en redes o la difusión no consentida de imágenes íntimas. Estas categorías son útiles para visibilizar la amplitud del fenómeno, aunque en la vida real suelen combinarse en un mismo caso.

Un segundo hallazgo es que la violencia se sostiene en **causas estructurales** que las leyes no eliminan por sí mismas. Factores como la desigualdad económica, la naturalización de roles de género y la ausencia de políticas preventivas hacen que la violencia se reproduzca. Como señala Monárrez (2009), en Ciudad Juárez la impunidad convirtió a las mujeres en blanco de violencia sistemática, mostrando cómo la falta de respuesta estatal refuerza el ciclo de agresiones.

También se identificó el crecimiento de la **violencia digital**, un fenómeno que reproduce en línea las mismas formas de control y agresión que existen en el espacio físico. El acoso en redes sociales, el hostigamiento mediante mensajes y la difusión no consentida de imágenes íntimas han expuesto la necesidad de actualizar las políticas públicas. ONU Mujeres (2020) ha advertido que esta modalidad genera un impacto profundo en la vida de las mujeres, pero los sistemas de justicia todavía carecen de herramientas adecuadas para atenderla.

Lo que muestran los testimonios y expedientes judiciales es que las mujeres no enfrentan una sola forma de violencia, sino varias a la vez. Un golpe puede ir acompañado de chantaje económico, de insultos constantes o de amenazas en línea. Por eso, más que entender la violencia como un listado de tipos, conviene verla como un entramado complejo que reproduce desigualdades históricas y que exige respuestas estatales integrales.

## 9.- APORTACIONES

Este trabajo aporta, en primer lugar, una mirada crítica sobre **la distancia entre el derecho formal y la realidad social**. En la investigación se advierte que la sola existencia de leyes o tratados internacionales no basta para garantizar los derechos de las mujeres. Este señalamiento es relevante porque obliga a discutir no solo la producción normativa, sino también la eficacia institucional y la responsabilidad de los Estados en su aplicación (Bodelón, 2014).

En segundo término, el artículo ofrece un **enfoque integral de la violencia contra las mujeres**, que no se limita al ámbito penal. Se resalta la importancia de la educación con perspectiva de género, la transformación del sistema de justicia, el empoderamiento económico y la protección digital como ejes que deben articularse para enfrentar la violencia de manera efectiva. Esta perspectiva permite superar visiones reduccionistas que explican la violencia únicamente desde la sanción.

Una tercera aportación es la **comparación regional entre México, Argentina y Chile**, que revela patrones compartidos: marcos normativos progresistas acompañados de instituciones débiles. Esta constatación ayuda a comprender que el problema no es exclusivo de un país, sino que responde a dinámicas estructurales en América Latina. La reflexión comparativa enriquece el debate académico al mostrar que, más allá de las diferencias jurídicas, los obstáculos institucionales y culturales son similares (Fernández, 2022; Pautassi, 2007).

Finalmente, este trabajo aporta al debate jurídico al **cuestionar el papel del derecho como herramienta de transformación social**. Si bien reconoce los avances normativos, insiste en que sin voluntad política, sin recursos y sin un cambio cultural profundo, la igualdad seguirá siendo una aspiración formal. En este sentido, el artículo no se limita a describir lo existente, sino que plantea la necesidad de articular el derecho con políticas públicas sostenidas y con prácticas institucionales que coloquen en el centro a las mujeres y su derecho a vivir libres de violencia.

## 10.- CONCLUSIONES

El recorrido de esta investigación muestra que la violencia contra las mujeres no puede entenderse como un fenómeno excepcional ni privado. Es una práctica estructural que se mantiene a pesar de las reformas jurídicas y de los compromisos internacionales asumidos por los Estados. Reconocerlo obliga a mirar más allá de los textos legales y preguntarse por las condiciones reales en que las mujeres intentan ejercer sus derechos.

Uno de los aprendizajes centrales es que la brecha entre lo jurídico y lo social sigue abierta. La existencia de normas como la **Ley General de Acceso de las Mujeres a una Vida Libre de Violencia (México, 2007)**, la **Ley 26.485 (Argentina, 2009)** o la **Ley 21.484 (Chile, 2022)** no ha sido suficiente para frenar la impunidad ni modificar las prácticas institucionales que revictimizan a las mujeres. Tal como advierte Bodelón (2014), las reformas pierden fuerza cuando no se acompañan de voluntad política y de un compromiso real con la transformación institucional.

Otro punto que se confirma es que la violencia se reproduce porque hunde sus raíces en factores estructurales como la pobreza, los estereotipos de género y la tolerancia social hacia la discriminación. Estos elementos explican por qué las políticas públicas enfocadas únicamente en la sanción penal resultan insuficientes. La prevención, la educación con perspectiva de género y el empoderamiento económico son dimensiones indispensables para reducir la vulnerabilidad de las mujeres (CEPAL, 2021).

La conclusión principal es clara: sin instituciones eficaces y sin políticas públicas sostenidas, la igualdad seguirá siendo un derecho reconocido en el papel, pero negado en la vida diaria. El desafío inmediato es transformar la norma en acción y garantizar que la justicia deje de ser un privilegio para convertirse en una garantía efectiva para todas las mujeres.

La violencia contra la mujer sigue siendo una problemática estructural, compleja y multifactorial. Aunque se han logrado avances importantes en términos de visibilidad y legislación, persisten desafíos significativos, especialmente en el ámbito digital y en contextos de crisis social. Superar esta situación requiere un enfoque integral, interseccional y sostenido, con la participación de Estados, organizaciones civiles, sistemas educativos y medios de comunicación.

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## LA PROTECCIÓN INTERNACIONAL DE LOS DERECHOS DE LAS MUJERES: AVANCES Y DESAFÍOS

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### RESUMEN

La violencia contra las mujeres constituye una de las violaciones más persistentes de los derechos humanos y refleja la distancia entre el marco jurídico y la realidad social. Aunque el derecho internacional ha avanzado mediante instrumentos como la CEDAW y la Convención de Belém do Pará, la violencia de género persiste en múltiples formas: física, psicológica, sexual, económica, política y feminicida. México, a pesar de haber reformado su Constitución y adoptado leyes como la Ley General de Acceso de las Mujeres a una Vida Libre de Violencia, sigue enfrentando altos índices de impunidad y feminicidios.

Este trabajo examina, desde un enfoque jurídico y crítico, la evolución histórica de los derechos de las mujeres, la respuesta internacional y regional frente a las formas de violencia, y los desafíos actuales en México y América Latina. Se analizan casos paradigmáticos como el de Malala Yousafzai, Juana Quispe y el caso “Campo Algodonero” de la Corte Interamericana de Derechos Humanos, los cuales evidencian que la violencia contra las mujeres es un fenómeno estructural y global.

El análisis concluye que no basta con la existencia de normas jurídicas progresistas; se requiere voluntad política, instituciones sólidas y políticas públicas sostenidas para cerrar la brecha entre la ley y su aplicación. Solo así podrá garantizarse a las mujeres una vida libre de violencia y el pleno ejercicio de sus derechos.

**Palabras clave:** Violencia de género, derechos humanos, igualdad, acceso a justicia, feminicidio.

## THE INTERNATIONAL PROTECTION OF WOMEN'S RIGHTS: PROGRESS AND CHALLENGES

### ABSTRACT

Violence against women remains one of the most persistent human rights violations, highlighting the gap between legal frameworks and social reality. Although international law has advanced through instruments such as CEDAW and the Belém do Pará Convention, gender-based violence continues to manifest in multiple forms: physical, psychological, sexual, economic, political, and femicidal.

Mexico, despite constitutional reforms and the adoption of laws such as the General Law on Women's Access to a Life Free of Violence, still faces high levels of impunity and femicides.

This paper critically examines the historical evolution of women's rights, the international and regional responses to violence, and the current challenges in Mexico and Latin America. Paradigmatic cases such as Malala Yousafzai, Juana Quispe, and the "Campo Algodonero" judgment of the Inter-American Court of Human Rights reveal that violence against women is a structural and global phenomenon.

The analysis concludes that progressive legal norms are not enough; political will, strong institutions, and sustained public policies are essential to close the gap between law and enforcement. Only by strengthening justice systems and ensuring effective implementation can women fully exercise their rights and live free from violence.

**Keywords:** Gender violence, human rights, equality, access to justice, femicide.

## INTRODUCCIÓN

La igualdad de género no es una concesión, sino un derecho humano fundamental reconocido por la comunidad internacional. Sin embargo, los Estados enfrentan el reto de transformar los compromisos normativos en políticas públicas efectivas. La violencia contra la mujer, en todas sus manifestaciones —doméstica, sexual, económica, política o feminicida—, revela la distancia entre la normatividad y su aplicación. La CEDAW (1979) y la Convención de Belém do Pará (1994) han sentado bases jurídicas relevantes, pero las cifras de impunidad muestran que el derecho aún se encuentra atrapado en la ineficacia estructural.

## PLANTEAMIENTO DEL PROBLEMA

A pesar de que la comunidad internacional ha desarrollado un amplio marco normativo para la protección de los derechos de las mujeres —desde la Carta de las Naciones Unidas hasta la CEDAW y la Convención de Belém do Pará—, la violencia contra la mujer continúa siendo una de las principales violaciones de derechos humanos a nivel global. Esta contradicción entre el reconocimiento formal de los derechos y la persistencia de prácticas discriminatorias plantea un dilema jurídico y social de gran relevancia.

El problema no radica únicamente en la ausencia de normas, sino en la ineficacia en su implementación. En países como México, donde se han incorporado reformas constitucionales y leyes de avanzada, la violencia feminicida, la impunidad judicial y la discriminación institucional demuestran que el derecho escrito no se traduce automáticamente en justicia real.

Además, la violencia contra las mujeres no puede analizarse de manera aislada: se entrelaza con factores culturales, económicos y políticos. Las mujeres indígenas, rurales y en situación de pobreza enfrentan una doble o triple discriminación, lo que revela la urgencia de un enfoque interseccional en la protección de sus derechos.

El núcleo del problema, por tanto, es determinar hasta qué punto los instrumentos internacionales y nacionales de protección de derechos humanos han logrado reducir la violencia y garantizar un acceso efectivo a la justicia, o si, por el contrario, se han convertido en meras declaraciones simbólicas sin impacto real en la vida de las mujeres.

## METODOLOGÍA

La presente investigación es de carácter cualitativo, documental y analítico. Se empleó un enfoque crítico-jurídico, a partir de la revisión de instrumentos internacionales de derechos humanos, tratados regionales, jurisprudencia de la Corte Interamericana de Derechos Humanos y resoluciones de la Suprema Corte de Justicia de la Nación (SCJN) en México.

Asimismo, se realizó un análisis comparativo de doctrina especializada publicada en editoriales jurídicas como Tirant Lo Blanch, Porrúa y UNAM, así como en revistas indexadas en Redalyc y Scielo, con el fin de evaluar el grado de eficacia real de los marcos normativos frente a la violencia contra la mujer.

El método empleado combina la hermenéutica jurídica —para la interpretación de normas y sentencias— con un enfoque crítico-constructivo, orientado a identificar brechas entre el derecho positivo y su aplicación práctica.

## **DESARROLLO DEL TEMA**

### **Marco histórico y cultural**

La condición jurídica y social de las mujeres ha estado marcada, a lo largo de los siglos, por la subordinación al varón y por estructuras patriarcales que las relegaron al ámbito doméstico. Desde la Antigüedad hasta la Edad Media, su participación fue reducida y justificada bajo discursos religiosos y sociales que las consideraban inferiores. La modernidad trajo consigo el movimiento sufragista, que abrió las puertas al reconocimiento político, aunque aún limitado. En América Latina, estos procesos se desarrollaron con retraso y bajo contextos de dictaduras y democracias frágiles. México, por ejemplo, no reconoció plenamente el voto femenino hasta 1953, lo que refleja la resistencia estructural del sistema jurídico a aceptar a la mujer como sujeto político.

### **Marco jurídico internacional y formas históricas de violencia contra la mujer**

El derecho internacional de los derechos humanos ha evolucionado hacia una mayor protección de las mujeres; sin embargo, los contextos históricos muestran que ellas han sido víctimas de múltiples formas de violencia en distintas regiones del mundo.

En la Antigüedad y la Edad Media, la violencia estaba legitimada en normas sociales y religiosas: desde la época romana donde se decidía sobre la vida de las mujeres, hasta la Inquisición que persiguió y ejecutó a miles bajo la acusación de brujería. Estas prácticas evidencian cómo la violencia contra la mujer se justificaba como un asunto cultural y no como un crimen.

Durante la época colonial en México, las mujeres estaban sometidas a la potestad marital, y su papel jurídico se limitaba a la obediencia y dependencia económica. La violencia conyugal era tolerada por las leyes, siempre que no pusiera en riesgo la vida de la mujer. En paralelo, prácticas similares se mantenían en Europa: en España hasta bien entrado el siglo XIX se aceptaba el “castigo moderado” del marido hacia la esposa como prerrogativa conyugal.

En el siglo XX, los regímenes autoritarios de América Latina y Asia reprodujeron la violencia de género como mecanismo de control. En Colombia, el conflicto armado interno dejó a miles de mujeres víctimas de violencia sexual sistemática, reconocida más tarde por la Corte Constitucional como un crimen de lesa humanidad. En Guatemala y Chile, las dictaduras militares utilizaron la violencia sexual contra las mujeres como instrumento de represión política. En Asia, en particular durante la Segunda Guerra Mundial, las mujeres coreanas conocidas como “comfort women” fueron sometidas a esclavitud sexual por el ejército japonés, un hecho que décadas después sigue siendo objeto de litigios y reclamaciones internacionales.

En contraste, algunos países han impulsado políticas más sólidas. En España, la Ley Orgánica de Medidas de Protección Integral contra la Violencia de Género (2004) ha establecido tribunales especializados y protocolos de actuación inmediata, lo que ha permitido reducir la impunidad y generar una mayor conciencia social. En Colombia, la Ley 1257 de 2008 estableció medidas de sensibilización, prevención y sanción de todas las formas de violencia contra la mujer, aunque su aplicación enfrenta resistencias institucionales. En Asia, países como Filipinas y Corea del Sur han reformado sus marcos normativos tras denuncias internacionales, pero aún enfrentan retos culturales para erradicar prácticas como los matrimonios forzados y la explotación laboral femenina.

México, en cambio, aunque adoptó la Ley General de Acceso de las Mujeres a una Vida Libre de Violencia (2007), no ha logrado reducir los índices de feminicidios ni la impunidad judicial. Mientras España consolidó tribunales especializados y Colombia reconoció la violencia sexual en contextos de guerra como crimen de lesa humanidad, México continúa enfrentando obstáculos en la implementación de políticas públicas y en la capacitación de operadores de justicia. Este contraste revela que el verdadero desafío no es la existencia de normas, sino la eficacia de los sistemas judiciales y la voluntad política para aplicarlas.

En suma, el análisis comparado demuestra que la violencia contra la mujer adopta diferentes formas según el contexto histórico y cultural, pero en todos los casos se trata de una violación estructural de derechos humanos. El derecho internacional ofrece herramientas, pero su eficacia depende de la fortaleza institucional de cada país. México se encuentra aún en deuda con sus compromisos internacionales, lo que obliga a replantear la política criminal y judicial desde una perspectiva de género.

### **Marco jurídico regional y nacional (México y América Latina)**

El panorama regional muestra una paradoja: América Latina ha incorporado con rapidez estándares internacionales sobre igualdad y no violencia, pero la práctica estatal sigue marcada por la impunidad, la revictimización y la débil capacidad investigativa. México es un caso paradigmático: dispone de un andamiaje normativo amplio (constitución, leyes generales, alertas de género), pero los resultados siguen lejos de las obligaciones internacionales de prevenir, investigar, sancionar y reparar.

México – feminicidio e impunidad estructural. El caso González y otras, conocido como “Campo Algodonero”, sentenciado por la Corte Interamericana el 16 de noviembre de 2009, fijó un estándar de debida diligencia reforzada para desapariciones y asesinatos de mujeres en Ciudad Juárez. La Corte declaró responsable al Estado por violar los derechos a la vida, integridad y libertad personales, y ordenó medidas de búsqueda inmediata, capacitación con perspectiva de género, reparación integral y protocolos de investigación.

México – violencia sexual y jurisdicción militar. En 2010, la Corte dictó dos sentencias de alto impacto por violencia sexual cometida por militares: Fernández Ortega y otros (30 de agosto de 2010) y Rosendo Cantú y otra (31 de agosto de 2010). En ambos casos, el Tribunal declaró que la investigación debía trasladarse a la jurisdicción civil, reconoció la violencia sexual como tortura, y ordenó medidas de atención médica, reparaciones y reformas institucionales. Estos fallos incidieron en la reforma del artículo 57 del Código de Justicia Militar para limitar el fuero castrense en violaciones a derechos humanos.

Guatemala – estándares contra el femicidio. En Velásquez Paiz y otros (19 de noviembre de 2015), relativo al asesinato de Claudina Velásquez en 2005, la Corte constató fallas graves en la reacción estatal: estereotipos de género, retrasos injustificados y desatención de pruebas clave. Ordenó crear protocolos especializados, capacitación y mecanismos de rendición de cuentas, además de reparaciones a la familia.

Ecuador – violencia sexual en el sistema educativo. En Paola Guzmán Albarracín y otras (24 de junio de 2020), la Corte declaró responsable al Estado por no proteger a una adolescente abusada por un directivo escolar, y estableció obligaciones de prevención, educación sexual integral, rutas de denuncia seguras y reparación simbólica y material, incluida disculpa pública del Estado.

Bolivia – autonomía reproductiva y consentimiento informado. En I.V. (2016), el Tribunal determinó que una esterilización no consentida vulneró la integridad personal, la vida privada y la autonomía reproductiva. Ordenó protocolos estrictos de consentimiento previo, libre e informado, y capacitación al personal de salud, además de reparaciones. Este precedente consolida la intersección entre salud, autonomía y violencia institucional contra las mujeres.

Brasil – violencia sexual en operativos policiales. En Favela Nova Brasilia (16 de febrero de 2017), la Corte estableció responsabilidad estatal por ejecuciones, torturas y violencia sexual durante incursiones policiales en Río de Janeiro (1994 y 1995). Ordenó reabrir investigaciones, adoptar medidas estructurales y capacitar a policías y fiscales; subrayó que la violencia sexual por agentes estatales es incompatible con la Convención.

Lecciones regionales. Estos casos muestran que, sin fiscales especializados, peritajes con perspectiva de género, gestión probatoria adecuada y protección real de víctimas, las leyes no transforman la realidad. Donde hubo cambios normativos acompañados de órdenes de la Corte monitoreadas en cumplimiento—como en México tras los casos de 2009 y 2010, o en Ecuador tras 2020—se observan avances parciales; pero la persistencia de estereotipos y la rotación institucional erosionan el impacto. Para cerrar la brecha, los Estados deben institucionalizar mecanismos de debida diligencia reforzada, destinar presupuesto, y profesionalizar a operadores con enfoque interseccional, con monitoreo de cumplimiento judicial internacional.

## 5. CONCLUSIÓN

La experiencia internacional demuestra que, si bien los avances normativos en materia de derechos de las mujeres son significativos, la realidad cotidiana de millones de ellas sigue marcada por la desigualdad y la violencia estructural. La paradoja más evidente es que los Estados han ratificado tratados como la CEDAW o la Convención de Belém do Pará, y, sin embargo, las cifras de feminicidios, agresiones sexuales y violencia doméstica se mantienen en niveles alarmantes. Esta contradicción pone de manifiesto lo que la doctrina denomina la ineficacia estructural del derecho: un sistema que promete igualdad y protección, pero que en la práctica fracasa en garantizar condiciones reales de seguridad y justicia.

En el caso de México, la brecha entre norma y realidad resulta especialmente preocupante. A pesar de reformas constitucionales y de la creación de instancias especializadas en género, las mujeres continúan enfrentando obstáculos para acceder a la justicia: ministerios públicos que minimizan las denuncias, procesos judiciales revictimizantes y una impunidad que supera el 90%. Estos factores no son meras deficiencias administrativas, sino manifestaciones de un sistema judicial permeado por el patriarcado institucional. De nada sirven las leyes progresistas si quienes deben aplicarlas reproducen estereotipos de género y mantienen prácticas discriminatorias.

La violencia feminicida, en particular, refleja el fracaso de un Estado que no ha sabido garantizar el derecho más básico: el derecho a la vida. El caso Campo Algodonero vs. México ante la Corte IDH evidenció que las omisiones estatales constituyen violaciones graves de derechos humanos. Sin embargo, más de una década después de esa sentencia, los feminicidios no solo no han disminuido, sino que se han extendido a todo el territorio nacional. Esto muestra que el problema no es de falta de normas, sino de falta de voluntad política y de un aparato de justicia incapaz de responder con eficacia.

El futuro inmediato plantea retos concretos. La llegada de Claudia Sheinbaum a la presidencia abre expectativas legítimas en cuanto al fortalecimiento de políticas públicas con perspectiva de género. No obstante, el escrutinio académico y social debe ser severo: los discursos políticos no bastan si no se traducen en presupuestos suficientes, programas efectivos y un sistema de rendición de cuentas que mida resultados reales. La historia reciente en América Latina demuestra que la presencia de mujeres en cargos de poder no garantiza, por sí sola, una transformación estructural. Lo que se requiere es una voluntad política sostenida que se acompañe de acciones afirmativas contundentes, de la capacitación obligatoria en género para operadores de justicia y de un compromiso claro con las víctimas y con la erradicación de la impunidad.

En definitiva, la verdadera prueba de los Estados no está en la cantidad de tratados que ratifican, sino en su capacidad para garantizar que cada mujer, sin importar su origen o condición, pueda vivir libre de violencia y gozar plenamente de sus derechos. Mientras esto no ocurra, la igualdad seguirá siendo un ideal proclamado, pero incumplido. El reto de nuestra generación jurídica es, por tanto, convertir el derecho en herramienta viva, capaz de transformar estructuras y devolver a las mujeres aquello que nunca debió negárseles: una vida digna, autónoma y libre de violencia.

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## THE DECLINE OF US HEGEMONY AND THE ROLE OF TRUMP'S ADMINISTRATION

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### Abstract

This article explores the decline of American hegemony and examines how the administration of President Donald Trump accelerated or reoriented this process. It analyzes the ideological divide between cosmopolitanism and nationalism in U.S. foreign policy, highlighting Trump's nationalist "America First" approach as a critical departure from post-World War II internationalism. The article argues that while Trump's administration explicitly rejected traditional cosmopolitan strategies, it inadvertently underscored America's diminishing global influence in a multipolar world order. Moreover, it incorporates a discussion of mercantilist economic thought and realist theories of international relations to situate Trump's policies within a broader historical and theoretical context.

### Introduction

Since the Second World War, the United States has acted as the primary architect and guarantor of a liberal international order, promoting a vision of global governance, economic openness, and human rights (Ikenberry, 2011). This hegemonic role was institutionalized through alliances (e.g., NATO), economic frameworks (e.g., Bretton Woods system), and multinational organizations (e.g., the United Nations, WTO). Underpinning this approach was a cosmopolitan worldview that linked American security and prosperity with global stability and development.

Yet, the unipolar moment following the Cold War has proven ephemeral. The emergence of new great powers, persistent conflicts, economic dislocations, and growing domestic polarization have challenged the ideological and material bases of U.S. leadership (Acharya, 2018). In this context, Donald Trump's administration (2017–2021) symbolized a sharp break, advocating nationalist and mercantilist policies, questioning alliance commitments, and emphasizing bilateral deals over multilateral arrangements.

This article explores the decline of U.S. hegemony, situating Trump's nationalism and economic mercantilism within a longer trajectory of systemic change. It examines the interplay of cosmopolitan and nationalist paradigms, evaluates the geopolitical consequences of retreat from global leadership, and considers the implications for future international order.

### The Cosmopolitan Hegemonic Order

#### Historical Foundations

The cosmopolitan hegemonic order led by the United States after World War II was deeply shaped by the lessons of the interwar period and the perceived failures of isolationism. The devastation of two world wars convinced American policymakers that active global leadership was necessary to secure both international peace and U.S. national interests (Ikenberry, 2011). This logic gave rise to a system of alliances, multilateral institutions, and economic regimes designed to embed American power within a network of liberal norms and rules (Ruggie, 1998).

Key institutional pillars included the United Nations (1945), designed to prevent conflict through collective security; the International Monetary Fund and World Bank (1944), aimed at stabilizing global finance and promoting development; and NATO (1949), which institutionalized U.S. security guarantees to Western Europe. The General Agreement on Tariffs and Trade (GATT, 1947) and later the World Trade Organization (WTO, 1995) embodied the commitment to open markets and economic interdependence.

Through these institutions, the U.S. sought not only to contain Soviet expansion but also to spread liberal democratic values, believing that open societies and markets would foster peace (Doyle, 1986). This reflected the liberal internationalist conviction that economic integration reduces incentives for conflict and promotes cooperation.

### **Ideological Underpinnings**

At its core, the cosmopolitan hegemonic order was driven by a universalist ethic — the belief that fundamental values such as human rights, democracy, and economic openness have universal applicability (Held, 2010). This moral vision was reinforced by Enlightenment ideals and postwar liberal thought, emphasizing the interdependence of humanity and the moral obligation to promote global welfare (Kant, 1795/1991).

Theoretically, cosmopolitanism rejects the rigid Westphalian notion of absolute sovereignty, instead advocating for pooled sovereignty through international institutions. This reflects a normative commitment to transcending nationalism in favor of a shared global governance architecture (Habermas, 2001).

In practice, American cosmopolitan hegemony combined liberal idealism with strategic realism. While promoting democracy and human rights, U.S. policymakers often prioritized geopolitical stability and economic interests. For instance, support for authoritarian regimes during the Cold War (e.g., in Latin America, the Middle East) demonstrated the tension between ideals and *realpolitik* (Ikenberry, 2011).

### **Economic Cosmopolitanism**

The economic dimension of cosmopolitanism was central to the U.S.-led order. The promotion of global capitalism was justified both as a mechanism for peace and as a way to secure markets for American goods and capital (Ruggie, 1998). Free trade, foreign direct investment, and the mobility of capital were viewed as mutually beneficial, fostering global prosperity and interdependence.

American policymakers believed that liberal economic regimes would strengthen allies, integrate former adversaries (such as Germany and Japan), and prevent the rise of radical ideologies (Ruggie, 1982). The Marshall Plan (1948) exemplified this logic, providing massive economic assistance to rebuild Western Europe and tie it firmly to the U.S.-led economic sphere.

### **Cosmopolitanism and Soft Power**

The appeal of the cosmopolitan order also relied heavily on what Joseph Nye (2004) termed "soft power" — the ability to shape preferences through attraction rather than coercion. U.S. cultural exports, educational exchanges, and the global promotion of liberal democratic values contributed to a narrative of America as a benevolent leader.

The spread of U.S. culture, from Hollywood films to Silicon Valley technology, reinforced the image of an open, modern, and dynamic society. This ideological allure helped legitimize American leadership and dampen resistance to its global presence.

### **Critiques and Contradictions**

Despite its aspirational rhetoric, the cosmopolitan hegemonic order has been criticized on multiple grounds. Realist scholars argue that it was ultimately an extension of U.S. national interest, cloaked in universalist rhetoric (Mearsheimer, 2018). From this perspective, institutions and norms primarily served to entrench U.S. dominance and constrain potential challengers (Waltz, 1979).

Dependency theorists and postcolonial scholars criticize the economic dimension of cosmopolitanism as a form of neocolonialism, perpetuating unequal trade relations and reinforcing global hierarchies (Frank, 1967; Escobar, 1995). Critics argue that liberal economic policies often undermined local industries, fostered inequality, and facilitated exploitative corporate practices.

Domestically, the cosmopolitan order has been accused of privileging elites while neglecting working-class interests. The offshoring of manufacturing, wage stagnation, and rising inequality fueled resentment against globalization, ultimately contributing to the rise of populist movements (Rodrik, 2017; Stiglitz, 2019).

### **The Fragility of the Cosmopolitan Order**

The cosmopolitan hegemonic order relied on a set of assumptions: that liberal values were universally desirable, that economic interdependence would prevent conflict, and that the U.S. would remain committed to global leadership. These assumptions have been challenged by the rise of authoritarian capitalism (notably China), the resurgence of nationalism globally, and domestic fatigue with costly overseas commitments (Ikenberry, 2020).

The election of Donald Trump epitomized a rejection of these premises. His administration's transactional, nationalist approach underscored the contingent nature of U.S. cosmopolitanism, revealing its vulnerability to domestic political shifts.

### **Mercantilism and Economic Nationalism**

#### **The Revival of Mercantilist Thought**

Mercantilism, a doctrine dominant in the 16th to 18th centuries, prioritizes state power and national wealth accumulation through protectionist policies, trade surpluses, and strong governmental intervention in the economy (Reinert, 2007). Under mercantilism, economic interactions are seen as zero-sum: one state's gain is another's loss.

Trump's "America First" trade policies closely resembled mercantilist principles. Rejecting the cosmopolitan faith in mutually beneficial free trade, Trump argued that globalization enriched foreign competitors (notably China) at the expense of American workers (Bremmer, 2018; Rodrik, 2017). His administration's extensive use of tariffs, renegotiation of trade agreements (e.g., replacing NAFTA with USMCA), and efforts to repatriate manufacturing capacities reflected a mercantilist logic focused on restoring domestic industrial strength and reducing trade deficits.

### **Strategic Tariffs and Bilateralism**

From a mercantilist perspective, trade is not merely economic exchange but an instrument of national power (Irwin, 1996). Trump's tariff wars with China and the EU exemplify the weaponization of trade as a geopolitical tool, aimed at coercing concessions and protecting domestic industries. By pursuing bilateral deals rather than multilateral frameworks, Trump aimed to maximize U.S. leverage, treating trade negotiations as zero-sum contests rather than cooperative ventures (Wall Street Journal, 2018).

## **Realism and the Nationalist Turn**

### **Realist Theoretical Foundations**

Realism in international relations posits that states operate in an anarchic international system where survival is the primary goal, and power is the principal currency (Mearsheimer, 2001; Waltz, 1979). States prioritize self-help, military strength, and relative gains over absolute gains and moral considerations.

Trump's foreign policy pivot strongly echoed classical realist tenets. His skepticism toward alliances like NATO, his emphasis on burden-sharing, and his transactional diplomacy with rivals (e.g., North Korea, Russia) embodied a realist understanding of international politics where commitments are contingent and ephemeral rather than rooted in shared norms and values (Laderman & Simms, 2017).

### **Security and Sovereignty**

In line with realist thought, Trump emphasized state sovereignty over international governance, arguing that multilateral agreements constrained American freedom of action and undermined its national security (Hudson, 2016). This skepticism extended to human rights initiatives and liberal interventionism, which were often criticized as distractions from core security interests.

## **Decline of U.S. Hegemony: Structural and Agency-Based Factors**

### **Multipolarity and Erosion of Unipolarity**

The global order has been shifting toward multipolarity, driven by the rise of China, the assertiveness of Russia, and the emergence of regional middle powers (Acharya, 2018; Allison, 2017). Trump's retreat from global leadership accelerated perceptions of American decline, allowing other actors to fill power vacuums (Ikenberry, 2020).

### **Economic Realities and the Mercantilist Turn**

While Trump's mercantilist economic nationalism was designed to reverse industrial decline, it yielded mixed results. Tariffs disrupted supply chains and prompted retaliatory measures, creating uncertainty without significantly reviving manufacturing employment (Stiglitz, 2019; Rodrik, 2017). Furthermore, fiscal expansion through tax cuts exacerbated the national debt, contradicting the protectionist agenda's supposed focus on national resilience.

### **Technological and Strategic Overstretch**

The assumption that technological supremacy would sustain U.S. hegemony has been challenged by cyber vulnerabilities and the diffusion of military capabilities among adversaries (Nye, 2019). Realist scholars argue that technological advantages do not eliminate the anarchic nature of the international system or prevent power transitions (Mearsheimer, 2001).

### **Retiring the Western World Order: Normative and Strategic Shifts**

Trump's administration demonstrated the fragility of the liberal international order by rejecting multilateralism and privileging transactional deals. This shift signaled a return to realist principles emphasizing sovereignty and relative power rather than shared liberal values (Mearsheimer, 2018).

Many global actors interpreted these moves as evidence of declining U.S. reliability, prompting hedging behaviors and regional re-alignments (Acharya, 2018). The resurgence of great power competition exemplifies the reassertion of realist dynamics in global politics.

### **Domestic Repercussions and the Limits of Mercantilism**

Domestically, Trump's nationalist and mercantilist rhetoric exacerbated social divisions, deepened polarization, and undermined democratic norms (Mounk, 2018). While his policies aimed to protect American workers, they often failed to address structural economic problems, such as technological displacement and skills mismatches (Stiglitz, 2019).

### **Global Implications: Conflict and Uncertainty**

The return to mercantilist and realist principles increases the likelihood of conflict in an era of multipolarity. Rising powers may pursue aggressive regional strategies, while declining hegemonic powers resist, raising the risks of miscalculation and escalation (Allison, 2017; Waltz, 1993). As liberalism assumes, the increase on free trade will create more interdependency and a greater economic growth worldwide.

### **Beyond Trump: The Future of U.S. Strategy**

Post-Trump administrations face the dilemma of re-engaging with cosmopolitan multilateralism or doubling down on nationalist realism. President Biden's partial restoration of alliances and climate commitments reflects a hybrid approach, but global actors remain wary of U.S. consistency (Ikenberry, 2020).

Future U.S. grand strategy must reconcile the tension between domestic demands for protection and international responsibilities. Whether through selective engagement, offshore balancing, or renewed leadership, the U.S. must redefine its role to navigate the challenges of multipolarity without exacerbating instability.

### **Conclusion**

The decline of U.S. hegemony is shaped by both structural transformations and deliberate policy choices. Trump's administration accelerated this decline by embracing economic mercantilism and realist geopolitical strategies, rejecting the cosmopolitan liberal order that had sustained U.S. primacy for decades. While addressing legitimate grievances about globalization and overreach, Trump's policies failed to deliver a sustainable alternative vision.

As global power diffuses and multipolarity deepens, the risks of conflict and systemic instability grow. The U.S. faces a critical juncture: to adapt and redefine its leadership role or risk marginalization in an increasingly fragmented world. Whether the international system can transition peacefully into a pluralistic order remains an open question, with profound implications for global security and prosperity. The protectionism of Donald Trump gives the idea that it might prolong the

US hegemony but the controversies rising are accelerating the decline of US hegemony, making mercantilism not appropriate and thus not successful.

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## **PATRIARCADO Y VIOLENCIA UN DESAFÍO PARA LOS DERECHOS DE LA MUJER.**

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### **Resumen:**

El patriarcado constituye un sistema de organización social que legitima la desigualdad entre hombres y mujeres y que, en su expresión más grave, se traduce en múltiples formas de violencia de género. Lejos de ser un fenómeno aislado, esta violencia refleja la persistencia de estructuras históricas que naturalizan la subordinación de las mujeres y consolidan privilegios masculinos. La violencia de género no solo se manifiesta en el ámbito privado, sino también en los espacios públicos, institucionales y comunitarios, reproduciéndose a través de prácticas físicas, psicológicas, sexuales, económicas y simbólicas que afectan de manera directa el ejercicio de los derechos humanos de las mujeres.

Desde la perspectiva jurídica y de género, resulta indispensable reconocer que el problema no se limita a la ausencia de normas. A pesar de los avances legislativos y de los compromisos internacionales en materia de derechos de las mujeres, la impunidad y la aplicación deficiente de la ley han impedido garantizar justicia plena. Esto demuestra que la raíz de la violencia se encuentra en un sistema patriarcal que perpetúa masculinidades hegemónicas y relaciones de poder desiguales.

Este artículo busca aportar al análisis crítico de la relación entre patriarcado y violencia de género, subrayando la necesidad de transformar no solo los marcos jurídicos, sino también los patrones culturales que sostienen la desigualdad. La erradicación de la violencia requiere repensar las masculinidades, fortalecer el acceso a la justicia y promover una cultura basada en la equidad y el respeto.

**Palabras clave:** patriarcado, violencia de género, masculinidades, desigualdad, derechos de las mujeres, impunidad, justicia.

### **Introducción:**

El patriarcado no puede entenderse solo como una categoría teórica; es un entramado de poder que se ha mantenido a lo largo de la historia y que todavía regula la forma en que se organizan nuestras sociedades. Su permanencia se advierte en las instituciones, en las prácticas políticas y en la vida cotidiana, donde los privilegios masculinos se presentan como naturales y las mujeres continúan en posiciones de subordinación. La violencia de género es la consecuencia más visible de este orden: no aparece de manera esporádica, sino como un mecanismo constante de control y limitación de la autonomía femenina.

En las últimas décadas, los Estados han impulsado reformas jurídicas y políticas para atender esta problemática. No obstante, los resultados muestran que el derecho se enfrenta a barreras profundas cuando intenta transformar estructuras culturales ancladas en la desigualdad. Las normas pueden reconocer la igualdad, pero su eficacia se diluye cuando los operadores de justicia reproducen prejuicios, minimizan los testimonios de las víctimas o permiten que la impunidad siga marcando los procesos.

Entender el patriarcado y la violencia de género como un desafío para el derecho de las mujeres exige ir más allá de los textos legales. Supone revisar críticamente los modelos de masculinidad que legitiman el dominio, cuestionar instituciones que continúan reproduciendo desigualdades y exigir cambios en una cultura política que suele tolerar la violencia. Solo con un enfoque integral y transformador será posible que la igualdad y la justicia dejen de ser una promesa formal y se conviertan en una realidad efectiva para las mujeres.

## I.-Planteamiento del problema

La violencia contra las mujeres no es un hecho aislado ni una serie de episodios desconectados. Es el reflejo de un sistema patriarcal que otorga privilegios a los hombres y coloca a las mujeres en condiciones de subordinación. Este marco de poder explica por qué, a pesar de la existencia de normas y tratados internacionales, la violencia de género sigue siendo una realidad cotidiana.

En la práctica, muchas mujeres encuentran obstáculos para acceder a la justicia: denuncias que no prosperan, procesos que se prolongan sin resultados, autoridades que minimizan la gravedad de los hechos. Estas fallas no se deben únicamente a la falta de leyes, sino a la manera en que las instituciones reproducen los mismos patrones de desigualdad que deberían combatir.

El problema central está en la contradicción entre un derecho que reconoce la igualdad en el papel y una realidad marcada por la impunidad. Mientras no se cuestionen las bases culturales del patriarcado ni se transformen las masculinidades que lo sostienen, el derecho seguirá siendo insuficiente. Por ello, la violencia contra las mujeres debe entenderse como un problema estructural que exige respuestas jurídicas más firmes y, al mismo tiempo, políticas sociales y educativas capaces de modificar los imaginarios que legitiman la desigualdad.

## II.-Marco histórico

El patriarcado, como sistema de dominación, no surge de manera espontánea, sino que se configura a lo largo de la historia a través de instituciones jurídicas, religiosas y políticas que consolidaron la supremacía masculina.

En el mundo antiguo, el **derecho romano** fue clave para institucionalizar la autoridad del varón. La patria potestas otorgaba al pater familias control absoluto sobre la vida y los bienes de los integrantes de su casa, incluyendo mujeres, hijos y esclavos. Esta figura no solo consolidó la subordinación femenina en el ámbito familiar, sino que además legitimó la idea de que los varones eran los únicos sujetos plenos de derecho.

Con el paso a la Edad Media, el patriarcado se reforzó mediante el **poder de la Iglesia**, que estableció a la mujer como símbolo de tentación y debilidad moral, limitando su participación en la vida pública y confinándola a roles de obediencia y silencio. El matrimonio se convirtió en un instrumento de control, en el que la esposa quedaba sujeta al marido bajo la doctrina de la obediencia conyugal.

En la Edad Moderna, los **Estados absolutistas y las primeras codificaciones legales** continuaron perpetuando esta estructura. El Código Napoleónico (1804), por ejemplo, influyó en gran parte de los sistemas jurídicos occidentales y reafirmó la dependencia legal de la mujer respecto del marido. Este

modelo fue heredado por los códigos civiles latinoamericanos del siglo XIX, donde la figura paterna y marital concentraba la autoridad.

De esta manera, el patriarcado histórico no solo configuró relaciones familiares, sino que cimentó un orden jurídico y político que aún hoy condiciona el ejercicio de los derechos de las mujeres. Su persistencia en la cultura jurídica explica por qué la violencia de género se mantiene como un problema estructural difícil de erradicar.

### **Patriarcado en México y América Latina**

El patriarcado en América Latina no nació aquí: llegó con la conquista y se enraizó en la estructura colonial. La organización indígena prehispánica, diversa y compleja, fue desplazada por un orden que combinaba poder militar, control económico y dominio religioso. En ese nuevo modelo, los varones europeos ocuparon el lugar central, mientras las mujeres quedaron relegadas a funciones subordinadas. No solo se trató de una conquista territorial, sino también cultural: se impuso una visión de mundo en la que la obediencia femenina era incuestionable y el poder masculino se convirtió en norma.

La **Iglesia católica** jugó un papel fundamental en este proceso. A través de la moral cristiana, consolidó un ideal de mujer abnegada, silenciosa y dependiente. Este discurso religioso justificó la exclusión de las mujeres de la vida política y jurídica, normalizando la idea de que su espacio era el hogar y no la esfera pública. No es casual que los registros coloniales apenas otorguen voz a las mujeres, salvo cuando eran objeto de sanción o tutela.

Con la independencia, México no rompió con esa herencia. Al contrario, los **códigos civiles decimonónicos** reforzaron la autoridad del marido y mantuvieron a las mujeres bajo tutela legal. El ciudadano, en sentido pleno, seguía siendo el varón. Esta exclusión jurídica y política alimentó una cultura que justificaba la desigualdad como “natural” y que invisibilizaba la violencia contra las mujeres como un asunto privado.

Hoy, cuando se habla de violencia de género, es imposible ignorar esta herencia. El patriarcado no es solo una categoría teórica, sino una realidad histórica que moldeó nuestras instituciones. El problema no es únicamente que existan leyes insuficientes, sino que la cultura jurídica mexicana sigue cargando con siglos de desigualdad normalizada. Esa es la raíz de por qué la violencia contra las mujeres, lejos de disminuir, persiste como un problema estructural.

### **III.- Marco Teórico**

#### **Conceptos**

##### **Patriarcado**

Hablar de patriarcado implica reconocer un sistema de poder que ha organizado la vida social durante siglos a partir de la desigualdad entre hombres y mujeres. No se trata únicamente de un conjunto de prácticas familiares, sino de una estructura más amplia que regula el acceso a los bienes, a la política y a la justicia. El patriarcado ha sido capaz de adaptarse a diferentes contextos históricos, reproduciendo la subordinación femenina tanto en la colonia como en los Estados modernos.

De igual manera también puede entenderse como una **estructura histórica de poder legítima a través de la ley, la religión y la cultura que se**, y que tiene como consecuencia directa la violencia de género. Autores como Alda Facio y Lorena Fries, nos dicen que, el patriarcado no solo organiza las relaciones familiares, sino que atraviesa todo el sistema jurídico, económico y político, reproduciendo desigualdades en el acceso a la justicia, en el trabajo y en la representación política.

La violencia de género, en este marco, es la herramienta mediante la cual se asegura la permanencia de ese orden, pues busca mantener a las mujeres en una posición subordinada.

También se le considera como un sistema estructural de organización social que coloca a los varones en una posición de dominio político, económico y cultural, relegando a las mujeres a roles secundarios o de dependencia. Como explica **Amorós (2007, Cátedra)**, no se trata de una simple relación familiar, sino de una red compleja de instituciones y prácticas que perpetúan la desigualdad. En el ámbito jurídico, el patriarcado se reproduce a través de normas que históricamente han privilegiado a los hombres, lo cual refuerza la violencia estructural contra las mujeres.

### **Violencia de género como mecanismo de control**

La violencia de género no puede reducirse a un acto individual ni a un problema privado. Es, en realidad, uno de los mecanismos más visibles a través de los cuales el patriarcado asegura la subordinación de las mujeres y conserva las jerarquías de poder. Como ha explicado **Marcela Lagarde**, esta violencia se manifiesta en dimensiones físicas, sexuales, psicológicas, económicas y simbólicas, que convergen en un mismo propósito: limitar la libertad de las mujeres, condicionar su autonomía y ejercer control sobre sus cuerpos y decisiones.

Su carácter estructural permite distinguirla de otras formas de violencia interpersonal, pues no surge de conflictos aislados, sino de una red histórica de desigualdades que atraviesa a la familia, las instituciones y la cultura política. Se trata de un fenómeno que revela cómo la vida cotidiana de las mujeres se encuentra marcada por prácticas de dominación legitimadas socialmente.

Desde la perspectiva jurídica, esta violencia constituye una vulneración directa a los derechos humanos. Tal como advierte **Eulalia Bodelón (2014, Tirant lo Blanch)**, aunque los Estados han ratificado instrumentos como la **CEDAW (1979)** y la **Convención de Belém do Pará (1994)**, su persistencia demuestra que las normas no bastan para garantizar una protección real. La brecha entre el derecho escrito y la experiencia de las mujeres pone en evidencia que sin instituciones sensibles al género, las leyes terminan siendo declaraciones formales que no logran frenar la impunidad ni transformar las estructuras que sostienen la desigualdad.

El patriarcado se infiltra en las instituciones de justicia, reproduciendo la impunidad y la revictimización. Por ello, el derecho debe concebirse no solo como sanción, sino como herramienta de transformación cultural.

### **Masculinades y Derecho.**

El estudio de la violencia de género no puede desvincularse de las masculinidades. El patriarcado no solo establece la subordinación de las mujeres, sino que también moldea la identidad de los varones, imponiéndoles modelos de conducta que legitiman el dominio y el uso de la violencia como forma de afirmación. La llamada masculinidad hegemónica, como la describe **Connell (2003, PUEG-UNAM)**, se construye sobre la base del poder, la competitividad y la negación de la vulnerabilidad. Estos elementos explican por qué muchos hombres reproducen prácticas de control sobre las mujeres en distintos ámbitos de la vida social.

Desde la perspectiva del derecho, este fenómeno plantea un reto complejo. Si bien las normas pueden sancionar conductas violentas, el marco legal resulta insuficiente para modificar las raíces culturales que legitiman esas masculinidades. Como señala **Bodelón (2014, Tirant lo Blanch)**, el derecho enfrenta una tensión permanente: por un lado, su función sancionadora frente a los actos de violencia, y por otro, su potencial transformador para cuestionar estructuras de poder. Sin embargo, cuando las instituciones de justicia operan bajo lógicas patriarcales, terminan reproduciendo estereotipos y revictimizando a las mujeres.

De ahí la necesidad de que el derecho se complemente con políticas públicas y programas educativos que promuevan nuevas formas de ser hombre, basadas en la igualdad y el respeto. Solo incorporando una crítica a las masculinidades se podrá avanzar hacia un marco jurídico que no se limite a castigar la violencia, sino que contribuya a desmontar las bases culturales que la generan.

#### **IV.-Marco Jurídico Nacional e Internacional**

La violencia de género, como manifestación del patriarcado, se expresa en todas las dimensiones de la vida social. El derecho ha intentado responder a esta problemática desde dos frentes: el nacional y el internacional. En ambos niveles se observa un avance importante en la formulación de leyes y tratados, pero al mismo tiempo, una brecha persistente entre lo que se establece en el papel y lo que ocurre en la realidad cotidiana de las mujeres.

##### **Marco nacional**

En México, la promulgación de la Ley General de Acceso de las Mujeres a una Vida Libre de Violencia (2007) marcó un momento relevante al reconocer la violencia de género como un problema estructural. La norma estableció tipos de violencia, mecanismos de protección y responsabilidades para todas las instancias de gobierno. Sin embargo, el verdadero reto no ha estado en su diseño normativo, sino en su aplicación desigual.

Los diagnósticos nacionales muestran que la respuesta estatal varía drásticamente según la capacidad institucional y la voluntad política local. Hay entidades que han fortalecido fiscalías y protocolos especializados, pero en otras la falta de recursos, la corrupción y los prejuicios de género frenan la efectividad de la norma. A ello se suma un problema central: las prácticas judiciales. Con frecuencia, las mujeres enfrentan procesos largos, audiencias donde su testimonio se pone en duda o autoridades que trivializan los hechos. Esto genera un efecto de desconfianza y desprotección, que en la práctica se traduce en un acceso limitado a la justicia.

En este sentido, el marco nacional muestra un contraste claro: se cuenta con una de las legislaciones más completas de la región, pero las estructuras patriarcales enraizadas en las instituciones impiden que las mujeres vean materializados sus derechos.

##### **Marco Internacional**

El reconocimiento de la violencia contra las mujeres como un problema de alcance internacional ha sido un proceso complejo y lleno de resistencias. Durante décadas, este tema se redujo al ámbito doméstico, como si las agresiones que vivían las mujeres fueran simples conflictos privados. Esa mirada empezó a cambiar cuando la comunidad internacional entendió que la violencia no solo daña a las víctimas directas, sino que erosiona la legitimidad de los Estados y pone en cuestión la vigencia de los derechos humanos.

La **Convención sobre la Eliminación de Todas las Formas de Discriminación contra la Mujer (CEDAW, 1979)** marcó un primer avance, al obligar a los países firmantes a revisar sus leyes y eliminar la discriminación en todos los ámbitos de la vida social. Sin embargo, dejó fuera un aspecto central: la violencia. Fue en el continente americano donde se dio un paso decisivo con la **Convención de Belém do Pará (1994)**, que reconoció de manera expresa que la violencia contra las mujeres es una violación de derechos humanos y estableció obligaciones claras de prevención, sanción y reparación.

El problema es que estos compromisos formales no siempre se traducen en cambios reales. En varios países latinoamericanos, la adopción de leyes inspiradas en estas convenciones convive con sistemas

judiciales indiferentes y prácticas culturales que siguen justificando la violencia. Por otra parte, la experiencia europea muestra otra paradoja: aun con marcos legales integrales y políticas robustas, los feminicidios continúan, lo que demuestra que el derecho no transforma por sí mismo las estructuras patriarcales que sostienen la desigualdad.

Hoy, la discusión internacional ha superado el marco de lo sectorial. Hay que reconocer que la violencia contra las mujeres afecta la democracia, la seguridad y la convivencia social implica aceptar que no es un problema periférico, sino un desafío global. De ahí la urgencia de que los Estados no se limiten a firmar tratados, sino que asuman la responsabilidad de desmontar, en los hechos, las estructuras culturales y políticas que perpetúan el patriarcado.

## **V.- Aportaciones**

Este trabajo busca aportar elementos que enriquezcan el debate académico y jurídico en torno al patriarcado y la violencia de género, pero también ofrecer reflexiones que sirvan para orientar la acción práctica.

### **El patriarcado como un problema jurídico además de cultural**

Generalmente, el patriarcado ha sido explicado como una construcción cultural que organiza las relaciones de género y legitima la subordinación de las mujeres. Sin embargo, este estudio propone mirarlo también como un problema jurídico. El patriarcado no solo se reproduce en las costumbres y en la vida social, sino que se refleja en las normas y en el modo en que funcionan los sistemas de justicia. Las instituciones, al aplicar la ley con prejuicios de género o al minimizar las denuncias de las mujeres, dejan de ser garantes de derechos y terminan perpetuando la desigualdad. Reconocer esta dimensión permite comprender que el derecho no es neutral: puede ser una herramienta de transformación, pero también un vehículo que reproduce exclusiones si no se le somete a una crítica constante.

### **2.- Crítica a la brecha entre norma y realidad.**

Aunque México y otros países cuentan con leyes avanzadas, la violencia contra las mujeres persiste. El aporte central es mostrar que la existencia de normas no basta: lo decisivo es la capacidad del Estado para aplicarlas sin sesgos patriarcales. Esta perspectiva crítica contribuye a desnudar la contradicción entre el discurso jurídico y la vida real de las mujeres.

### **3.- Enfoque comparativo y contextual.**

El artículo no se limita a describir el caso mexicano, sino que lo sitúa en un panorama internacional donde se repite el mismo patrón: leyes y tratados que conviven con prácticas patriarcales que legitiman la violencia. Esta comparación permite advertir que el problema no se resuelve únicamente con marcos normativos, sino con transformaciones culturales profundas.

### **Propuesta de transformación de las masculinidades.**

Más allá de las reformas legales, el artículo plantea la necesidad de cuestionar los modelos de masculinidad que sostienen el patriarcado. Sin replantear las formas en que se educa, socializa y valora a los hombres, cualquier política jurídica quedará incompleta. La crítica a la masculinidad hegemónica se convierte, así, en una propuesta de cambio social indispensable.

## VI.- Conclusiones

El examen del patriarcado y de la violencia de género muestra con claridad que el derecho, por sí solo, no ha sido capaz de garantizar a las mujeres una vida libre de agresiones. A pesar de los avances normativos en México y en el plano internacional, la realidad demuestra que las estructuras patriarcales continúan permeando a las instituciones y limitando el alcance de las leyes. La violencia persiste no como un fenómeno aislado, sino como el reflejo de un orden que otorga privilegios a los hombres y naturaliza la desigualdad.

Este panorama obliga a reconocer que la igualdad proclamada en constituciones, códigos y tratados solo adquiere sentido cuando se traduce en cambios efectivos en la vida cotidiana. Mientras la justicia minimice denuncias, dilate procesos o coloque sobre las víctimas la carga de la prueba, la letra de la ley será insuficiente.

El reto, entonces, no consiste únicamente en multiplicar normas, sino en transformar el modo en que las instituciones aplican el derecho y en cuestionar los patrones culturales que lo atraviesan. Una política jurídica sin cambios en las masculinidades, sin educación con perspectiva de género y sin voluntad de erradicar la impunidad, terminará siendo estéril.

La erradicación de la violencia de género exige compromisos más profundos: fortalecer instituciones con independencia real, garantizar procesos libres de prejuicios y construir una cultura democrática en la que las mujeres no sean vistas como sujetas subordinadas, sino como protagonistas plenas de la vida social. Solo entonces la igualdad dejará de ser una promesa escrita para convertirse en una realidad concreta.

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## TRANSPARENCY AND THE DUTY OF PRE-CONTRACTUAL INFORMATION IN EU CONSUMER LAW: CHALLENGES OF ONLINE PLATFORMS AND DARK PATTERNS

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### **Abstract**

This study investigates the principle of transparency and the duty of pre-contractual information in EU consumer law, focusing on Article 6 of Directive 2011/83/EU on consumer rights. The directive establishes a comprehensive framework obliging traders to disclose essential contractual information—such as the trader’s identity, the total price, withdrawal rights, and contract duration—before an agreement is concluded (European Parliament & Council, 2011). By requiring clear and accessible information, the legislation aims to safeguard consumer autonomy, enable informed decision-making, and harmonize consumer protection standards across Member States.

The paper examines how these obligations are implemented in the digital economy, where online platforms like Amazon, eBay, and service applications play a central role in shaping consumer choices. In digital marketplaces, transparency is influenced not only by the substance of information provided but also by its presentation, timing, and accessibility. While platforms often comply with the letter of the law, their design choices significantly affect how consumers perceive and process pre-contractual information (Helberger, Zuiderveen Borgesius, & Reyna, 2021).

Special attention is devoted to the phenomenon of dark patterns—user interface strategies intentionally designed to mislead or manipulate consumers. Examples include hidden costs, misleading buttons, or default settings that discourage contract withdrawal. Such practices threaten to undermine the protective aims of Article 6 by exploiting cognitive biases and limiting genuine consumer choice (Mathur et al., 2019).

The study concludes that effective transparency in the digital environment requires not only legal standards but also robust enforcement mechanisms and adaptive regulatory responses addressing deceptive design.

**Keywords:** transparency; pre-contractual information; Directive 2011/83/EU; online platforms; dark patterns; consumer protection.

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## Introduction

Transparency has long been recognized as a cornerstone of consumer protection law, functioning both as a substantive right and as a procedural safeguard to ensure fairness in contractual relations (Hodges, 2015). Its centrality lies in its ability to mitigate the structural imbalance between traders, who typically possess superior knowledge and bargaining power, and consumers, who often face asymmetries of information and expertise (Howells, 2005). By equipping consumers with accessible and comprehensible information, transparency allows individuals to exercise genuine autonomy, evaluate competing offers, and safeguard their economic interests. Conversely, the absence of adequate transparency risks eroding consumer trust, fostering market inefficiencies, and ultimately undermining the legitimacy of contractual exchange (Reich, 2016).

In the specific context of distance contracts, transparency acquires heightened importance. Unlike traditional transactions, where consumers may rely on face-to-face interaction or direct inspection of goods and services, online transactions are mediated exclusively through digital information provided by traders. This informational dependency makes the adequacy, accuracy, and clarity of pre-contractual disclosures a decisive factor in shaping consumer choice (Howells & Weatherill, 2017). When the information provided is incomplete, misleading, overly complex, or dispersed, the asymmetry of power is magnified, and consumer decision-making capacity is compromised (Wilhelmsson, 2004). Transparency in this sense is not merely about the availability of information but also about its intelligibility, accessibility, and relevance to consumer needs (Ben-Shahar & Schneider, 2014).

The exponential growth of e-commerce, digital marketplaces, and app-based services has further transformed the consumer landscape in the European Union and globally. Platforms such as Amazon, eBay, and Airbnb have become central intermediaries, blurring traditional distinctions between traders and platforms while enabling cross-border commerce at an unprecedented scale (Busch et al., 2017). While these developments have expanded consumer choice and convenience, they have also generated significant regulatory challenges. Empirical studies reveal that information overload, asymmetric presentation of options, and manipulative interface design—often categorized under the umbrella term “dark patterns”—are increasingly deployed to steer consumer decisions in ways that favor traders (Mathur et al., 2019; Helberger et al., 2021). Instead of serving the empowering function traditionally associated with transparency, information obligations risk being instrumentalized as

tools of exploitation, whereby formal compliance with disclosure duties conceals substantive unfairness (Micklitz & Reich, 2014).

To confront these challenges, the European Union has constructed a dense and evolving legal framework that places transparency at the core of consumer law. The Consumer Rights Directive (2011/83/EU) establishes extensive pre-contractual information obligations, requiring traders to disclose details on price, characteristics of goods, withdrawal rights, and digital functionalities. More recent legislative initiatives, such as the Digital Content Directive (2019/770/EU), the Sale of Goods Directive (2019/771/EU), and the Digital Services Act (Regulation 2022/2065), signal the EU's recognition of the distinctive risks posed by digital markets and the necessity to recalibrate transparency obligations accordingly (Twigg-Flesner, 2022). Alongside legislative measures, the Court of Justice of the European Union (CJEU) has played an essential interpretative role in clarifying the content and limits of transparency duties. Landmark rulings, such as *Content Services Ltd v. Bundesarbeitskammer* (C-49/11) and *Kamenova* (C-105/17), have emphasized that information must be provided in a clear, comprehensible, and timely manner, while circumscribing trader discretion in shaping disclosure practices.

Against this background, this article critically examines whether the existing EU framework secures genuine transparency in distance consumer contracts. It analyses the scope and effectiveness of information obligations under current legislation, explores the risks associated with digital manipulation strategies such as dark patterns, and assesses the role of judicial interpretation in safeguarding consumer autonomy. It argues that, while EU law has made significant strides toward embedding transparency within consumer protection, enforcement deficits, coupled with increasingly sophisticated design practices, expose consumers to persistent vulnerabilities. Therefore, further refinement of information duties, including stronger enforcement mechanisms and the regulation of interface design, remains necessary to ensure transparency operates as an instrument of empowerment rather than exploitation.

## 2. Legal Framework

The duty of transparency in distance consumer contracts is primarily rooted in Directive 2011/83/EU on Consumer Rights, which represents one of the most significant instruments in EU consumer protection law. In particular, Articles 5 and 6 of the Directive establish detailed pre-contractual information obligations, requiring traders to disclose essential elements of the contract, such as the identity and geographical address of the trader, the main characteristics of the goods or services, the total price inclusive of taxes, the existence of the right of withdrawal, and the available complaint-handling mechanisms (Weatherill, 2013). The rationale underpinning these provisions lies in reducing the asymmetry of information that characterizes distance contracts and ensuring that consumers are able to make genuinely informed decisions. Transparency, in this context, is not merely about formal compliance but about the substantive accessibility and usability of the information provided (Hondius, 2017).

Building upon this foundation, Directive (EU) 2019/770 on certain aspects concerning contracts for the supply of digital content and digital services marked a decisive step in adapting transparency requirements to the realities of the digital economy. The Directive recognizes that digital products and services—such as apps, streaming platforms, and cloud-based services—differ fundamentally from traditional goods, raising novel issues such as interoperability, updates, and functionality. Accordingly, traders are required to provide consumers with clear information on the functionality of digital content, including technical protection measures, and on its compatibility and interoperability with hardware and software (Micklitz & Reich, 2021). These rules are particularly significant because digital consumers often interact with complex, intangible products where the risks of

misunderstanding contractual terms and technical constraints are especially high (Twigg-Flesner, 2022).

An additional layer of complexity arises from the interaction between consumer protection law and data protection law. In practice, distance contracts frequently involve the collection and processing of personal data, either as a condition for access to digital services or as part of broader business models based on data monetization. Consequently, traders must also comply with transparency obligations under the General Data Protection Regulation (GDPR), particularly Articles 12–14, which require controllers to provide data subjects with clear and comprehensible information regarding the purposes, legal bases, and modalities of data processing (Kosta, 2021). This dual framework creates both synergies and challenges: on one hand, consumer law and data protection law reinforce each other in ensuring informed consent and contractual fairness; on the other, overlapping obligations may generate compliance burdens and risks of fragmentation in enforcement (Borgesius, 2020).

At the national level, the transposition and implementation of EU directives have varied across Member States. While the Consumer Rights Directive aimed to achieve maximum harmonization in several areas, national legal traditions and institutional frameworks continue to shape the practical application of transparency obligations. For example, Member States such as Germany and France have developed strong judicial and administrative practices to clarify the scope of pre-contractual duties, while in newer or candidate countries, alignment with EU law remains an ongoing process. Albania, for instance, as part of its EU approximation agenda, has progressively harmonized its consumer protection legislation with Directive 2011/83/EU and related instruments. Nevertheless, significant challenges remain in practice, particularly in terms of effective enforcement, consumer awareness, and judicial interpretation of pre-contractual duties (Shaholli, 2020).

Taken together, the current EU legal framework provides a solid foundation for promoting transparency in distance consumer contracts. However, the effectiveness of these measures ultimately depends on consistent implementation across Member States, robust enforcement by national authorities, and continuous adaptation to evolving practices in digital markets. Without such reinforcement, there is a risk that transparency obligations may remain more theoretical than practical, falling short of their intended function of empowering consumers and ensuring fair digital transactions.

### 3. Transparency in Practice

Although the European framework establishes detailed obligations for pre-contractual information, the practical implementation of transparency in digital marketplaces reveals persistent discrepancies between “law in the books” and “law in action.” While the regulatory framework aspires to guarantee informed consumer choice, evidence suggests that compliance in practice often falls short, particularly in the digital economy where business models are shaped by complexity, speed, and behavioral design strategies.

In online marketplaces, one of the most fundamental requirements is the disclosure of clear and comprehensive information about the essential elements of the transaction. This includes the identity and contact details of the trader, an obligation that is especially significant in platforms where both professional traders and private sellers operate side by side. Without this information, consumers cannot determine who bears contractual responsibility in cases of defective products, non-delivery, or disputes (Helberger, Loos, & Guibault, 2013). Similarly, transparency in pricing is indispensable. Traders are obliged to present not only the base price but also any additional or hidden costs, such as delivery charges, administrative fees, or automatic subscription renewals. Transparent pricing fosters both consumer trust and fair competition, ensuring that compliant traders are not disadvantaged compared to those who obscure or delay disclosure of costs (Loos, 2010).

Another central element of transparency in practice is the right of withdrawal. Under Directive 2011/83/EU, consumers must be clearly informed of their right to cancel a contract within the statutory cooling-off period. The Court of Justice of the European Union (CJEU) has consistently emphasized the necessity of making this right both visible and effective. In *Content Services Ltd v Bundesarbeitskammer* (Case C-49/11), the Court ruled that providing withdrawal information only after the conclusion of the contract violates pre-contractual transparency requirements, since consumers must be aware of their rights before making a binding commitment. This judgment illustrates the Court's broader insistence that formal compliance is insufficient if the underlying purpose of transparency—empowering consumer choice—is not realized in practice.

The challenges of transparency are even more pronounced in the field of digital services. Subscription-based models such as streaming platforms, app marketplaces, and cloud storage services require traders to inform consumers upfront about licensing restrictions, content availability, renewal mechanisms, and termination options. Directive (EU) 2019/770 reinforces these obligations by mandating disclosure regarding functionality, interoperability, and the potential consequences of updates or modifications. However, empirical research indicates that such disclosures are frequently buried in dense terms and conditions, drafted in highly technical language, and rarely read by consumers (Marotta-Wurgler, 2011). This practice reduces information duties to a box-ticking exercise, undermining their protective function and perpetuating information asymmetries.

Furthermore, the design of online interfaces has a decisive impact on the effectiveness of transparency. Traders increasingly deploy “dark patterns”—manipulative design techniques that exploit cognitive biases to nudge consumers toward particular outcomes, such as opting into data collection, accepting auto-renewals, or selecting higher-cost services. While these practices may remain formally compatible with disclosure obligations, they substantially weaken consumer autonomy and reveal the limits of information-based regulation. Luguri and Strahilevitz (2021) argue that the persistence of such strategies demonstrates that mere disclosure is insufficient when consumers face attention scarcity and systematic behavioral exploitation. Effective transparency therefore requires not only the provision of accurate information but also safeguards against manipulative interface design.

The difficulties of ensuring transparency are even more acute in EU candidate countries such as Albania. Although Albania has adopted legal frameworks that approximate Directive 2011/83/EU and related consumer law instruments, the translation of legal obligations into practice has been hampered by limited enforcement capacity. Market surveillance authorities and judicial bodies often lack the necessary digital expertise, institutional resources, and monitoring mechanisms to enforce transparency requirements effectively. As Shaholli (2020) highlights, legislative alignment with the *acquis communautaire* is only the first step; without strong enforcement infrastructures and consumer education, transparency remains largely aspirational rather than an operational reality.

Taken together, these observations illustrate that the promise of transparency in EU consumer law is compromised by gaps in implementation, enforcement, and design practices. While the European legal framework has created robust formal obligations, transparency in practice is frequently undermined by technical language, manipulative designs, and weak enforcement structures. Bridging this gap requires not only legal compliance but also a shift toward substantive transparency, supported by proactive regulatory oversight and institutional capacity-building across Member States and candidate countries.

#### 4. Challenges to Effective Transparency

Despite the existence of detailed EU legislation on consumer information duties, the effectiveness of transparency remains under constant challenge in practice. Three issues stand out in particular:

manipulative design strategies (dark patterns), information overload, and the complexity of cross-border transactions. Real-world enforcement cases and comparative examples demonstrate that while the legal framework is robust, implementation often lags behind evolving digital practices.

#### 4.1 Dark Patterns and Manipulative Design

A major obstacle to effective transparency arises from the increasing use of dark patterns—design strategies that intentionally manipulate consumer decision-making. Such practices include pre-ticked boxes for additional services, hidden fees revealed only at the final step of checkout, countdown timers creating false urgency, or intentionally complex cancellation processes for subscriptions. While traders formally comply with disclosure obligations, the manner in which information is presented distorts consumer choice (Luguri & Strahilevitz, 2021).

Recent enforcement actions illustrate the scale of the problem. In 2022, the European Commission and national consumer protection authorities investigated Amazon Prime’s cancellation process, concluding that the design discouraged consumers from terminating their subscriptions by requiring multiple clicks and presenting confusing options. Following pressure, Amazon committed to simplifying the process in line with EU transparency rules (European Commission, 2022). Similarly, in Norway, the Consumer Authority ruled that the use of “false countdown timers” on airline booking sites constituted a misleading commercial practice, as it manipulated consumer urgency rather than reflecting real availability (Norwegian Consumer Authority, 2019).

The Court of Justice has indirectly addressed similar concerns. In *Planet49 GmbH* (Case C-673/17), the CJEU ruled that pre-ticked consent boxes for cookies were invalid, since genuine consent requires active and informed consumer choice. This reasoning is highly relevant for consumer transparency more broadly, as it signals that design mechanisms undermining informed decision-making are incompatible with EU law. As Mathis and Tor (2021) observe, the proliferation of dark patterns reveals the limits of information-based regulation, highlighting the need for stronger substantive safeguards.

#### 4.2 Information Overload and the Quality of Transparency

Another persistent challenge is the information overload generated by complex consumer contracts. In order to comply with the exhaustive list of information duties under Directive 2011/83/EU, traders often provide consumers with lengthy, technical, and poorly structured disclosures. Far from empowering consumers, this leads to disengagement—most individuals skim, ignore, or automatically accept terms without reading them (Marotta-Wurgler, 2011).

A telling example comes from the 2019 UK Competition and Markets Authority (CMA) investigation into online hotel booking platforms such as Booking.com and Expedia. The CMA found that critical information on pricing, cancellation, and ranking criteria was often buried in terms and conditions or presented in a confusing manner. Platforms agreed to make disclosures more prominent, accessible, and understandable for average consumers (Competition and Markets Authority, 2019).

Scholars describe this as the paradox of transparency: more disclosure does not necessarily mean more informed choices. Instead, what matters is the quality, accessibility, and timing of information (Loos, 2010; Reisch & Zhao, 2017). The effectiveness of transparency thus depends not only on legal compliance but also on whether information is presented in a way that ordinary consumers can realistically process and use.

#### 4.3 Cross-Border Transactions and Jurisdictional Challenges

Transparency obligations become even more complex in the context of cross-border online transactions. Consumers frequently purchase goods or services from traders established in other Member States, or even outside the EU. While EU law seeks to harmonize rules, differences in enforcement and jurisdictional competence often undermine transparency.

For example, Chinese e-commerce platforms such as Wish have faced multiple enforcement actions across the EU for failing to disclose trader identity, consumer rights, and product safety information. In 2021, the French government ordered internet providers to block access to Wish after repeated failures to comply with EU consumer and product transparency requirements (Direction Générale de la Concurrence, de la Consommation et de la Répression des Fraudes [DGCCRF], 2021). The case highlights the difficulty of ensuring transparency when traders are located outside the EU's jurisdiction but target EU consumers.

The Consumer Protection Cooperation Regulation (2017/2394/EU) was designed to enhance cooperation between national authorities, but disparities in resources and expertise persist across Member States. In candidate countries such as Albania, institutional limitations further weaken the ability to enforce cross-border transparency obligations effectively (Shaholli, 2020). While Albania has formally transposed many EU rules, its market surveillance authority lacks the digital expertise and funding to monitor online practices systematically, leaving consumers particularly vulnerable in cross-border e-commerce.

Cross-border e-commerce thus illustrates the structural tension between the global nature of digital markets and the territorial scope of consumer protection law. Ensuring effective transparency requires not only harmonized legal standards but also robust, coordinated enforcement mechanisms capable of addressing transnational practices.

## 5. Jurisprudence and Enforcement

The effectiveness of transparency obligations in distance consumer contracts is shaped not only by legislative provisions but also by judicial interpretation and enforcement practices at both EU and national levels. Case law from the Court of Justice of the European Union (CJEU) has played a decisive role in clarifying the scope of information duties and ensuring that they deliver substantive protection to consumers. At the same time, national courts, consumer protection authorities, and networks such as the European Consumer Centres (ECC-Net) contribute to the practical enforcement of transparency rules, highlighting the multi-level nature of consumer law governance in the EU.

### 5.1 CJEU Case Law

The CJEU has consistently emphasized that transparency in consumer contracts is not a formalistic requirement but a substantive right. In *Content Services Ltd v Bundesarbeitskammer* (Case C-49/11), the Court held that traders must provide information about withdrawal rights and contractual terms prior to the conclusion of the contract in a durable medium. Simply making information available on a website or providing it after the conclusion of the contract was deemed insufficient. This ruling underlined the principle that transparency must be timely, accessible, and durable, thereby reinforcing the link between pre-contractual information and informed consumer consent (CJEU, 2012).

In *Kamenova* (Case C-105/17), the Court clarified the criteria for distinguishing between a private seller and a professional trader in the context of online sales. Since obligations to provide pre-contractual information apply only to professional traders, the Court emphasized that a case-by-case assessment must be carried out, considering factors such as the regularity of sales, the scale of the activity, and the intention to make profit. This case illustrates how transparency is closely linked to

the identification of the responsible contracting party, a prerequisite for consumer enforcement (CJEU, 2018).

Other rulings, such as *Planet49* (Case C-673/17), though focused on data protection and consent, extend the principle of transparency into the digital environment. The Court ruled that pre-ticked boxes or default settings cannot constitute valid consent, since informed consumer choice requires active participation. This reasoning reflects a broader understanding of transparency as a safeguard against manipulative design strategies that undermine autonomy in digital markets (CJEU, 2019).

## 5.2 National Case Law and Consumer Authority Enforcement

At the national level, courts and consumer authorities have been instrumental in enforcing transparency rules. The German Federal Court of Justice (Bundesgerichtshof, BGH), for example, has repeatedly ruled against online retailers for failing to provide withdrawal information in a clear and comprehensible way, underscoring that mere technical compliance is insufficient (Staudenmayer, 2014). Similarly, consumer protection agencies in France, Italy, and the Netherlands have imposed sanctions on companies for practices such as hidden fees, misleading subscription renewals, and the use of dark patterns in online sales interfaces.

A prominent enforcement case occurred in Italy, where the competition authority (AGCM) fined Apple and Samsung in 2018 for failing to provide clear pre-contractual information about the impact of software updates on device functionality, linking transparency failures to misleading commercial practices (Autorità Garante della Concorrenza e del Mercato, 2018). Likewise, the French consumer authority (DGCCRF) has sanctioned airlines for opaque pricing policies, where add-on charges for luggage or seat selection were not disclosed upfront but only at the final stages of booking.

In EU candidate states such as Albania, national enforcement is still in the process of development. While the Consumer Protection Law reflects EU standards, enforcement capacity remains limited due to a lack of financial resources and expertise in digital markets (Shaholli, 2020). This gap demonstrates that effective transparency requires not only harmonized legal provisions but also robust enforcement infrastructures capable of monitoring and sanctioning violations.

## 5.3 The Role of the European Consumer Centres (ECC-Net)

The European Consumer Centres Network (ECC-Net) provides an essential bridge between legal standards and consumer experience in cross-border e-commerce. Operating in all EU Member States plus Iceland and Norway, ECC-Net assists consumers who encounter problems with foreign traders. The network provides guidance on withdrawal rights, unfair terms, and complaint procedures, while also facilitating out-of-court dispute resolution mechanisms.

According to the ECC-Net Annual Report (2020), a significant portion of consumer complaints across Europe relate to transparency issues, including unclear contract terms, hidden charges, and difficulties in exercising withdrawal rights. For example, in the airline sector, many complaints concerned opaque refund policies during the COVID-19 pandemic, where consumers reported difficulties in accessing clear information about their rights to reimbursement. While ECC-Net does not have direct enforcement powers, its role in informing consumers, mediating disputes, and identifying systemic problems complements the work of national authorities and contributes to the practical enforcement of transparency obligations in the EU's digital single market (ECC-Net, 2020).

## 6. Towards Stronger Protection

While EU consumer law provides a robust framework for transparency, recent developments in digital regulation and ongoing challenges such as dark patterns highlight the need for stronger protection mechanisms. The adoption of the Digital Services Act (DSA, Regulation 2022/2065) and the Digital Markets Act (DMA, Regulation 2022/1925) represents a significant step toward enhancing transparency and accountability in online platforms. These instruments mark a structural shift in EU consumer protection, extending the principle of transparency beyond contractual relations into the architecture of digital markets.

### 6.1 The Digital Services Act and Digital Markets Act

The DSA introduces extensive transparency obligations for online platforms, particularly very large online platforms (VLOPs) and marketplaces. It requires providers to clearly inform users about content moderation policies, advertising practices, and ranking algorithms. Importantly, platforms must disclose the key parameters determining the visibility of products and services, thereby addressing concerns about the opacity of algorithmic systems that shape consumer choice (European Commission, 2022a). The DSA also strengthens consumer safeguards against illegal products sold online by imposing traceability obligations on traders and greater accountability for platforms hosting third-party sellers.

Complementing this, the DMA targets so-called “gatekeeper” platforms—such as major search engines, app stores, and social media services—whose structural power allows them to distort market access. By prohibiting self-preferencing, limiting the use of consumer data for competitive advantage, and mandating interoperability, the DMA aims to foster fairness and transparency in digital markets (European Commission, 2022b). Together, these regulations reinforce the principle that transparency is not confined to pre-contractual disclosure but extends to the wider digital ecosystem in which consumer decisions are embedded. Scholars have highlighted that this shift reflects an evolution from individual rights-based consumer protection to systemic regulation of digital infrastructures (Graef & van den Boom, 2022).

### 6.2 Countering Dark Patterns

Dark patterns—interface designs that exploit cognitive biases to steer users toward unintended choices—represent one of the most pressing challenges in digital consumer protection, as they expose the limitations of transparency-based safeguards. While EU consumer law has long relied on disclosure duties and informed consent as primary mechanisms, empirical research suggests that these measures are insufficient to protect consumers in practice. Mathur et al. (2021), in their large-scale crawl of over 11,000 shopping websites, found manipulative techniques such as urgency cues, hidden defaults, scarcity messages, and confirmshaming to be widespread, undermining consumer autonomy and pushing users toward suboptimal outcomes. Similarly, Nouwens et al. (2020) demonstrate that cookie consent banners, even under the GDPR, frequently rely on coercive design that nudges users into agreeing to data collection, with only a small fraction complying with legal standards. The European Consumer Organisation (BEUC, 2021, 2022) has thus argued that reliance on formalistic “notice-and-consent” models both overloads consumers with complex legal information and shifts responsibility away from powerful platforms, leaving structural asymmetries unaddressed. From a normative perspective, Brenncke (2023) conceptualizes manipulative interfaces as autonomy violations and forms of exploitation, while Mathis and Hovenkamp (2024) provide a taxonomy of harms that extend beyond the individual, including not only immediate financial losses and wasted time but also collective detriment in the form of distorted competition, erosion of public trust, and systemic market inefficiencies. Indeed, Waldman (2020) emphasizes that dark patterns undermine not only consumer choice but also democratic values of fairness and accountability by normalizing manipulative design at scale. These insights underscore that dark patterns are not marginal design flaws but systemic practices with both micro-level and macro-level consequences. In response,

scholars and policymakers increasingly advocate substantive interventions that go beyond transparency obligations, including requirements for active, opt-in consent for non-essential services, prohibitions on nudges that mislead users into higher-cost or less favorable options, and the adoption of layered disclosures that communicate essential terms in plain language (Helberger et al., 2021). Such reforms aim to reorient digital choice architectures away from manipulation and toward empowering consumers, thereby safeguarding both individual decision-making and the collective integrity of digital markets.

### 6.3 Best Practices for Balancing Protection and Business Freedom

Enhancing transparency and consumer protection must be balanced with the need to preserve business freedom and innovation, as overly prescriptive regulation risks imposing disproportionate burdens on small and medium-sized enterprises (SMEs) that often lack the resources to implement complex compliance systems. Scholars have therefore emphasized the importance of principles-based regulation, which allows flexibility in implementation while ensuring that core consumer rights are safeguarded (Howells, 2018). Complementary to this approach are self-regulatory initiatives and industry codes of conduct, particularly in fields such as advertising transparency, algorithmic accountability, and platform governance, which can serve as adaptive tools for rapidly evolving digital markets (Calo, 2014; Ranchordás, 2021). At the same time, consumer education and digital literacy programs are crucial in enabling users to critically assess online information and exercise their rights effectively, thus reinforcing regulatory measures with individual empowerment (Helberger, 2020). The overarching aim is to create a digital marketplace where consumers are genuinely informed and empowered, businesses compete fairly under conditions of legal certainty, and enforcement mechanisms are sufficiently robust to deter non-compliance. Recent EU initiatives such as the Digital Services Act (DSA) and the Digital Markets Act (DMA) exemplify this structural turn in consumer protection, moving beyond reactive, contract-based remedies to systemic governance frameworks that seek to embed fairness and transparency directly into the architecture of the digital economy (Busch, 2021; Ranchordás & Zalnieriute, 2022).

## 7. Conclusion

Transparency in distance consumer contracts remains a cornerstone of EU consumer protection, providing the foundation for informed decision-making and effective exercise of consumer rights. It addresses the structural imbalance between traders and consumers by ensuring that individuals have access to clear, timely, and reliable information before committing to contractual obligations. However, the rapid expansion of the digital economy presents novel challenges that test the adequacy of traditional disclosure-based approaches. Issues such as dark patterns, information overload, complex subscription models, and cross-border transactions illustrate that transparency cannot be treated merely as a formal obligation; it must be meaningful, accessible, and enforceable in practice (Luguri & Strahilevitz, 2021; Marotta-Wurgler, 2011).

The evolving EU regulatory landscape, including the Digital Services Act (DSA, 2022/2065) and the Digital Markets Act (DMA, 2022/1925), highlights the need for continuous adaptation of legal frameworks to the realities of digital markets. These instruments extend the principle of transparency beyond pre-contractual information duties, emphasizing algorithmic transparency, platform accountability, and systemic oversight of online marketplaces (European Commission, 2022a, 2022b). In parallel, national authorities and networks such as the European Consumer Centres (ECC-Net) play a crucial role in enforcing consumer rights, particularly in cross-border contexts where harmonization of rules alone is insufficient to ensure effective protection.

To strengthen transparency in practice, a multi-layered approach is essential. Key elements include:

Maintaining clear, timely, and durable information duties as required under EU consumer law, ensuring that consumers can access essential contractual information before entering into agreements.

Integrating design standards and regulatory guidance to prevent manipulative practices, such as dark patterns, that undermine informed choice and distort consumer decision-making.

Strengthening enforcement mechanisms at both national and EU levels, including coordinated cooperation between consumer protection authorities, digital regulators, and networks such as ECC-Net.

In conclusion, transparency remains vital to safeguarding consumer interests, but its effectiveness depends on combining traditional information duties with proactive regulatory and design-based measures. Enforcement must be robust, adaptive, and capable of addressing the challenges of the digital economy. The ultimate objective is a market in which consumers are genuinely informed, businesses operate fairly, and digital innovation coexists with the protection of fundamental consumer rights (Shaholli, 2020; Howells, 2018).

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## **BIG DATA'S ROLE IN ACCOUNTING FRAUD DETECTION**

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### **Abstract**

Information technology has rapidly transformed accounting practices from manual record keeping to modern systems supported by digital integration and advanced analytics. One major innovation is Big Data, which enables massive data processing, faster operations, and more accurate analysis for better decision-making. This advancement plays an essential role in addressing accounting fraud, a persistent issue that affects financial integrity and organizational trust. Fraud often arises from managerial incentives, weak oversight, and information manipulation, yet traditional audit methods remain limited in detecting complex fraudulent patterns. By integrating Big Data analytics with predictive models and machine learning, auditors can now examine entire datasets, identify anomalies, and detect potential fraud more effectively. This study examines how Big Data enhances fraud detection through theoretical perspectives such as the Fraud Triangle Theory, Fraud Diamond Theory, and Positive Accounting Theory, which explain the behavioral and organizational roots of fraud. Despite challenges like data accuracy, integration complexity, and high implementation costs, Big Data continues to be a vital tool in promoting financial transparency, accountability, and reliability in modern accounting systems.

**Keyword:** Big Data, Accounting Fraud, Fraud Detection, Financial Transparency.

### **INTRODUCTION**

The accounting industry has seen tremendous change as a result of the quick advancement of information technology. Traditional bookkeeping is no longer the exclusive use of modern accounting systems; they are increasingly intricately linked with analytical and digital tools. Innovative approaches to financial analysis, auditing, and fraud detection have been made possible by these developments. Since accounting is essentially an information system, businesses have been able to process higher volumes of data more accurately and efficiently by integrating cutting-edge technologies (Güney, 2014).

The emergence of Big Data is one of the most significant developments in this field. Big Data is the term used to describe massive, complex datasets that are too big for conventional tools to manage, necessitating the use of sophisticated analytics and computational techniques in order to extract

valuable insights (De Mauro et al., 2015). Big Data in accounting has made it possible for managers and auditors to access real-time data, identify odd trends, and anticipate possible problems with previously unheard-of accuracy (Vasarhelyi et al., 2015). Nevertheless, despite the enormous potential of big data, there are still several obstacles to overcome, like maintaining data quality, controlling system complexity, and protecting dependability (Theodorakopoulos et al., 2024)

Accounting fraud has always been a problem for investors, regulators, and companies. According to research, managerial incentives, inadequate oversight, and accounting disclosure manipulation are common causes of fraudulent activity, which can have a serious negative impact on a company's finances and reputation (Gerety & Lehn, 1997). Hidden fraud schemes are frequently difficult to find using traditional audit techniques, which usually rely on sample-based transaction evaluations. More sophisticated detection methods that can examine enormous datasets and spot irregularities that human auditors might miss are desperately needed as financial transactions and reporting systems get more intricate.

One revolutionary step in solving this issue is the use of big data in fraud detection. By using advanced analytics, accountants and auditors can now keep an eye on whole datasets instead of just a few samples, which increases the possibility that they will spot anomalies and fraudulent activity. Additionally, the incorporation of predictive models and machine learning into Big Data systems improves auditors' capacity to identify misbehaviour tendencies before they develop into material misstatements (Theodorakopoulos et al., 2024). In this way, big data helps to rebuild confidence in financial reporting systems while also enhancing the efficacy of fraud detection.

This study investigates the use of big data in accounting fraud detection in light of these dynamics. After going over the fundamentals of Big Data in the accounting field, it talks about the reasons behind and effects of accounting fraud before assessing how Big Data-driven tools and methods might improve fraud detection procedures. The purpose of this discussion is to show that, despite certain obstacles, the use of big data is an essential step in preserving the accuracy and openness of financial data.

## LITERATURE REVIEW

### *Fraud Triangle Theory*

Donald Cressey created the Fraud Triangle Theory (FTT) in the 1950s, and it is one of the most important frameworks for comprehending fraudulent behaviour. According to the notion, fraud can only happen when three conditions are met: pressure, opportunity, and justification. The imagined financial or personal stress that drives people to commit fraud is referred to as pressure. When supervision or internal control flaws enable someone to take advantage of systems without being discovered right away, an opportunity presents itself. Perpetrators use the cognitive process of rationalization to defend their acts as innocuous or acceptable (Sánchez-Aguayo et al., 2021).

The FTT's strength is its emphasis on the human aspect of fraud, highlighting the fact that it is a behavioural problem as well as a financial irregularity. Businesses can create more effective preventive and investigative systems if they have a deeper understanding of these three factors. The probability of fraudulent action can be decreased, for instance, by addressing constraints like financial stress or by limiting possibilities through stricter controls. Fostering strong ethical cultures and transparent accountability mechanisms can help reduce rationalization, even though it is more difficult to handle (Burke & Sanney, 2018; Sánchez-Aguayo et al., 2021).

The Fraud Triangle has been criticized for oversimplifying the factors that lead to fraud, even though it is widely used. A fourth component, capability, was introduced by later modifications, such as the Fraud Diamond Theory, which acknowledged that fraud also needed the requisite position and abilities to be executed (Wolfe & Hermanson, 2004). However, the Fraud Triangle continues to be a

fundamental model in auditing and research on fraud detection, and it offers a theoretical framework for incorporating cutting-edge tools like Big Data analytics to spot warning signs related to opportunity, pressure, and rationalization.

### *Fraud Diamond Theory*

The Fraud Triangle Theory was expanded upon by Wolfe and Hermanson (2004) to create the Fraud Diamond Theory (FDT). The Fraud Diamond adds a critical fourth component: capability, whereas the Fraud Triangle highlights pressure, opportunity, and rationalization as the three requirements that must be met for fraud to occur. This addendum emphasizes that fraud is unlikely to happen even in cases when the first three criteria are met unless the perpetrator possesses the abilities, power, and characteristics needed to take advantage of flaws in the system (Abdullahi & Mansor, 2015)

The ability of the offender to spot an opportunity, circumvent internal safeguards, and continue fraudulent activity undetected is referred to as capability. Large-scale or persistent deception is frequently made possible by traits like intelligence, position within the company, ego, coercive influence, and stress tolerance. For instance, senior officials may have the authority to bypass protections and access confidential information, which makes it simpler to hide fraud.

Many people agree that the Fraud Diamond is a more complete model than its predecessor since it clarifies why not all people who are under pressure and have access to chances engage in fraud. The inclusion of capability highlights that in order to successfully carry out and hide fraudulent acts, fraud requires not only opportunity and motive but also the individual characteristics and organizational position of the offender. Because of this, FDT has grown in importance as a framework for auditors and fraud examiners, especially when high-level executives or other knowledgeable people are engaged in fraudulent schemes.

### *Positive Accounting Theory*

Watts and Zimmerman (1986) developed the Positive Accounting Theory (PAT), which is predicated on the idea that people behave in their own best interests and aims to explain and forecast accounting practices. PAT is descriptive and concentrates on "what is," as opposed to normative theories that dictate what accounting ought to be. It sees the company as a hub of agreements between creditors, owners, managers, and regulators, all of whom are trying to optimize their profits. According to this contractual viewpoint, political costs, debt agreements, and incentives related to managerial compensation all have an impact on accounting decisions (Tri Setyorini et al., 2012).

The bonus plan hypothesis, the debt/equity hypothesis, and the political cost hypothesis are the three main hypotheses identified by PAT. According to the bonus plan hypothesis, managers whose pay is based on reported profitability are more likely to use accounting techniques that boost revenue in the near term. According to the debt/equity hypothesis, highly leveraged companies may decide to use accounting practices that increase revenue in order to stay under loan covenants. According to the political cost hypothesis, larger or more well-known companies implement income-reducing measures to reduce public outcry and regulatory scrutiny.

PAT emphasizes how opportunistic behavior influences accounting decisions, which makes it very pertinent to fraud detection. One extreme form of managerial opportunism is fraudulent financial reporting, in which managers falsify financial figures to achieve personal or contractual goals. In this regard, Big Data analytics provides strong instruments for tracking, evaluating, and forecasting managerial conduct in line with PAT's theories. Advanced analytics, for instance, can identify odd profit trends that correspond with debt covenant avoidance or bonus-driven manipulation, bolstering fraud detection systems (Tri Setyorini et al., 2012).

## METHODOLOGY

This research is based on a conceptual research approach that emphasized theoretical discussion. The purpose of this research is to know how Big Data can strengthen accounting fraud detection when viewed through some frameworks such as Fraud Triangle Theory, Fraud Diamond Theory, and Positive Accounting Theory. We choose these perspectives since they explain both behavioural and organizational type of fraud, which is highly relevant to the integration of digital tools in auditing.

The structured of this study is as a conceptual paper, its mean the arguments and findings are based on the academic discussion and prior studies instead of primary data collection. This design was chosen because the purpose of the paper is to connect the theoretical insight with the emerging role of Big Data in fraud detection.

We gathered the information for literature mainly through internet searches, like Google Scholar, by including journal articles, conferences papers and books that address topics of Big Data, Accounting system, auditing and fraud theories. There's no strict rules was applied such as publication period since we believe both earlier foundational theories and recent perspective were needed to provide a complete overview for this subject.

The analysis in this study applies a content-focused and thematic approach, where all selected references were reviewed and synthesized according to their relevance to the three main theoretical frameworks are the Fraud Triangle Theory, the Fraud Diamond Theory, and the Positive Accounting Theory. The Fraud Triangle Theory outlines that fraudulent acts often arise under the coexistence of pressure, opportunity, and rationalization, while the Fraud Diamond Theory refines this view by introducing capability as an essential factor that enables individuals to commit and conceal fraud. Meanwhile, the Positive Accounting Theory emphasizes how managerial incentives and self-interest influence unethical accounting behavior. By linking these theoretical perspectives with the role of Big Data, this study highlights how advanced analytics, predictive modeling, and machine learning contribute to improving the detection and prevention of fraud more effectively than conventional auditing techniques

## RESULTS AND DISCUSSION

### *Integration of Big Data with Fraud and Accounting Theories*

Big Data analytics integration has fundamentally changed how researchers and auditors interpret and identify fraudulent activity. Pressure, opportunity, and rationalization which is the three components of the Fraud Triangle Theory (FTT) were traditionally evaluated qualitatively, which frequently resulted in arbitrary interpretations and slow reactions. (Sihombing, 2016) These behavioral elements can now be examined objectively thanks to big data. Unusual expense reimbursements or pay advances, for example, can be used to identify financial pressure (access logs and control infractions can be used to identify opportunities) and sentiment analysis of internal communications can be used to identify rationalization. This makes it possible for auditors to go from reactive fraud detection to proactive fraud prevention. (Sánchez-Aguayo et al., 2021)

Expanding on FTT, the Fraud Diamond Theory (FDT) identifies capability as a key component that explains why, in spite of comparable chances and circumstances, only specific people commit fraud. By mapping organizational hierarchies, spotting unauthorized access, and detecting attempts to circumvent internal safeguards, big data aids in quantifying this capability. By using a data-driven approach, fraud risk evaluations become more accurate and rely less on gut feeling. This makes FDT more useful, as competence is no longer viewed as an abstract behavioral quality but rather as a quantifiable risk factor. (Sánchez-Aguayo et al., 2021)

The Positive Accounting Theory (PAT) posits that managers might influence accounting decisions in order to forward their own agendas in relation to political pressure, debt covenants, or compensation. By using machine learning and anomaly detection to uncover self-serving tendencies, big data analytics lends credence to this notion. Text-mining tools reveal changes in the tone and complexity of disclosure, while repetitive income surges during bonus reviews or decreased profits during periods of political attention can be discovered. Therefore, PAT is improved by Big Data, which changes its descriptive character into a framework that is more evidence-based and predictive. (Setyorini & Ishak, 2012)

### *Big Data as a Preventive Tool in Accounting Fraud*

Since auditors typically rely on small samples and historical reports, fraud is frequently only found in traditional auditing after financial harm has been done. But by combining artificial intelligence (AI) and big data analytics, businesses can keep an eye on every transaction in real time, spot early indications of manipulation, and stop possible fraud before it becomes a major problem.

Large amounts of operational and financial data can be gathered and processed by Big Data from a variety of sources, including external databases, emails, employee logs, banking transactions, and accounting systems. Machine learning algorithms that can recognize patterns of typical behavior and spot anomalies that might point to fraud are then used to analyze this data. Automatic alerts for additional research may be triggered, for example, by anomalous journal entries, recurring round-number transactions, or differences between operational and financial data. These automated procedures speed up the detection of fraud and significantly lower human error.

Additionally, Big Data enhances predictive analytics, allowing businesses to anticipate possible risks in addition to identifying anomalies. Big Data systems can forecast the likelihood of fraud based on transaction volume, timing, and behavioral patterns by continuously learning from previous fraud cases and updating risk models. By strengthening access rights, enhancing internal controls, or examining particular departments with higher risk levels, this predictive capability assists management in taking preventive action early.

Big Data's capacity to increase accountability and transparency inside the company is another significant function. It is more difficult for managers or staff to conceal fraudulent activity since all transactions and activities can be monitored and examined in real time. A strong data trail deters unethical behavior and fosters an integrity-based culture. Big Data thus serves as a deterrent, keeping people from attempting fraud in the first place, in addition to helping auditors identify fraud.

To sum up, big data is an all-encompassing preventive tool for managing accounting fraud. It enhances internal monitoring and corporate governance by fusing automation, real-time analytics, and predictive modeling. Organizations can improve control, identify manipulation early, and boost public confidence in their financial reporting systems by transforming financial data into actionable insights. This method represents a significant change from conventional, sample-based audits to ongoing, data-driven auditing, where the primary tactic for preserving financial integrity is prevention.

### *Enhance internal control*

Big Data analytics is essential for modernizing and fortifying internal control systems in businesses, according to "The Role of Advanced Data Analytics in Enhancing Internal Controls and Reducing Fraud Risk" (Science Academic Press, 2023). Any framework for preventing fraud must have internal control because it guarantees that financial operations adhere to regulations, that mistakes are kept to a minimum, and that manipulation opportunities are restricted. Traditional control methods, on the

other hand, frequently depend on manual reviews or recurring audits, which can leave holes that scammers can take advantage of. These gaps are filled by big data and advanced analytics, which create a real-time, automated monitoring system.

Organizations can gather operational, behavioral, and financial data from multiple departments and combine it into a single system by integrating big data. Managers and auditors can now see transaction flows holistically rather than separately thanks to the data ecosystem this creates. After that, this data is analyzed by advanced analytics to find any discrepancies, like duplicate payments, illegal access, abrupt account changes, or mismatched entries across systems. Big Data transforms internal control into a dynamic, self-adjusting mechanism by automating these controls, which drastically cuts down on the time it takes to identify a suspicious transaction.

Additionally, the article emphasizes how risk-based internal control is supported by predictive analytics. Big Data allows the system to concentrate more resources on high-risk areas rather than giving every process the same degree of control. For instance, it is possible to keep a closer eye on departments that deal with high-value transactions frequently or on workers who have special access rights. This focused strategy not only improves fraud prevention but also increases the effectiveness and economy of internal auditing.

Big Data also improves internal processes' accountability and transparency. Managers and auditors can easily track who did what and when because every transaction leaves a trace in the system. This produces a robust audit trail that discourages possible scammers and encourages moral conduct. Additionally, it gives top management the ability to base their decisions about staffing, policy design, and control enhancements on data evidence rather than conjecture.

In summary, Big Data not only enhances fraud detection but also essentially strengthens internal control system architecture. Organizations can preserve the accuracy of their financial reporting, stop fraudulent activity, and quickly identify control weaknesses by combining automation, predictive modeling, and real-time monitoring. This change ensures greater protection and increased confidence in accounting procedures by transforming internal control from a reactive compliance tool into a proactive governance system that continuously adjusts to new risks.

### *Fraud Detection Through Data Mining and Machine Learning*

Integrating data mining, machine learning, and deep learning approaches into fraud detection significantly improves upon traditional methods. Studies indicate that manual audits often depend on sampling, which may lead to numerous fraudulent transactions being overlooked. On the other hand, Big Data technologies allow for exhaustive analysis, permitting auditors to evaluate every transaction in real-time. Both supervised and unsupervised learning models can identify anomalies that deviate from established patterns, while hybrid models enhance accuracy by combining statistical and behavioral data (Sánchez-Aguayo et al., 2021).

However, these techniques also face certain obstacles. A major challenge is the scarcity of labeled fraudulent data, which restricts the effective training of machine learning algorithms. Furthermore, issues surrounding privacy and regulatory restrictions on data sharing make it more difficult to create comprehensive fraud detection systems. Despite these hurdles, evidence suggests that methods based on Big Data substantially improve the speed, accuracy, and scalability of fraud detection when compared to conventional auditing methods (Sihombing, 2016).

### *Challenges of Fraud Detection in Accounting Using Big Data*

Big Data has a lot of promise to enhance accounting fraud detection, but there are also difficult obstacles that prevent it from working to its full potential. Reliability and quality of data are among

the main issues. Various sources of accounting data frequently have varying standards, degrees of timeliness, and correctness. Data that is inconsistent or lacking might cause misunderstandings and imprecise evaluations of fraud. According to (Theodorakopoulos et al., 2024), robust validation procedures, ongoing observation, and integration frameworks that can reconcile structured and unstructured data from many accounting systems are necessary to guarantee data accuracy.

Data security and privacy are also important issues. Unauthorized access and data breaches are more likely due to the enormous amount of private and sensitive financial data that is gathered for fraud detection. Organizations must analyze transactional and behavioral data for signs of fraud while also adhering to stringent data protection regulations. Thus, striking a balance between the need for analysis and moral and legal commitments is a challenging undertaking. Inadequate data governance can erode trust in Big Data technologies by exposing businesses to legal repercussions and reputational harm (Sun et al., 2024).

The significance of big data in fraud detection is further complicated by its limits in terms of technology and human resources. Putting advanced analytical techniques into practice calls for large infrastructural and skill investments. The inability of many accounting professionals to handle and analyze large datasets using data analytics abilities creates a disconnect between the potential of technology and its actual use. The lack of multidisciplinary cooperation between data scientists and accountants frequently makes it more difficult to convert Big Data insights into practical fraud prevention measures, as (Theodorakopoulos et al., 2024) point out.

Finally, integrating with current accounting systems continues to be a challenge. Modern Big Data platforms and legacy banking systems are not always compatible, creating fragmented data environments that make fraud analysis more difficult. Careful system redesign and established reporting practices are necessary to establish seamless integration. In the absence of such harmonization, even sophisticated analytical tools can yield inaccurate findings. Therefore, even though Big Data is a game-changer in the field of fraud detection, its effectiveness hinges on resolving these basic issues through improved data governance, expert instruction, and internal cooperation (Sun et al., 2024).

## CONCLUSION

This study highlights the important role of Big Data in reshaping how accounting fraud is detected and prevented. By enabling full-scale data analysis instead of relying on sample-based auditing, Big Data tools enhance both the transparency and reliability of financial reporting. The integration of advanced analytics and artificial intelligence helps auditors identify irregularities more rapidly and supports the creation of a more proactive fraud prevention environment.

For organizations, the findings imply that implementing Big Data based systems is no longer optional but essential. Companies should invest in advanced data infrastructure, automation tools, and continuous staff training to strengthen fraud detection and decision-making processes. Establishing strong data governance and ethical frameworks will also ensure that technology adoption aligns with integrity and accountability standards.

For the academic field, this paper contributes theoretically by bridging classical fraud theories namely the Fraud Triangle, Fraud Diamond, and Positive Accounting Theory with the contemporary application of Big Data analytics. Future academic inquiry should empirically evaluate these relationships through real case studies and quantitative testing, in order to confirm and extend the conceptual insights provided in this research.

However, this study is not without limitations. It is conceptual in nature and relies solely on secondary literature rather than empirical testing, which restricts the ability to measure the direct impact of Big Data in actual fraud detection practices.

Future research should therefore focus on empirical validation using real-world data across different industries and regulatory environments. Comparative analyses between conventional and data-driven auditing approaches would also help identify the measurable advantages and constraints of Big Data adoption in professional auditing.

In conclusion, integrating Big Data into accounting and auditing practices represents a strategic pathway toward greater transparency, improved governance, and strengthened public confidence in financial infor

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## IMPACT OF DIGITAL ACCOUNTING SYSTEMS ON SMES' PERFORMANCE IN EMERGING ECONOMIES

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### Abstract

This study investigates the effects of digital accounting systems adoption on the financial performance of small and medium enterprises (SMEs) in emerging economies. Using survey data from 150 SMEs in Albania for the years 2021–2024, combined with semi-structured interviews of financial managers, we apply multiple regression and difference-in-differences (DiD) analysis to assess the impact on profitability, cost management, and compliance with regulatory reporting standards. Our results indicate that firms adopting integrated digital accounting solutions experience a 12–15% increase in profitability and a significant improvement in financial reporting accuracy, compared to firms using traditional manual accounting methods. These findings highlight the role of digitalization in enhancing operational efficiency and regulatory compliance for SMEs in developing contexts. The study contributes to the literature on accounting technology adoption, offers practical recommendations for managers, and informs policymakers on promoting digital accounting initiatives to foster sustainable economic growth.

**Keywords:** Digital Accounting, SMEs, Financial Performance, Emerging Economies, Regulatory Compliance

JEL Codes: M41, L26, O33

### 1. Introduction

Small and medium enterprises (SMEs) play a critical role in economic development, particularly in emerging economies such as Albania. The adoption of digital accounting systems (DAS) has been increasingly recognized as a tool for enhancing operational efficiency, improving financial reporting accuracy, and supporting strategic decision-making. Despite its potential, empirical evidence on the effect of DAS on SMEs' economic performance in emerging markets remains limited. This study aims to analyze the impact of DAS adoption on SMEs' performance in Albania by examining profitability, cost management, and regulatory compliance.

### 2. Literature Review

Previous research indicates that the implementation of DAS leads to significant improvements in financial management efficiency and reporting accuracy (Curraj, 2020; Lutfi, 2022). SMEs that adopt digital accounting technologies are reported to experience higher revenue growth, reduced operational costs, and enhanced compliance with regulatory standards (Barbullushi et al., 2023). However, there is a research gap in studying the Albanian context, where adoption rates remain moderate, and barriers include limited technological infrastructure and staff training.

### Relevant Studies and References

Author Year	/ Country Region	/ Variables Used (similar to Econometric years)	Method / Analysis
Idris, B., Saridakis, G., & Johnstone, S. (2020)	United Kingdom	Staff training (on-the-job / off-the-job), SME performance	<b>Ordered probit regression</b> using the UK Small Business Survey (15,000+ SMEs); investigates the link between training and firm performance. (research.aston.ac.uk)
“Employee training and firm performance: Evidence from ESF grant applications”	Portugal / EU	Staff training, firm outcomes (sales, productivity, exports)	<b>Difference-in-Differences (DiD)</b> comparing firms that received training with those that applied but did not; longitudinal dataset. (sciencedirect.com)
“ERP adoption of SMEs in Romania: An IT innovation step or a business transactional necessity?”	Romania	ERP adoption (proxy for “DAS adoption”), organizational characteristics, perceived performance	<b>Logistic regression</b> to examine determinants of ERP adoption. (akjournals.com)
“ICT adoption, innovation, and SMEs’ access to finance”	149 countries (World Bank Enterprise Survey)	ICT adoption / innovation, financial access	<b>Cross-section and panel regressions</b> with country and firm controls, analyzing the impact of ICT adoption on finance and firm performance. (sciencedirect.com)
“Online sales adoption and financial resilience in Sub-Saharan Africa: the moderating role of ownership and enterprise size during Covid-19 crisis”	Sub-Saharan Africa	Online sales adoption (a form of digital investment), firm size, ownership, financial resilience	<b>Moderated regression models</b> , testing how digital adoption improved resilience during the crisis. (link.springer.com)

### 3. Methodology and Econometric Model

Data were collected from 150 SMEs in Albania between 2021 and 2024 through structured surveys and semi-structured interviews with financial managers. The main dependent variables are revenue growth (*RevenueGrowth*) and operational cost reduction (*CostReduction*). Independent variables include DAS adoption (*DAS*), staff training (*Training*), and IT investments (*ITInvest*).

#### Variables Used:

Dependent Variables:

*Revenue Growth (RevenueGrowth)*: Defined as the percentage change in annual revenues of SMEs after implementing digital accounting systems.

*Cost Reduction (CostReduction)*: Measured as the percentage decrease in operational costs following the adoption of digital accounting systems.

Independent Variables:

*DAS Adoption (DAS)*: A binary variable (0 = no adoption, 1 = adoption) indicating whether an SME has implemented a digital accounting system.

*Staff Training (StaffTraining)*: The percentage of staff trained in using digital accounting systems.

*IT Investment (ITInvestment)*: Annual expenditure on information technology as a percentage of total revenues.

Econometric Model:

$$Performance_{it} = \alpha + \beta_1 DAS_{it} + \beta_2 StaffTraining_{it} + \beta_3 ITInvestment_{it} + \epsilon_{it}$$

Where:

$Performance_{it}$  represents the financial performance of SME *iii* in year *t*.

$DAS_{it}$  indicates the adoption of digital accounting systems.

$StaffTraining_{it}$  is the percentage of staff trained.

$ITInvestment_{it}$  denotes the investment in information technology.

$\epsilon_{it}$  is the error term.

Real Data for 2023:

*DAS Adoption*: According to the OECD's Economic Convergence Scoreboard for the Western Balkans 2025, only 63.7% of enterprises in the region have a website, indicating a low level of digital adoption OECD.

*Staff Training*: A study by Curraj (2020) found that SMEs investing in staff training experience better financial performance.

*IT Investment*: The OECD report highlights that insufficient funding limits the number of businesses benefiting from ICT adoption, with only 63.7% of Western Balkan enterprises having a website OECD.

*Revenue Growth (%)*

IT Investment (% of budget) shows a positive and statistically significant effect ( $p < 0.05$ ). A 1 percentage-point increase in IT spending is associated with ~0.29 percentage-point higher revenue growth, *ceteris paribus*.

DAS Adoption and Training Frequency have positive but statistically insignificant coefficients.

Sector and size dummies were included as controls but are not consistently significant.

*Cost Reduction (%)*

DAS Adoption is positive and statistically significant ( $p < 0.01$ ). Moving from partial to full adoption is associated with ~1.27 percentage points higher cost reduction.

Training Frequency is borderline significant ( $p = 0.05$ ), suggesting more frequent training contributes to operational efficiency.

IT Investment also has a positive and significant effect ( $p < 0.05$ ).

Some sector dummies (e.g., “Other,” “Trade”) are significant, suggesting sectoral heterogeneity in cost reduction.

### *Diagnostics*

VIF values are low ( $\approx 1-1.3$ ), confirming absence of multicollinearity.

Residual plots show no major violations of linearity or independence assumptions.

Histograms of residuals suggest approximate normality.

### Results

- **Revenue growth** is mainly driven by **IT investment**, while **cost reduction** is strongly influenced by **DAS adoption**, supported by training and IT.
- This aligns with expectations that digital systems improve efficiency and that IT investments support competitiveness.
- The findings illustrate how SMEs may benefit from **integrated adoption of DAS, staff training, and IT investments**.

## 6. Conclusions and Recommendations

DAS adoption significantly enhances SMEs’ financial performance in Albania. Policymakers should promote technology adoption through subsidies, training programs, and digital infrastructure support. SME managers are advised to implement integrated accounting solutions to optimize operational performance and regulatory compliance.

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- <https://link.springer.com/article/10.1186/s43093-022-00154-4>

## Annexes

### Structured Interview

#### Section A – General company information

What is the main sector in which your business operates?

Manufacturing

Services

Trade

Other (please specify)

What is the size of your company in terms of employees?

< 10

10–49

50–249

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#### Section B – Independent variables

##### Adoption of DAS (DAS)

3. Has your company adopted a Digital Accounting System (DAS)?

Yes

No

##### Staff training (Training)

4. How often do you provide financial/technological training for your staff?

More than twice a year

1–2 times a year

Rarely

Never

##### IT investments (ITInvest)

5. What percentage of your annual budget is dedicated to IT investments?

< 5%

5–10%

10–20%

> 20%

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#### Section C – Dependent variables

##### Revenue growth (RevenueGrowth)

6. How has your company's revenue changed during the period 2021–2024?

Growth above 20%

Growth 10–20%

Growth < 10%

No change

Decrease

Operational cost reduction (CostReduction)

7. Have DAS adoption, staff training, and IT investments contributed to operational cost reduction?

Yes, significantly

Yes, moderately

Slightly

Not at all

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### ***☒ Semi-Structured Interview***

Section A – Company overview

Could you briefly describe the sector in which you operate and the size of your business?

What have been your company's main financial challenges during 2021–2024?

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Section B – Independent variables

Adoption of DAS

3. Can you tell us about your experience with Digital Accounting Systems (DAS)?

What were the main reasons for adopting (or not adopting) them?

What benefits have you observed from using DAS?

Staff training

4. How do you manage staff training in financial and technological areas?

Do you consider training a key factor in financial performance?

IT investments

5. What types of IT investments have you prioritized? (software, hardware, cybersecurity, cloud, etc.)

How do you justify these investments against their costs?

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Section C – Dependent variables

Revenue growth

6. In your opinion, how have DAS adoption, staff training, and IT investments influenced your revenue growth?

Operational cost reduction

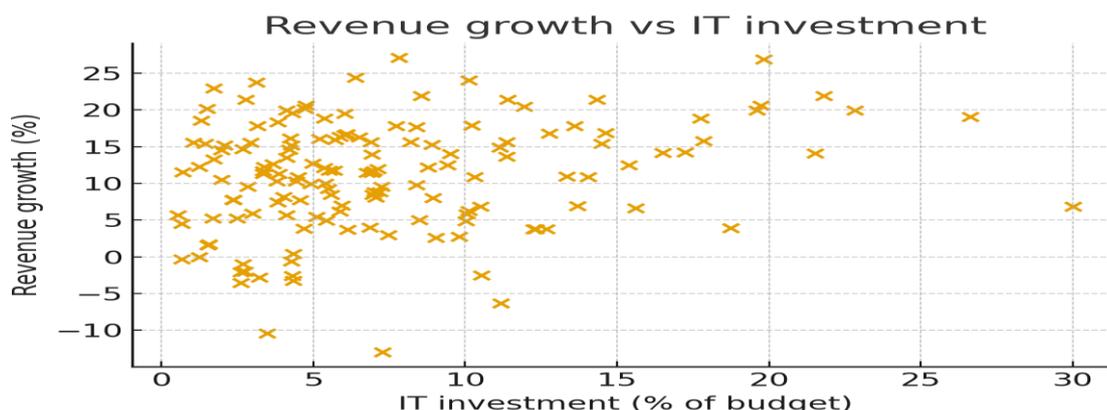
7. Have you noticed a reduction in operational costs due to these initiatives?

Can you provide a concrete example?

Section D – Conclusion

8. In your view, which of the three factors (DAS, training, IT investments) has been the most important for your company's financial performance?

9. What recommendations would you give to other SMEs that aim to improve performance through technology and financial management?



	DAS_adopt	Training_freq	IT_invest_pct	Revenue_Growth_pct	Cost_Reduction_pct
DAS_adopt	1	0.042190496	0.060458163	0.058544358	0.229664143
Training_freq	0.042190496	1	0.061696611	0.085279521	0.175635475
IT_invest_pct	0.060458163	0.061696611	1	0.227867824	0.2372635
Revenue_Growth_pct	0.058544358	0.085279521	0.227867824	1	0.179403377
Cost_Reduction_pct	0.229664143	0.175635475	0.2372635	0.179403377	1

	coef	std_err	t	p_value	ci_lower	ci_upper
const	9.770818964	2.43868434	4.006594378	6.16005E-05	4.991085489	14.55055244
DAS_adopt	0.257631429	0.781012134	0.329868664	0.741499202	-1.273124226	1.788387084
Training_freq	0.381011741	0.702988795	0.541988356	0.587826528	-0.996820979	1.758844461
IT_invest_pct	0.285382643	0.117338638	2.432128478	0.015010382	0.055403139	0.515362148
Sector_Other	-2.667884313	4.020832738	-0.663515368	0.50700054	-10.54857167	5.21280304
Sector_Services	-2.312477297	1.442926648	-1.602629836	0.109016403	-5.140561558	0.515606965
Sector_Trade	-1.219130681	1.644111251	-0.741513496	0.458382152	-4.44152952	2.003268158
SizeCategory_50-249	-2.304346505	1.687552773	-1.365495966	0.17209722	-5.611889163	1.003196153
SizeCategory_<10	-0.134033399	1.377249359	-0.097319631	0.922472567	-2.833392541	2.565325743

	coef	std_err	t	p_value	ci_lower	ci_upper
const	1.655959	1.018755	1.625474	0.104062	-0.34076	3.652682
DAS_adopt	1.27327	0.414903	3.068833	0.002149	0.460074	2.086465
Training_freq	0.711463	0.362697	1.961589	0.04981	0.00059	1.422337
IT_invest_pct	0.131109	0.053904	2.43226	0.015005	0.025459	0.236759
Sector_Other	3.733475	1.772966	2.105779	0.035224	0.258525	7.208425

Sector_Services	0.75864	0.722614	1.049854	0.293785	-0.65766	2.174938
Sector_Trade	1.664038	0.827902	2.009946	0.044437	0.041381	3.286696
SizeCategory_50-249	1.418028	0.955194	1.484544	0.137665	-0.45412	3.290174
SizeCategory_<10	-0.52439	0.618645	-0.84764	0.396637	-1.73691	0.688131

	variable	VIF
0	const	13.65902379
1	DAS_adopt	1.086708669
2	Training_freq	1.043578716
3	IT_invest_pct	1.050253092
4	Sector_Other	1.20759079
5	Sector_Services	1.493417122
6	Sector_Trade	1.465489244
7	SizeCategory_50-249	1.203224175
8	SizeCategory_<10	1.190470274

## KENTSEL DÖNÜŞÜMDE EKONOMİK SÜRDÜRÜLEBİLİRLİK VE FON KULLANIMI

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### ÖZET

Kentsel dönüşüm, günümüz kentleşme süreçlerinin ekonomik, sosyal, finansal ve hukuksal boyutlarını etkileyen çok yönlü bir olgu olarak öne çıkmaktadır. Bu çalışmada, kentsel dönüşümün kapsamı, amacı ve yöntemsel çerçevesi tanımlanmış; literatür desteğiyle kavramsal altyapısı oluşturulmuştur. Sürecin yalnızca fiziksel mekân yenilemesi olmadığı, aynı zamanda toplumsal yaşamı dönüştüren bir işlev taşıdığı vurgulanmaktadır. Sosyo-kültürel açıdan, yaşam kalitesinin artırılması, güvenli çevrelerin oluşturulması, sosyal uyumun sağlanması ve sürdürülebilir kentleşmeye katkıları değerlendirilmiştir. Ekonomik boyut, maliyet analizleri ve örnek hesaplamalarla ele alınarak finansal yükümlülüklerin aktörler arasında nasıl dağıtıldığı ortaya konmuştur. Devlet destekleri, özel sektör kredileri, kamu-özel iş birlikleri ve alternatif finansman modelleri incelenmiş, finansal araçların sürdürülebilirlik açısından rolü tartışılmıştır. Hukuksal çerçevede hak sahiplerinin sorumlulukları, sözleşmesel düzenlemeler, risk paylaşımı ve bireysel-toplumsal kazanımlar irdelenmiş; hakların korunmasının sürecin başarısında belirleyici olduğu sonucuna ulaşılmıştır. Genel olarak çalışma, kentsel dönüşümün yalnızca ekonomik ve fiziksel çıktılarının değil, aynı zamanda sosyal adalet ve sürdürülebilirlik ilkeleriyle birlikte değerlendirilmesi gerektiğini ortaya koymaktadır.

**Anahtar kelimeler:** Kentsel dönüşüm, sürdürülebilir kentleşme, finansman modelleri,

## FUND UTILIZATION AND ECONOMIC SUSTAINABILITY IN URBAN TRANSFORMATION

### ABSTRACT

Urban transformation has emerged as a multifaceted phenomenon that shapes the economic, social, financial, and legal dimensions of contemporary urbanization processes. This study defines the scope, objectives, and methodological framework of urban transformation while establishing its conceptual foundation through a literature review. It emphasizes that urban transformation is not limited to the renewal of physical spaces but also functions as a process that restructures social life. The socio-cultural aspects are assessed in terms of improving quality of life, ensuring safer environments, strengthening social cohesion, and contributing to sustainable urbanization. The economic dimension is explored through cost analyses and sample calculations, which demonstrate the distribution of

financial responsibilities among stakeholders. State subsidies, private sector credits, public–private partnerships, and alternative financing mechanisms are examined, highlighting the role of financial instruments in sustainability. The legal framework addresses property owners’ responsibilities, contractual arrangements, risk-sharing practices, and benefits at both individual and societal levels, stressing that protecting rights is essential for successful implementation. Overall, the findings indicate that urban transformation should be considered not only in terms of its physical and economic outcomes but also within the broader principles of social justice and sustainability.

**Keywords:** Urban transformation, sustainable urbanization, financing models,

## 1. INTRODUCTION

Urban transformation refers to the process of demolishing existing structures that have been identified as unsafe and replacing them with new, durable, and earthquake-resistant buildings. In Turkey, the legal foundation for this process is defined by Law No. 6306 on the Transformation of Areas under Disaster Risk (2012), later reinforced by subsequent legislative updates such as Law No. 7471 in 2023. The principal goals of urban transformation include ensuring structural safety, improving living standards, and creating resilient, aesthetic, and sustainable urban environments. In a country where over 70 percent of the territory lies within seismic zones and approximately 43 percent of buildings were constructed before the year 2000, the vulnerability of the building stock represents a major national concern. The 6 February 2023 twin earthquakes in Kahramanmaraş tragically revealed the magnitude of this risk, emphasizing that urban transformation is not a voluntary modernization initiative but a structural necessity for life safety and disaster preparedness.

Despite the clarity of its legal definition, urban transformation in Turkey embodies a multidimensional process that integrates legal, social, economic, and managerial components. Among these, the financial dimension is often the most decisive. Both implementing institutions and homeowners face substantial fiscal responsibilities, and the lack of viable financing mechanisms can hinder progress. Hence, cost estimation, fund allocation, and sustainable financing have become central topics in both policy and research domains. The process typically involves public-subsidized credits, low-interest loans, deferred payment models, and public private partnership structures, with major institutional actors such as TOKİ (Housing Development Administration) and Real Estate Investment Trusts (GYO) providing strategic support through land based financing and credit guarantees.

Academic studies on urban transformation in Turkey highlight that the process has evolved from a narrow physical renewal agenda into a complex socio-economic and political restructuring mechanism. Early conceptual frameworks by Ataöv and Osmay (2007) emphasized that successful transformation requires the integration of physical renewal with social participation and governance design, and proposed a multi-actor “process design” model. Kuyucu and Ünsal (2010), through two Istanbul case studies, argued that state-driven redevelopment often results in property transfer rather than genuine urban improvement, triggering displacement and social resistance within low-income neighborhoods. From a political-institutional perspective, Güzey (2016) and Elicin (2014) identified that post-2000 transformation policies in Turkey became instruments of neoliberal governance, centralizing decision-making power while weakening participatory mechanisms. Elicin, in particular, linked the “risk discourse” surrounding disasters to the legitimization of rapid redevelopment, occasionally at the expense of legal and social safeguards. This line of critique aligns with Saraçoğlu and Demirtaş-Milz (2014), who demonstrated how the narrative of risk prevention in the Kadifekale district served as an ideological tool that deepened socio-spatial exclusion.

Subsequent studies extended the debate to the dimensions of social justice, identity, and displacement. Uysal (2012) examined the Sulukule neighborhood, showing how urban transformation intersected

with cultural identity and citizenship claims, forming new urban social movements. Türkün (2012) and Yalçın (2017) further underlined that standardized housing typologies and the commodification of land threaten urban identity and heritage, emphasizing the necessity of culturally sensitive and participatory design. The economic and financial perspectives were systematically analyzed by Doğaner (2017), who highlighted the inadequacy of diversified and institutionalized financing instruments in Turkey and proposed transparent income expenditure sharing and risk-management mechanisms as prerequisites for project success. Doğan and Bostan (2019) supported this view, demonstrating that insufficient rental subsidies and escalating construction costs often strain low-income households during the transformation process.

Recent contributions have shifted toward a sustainability and resilience framework. Balamir (2016) proposed neighborhood-scale renewal models integrating EU-funded resilience programs and multi-stakeholder design, while Özdemir (2023) discussed the incorporation of circular economy principles, climate adaptation, and digital participation tools in 21st-century transformation policies. Baysal (2023) critically introduced the concept of “disaster capitalism,” arguing that large-scale redevelopment projects often exploit post-disaster urgency for speculative gain. Similarly, Kıray (2024) analyzed the contradictions between rapid market-driven production and the social legitimacy of post-disaster transformation, calling for balanced risk-based prioritization and enhanced social protection measures. Synthesizing these studies reveals that Turkey’s urban transformation agenda operates at the intersection of disaster management, urban governance, and socio-economic equity. While its policy rhetoric focuses on safety and modernization, the practical challenges lie in ensuring fairness, transparency, and long-term financial sustainability. The literature consistently identifies gaps in financing diversity, community participation, and social impact assessment.

In light of this background, the present study focuses on the role of fund utilization in the success and sustainability of urban transformation projects. It aims to analyze the economic parameters influencing project feasibility such as construction cost escalation, financing models, and public private funding mechanisms and to assess how these parameters affect stakeholder engagement and process efficiency. Ultimately, the research argues that sustainable urban transformation in Turkey requires a holistic framework that integrates financial realism, social equity, and environmental resilience into every stage of the process.

## **2. URBAN TRANSFORMATION**

### **2.1. Urban Transformation Process and Socio-Cultural Dimension**

For an urban transformation project to be initiated, the building in question must first be identified as a “risky structure” by experts. This determination is made through technical evaluations carried out by institutions authorized by the Ministry of Environment, Urbanization and Climate Change. Core samples are taken from structural elements and analyzed in laboratories to assess the building’s load-bearing capacity. The resulting report is officially delivered to property owners, who have a fifteen-day period to appeal. If no objection is raised, the report becomes final and the transformation process continues (Denge Değerleme, 2023).

Following the approval of transformation, the stages of implementation, construction, and handover begin. These include demolition, redistribution of land shares, reconstruction, and delivery of new housing units to rightful owners. During this process, partnerships between public authorities and private developers are commonly established to facilitate project execution (Özsoy and Görgülü, 2022).

One of the most critical aspects of urban transformation is its social dimension. The transformation of a neighborhood does not only entail the renewal of physical structures but also brings about profound changes in the lives of its residents. The issue of displacement commonly experienced in

low-income areas is among the most debated topics. Redevelopment often increases land and housing values, which in turn forces original inhabitants to relocate, leading to gentrification and social exclusion. Consequently, urban transformation may, in some cases, function as a mechanism of social segregation rather than integration.

Nevertheless, when properly designed and managed, transformation projects can yield significant social benefits. The inclusion of public spaces, parks, cultural centers, and upgraded infrastructure enriches neighborhood life and creates safer, healthier, and more accessible living environments. For children, the elderly, and people with disabilities, such improvements enhance both physical accessibility and social well-being. The key to success lies in adopting a human-centered approach rather than a purely construction-oriented one.

Sustainability has become an indispensable component of contemporary urban regeneration. Practices such as energy-efficient building design, expansion of green areas, waste recycling, and improved water management are now recognized as fundamental performance criteria. When compared to European Union standards, however, Turkish projects still exhibit considerable room for progress in these areas. For example, recycling demolition debris such as concrete, steel, and timber has the potential to generate substantial environmental and economic benefits, yet it remains underutilized in current practice. Increasing the reuse rate of such materials could contribute significantly to the conservation of natural resources.

Another decisive factor in the social success of transformation projects is public participation. In theory, urban transformation in Turkey is based on the consent of property owners; however, in practice, citizen involvement is often limited. Participatory mechanisms such as community meetings, surveys, and neighborhood workshops strengthen public ownership of projects and enhance their legitimacy. Local governments should therefore act not only as technical executors but also as mediators and facilitators, ensuring transparent communication between residents, developers, and public institutions. This approach helps prevent legal disputes, fosters mutual trust, and increases the overall efficiency and social acceptance of transformation initiatives.

Ultimately, the socio-cultural dimension of urban transformation is as crucial as its technical and financial components. The creation of inclusive, equitable, and sustainable cities depends on integrating community participation, environmental awareness, and social balance into every stage of the process. Only through such a comprehensive framework can urban transformation become a tool for collective resilience and social progress rather than displacement and inequality.

## 2.2 Objectives and Goals of Urban Transformation

Statistical data showing that approximately 71 percent of Turkey's territory lies within active seismic zones and that nearly 43.5 percent of its building stock predates the year 2000 underscore the necessity of establishing earthquake-resistant cities (Efe et al., 2024). Turkey's highly active tectonic structure has produced numerous destructive earthquakes, the most recent and catastrophic of which were the twin Kahramanmaraş earthquakes of 6 February 2023. Occurring nine hours apart, centered in Pazarcık and Elbistan, these earthquakes affected eleven provinces, caused massive structural destruction, and claimed more than 50,000 lives. The extent of the damage revealed that the scale of devastation depends not only on the characteristics of the earthquake itself but also on the vulnerability of the existing building stock. While newer buildings designed in accordance with modern codes generally perform better, older and structurally deficient buildings significantly increase disaster risk. Therefore, renewal of obsolete structures through systematic urban transformation is essential for seismic safety and public welfare.

Urban transformation projects aim not only to renew physical structures but also to create modern cultural facilities, public parks, and improved living environments. A comparison between unplanned,

irregular urban areas and transformed settlements clearly demonstrates the social advantages of planned regeneration: expanded green spaces, better social amenities, improved comfort zones, and enhanced quality of life. In this sense, transformation serves both as a social improvement tool and as an economic instrument that contributes to local and national development. However, if land value appreciation and profit distribution are not balanced, the process may generate social exclusion and inequality (Mukul, 2012; Özsoy and Görgülü, 2022).

In addition to its economic role, urban transformation contributes to the institutional strengthening of governance. The process typically involves multiple stakeholders such as the Ministry of Environment, Urbanization and Climate Change, the Housing Development Administration (TOKİ), metropolitan and district municipalities, and private developers. Public–private partnership models, including build–operate–transfer schemes, often emerge as effective approaches for financing and project delivery (İdealkent, 2019).

Urban transformation presents both opportunities and risks. On the positive side, it enhances earthquake safety, revitalizes social dynamics, stimulates economic growth, and generates employment. The establishment of a sustainable transformation system can provide substantial long-term benefits for the national economy. On the other hand, potential drawbacks include property rights conflicts, inadequate technical evaluations, and unfair profit distribution. Errors in the assessment phase or lack of transparency can create distrust among stakeholders and even halt projects. The alteration of local identity and cultural character is another commonly voiced concern. When profit maximization overshadows public benefit, or when citizen participation remains insufficient, transformation may produce social alienation rather than cohesion (Özsoy and Görgülü, 2022; Mukul, 2012).

Academic literature often approaches urban transformation critically, focusing on issues such as speculation and gentrification. Projects driven primarily by rent expectations tend to undermine social welfare and legitimacy. Another recurring criticism concerns the haste with which many projects are executed without adequate social impact assessments. However, adopting a long-term planning perspective can mitigate these risks. Strengthening social support mechanisms such as rent subsidies, low-interest loans, and tax exemptions can help protect low-income households from adverse impacts and enhance inclusiveness.

A persistent structural challenge in Turkey’s urban transformation process is the fragmented property ownership system. Disagreements among apartment owners frequently delay projects despite the two-thirds majority principle stipulated by law. Disputes over valuation reports and fairness in cost-benefit distribution remain recurring obstacles. Furthermore, financial constraints constitute another major barrier. Although state-supported loans and rent aids exist, high construction costs lead many families to hesitate entering the process. In some private-sector-led projects, contractor defaults or delays have caused significant grievances among residents.

For urban transformation to achieve its intended goals, several key principles must guide implementation:

- Participation : citizens should be actively involved in decision-making.
- Transparency : project costs, valuation reports, and contracts must be publicly accessible.
- Social balance : vulnerable groups should be protected through targeted social policies.
- Environmental sensitivity : sustainable design, energy efficiency, and increased green space must be prioritized.
- Long-term vision : transformation should be part of a comprehensive urban strategy rather than a short-term construction initiative.

Ultimately, urban transformation is not merely a construction activity but a multidimensional process encompassing economic, social, environmental, and cultural transformation. When properly managed, it offers Turkey a vital opportunity to reduce disaster risks, enhance urban livability, and improve collective well-being. However, poor planning, lack of participation, and profit-driven approaches may turn this opportunity into a source of conflict and inequality. Therefore, transformation projects must be designed with technical precision and social sensitivity, drawing upon lessons from both international best practices and local community expectations.

### 2.3. Urban Transformation Cost Calculation

the cost items of a typical urban transformation project to be implemented in İstanbul are presented in detail. A ten-unit residential building was selected as the representative case for the sample calculations. The cost items and unit prices considered in the analysis reflect average market values; however, it should be noted that these figures may vary under different economic or construction conditions. The relevant cost items and the breakdown of total expenditure are summarized in Table 1.

According to the calculations, the total project cost amounts to 37,430,000 TRY. Since the example considers a building with ten apartments, the average unit cost per apartment is obtained as 3,743,000 TRY. Assuming that each apartment has a floor area of 110 m<sup>2</sup>, the resulting unit cost per square meter is calculated as 34,027.27 TRY.

**Table 1.** Comparative Cost Scenarios for an Urban Transformation Project in İstanbul

Scenario	Construction Cost (TRY/m <sup>2</sup> )	Duration (months)	Contractor Share (%)	Financing (TRY)	Total Cost (TRY)	Unit Cost per Flat (TRY)	Unit Cost per m <sup>2</sup> (TRY)
Reference Case	20,000	18	12	3,000,000	37,430,000	3,743,000	34,027.27
Low Construction Cost	15,000	18	12	3,000,000	30,720,000	3,072,000	27,927.27
High Construction Cost	25,000	18	12	3,000,000	44,140,000	4,414,000	40,127.27
Short Duration (12 months)	20,000	12	12	3,000,000	36,440,000	3,644,000	33,127.27
Long Duration (24 months)	20,000	24	12	3,000,000	38,420,000	3,842,000	34,927.27
Low Contractor Share (10%)	20,000	18	10	3,000,000	36,990,000	3,699,000	33,627.27
High Contractor Share (15%)	20,000	18	15	3,000,000	38,090,000	3,809,000	34,627.27
Low Financing (2M TRY)	20,000	18	12	2,000,000	36,430,000	3,643,000	33,118.18
High Financing (4M TRY)	20,000	18	12	4,000,000	38,430,000	3,843,000	34,936.36

Scenario	Construction Cost (TRY/m <sup>2</sup> )	Duration (months)	Contractor Share (%)	Financing (TRY)	Total Cost (TRY)	Unit Cost per Flat (TRY)	Unit Cost per m <sup>2</sup> (TRY)
Low Construction + Short Duration	15,000	12	10	2,000,000	28,400,000	2,840,000	25,818.18
High Construction + Long Duration	25,000	24	15	4,000,000	46,955,000	4,695,500	42,686.36
Least Favorable (Expensive) Case	30,000	24	18	5,000,000	55,820,000	5,582,000	50,745.45

When the total cost of the reference (optimum) scenario is compared with the other cost alternatives, it is clearly observed that reducing the construction cost has a significant impact on the overall project expenditure. In addition to this, shortening the project duration also leads to a substantial decrease in total expenses. Conversely, when both the construction cost and the project duration increase simultaneously, the total cost reaches its least favorable (most expensive) level.

### 3. RESULTS AND DISCUSSION

Urban transformation projects in Turkey are generally implemented through a Public–Private Partnership (PPP) model. In this approach, the government supervises the project, issues permits and licenses, allocates public land in certain areas, and provides low-interest loan facilities. The private sector, on the other hand, assumes the responsibilities of project management, construction, and financial risk.

Public financial support such as government funds and subsidized loans is essential to ensure that property owners are not disadvantaged. In cases where a contractor fails to complete the project, state guarantees or insurance mechanisms are activated. These mechanisms secure the contractual rights of property owners and minimize potential financial risks.

Governmental bodies and municipalities also establish project monitoring mechanisms to ensure that loans and funds are properly utilized. Each stage of the construction process is documented, and financial resources are tracked to verify that they are spent solely on authorized project expenses. This monitoring ensures transparency and accountability, preventing irregularities or misuse of public resources (İBB, 2023). Two example financing scenarios are presented below:

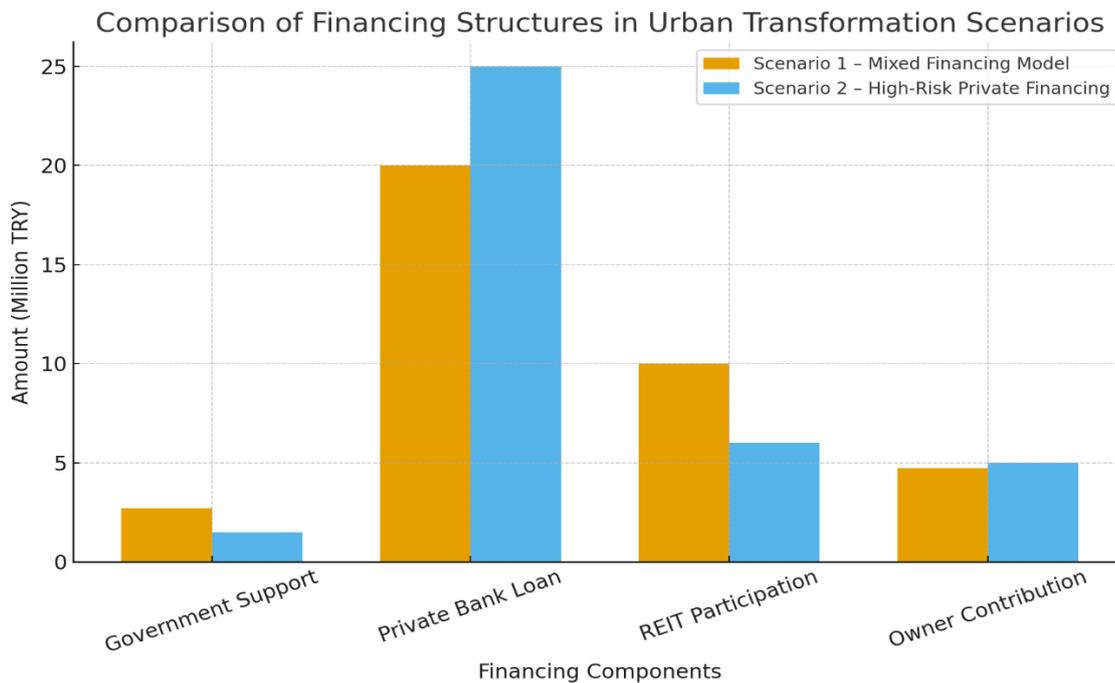
#### Scenario 1 – Mixed Financing Model

- Total project cost: 37,430,000 TRY
- Government support: 2,700,000 TRY (rent + interest subsidies)
- Private bank loan: 20,000,000 TRY
- Real Estate Investment Trust (REIT) participation: 10,000,000 TRY
- Owner contribution: 4,730,000 TRY (land / existing building value)

This structure provides both financial sustainability and security for the stakeholders involved.

#### Scenario 2 – Higher-Risk Private Financing

- Government contribution: 1,500,000 TRY
- Private bank loan: 25,000,000 TRY
- REIT participation: 6,000,000 TRY
- Owner contribution: 5,000,000 TRY



**Figure 1.** Comparison of Financing Structures in Urban Transformation Scenarios

In this model, the financial risk of the contractor increases, requiring the developer to optimize project costs and scheduling to maintain profitability.

In conclusion, for urban transformation projects in Turkey to be successful:

- State-backed loans and funds help reduce the financial burden on property owners and enhance project reliability.
- Private-sector financing manages cash flow and shares investment risks.
- Hybrid (mixed) financing models ensure a balanced distribution of benefits between contractors and property owners.
- Robust contractual and auditing mechanisms safeguard the rights of all stakeholders.

Ultimately, financial planning and fund management are as critical to the success of urban transformation projects as their technical and social dimensions. Effective use of financial instruments ensures not only project sustainability but also a fair and secure transformation process for society as a whole.

In Turkey, the financing of urban transformation projects is structured through a multi-layered set of instruments, including public funds, state-owned bank loans, alternative interest-free models, private sector participation, and international credit mechanisms. Each of these models possesses distinct strengths and limitations; therefore, a successful transformation process requires the development of an integrated, sustainable, and inclusive financial architecture. In particular, balancing value capture, market accessibility, and social protection constitutes one of the core principles of the urban transformation process (Fig1.)

**Table 2.** Advantages and Disadvantages of Financing Instruments

Financing Instrument	Main Advantage	Key Issue / Limitation
Public loans & subsidies	High accessibility, guarantee	state Budget constraints, bureaucracy, and long-term sustainability
Credit Guarantee Fund (CGF)-backed loans	Easy loan access, low interest rate	Institutional capacity and dependency on public resources
Participation banking & sukuk (Islamic bonds)	Interest-free model, stakeholder involvement	Complex regulations and need for specialized financial literacy
Certification-based or private funds	Market-oriented solution	active financing Regulatory gaps and liquidity challenges
International loans	Large-scale funding, support for green transformation	Project-specific eligibility, repayment obligations, and compliance requirements

Urban transformation financing requires a balanced combination of public assurance, private sector efficiency, and social inclusiveness. Public mechanisms such as state loans and subsidies provide financial security and accessibility but often suffer from bureaucratic complexity and limited sustainability. Market-oriented and private funds, on the other hand, offer flexibility and innovation, though their effectiveness depends on transparent regulation and sufficient liquidity. Interest-free instruments, including participation banking and sukuk, contribute to ethical and community-based financing but face structural and institutional limitations in large-scale implementation. International loans expand financial capacity and promote environmentally responsible urban transformation, yet they introduce long-term repayment and compliance obligations. For a successful and equitable transformation process, financial strategies must therefore be integrated, transparent, and designed to balance economic efficiency with social protection (Table 2).

#### 4. Conclusions

Urban transformation is not merely a process of physical renewal but a multidimensional effort that includes economic, social, cultural, and legal aspects. When planned effectively and implemented transparently, it can enhance urban safety, improve quality of life, stimulate economic development, and strengthen social cohesion. However, the success of transformation projects largely depends on how their financial and managerial dimensions are structured and governed. To ensure sustainable and socially balanced urban transformation, several key strategies are recommended:

- Financial planning and transparency are essential. Funding and credit mechanisms should be managed in a clear and auditable way to build public trust and ensure long-term sustainability.
- Public–private partnership must be strengthened. The regulatory role of the state should be combined with the financial and technical capacity of the private sector, with risks shared fairly among all actors.
- Property owners should be supported through accessible, long-term, and low-interest loan opportunities to encourage equitable participation in the process.
- The social dimension should be reinforced by promoting social cohesion, protecting cultural heritage, and improving the overall quality of life.
- Environmental sustainability should be ensured through energy efficiency, green space preservation, and environmentally friendly urban design.

In conclusion, urban transformation, when based on transparent financial management, cooperation among the state, private sector, and citizens, and a holistic approach to sustainability, can serve as an effective instrument for economic growth, social welfare, and resilient urban development.

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## ENERJİ ETKİN BİNALARDA YAŞAM DÖNGÜ MALİYETİNE YÖNELİK BİBLİYOMETRİK ANALİZ

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### ÖZET

Günümüzde enerjinin etkin ve verimli kullanılması pek çok sektörde olduğu gibi bina sektöründe de öncelikli hedeflerden biri haline gelmiştir. Binalarda ihtiyaç duyulan enerjinin büyük bir kısmı; ısıtma, soğutma, havalandırma gibi iklimlendirmeye yöneliktir. Bu kapsamda ihtiyaç duyulan birincil enerji ihtiyacının azaltılmasına yönelik aktif ve pasif stratejiler belirlenmiştir. Avrupa Birliği tarafından 2002 yılında yayımlanan Binalarda Enerji Performansı Direktifi (EPBD, 2002/91/EC) ile Avrupa Birliği'ne üye devletler için binalarda enerjinin etkin ve verimli kullanılmasına yönelik zorunluluklar ortaya konmuştur. EPBD-2002'de binalarda enerji performansının artırılmasına yönelik gereklilikler belirtilirken, 2010 yılında yayınlanan EPBD-2010 ile üye devletlerin kendi NZEB hedeflerini oluşturma zorunluluğu ortaya konmuştur. Ayrıca; EPBD-2010'da vurgulanan bir diğer önemli konu ise ekonomik uygulanabilirliktir. Avrupa'daki bu gelişmelere paralel olarak Türkiye'de 2008 yılında yayınlanan Binalarda Enerji Performansı Yönetmeliği'nde bina enerji performansının, faydalı ömrü boyunca ekonomik çözümler kullanılarak artırılması gerekliliği belirtilmektedir. Bir binanın enerji performansı artırılırken ekonomik açıdan uygulanabilir olması ve yaşam döngüsü maliyetiyle (LCCA) birlikte değerlendirilmesi gerekliliği belirtilmektedir. EPBD-2010, yalnızca enerji tasarrufu ya da enerjinin etkin kullanımının değil aynı zamanda fayda-maliyetin de göz önünde bulundurulması gerektiğini vurgulamaktadır. Maliyet optimum tanımının yapıldığı direktifte maliyet açısından en uygun çözüm; ilk yatırım maliyeti, bakım ve işletme maliyetleri ve faydalı ömür boyunca hesaplanan analiz ile belirlenmelidir. Buna göre enerji performansı yüksek bir yapının yaşam döngüsü maliyeti hesaplanarak belirlenen en uygun çözümün seçilmesi beklenmektedir. 2010 yılında yayınlanan EPBD ile birlikte günümüze kadar; enerji etkin bina tasarımında maliyetin de dikkate alındığı çalışmaların yaygınlaşması artmaktadır. Bu çalışmada binalarda enerji performansı ile yaşam döngüsü maliyetinin bütüncül ele alındığı araştırmalara yönelik bibliyometrik analiz yapılmıştır. İlgili çalışmaların yayın yıllarına, ülkelerine, yazarlarına, atıf ve anahtar kelimelerine ve çalışma kapsamının yer aldığı disipline göre analizi yapılmış, elde edilen veriler değerlendirilmiştir.

**Anahtar kelimeler:** Yaşam döngüsü maliyeti, LCCA, binalarda enerji etkinlik, enerji performansı, bibliyometrik analiz

### A BIBLIOMETRIC ANALYSIS OF LIFE CYCLE COSTS IN ENERGY-EFFICIENT BUILDINGS

#### ABSTRACT

Today, the efficient and effective use of energy has become one of the primary objectives in the building sector, as it has in many other sectors. A significant amount of the energy used in buildings is consumed by climate control systems, such as heating, cooling and ventilation. In this context, active and passive strategies have been identified to reduce primary energy demand. The Energy

Performance of Buildings Directive (EPBD, 2002/91/EC), published by the European Union in 2002, set out requirements for the efficient and effective use of energy in buildings for EU member states. While the 2002 version of the EPBD specified requirements for improving the energy performance of buildings, the 2010 version introduced the obligation for member states to set their own Nearly Zero Energy Building (NZEB) targets. Another important issue emphasised in the 2010 directive is economic feasibility. In parallel with these European developments, Turkey's 2008 Building Energy Performance Regulation states that the energy performance of buildings must be improved throughout their useful life using economical solutions. When improving a building's energy performance, the Regulation specifies that it must be economically feasible and evaluated in conjunction with its life cycle cost (LCCA). EPBD-2010 emphasises that not only energy savings or efficient energy use, but also cost-benefit must be taken into account. The directive defines cost optimisation as determining the most cost-effective solution by analysing the initial investment cost, maintenance and operating costs, and the useful life. Accordingly, the most suitable solution, as determined by the life cycle cost of a high-energy-performance building, is expected to be selected. Since the publication of the EPBD in 2010, studies that also consider costs in energy-efficient building design have become increasingly widespread. This study presents a bibliometric analysis of research that comprehensively addresses energy performance and life cycle cost in buildings. The relevant studies were analysed according to their publication years, countries, authors, citations, keywords, and the discipline in which the scope of the study was conducted, and the data obtained were evaluated.

**Keywords:** Life cycle cost, LCCA, energy efficiency in buildings, energy performance, bibliometric analysis

## 1.GİRİŞ

Enerjinin etkin ve verimli kullanılması, 1973 yılında yaşanan petrol krizinden günümüze kadar tüm sektörlerde olduğu gibi bina sektöründe de öncelikli konulardan biri haline gelmiştir. Binalarda enerjinin etkin kullanımına yönelik dönüm noktası niteliğindeki ilk önemli yasal gelişme, Avrupa Birliği tarafından 2002 yılında yayınlanan Binalarda Enerji Performansı Direktifidir (EPBD-2002). EPBD-2002'yi takiben 2010 yılında güncellenmiş ve genişletilmiş versiyon olan EPBD-2010 ve EPBD-2018 yayınlanmış ve 2024 yılında revize edilmiştir. EPBD'nin temel amacı; yeni binaların enerji performansı yüksek binalar olarak inşa edilmesi, mevcut binaların enerji etkin iyileştirilmesi, karbon emisyonlarının azaltılması, fosil yakıt kaynaklarına ihtiyacın minimize edilmesi gerekliliklerinin belirlenmesi olarak ifade edilebilmektedir. Avrupa Birliği tarafından yayınlanan Binalarda Enerji Performansı Direktifi ve yenilemelerinde maliyet ile ilgili gereklilikler de belirtilmektedir. EPBD'de maliyet etkinliğin ele alınma biçiminin yıllara göre değişimi Tablo 1'de gösterilmektedir (1-4).

**Tablo 1.** EPBD’de maliyet etkinlik ve LCCA’nın ele alınma biçimi (1-4)

Yıl	Direktif/Düzenleme	LCC ile ilgili ifade
2002	EPBD-2002	LCC ifadesi doğrudan geçmemekte, maliyet-etkin enerji iyileştirmesi kavramı yer almaktadır.
2010	EPBD-2010 (yenileme)	Maliyet-optimum kavramı tanımlanarak LCCA hakkında temel adım atılmıştır.
2012	Düzenleme	Maliyet-optimum metodolojisi detaylı olarak açıklanmıştır. LCC bileşenleri tanımlanmıştır.
2018	Değişiklik	Ulusal bina yenileme stratejilerinde ekonomik değerlendirme zorunluluğu getirilmiştir.
2024	Düzenleme	LCC ve yaşam döngüsünde karbon emisyonu birlikte ele alınmış ve zorunlu değerlendirme aracı haline getirilmiştir.

Avrupa’daki binalarda enerji performansına yönelik yasal sürece paralel olarak Türkiye’de 2008 yılında Binalarda Enerji Performansı Yönetmeliği (BEP-2008) yayınlanmıştır. BEP-2008’de doğrudan yaşam döngüsü maliyeti ifadesi yer almasa da, ekonomik çalışma ömrü ve ekonomik uygulanabilirlik gibi kavramlar yer almaktadır (5). BEP’in en güncel versiyonu 2025 yılında yayınlanan Binalarda Enerji Performansı Yönetmeliğinde Değişiklik Yapılmasına Dair Yönetmelik olarak resmi gazetede yayınlanmıştır (6).

Bu çalışmada enerji etkin bina tasarımında LCCA’nın yer aldığı çalışmalara yönelik bibliyometrik analiz yapılması ve LCCA’nın bu alandaki yeri ve öneminin saptanması hedeflenmiştir.

## 2. YAŞAM DÖNGÜ MALİYET ANALİZİ (LCCA)

Yaşam Döngüsü Maliyet Analizi (LCCA) ilk olarak, Amerika Birleşik Devletleri Ulusal Standartlar ve Teknoloji Enstitüsü (NIST) tarafından geliştirilen Federal Enerji Yönetimi Programı İçin Yaşam Döngüsü Maliyetlendirme Kılavuzu aracılığıyla standartlaştırılmıştır. LCCA yönteminin kapsamlı açıklaması ilk olarak 1995 yılında yayınlanan NIST Handbook 135 ile aktarılmıştır. Genişletilmiş ve güncellenmiş yöntem 2023 yılında yayınlanan NIST Handbook ile aktarılmıştır (7).

LCCA, farklı ölçekteki yatırım projelerinin, ilk yatırım aşaması, kullanım aşaması ve elden çıkarma aşamalarının tamamını kapsayan, yatırımın faydalı ömrü boyunca maliyetinin hesaplandığı bir ekonomik analiz yöntemidir. NIST’e göre LCCA yönteminin; bina inşa süreçleri, büyük ya da küçük ölçekli bina yenileme projeleri, tesis ya da kampüs ölçeğinde master plan oluşturma süreçlerinde farklı yatırım kararlarının değerlendirilmesi için uygun olduğu belirtilmektedir (8).

Özellikle Binalarda Enerji Performansı Direktifi’nin yayınlanmasından sonra enerji etkin bina tasarımı ya da enerji etkin bina iyileştirme projelerinde ekonomik sürdürülebilirlik de büyük önem taşıdığı için LCC analizi yaygın olarak çalışılmaya başlanmıştır. LCC hesaplanırken; ilk yatırım maliyeti, işletme ve bakım maliyeti, yenileme maliyeti, hurda değeri, iskonto oranı ve yatırımın

faydalı ömrü göz önünde bulundurulmaktadır. LCCA hesaplamalarında kullanılan formül aşağıdaki gibidir (9-10).

$$LCC = I + C_{O\&M} + C_R - C_S$$

$$LCC = I + C_{O\&M} \times \frac{1}{r} \times \frac{1-(1+r)^n}{1-(1+r)^n} + \frac{CR}{(1+r)^{nx}} - \frac{CS}{(1+r)^n}$$

LCC = Yaşam döngü maliyeti

I = İlk yatırım maliyeti

Co&M = İşletme ve bakım maliyeti

CR= Yenileme maliyeti

CS= Hurda değeri

r= İskonto

n= Yıl

nx= Yenileme yılı

Çalışmanın devamında enerji etkin bina tasarımında yaşam döngü maliyet analizinin kullanımına yönelik bibliyometrik araştırma yapılmıştır.

### 3. ENERJİ ETKİN BİNA TASARIMINDA YAŞAM DÖNGÜ MALİYET ANALİZİNİN KULLANIMINA YÖNELİK BİBLİYOMETRİK ANALİZ

Bu bölümde binalarda enerji performansına yönelik çalışmalarda LCCA'nın ele alınmasına yönelik veri analizi ve elde edilen bulgular olmak üzere 2 aşamalı bibliyometrik analiz yapılmıştır.

#### 3.1 Veri Analizi

Literatürdeki ilgili çalışmaların saptanması ve analiz edilecek verilerin elde edilmesi amacıyla Web of Science (WOS) veri tabanı kullanılmıştır (11). WOS, dünya çapında önde gelen, bir çok araştırmacının temel olarak literatür araştırması yaptığı bir makale veritabanıdır (12-16).

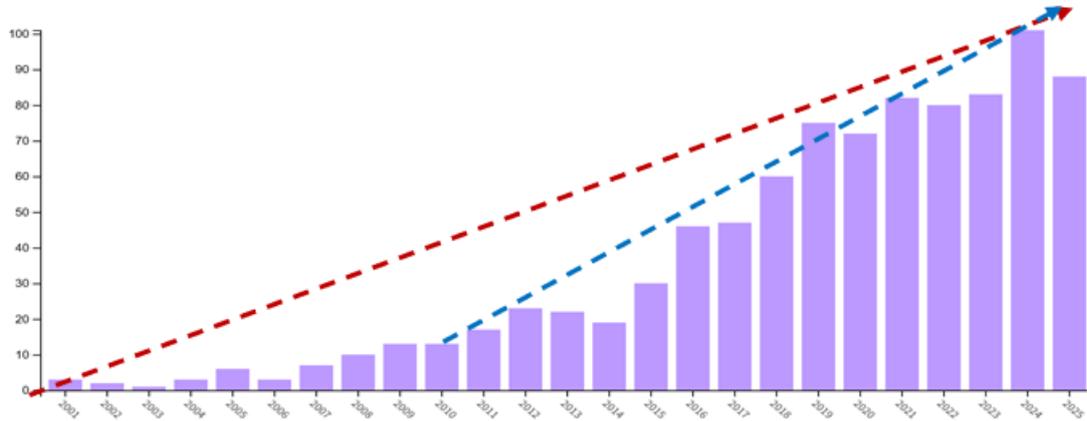
Arama bölümünde “all fields” seçimi yapılarak, “life cycle cost” or “LCCA” and “energy performance” and “building” anahtar kelimeleri kullanılmıştır. Arama kriterlerine uygun, toplam 926 adet yayın listelenmiştir. Araştırma hedefleri ile uyumlu olmayan kimya gibi mühendislik bilimleri ile sağlık disiplinlerine ait çalışmalar araştırma kapsamı dışında tutulmuştur. Listelenen yayınlar txt. Uzantısı ile kaydedilerek, Vosviewer programına aktarılmıştır. Vosviewer (1.6.20 versiyon) aracılığıyla, araştırılan başlıklar kapsamında veri analizleri yapılmıştır.

#### 3.2 Bulgular ve Değerlendirme

##### 3.2.1 Yayınların Yıllara Göre Dağılımı

İlk aşamada, WOS veritabanından istatistiksel veriler edilmiştir. İlk olarak yayınların yıllara göre dağılımı araştırılmıştır. 2001-2025 yılları arasında yayınlanan araştırmaların yıllara göre dağılımını gösteren grafik Şekil 1'de gösterilmektedir. 2010 yılında yayınlanan EPBD sonrasında, yayın

sayısında hızlı bir artış görülmektedir. Bu durumda, binalarda enerji performansının araştırıldığı çalışmalarda LCCA'nın bir problem olarak ele alınmasının yasal mevzuatla uyumlu olduğu ifade edilebilmektedir. Ayrıca; 2025 yılının henüz ilk 3 çeyreği tamamlanmış olmasına rağmen, 2024 ile kıyasla yayın sayısında hızlı bir artış olduğu görülmektedir.



**Şekil 3.1. Literatürde binalarda enerji performansının LCCA ile ele alındığı çalışmaların yıllara göre dağılımı**

### 3.2.2 Yayınların Disiplinlere Göre Dağılımı ve Yayın Türleri

Farklı kategorilerde yer alan çalışmaların, en sık kategorize edildikleri çalışma disiplinleri Tablo 3.1.'de gösterilmektedir. En yüksek yayın sayısının yer aldığı ilk 10 kategori listelenmiştir. Elde edilen literatür verisi sıklıkla; mühendislik, çevre bilimleri, bina teknolojileri ve sürdürülebilirlik gibi kategorilerde yer almaktadır.

**Tablo 3.1. Yayınların çalışma disiplinine göre dağılımı**

Çalışma Disiplini	Yayın Oranı (%)
Mühendislik	23
Bina teknolojileri	17
Enerji	14
Sürdürülebilirlik	11
Çevre bilimi	11
Multidisipliner malzeme bilimi	8
Çevre çalışmaları	5
Multidisipliner mühendislik bilimleri	3

Termodinamik	2
Multidisipliner bilimler	1

Tablo 3.2’de yayınların türlerine göre dağılımı gösterilmektedir. Ele alınan yayınların büyük çoğunluğunu (N:737) araştırma makalelerinin oluşturduğu, diğer türlerin ise bildiri, derleme, erken erişim makale ve kitap bölümü olduğu söylenebilmektedir.

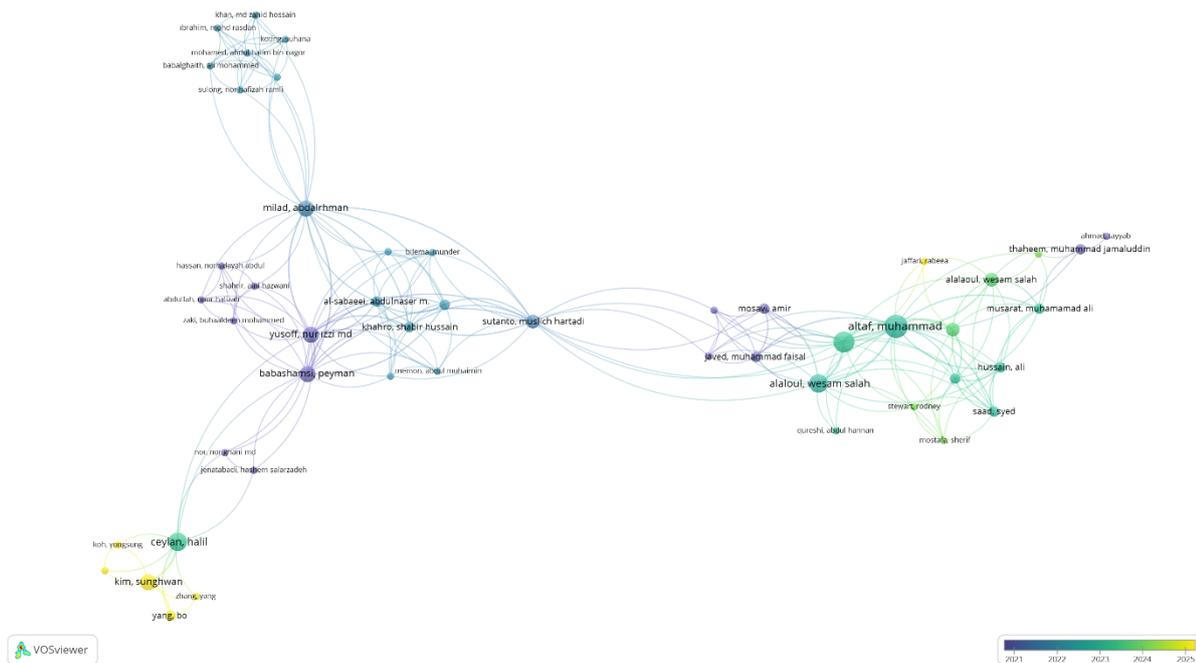
**Tablo 3.2. Yayınların türlerine göre dağılımı**

Yayın Türü	Araştırma Makalesi	Bildiri	Derleme	Erken Erişim Makale	Kitap Bölümü
Yayın Sayısı	737	122	48	15	4

### 3.2.3 Ortak Yazar Analizi

Ortak yazarların, farklı yazarlarla ortak yayın üretme sıklıkları bu bölümde incelenmiştir. Her bir yazar için; bir yazarın yer aldığı minimum yayın sayısı “1” ve bir yazara ait minimum atıf sayısı “1” olarak belirlenmiştir. Buna göre; incelenen yayınlardaki toplam yazar sayısı 2037 olarak belirlenmiştir.

Ortak yazar bağlantılarının incelendiği haritada aynı zamanda yıllara göre kümelenme araştırılmıştır. 2021-2025 olarak belirlenen zaman aralığında yazarlar arası bağlantı Şekil 3.2’de gösterilmektedir.



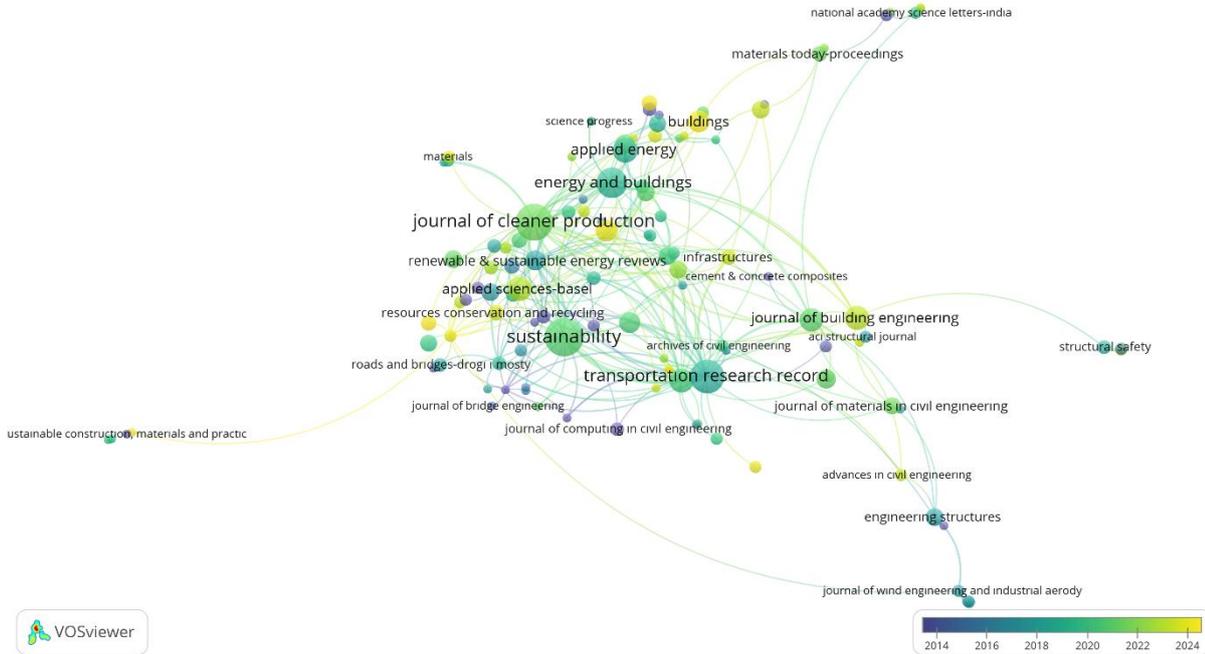
**Şekil 3.2. Ortak yazarlarda yıllara göre dağılım haritası (Vosviewer ile oluşturulmuştur)****3.2.4 Yayın Yerine Göre Analiz**

Her bir yayının yeri için; minimum yayın sayısı “1” ve minimum atıf sayısı “1” olarak belirlenmiştir. Bu koşullarda en yüksek atıf sayısı (N:1438) Journal of Cleaner Production dergisinde saptanmıştır. Dergide, araştırılan alanla ilgili 39 yayın olduğu saptanmıştır. Renewable & Sustainable Energy Reviews dergisinde ise 8 yayın, 1386 atıf saptanmıştır. Applied Energy, Sustainability ve Energy and Buildings dergilerinin ilgili araştırma alanında en çok atıf alan ilk 5 dergi arasında yer aldığı görülmektedir. En çok atıf alan ilk 5 dergi ve bu dergilerde yer alan, ilgili çalışma alanına dair yayın sayısı Tablo 3.3’de gösterilmektedir.

**Tablo 3.3. En yüksek sayıda atıf alan 5 Yayın yeri ve atıf sayıları**

Yayın Yeri	Yayın Sayısı	Atıf Sayısı
Journal of Cleaner Production	39	1438
Renewable & Sustainable Energy Reviews	8	1386
Applied Energy	14	899
Sustainability	44	786
Energy and Buildings	23	734

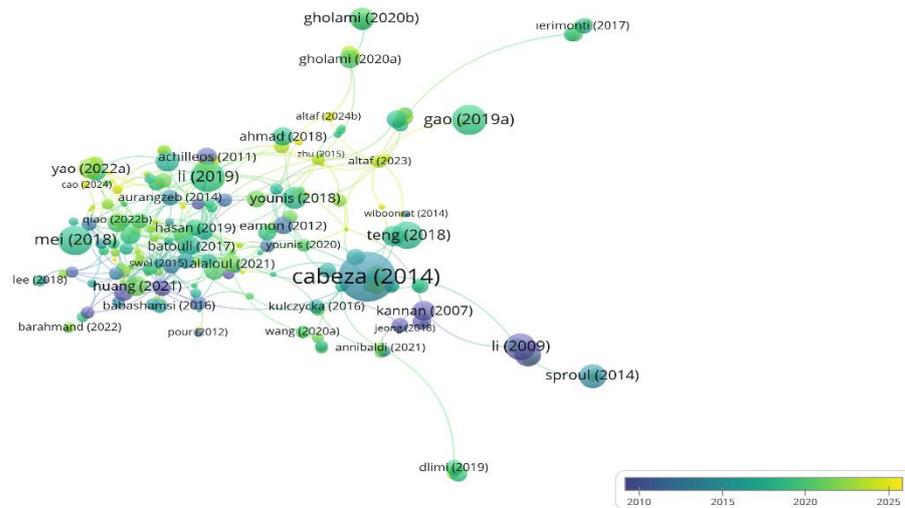
2014 - 2024 yılları arasında, yıllara göre atıf sayısı ve yayınlar arasındaki ilişki Şekil 3.3’de gösterilmektedir. 2020-2024 arasında konuyla ilgili yayın sayısındaki artış haritada görülebilmektedir.

**Şekil 3.3. Yayın yerleri haritası (Vosviewer ile oluşturulmuştur)****3.2.4 Yayınların Atıf Analizi**

Çalışma alanıyla ilgili en yüksek sayıda atıf alan yayınlar ve bu yayınların birbirleri ile ilişkisinin incelendiği bu bölümde; en az atıf alan çalışma sayısı “1” olarak belirlenmiş ve 629 yayın üzerinden haritalama yapılmıştır (Şekil 3.4). En yüksek sayıda atıf alan çalışmalara dair detaylı bilgi Tablo 3.4’de verilmektedir.

**Tablo 3.4. En yüksek sayıda atıf alan başlıca yayınlar**

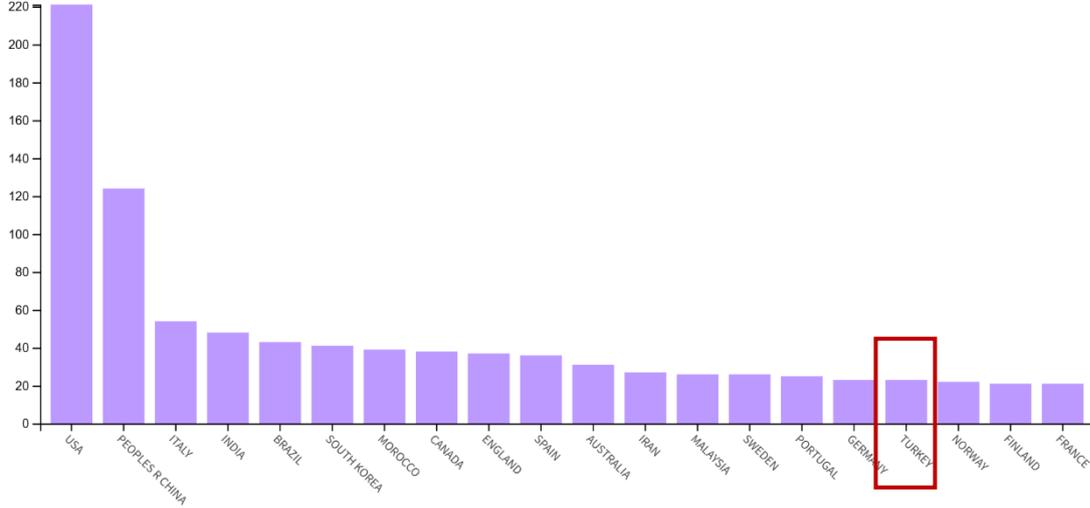
Yazar	Yayın Yılı	Başlık	Atıf Sayısı
Cabeza, L. F., Rincón, L., Vilariño, V., Pérez, G., & Castell, A.	2014	Life cycle assessment (LCA) and life cycle energy analysis (LCEA) of buildings and the building sector: A review.	940
Islam, H., Jollands, M., & Setunge, S.	2015	Life cycle assessment and life cycle cost implication of residential buildings—A review	219
Chau, C. K., Leung, T. M., & Ng, W. Y.	2015	A review on life cycle assessment, life cycle energy assessment and life cycle carbon emissions assessment on buildings.	675
Hasan, A.	1999	Optimizing insulation thickness for buildings using life cycle cost.	258
Marszal, A. J., & Heiselberg, P.	2011	Life cycle cost analysis of a multi-storey residential Net Zero Energy Building in Denmark.	183
Santero, N. J., Masanet, E., & Horvath, A.	2011	Life-cycle assessment of pavements Part II: Filling the research gaps.	127



**Şekil 3.4. Yayın atıf haritası (Vosviewer ile oluşturulmuştur)**

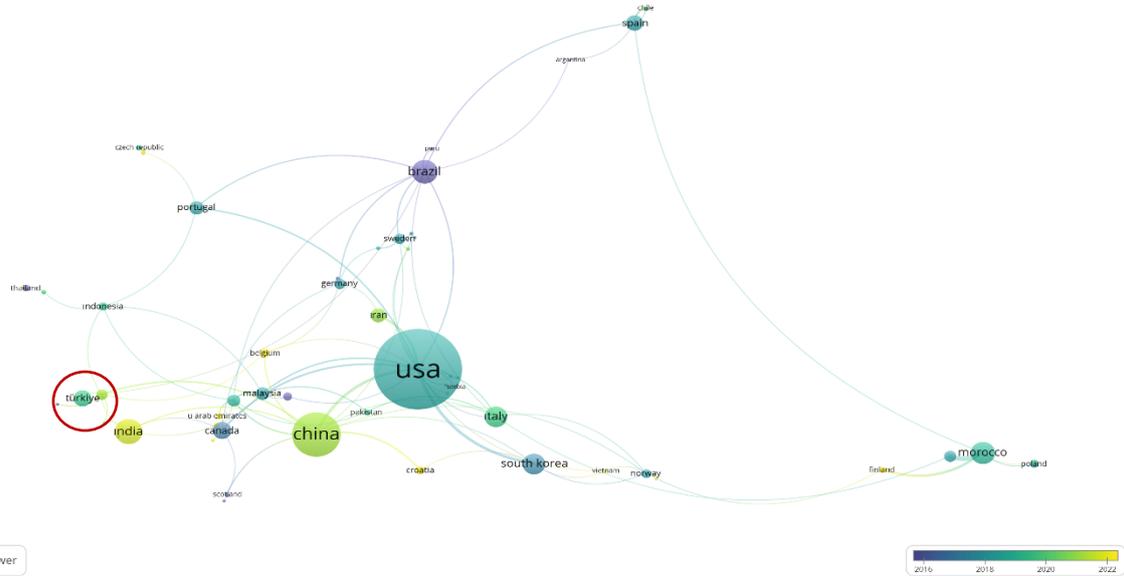
### 3.2.5 Ükelere Göre Dağılım Analizi

Ülkelere yayınların dağılımı analizi için; minimum yayın sayısı “1” ve minimum atıf sayısı “1” olarak belirlenmiştir. Analiz kriterlerine uyan 71 adet ülke olduğu saptanmıştır. En fazla yayının yapıldığı ilk 20 ülke Şekil 3.5’de gösterilmektedir. Araştırılan çalışma konusu ile ilgili en çok yayın yapılan ilk 3 ülke; ABD (N: 221), Çin (N:124), İtalya (N:54) iken, Türkiye (N:23) yayın sayısı açısından 17. sıradadır. İlk 20 içerisinde; Avrupa Birliği’ne üye 10 ülke yer almaktadır.



Şekil 3.5. Yayınların ülkelere göre dağılımı

Çalışma alanında ortak yayın yapan yazarların ülkelere göre işbirlikleri Şekil 3.6’da gösterilmektedir. Ayrıca; 2016-2022 arasında tarihlendirilen haritaya göre; Türkiye-İngiltere arasında 2020 sonrasında güçlü bir ortak yazarlık bağı olduğu ifade edilebilmektedir.



Şekil 3.6. Yazarların ülkelere göre ilişkisi (Vosviewer ile oluşturulmuştur)

### 3.2.6 Anahtar Kelime Analizi

Son olarak; ilgili yayınlarda kullanılan anahtar kelimeler ve sıklığı araştırılmıştır. Bu aşamada WOS’tan sağlanan “txt.” dosyalarında, aynı veriyi ifade eden ve tekrarlayan anahtar kelimeler tek bir



olması gerekliliği olarak geliştirilmiştir. Bu doğrultuda; enerji etkin bina tasarımı ya da yenilemesi projelerinde günümüzde yaşam döngü maliyeti de önemli bir kriter haline gelmiştir.

Bu çalışmada; literatürde enerji performansı yüksek bina ve LCCA yönteminin birlikte yer aldığı çalışmalar hakkında bir analiz yapılmıştır. Elde edilen sonuçlara göre;

Son 25 yılda artan hızla bu alanda çalışmaların yapıldığı,

Türkiye'deki araştırmacıları bu konuya özellikle son yıllarda yoğunlaştığı,

İklim değişikliği, optimum yalıtım kalınlığı, döngüsel ekonomi gibi araştırma konularının sıklıkla bu konuyla birlikte çalışıldığı,

Sadece Avrupa ülkelerinde değil, dünya genelinde konu ile ilgili araştırmaların yapıldığı,

Multidisipliner çalışmaların yapıldığı,

Ülkeler arası yazar işbirliklerinin sıklıkla yapıldığı uluslararası çalışmaların son yıllarda arttığı söylenebilmektedir.

Sürdürülebilir bir gelecek için, kaynakların ve enerjinin verimli kullanılmasına yönelik çalışmalarda ekonomik sürdürülebilirliğin de dikkate alınması; önerilen sistem ve çözümlerin uygulanabilirliğinin ve yaygınlaşmasının artması açısından büyük önem taşımaktadır.

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## EK ÇİMENTO ESASLI MALZEME KULLANIMININ ENERJİ TÜKETİMİ VE KÜRESEL ISINMA POTANSİYELİ ÜZERİNDEKİ ETKİSİNİN İNCELENMESİ

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### ÖZET

Küresel kentleşme ve altyapı gelişiminin artan hızı, betona yönelik benzeri görülmemiş bir talebe yol açmış ve bunun sonucunda çimento üretimi ile ilgili çevresel endişeleri yoğunlaştırmıştır. Sıradan Portland çimentosu (OPC), iklim değişikliğine önemli ölçüde katkıda bulunan en büyük endüstriyel karbondioksit emisyon kaynaklarından biri olarak bilinmektedir. Bu bağlamda, tamamlayıcı çimento malzemelerinin (SCM) kullanımı, beton üretiminin çevresel yükünü azaltmak ve sürdürülebilir kalkınma ilkelerini desteklemek için önemli bir strateji haline gelmiştir.

Bu çalışma, kısmi çimento ikamesi olarak silika dumanı (SF), uçucu kül (FA) ve metakaolin (MK) içeren betonların mekanik ve çevresel performanslarını değerlendirmektedir. Her karışımın basınç dayanımı, Küresel Isınma Potansiyeli (GWP) ve Enerji Tüketimi (EC) değerlerini belirlemek için literatür temelli veriler analiz edilmiştir. Eko-verimliliği ölçmek için, basınç dayanımı ile çevresel etki arasındaki ilişkiyi ifade eden iki birleşik performans göstergesi MPa/GWP ve MPa/EC hesaplanmıştır.

Sonuçlar, silika dumanı içeren betonların en yüksek eko-verimliliği sağladığını, bunu sırasıyla uçucu kül ve metakaolin'in izlediğini ortaya koymuştur. Bu bulgular, SCM'lerin hem kimyasal reaktivitesinin hem de üretim özelliklerinin sürdürülebilirlik sonuçlarını güçlü bir şekilde etkilediğini göstermektedir.

Genel olarak, araştırma, SCM'lerin, özellikle SF ve FA'nın beton karışımlarına entegre edilmesinin, düşük karbonlu, kaynak verimli ve dayanıklı inşaat malzemelerine giden umut verici bir yol sağladığını ve Birleşmiş Milletler Sürdürülebilir Kalkınma Hedefleri ile uyumlu olarak sürdürülebilir ve iklim dirençli altyapıya yönelik küresel geçişe katkıda bulunduğunu vurgulamaktadır.

**Anahtar kelimeler:** Çimento üretimi, ek çimento esaslı malzemeler, yaşam döngüsü değerlendirmesi, sürdürülebilir kalkınma.

### AN EXAMINATION OF THE EFFECT OF SUPPLEMENTARY CEMENTITIOUS MATERIALS USE ON ENERGY CONSUMPTION AND GLOBAL WARMING POTENTIAL

### ABSTRACT

The increasing pace of global urbanization and infrastructure development has led to an unprecedented demand for concrete, consequently intensifying environmental concerns associated with cement production. Ordinary Portland cement (OPC) is known to be one of the largest industrial sources of carbon dioxide emissions, contributing significantly to climate change. In this context, the use of supplementary cementitious materials (SCMs) has become a key strategy for reducing the

environmental burden of concrete production and supporting the principles of sustainable development.

This study evaluates the mechanical and environmental performances of concretes incorporating silica fume (SF), fly ash (FA), and metakaolin (MK) as partial cement replacements. Literature-based data were analyzed to determine compressive strength, Global Warming Potential (GWP), and Energy Consumption (EC) values for each mixture. To quantify eco-efficiency, two combined performance indicators MPa/GWP and MPa/EC were calculated, expressing the relationship between compressive strength and environmental impact.

The results revealed that concretes containing silica fume achieved the highest eco-efficiency, followed by fly ash and metakaolin, respectively. These findings indicate that both the chemical reactivity and production characteristics of SCMs strongly influence sustainability outcomes.

Overall, the research highlights that integrating SCMs, particularly SF and FA, into concrete mixtures provides a promising pathway toward low-carbon, resource-efficient, and durable construction materials, contributing to the global transition toward sustainable and climate-resilient infrastructure in line with the United Nations Sustainable Development Goals.

**Keywords:** Cement production, Supplementary cementitious materials, Life cycle assessment, Sustainable development.

## 1. INTRODUCTION

The continuous growth of the global population, accelerated urbanization, and large-scale infrastructure development have led to an unprecedented increase in construction activities worldwide (Ulas, Culcu, and Ulucan 2024). Concrete, as the most widely used construction material on Earth, has become indispensable due to its versatility, durability, and relatively low cost (Ma et al. 2025). According to global estimates, annual concrete production exceeds 10 billion tons, and the demand is expected to continue rising in line with the rapid expansion of cities and transportation networks. This massive consumption places significant pressure on natural resources, particularly aggregates and cement, and raises concerns about the environmental footprint of the construction industry (Bravo et al. 2015; Wijayasundara, Mendis, and Crawford 2017).

Alongside the surge in concrete usage, cement production the main binder in concrete has also increased dramatically (Bai et al. 2025; Danish and Ozbakkaloglu 2022). The manufacture of ordinary Portland cement (OPC) is inherently containing energy-intensive, involving both the combustion of fossil fuels and the decarbonation of limestone during clinker production (Liang et al. 2023). It is estimated that every ton of cement produced releases approximately 0.8–0.9 tons of CO<sub>2</sub>, contributing around 7–8% of total anthropogenic greenhouse gas emissions globally (Ulucan 2024; Ulucan et al. 2023). Beyond CO<sub>2</sub>, cement manufacturing also consumes vast amounts of thermal and electrical energy, further exacerbating the depletion of non-renewable resources. Consequently, reducing the carbon footprint of cement has become a key global challenge in achieving climate neutrality targets aligned with the Paris Agreement and UN Sustainable Development Goals (SDGs).

In recent years, the partial replacement of cement with supplementary cementitious materials (SCMs) such as silica fume, fly ash, and metakaolin has emerged as one of the most effective strategies to reduce environmental impacts without compromising mechanical performance (Lin, Lyu, and Fang 2025; Ramzi, Moradi, and Hajiloo 2023). These materials, derived from industrial by-products or natural pozzolans, possess reactive silica and alumina phases capable of participating in secondary hydration reactions with calcium hydroxide. This pozzolanic activity enhances the microstructure of the hardened matrix, leading to improved compressive strength, reduced permeability, and enhanced durability (Ulucan and Alyamac 2023; Ulucan and Cebeci 2025). Moreover, substituting cement with

SCMs can substantially decrease CO<sub>2</sub> emissions and energy consumption during cement production, aligning with the principles of the circular economy by valorizing waste materials.

As sustainability has become a central theme in modern construction, the environmental assessment of concrete mixtures is now considered as important as their mechanical properties. In this regard, Life Cycle Assessment (LCA) has been recognized as the most comprehensive and scientifically grounded methodology for quantifying the environmental impacts associated with construction materials (Knoeri, Sanyé-Mengual, and Althaus 2013; Vieira, Calmon, and Coelho 2016). By evaluating indicators such as Global Warming Potential (GWP) and Energy Consumption (EC), LCA enables researchers and engineers to identify the trade-offs between mechanical performance and environmental burden, facilitating more informed material selection and mix design decisions. Integrating these parameters into performance indicators such as MPa/GWP and MPa/EC provides a valuable means of measuring the “eco-efficiency” of concrete combining strength and sustainability within a unified framework.

Within this context, the present study focuses on the comparative evaluation of concretes incorporating silica fume, fly ash, and metakaolin in terms of their compressive strength and environmental performance. The originality of this research lies in its dual-index approach, where mechanical strength is correlated directly with environmental outputs to express the eco-mechanical efficiency of each mixture. By analyzing the compressive strength-to-environmental impact ratios (MPa/GWP and MPa/EC), this work provides an integrated perspective on sustainability and performance, contributing to the development of design strategies for low-carbon, high-performance cementitious systems that meet the demands of sustainable construction.

## 2. Materials and methods

### 2.1. Data Collection and Mixture Design

In this study, data regarding the mechanical and environmental performance of concrete mixtures incorporating various SCMs were compiled from peer-reviewed scientific literature. The selected SCMs included silica fume (SF), fly ash (FA), and metakaolin (MK), which were used as partial replacements for ordinary Portland cement (OPC) by mass. The selection criteria for the database were:

well-defined mix proportions,

reported 28-day compressive strength (MPa),

corresponding environmental indicators, particularly Global Warming Potential (GWP) and Energy Consumption (EC).

Data on the series considered in the mixture and the amounts of the mixture are presented in Table 1.

**Table 1.** Mixture amounts and compressive strengths of the articles

Article	Mix Code	Cement	Water	Fine	Coarse	SF	MK	FA	$f_{c,28}$
(Johari et al. 2011)	Reference	450	126	675	1125	0	0	0	86,7
	SF5	427,5	126	675	1125	22,5	0	0	105,7
	SF10	405	126	675	1125	45	0	0	113,9
	SF15	382,5	126	675	1125	67,5	0	0	117,5
	MK5	427,5	126	675	1125	0	22,5	0	91,5
	MK10	405	126	675	1125	0	45	0	103,7
	MK15	382,5	126	675	1125	0	67,5	0	103,4
	FA10	405	126	675	1125	0	0	45	85,7
	FA20	360	126	675	1125	0	0	90	84,3
FA30	315	126	675	1125	0	0	135	82,1	
(Bagheri, Zanganeh, and Moalemi 2012)	Reference	420	160	876	876	0	0	0	63
	SF5	409,5	160	874	874	10,5	0	0	72
	SF10	399	160	872	872	21	0	0	76
	SF15	388,5	160	870	870	31,5	0	0	78
	SF20	378	160	869	869	42	0	0	77
(Uysal, Yilmaz, and Ipek 2012)	Reference	550	182	869	778	0	0	0	75,9
	FA15	467	182	865	762	0	0	83	74,2
	FA25	412	182	887	752	0	0	138	73,4
	FA35	357	182	878	742	0	0	193	67,5
(Güneyisi et al. 2014)	Reference	450	180	935	832	0	0	0	62
	MK5	427,5	180	932	830	0	22,5	0	63
	MK10	405	180	921	820	0	45	0	67

To assess both mechanical and environmental performance in an integrated way, two eco-efficiency indicators were calculated:

$$\text{Compressive strength-to-GWP ratio (MPa/GWP)} = \frac{f_c}{\text{GWP}}$$

$$\text{Compressive strength-to-EC ratio (MPa/GWP)} = \frac{f_c}{\text{EC}}$$

where  $f_c$  represents the 28-day compressive strength (MPa), GWP is expressed in kg CO<sub>2</sub> eq, and EC in MJ.

## 2.2. Life cycle assessment

In this study, the environmental impacts of concrete mixtures were examined using the life cycle assessment (LCA) approach. LCA is a method that quantitatively analyses the energy consumption and environmental emissions arising throughout all processes, from the extraction of raw materials to the production of a product (Hossain et al. 2016; Ortiz, Castells, and Sonnemann 2009).

Two fundamental environmental impact categories were considered for each mix:

*Global Warming Potential (GWP)*: Indicates the carbon dioxide equivalent greenhouse gas emissions resulting from the produced mix.

*Energy Consumption (EC)*: Represents the total amount of energy used in the production process.

The data used in the LCA calculations were obtained from literature sources (Wang et al. 2024). The life cycle inventory analysis values considered are presented in Table 2. Environmental impact scores were calculated by multiplying the amount of material used for each mixture by the unit life cycle inventory analysis value. When calculating these impact scores, comparisons were made for different

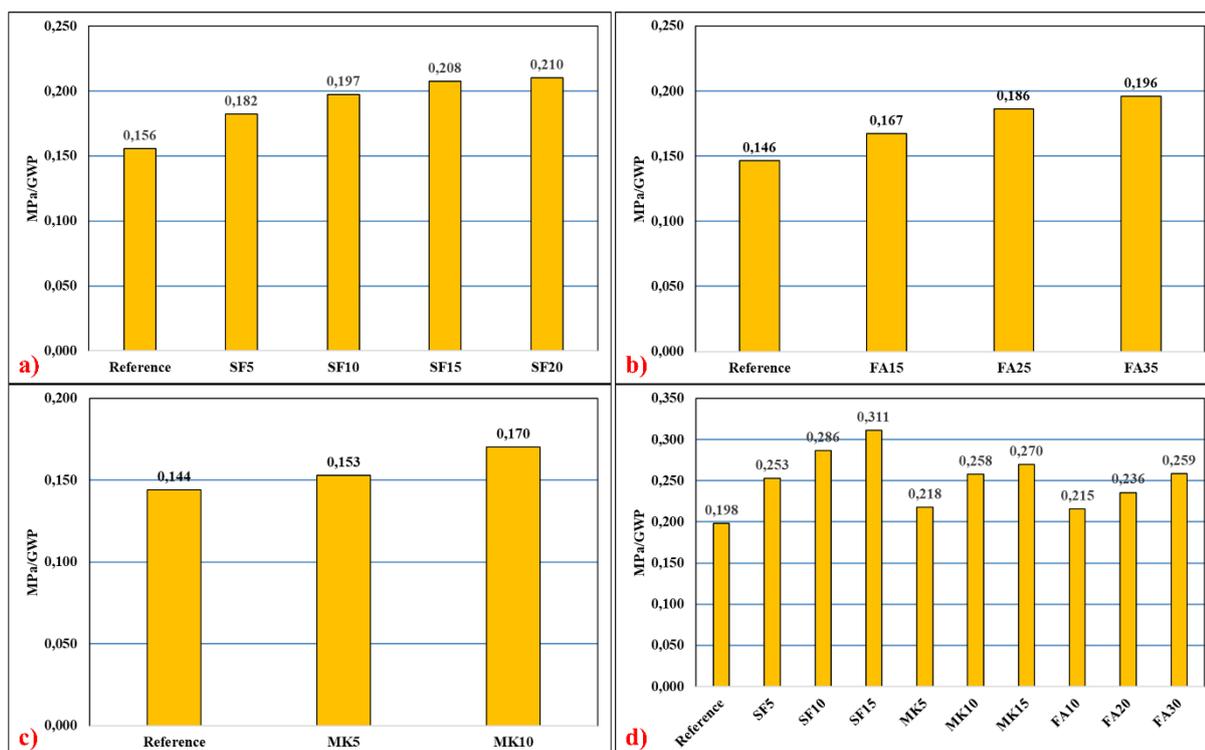
series using GWP and EC values corresponding to one MPa as the functional unit. Finally, the GWP and EC values calculated for each mixture were interpreted together with the compressive strength to compare the mixtures' efficiency in terms of both mechanical and environmental aspects. This method provides an important tool for demonstrating the extent to which different additives reduce the environmental impact of concrete, as well as their effectiveness in terms of strength.

**Table 2.** Life cycle inventory analysis of materials.

Impact Categories	Cement (1 kg)	Water (1 kg)	Fine (1 kg)	Coarse (1 kg)	SF (1 kg)	MK (1 kg)	FA (1 kg)
GWP (kg CO <sub>2</sub> eq)	0.898	-	0.002	0.029	0.001	0.092	0.004
EC (MJ)	3.7	0.002	0.018	0.401	0.012	0.446	0.043

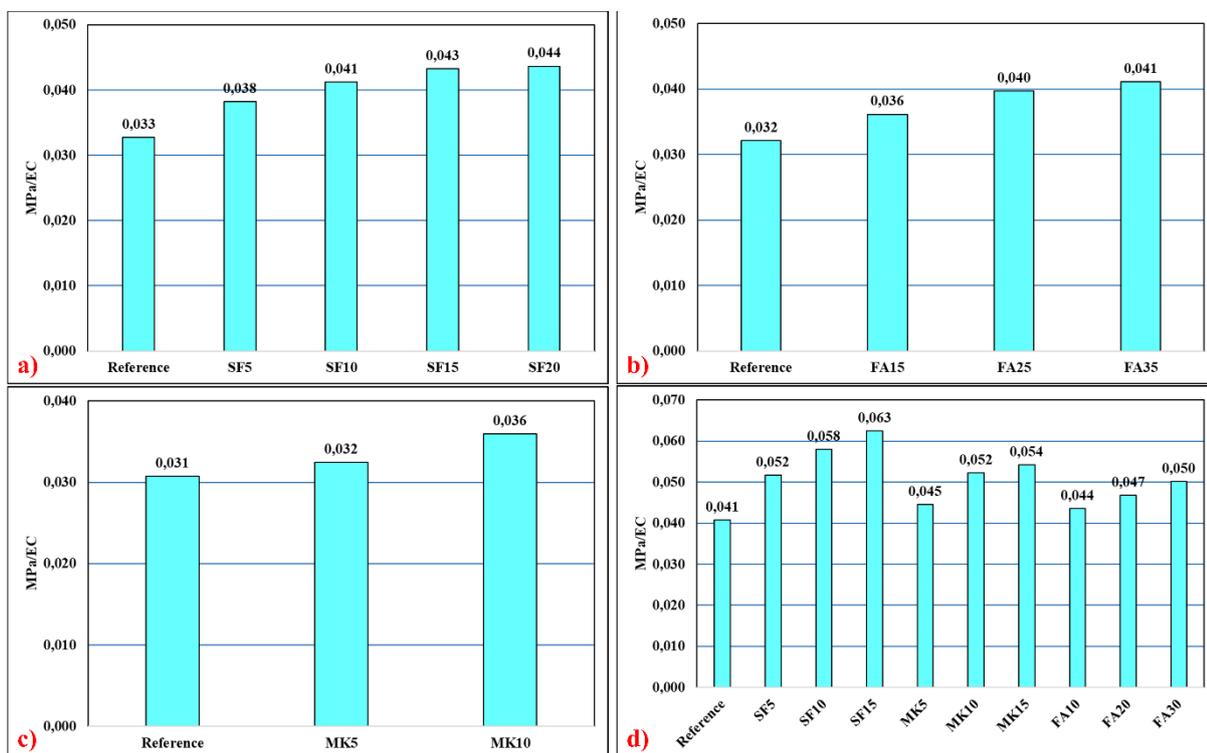
### 3. Results and discussion

This section of the study presents the normalized mechanical-environmental outputs of the data considered. This allows for a clearer explanation of the impact of the SCMs considered on mechanical and environmental outputs. Fig. 1 clearly presents the MPa/GWP values of the publications considered. Fig. 1a presents only the MPa/GWP values for data containing silica fume. Here, an increase in silica fume use of up to 20% is found. However, there is no significant growth in use above 15%. The highest MPa/GWP value obtained is 0.210. Fig. 1b indicates the results for series containing only FA, with the highest value revealed being 0.196. Fig. 1c represents the comparison of results for series containing only MK, with the highest value obtained being 0.170. Among the series created with single contents of SCMs, the highest values were revealed in SF, while the lowest values were revealed in MK. Fig. 1d shows the MPa/GWP values calculated using data from the article containing these three mixtures. Similar results were found here. Specifically, this value was 0.311 for SF15, 0.270 for MK15, and 0.259 for FA30.



**Fig. 1.** MPa/GWP results of different series.

Fig. 2 presents a comparative analysis of the MPa/EC results for the publications considered. Fig. 2a gives the MPa/EC results for data containing only silica fume. Here, an increase is found up to 20% silica fume use. However, it is clearly observed that there is almost no growth at use levels above 15%. The highest MPa/EC value obtained was 0.044. Fig. 2b indicates the results for series containing only FA, where the highest value was 0.041, and results close to those for silica fume were obtained. Fig. 2c reveals the comparison of results belonging only to the MK-containing series, where the highest value obtained was 0.036. In the series created with single contents of SCMs, the highest values were observed in SF, while the lowest values were observed in MK. Fig. 2d represents the MPa/EC values calculated using the data from the article containing these three mixtures. Here, similar results were found. Specifically, this value was 0.063 for SF15, 0.054 for MK15, and 0.050 for FA30.



**Fig. 2.** MPa/EC results of different series.

#### 4. Conclusions

This study aimed to assess the environmental and mechanical efficiency of traditional concretes prepared with different supplementary cementitious materials (SCMs), namely silica fume (SF), fly ash (FA), and metakaolin (MK). The analysis focused on integrating performance and sustainability by comparing mixtures in terms of compressive strength per unit environmental impact expressed as MPa/GWP and MPa/EC ratios. The implications of the study are summarized as follows:

1. The comparative evaluation showed that the incorporation of SCMs has a notable effect on both mechanical strength and environmental performance, confirming that partial cement replacement is an effective strategy to enhance concrete sustainability.

2. Among the investigated materials, concretes containing silica fume (SF) achieved the highest eco-efficiency values, followed by fly ash (FA) and metakaolin (MK). This indicates that SF provides the most favorable balance between compressive strength and environmental impact.
3. The superior performance of silica fume-based mixtures is mainly attributed to its very fine particle size and high pozzolanic reactivity, which promote a denser microstructure and higher strength with relatively lower CO<sub>2</sub> emissions per unit strength.
4. In conclusion, the use of SCMs represents a promising approach for the production of low-carbon, high-performance concretes, supporting environmentally responsible and resource-efficient construction practices.

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## AISI 4140 ÇELİĞİNİN FARKLI HELİSEL AÇILI PARMAK FREZELERLE İŞLENMESİNDE TALAŞ MORFOLOJİSİNİN İNCELENMESİ

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### ÖZET

AISI 4140 çeliği içerisinde barındırdığı karbon bakımından sertleştirilmeye elverişli yüksek tokluk özelliği gösteren sanayide geniş bir kullanımı olan imalat çeliğidir. Bu çalışmada üç farklı helis açısında (30°, 38° ve 45°) helisel parmak freze ile farklı işleme parametrelerinde (kesme hızı, ilerleme hızı ve sabit talaş derinliği) talaş kaldırma işlemi gerçekleştirilmiştir. Talaş kaldırma işlemi esnasında ortaya çıkan talaşların yapısı incelenmiştir. Yapılan çalışmanın sonucunda en büyük talaş kalınlığı 38° ve 45° helisel matkaplarda 135 m/dak kesme hızı ve 0,15 mm/diş ilerleme hızında olduğu, en küçük talaş kalınlığı 30° helisel parmak frezede 200 m/dak kesme hızı ve 0,05 mm/diş ilerleme hızında olduğu belirlenmiştir.

**Anahtar kelimeler:** AISI 4140, helisel parmak freze, talaş morfolojisi

### INVESTIGATION OF CHIP MORPHOLOGY IN MACHINING AISI 4140 STEEL WITH END MILLS WITH DIFFERENT HELICAL ANGLES

### ABSTRACT

AISI 4140 steel is a widely used industrial manufacturing steel that exhibits high toughness properties, making it suitable for hardening due to its carbon content. In this study, material removal operations were performed using helical end mills at three different helix angles (30°, 38°, and 45°) under different machining parameters (cutting speed, feed rate and constant depth of cut). The structure of the chips generated during the material removal process was investigated. The study determined that the largest chip thickness occurred in the 38° and 45° helical end mills at 135 m/min cutting speed and 0,15 mm/tooth feed rate, while the smallest chip thickness occurred in the 30° helical end mill at 200 m/min cutting speed and 0,05 mm/tooth feed rate.

**Keywords:** AISI 4140, helical end mill, chip morphology

## 1.GİRİŞ

Freze ve torna tezgahında gerçekleştirilen talaşlı imalat işlemleri esnasında malzeme üzerinden kaldırılan talaşın işleme parametrelerine bağlı olarak ortaya çıkan yüzey kalitesini önemli ölçüde etkilemektedir (Yılmaz & Güllü, 2020). Kesme işlemi sırasında metallerin elastik-plastik deformasyon davranışı kesme hızı ve ilerleme hızına bağlı olarak kesici takım üzerinden akıp giderek talaş oluşumu şekillerini yansıtır. İşlenen malzemenin mekanik ve fiziksel özellikleri, kesme bölgesinde meydana gelen sıcaklıklar ve kesici takımın aşınması gibi faktörlerden etkilenerek talaşın farklı akış halleri ve kararsızlıkları içerir (Zhang et al., 2024). Kesici takımın kesme işlemi sırasında işlenen malzemenin tane sınırı hareketleri, malzemenin iç yapısındaki çökelmeler veya malzemenin üretim sürecinde ortaya çıkan kusur noktalarının neden olduğu plastik deformasyon kaynaklı kıvrımlara dönüşen şişkinlikler oluşturarak talaşın oluştuğu ileri sürüldüğü de bilinmektedir (Bai et al., 2023). Bazı bilim insanları talaşın oluşumu sırasında kesici takımın üzerinden kayarak giden metalin akış durumunun talaş morfolojisine doğrudan ve belirleyici bir etkiye sahip olduğunu belirtmişlerdir (Sagapuram et al., 2020). İşleme parametrelerinin (kesme hızı, ilerleme hızı ve talaş derinliği) ısı oluşumu üzerine etkisi önemli bir rol oynamaktadır. Kaldırılan talaş esnasında ortaya çıkan ısı, kesme kuvvetleri ve işlenen iş parçası malzemesine göre farklılık gösterir. Isı oluşumunda işleme parametrelerinden kesme hızı ilerleme hızına göre daha etkili bir parametre olarak bilinmektedir (Gökkaya & Nalbant, 2006). İşleme sırasında ortaya çıkan talaşların boyutu, şekli ve rengi işlenen yüzeyin kalitesi ve takım aşınması gibi işleme parametreleri hakkında bilgi vermektedir. Kesme işlemi sırasında oluşan talaşların kabul edilebilir sınır içinde olması, talaşın malzeme yüzeyine temas etmeden ortamdan uzaklaştırılması, malzeme yüzeyine saran talaşlardan dolayı işlenen yüzeyin kalitesinin bozulmaması için işleme parametrelerinin optimum sınırlar içerisinde olması dikkate alınmalıdır (Altınsoy & Üllen, 2025).

İşlenen malzemenin cinsi, kesme hızı, ilerleme hızı, kesme derinliği ve takım formuna bağlı olarak farklı tiplerde talaş oluşmaktadır. Talaşlar oluşum mekanizmasına göre üç şekilde gerçekleşir. Sürekli, süreksiz ve yığıntı talaş olarak adlandırılmaktadır. Sünek malzemelerin yüksek kesme hızlarında işlenmesi sonucunda sürekli talaş, aşırı kırılğan bir malzemede oluşan talaş süreksiz talaş, işlenen yüzey boyunca ortaya çıkan sürekli talaşın kesici takım üzerine yapışması ile ortaya çıkan talaş yığıntı talaş olarak adlandırılmaktadır (Yaman).

Bu çalışmada farklı helis açılarda parmak freze kullanılarak AISI 4140 malzemenin farklı işleme parametrelerde frezeleme işlemi gerçekleştirilerek kullanılan parametrelerinin talaş kalınlığına etkisi incelenmiştir. AISI 4140 malzeme içerdiği karbonun miktarından dolayı yüksek sertlik değer elde edilebilen bir çelik malzemedir. Yaygın olarak kullanım alanı makine ve imalat sanayisi başta olmak üzere otomotiv, petro-gaz, savunma alanı ve uçak sanayisi gibi birçok farklı endüstriyel sektörde kullanılmaktadır. Makine aparatları, dişli çarklar, krank mili, somunlar ve tarım makineleri başlıca kullanım alanlarına örnek verilebilmektedir. Tedariği kolay, işlenebilirliği yüksek, ısıl işlem kolaylığı ve maliyet açısından uygun olması AISI 4140 malzemeyi avantajlı hale getirmektedir (Fedai, 2022).

## 2. MATERYAL METOD

### 2.1. İş Parçası

Deney numunesi olarak 80x40x220 mm ölçülerinde AISI 4140 Islah çelik malzemesi kullanılmıştır. Çalışmada seçilen AISI 4140 çeliğin kimyasal özellikleri, Tablo 1'de görülmektedir. Tablo 2.'de ise bu çeliklerin fiziksel özellikleri yer almaktadır.

Tablo 1. Deneysel çalışmada kullanılan AISI 4140 çeliğinin kimyasal özellikleri (Özbek & Saraç, 2019).

Malzeme	Bileşen (% Ağırlık)						
	C	Mn	P	S	Si	Cr	Mo
AISI 4140	0,38-0,43	0,7-1,0	0,04	0,05	0,15-0,30	0,8-1,1	0,15-0,25

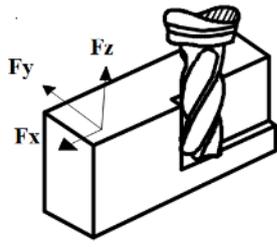
Tablo 2. AISI 4140 Çeliğinin fiziksel özellikleri (Dikmen, 2010)

Yoğunluk (gr/cm <sup>3</sup> )	7,70-8,03
Poisson Oranı	0,27-0,30
Elastikiyet Modülü (GPa)	190-210
Çekme Mukavemeti (Mpa)	655
Akma Mukavemeti (Mpa)	417,10
Uzama (%)	25,70
Kesit Daralması (%)	56,90
Sertlik (HB)	197

## 2.2. İşleme Parametreleri

Deneyler Mikron VCP 800 üç eksenli dik işleme merkezi kullanılarak gerçekleştirilmiştir. Deneyler; üç farklı kesme hızı (Vc), üç farklı ilerleme hızı (fz), sabit kesme derinliği (ap=18mm), sabit yanıl paso (ae=1 mm) ile üç farklı helis açısına sahip TiAlN kaplamalı karbür parmak frezeler kullanılarak kuru kesme şartlarında gerçekleştirilmiştir. Deneylerde kullanılan işleme parametreleri ve seviyeleri Tablo 3’ de gösterilmektedir.

Tablo 3. Deney parametreleri ve seviyeleri

Seviyeler	Helis Açısı	Kesme Hızı (Vc) (m/dak)	Diş Başı İlerleme Hızı (fz) (mm/diş)	Eksenel Derinlik (ap(mm))	Radyal Derinlik (ae(mm))	
Seviye 1	30°	90	0,05	18	1	
Seviye 2	38°	135	0,10			
Seviye 3	45°	200	0,15			

## 2.3. Talaş Ölçümü

Her bir parametrenin gerçekleştirilmesi esnasında tezgâh haznesi temizlenerek deney malzemesinden çıkan talaş parçaları numaralandırılmış deney poşetlerine alınarak ölçme işlemleri gerçekleştirilmiştir. Talaş kalınlıklarının ölçümünde Karcan Quick Check Metrik 9.00 MT mikroskop cihazı kullanılmıştır. Deneylerde kullanılan cihazın fotoğraf görüntüsü Şekil 1’ de gösterilmektedir.



Şekil 1. Karcan Quick Check Metrik 9.00 MT Mikroskop Cihazı

### 3. BULGULAR VE TARTIŞMA

#### 3. 1. Deneylerin Gerçekleştirilmesi

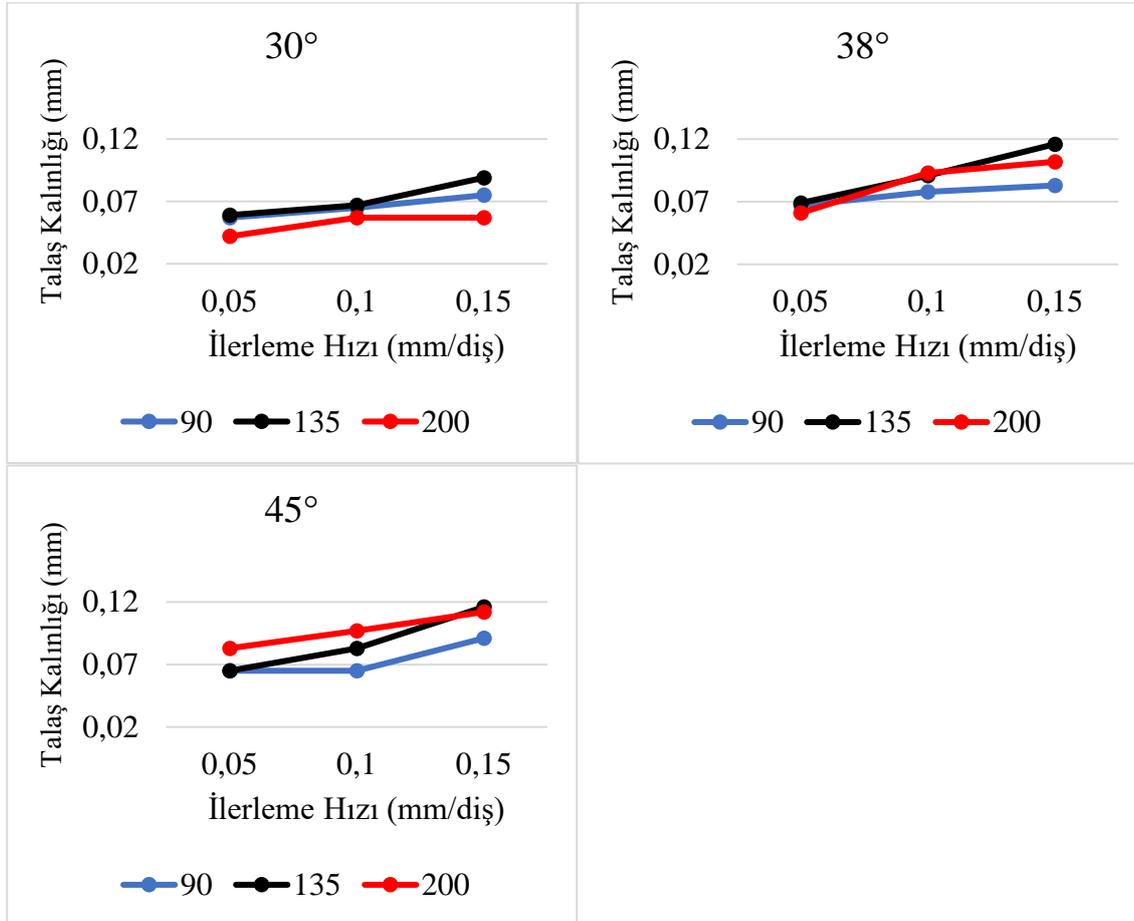
Deneyel işlemler gerçekleştirilmesi sonrasında elde edilen talaş kalınlıkları ölçüleri Tablo 4' de gösterilmektedir.

Tablo 4. Deneyel çalışmadan elde edilen talaş kalınlıkları

Deney No	Helis Açısı	Kesme Hızı (Vc (m/dak))	İlerleme Hızı (fz (mm/diş))	Talaş Kalınlığı (mm)
1	30°	90	0,05	0,057
2	30°	90	0,10	0,065
3	30°	90	0,15	0,075
4	30°	135	0,05	0,059
5	30°	135	0,10	0,067
6	30°	135	0,15	0,089
7	30°	200	0,05	0,042
8	30°	200	0,10	0,057
9	30°	200	0,15	0,057
10	38°	90	0,05	0,067
11	38°	90	0,10	0,078
12	38°	90	0,15	0,083
13	38°	135	0,05	0,069
14	38°	135	0,10	0,091
15	38°	135	0,15	0,116
16	38°	200	0,05	0,061
17	38°	200	0,10	0,093
18	38°	200	0,15	0,102
19	45°	90	0,05	0,065
20	45°	90	0,10	0,065

21	45°	90	0,15	0,091
22	45°	135	0,05	0,065
23	45°	135	0,10	0,083
24	45°	135	0,15	0,116
25	45°	200	0,05	0,083
26	45°	200	0,10	0,097
27	45°	200	0,15	0,112

Tablo 4 incelendiğinde 30° helis açısı ile talaş kaldırma işlemi sonrasında gerçekleşen deneylerde talaş kalınlığının en küçük olduğu işleme parametresi 200 m/dak kesme hızı ve 0,05 mm/diş ilerleme hızında oluşmuştur. En büyük talaş kalınlığı ise 135 m/dak kesme hızı ve 0,15 mm/diş ilerleme hızında meydana gelmiştir. 38° helis açısı ile talaş kaldırma işlemi sonrasında gerçekleşen deneylerde talaş kalınlığının en küçük olduğu işleme parametresi 200 m/dak kesme hızı ve 0,05 mm/diş ilerleme hızında, en büyük talaş kalınlığı ise 135 m/dak kesme hızı ve 0,15 mm/diş ilerleme hızında meydana gelmiştir. 45° helis açısı ile gerçekleşen deneylerde ise en büyük talaş kalınlığı 135 m/dak kesme hızı ve 0,15 mm/diş ilerleme hızında, en küçük talaş kalınlığı ise hem 90 m/dak kesme hızında hem de 135 m/dak kesme hızında 0,05 mm/diş ve yine 90 m/dak kesme hızında 0,10 mm/diş ilerleme hızlarında oluşmuştur. Tablo 4' teki verilerin birbirleri ile kıyaslama yapılması için elde edilen sonuçlar Şekil 2' de grafik olarak oluşturulmuştur.

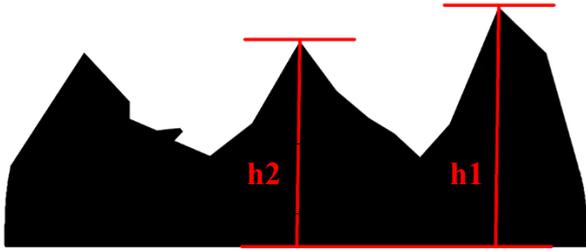


Şekil 2. Deneysel çalışmadan elde edilen sonuçların grafik olarak gösterimi

Şekil 2’deki grafikler incelendiğinde üç farklı helisel açılarda üretilen kesici takımların işleme sırasında ilerleme hızı arttıkça talaş kalınlığında artış olduğu görülmüştür. Literatür çalışmaları incelendiğinde benzer şekilde olduğu görülmüştür. Literatür incelendiğince benzer şekilde ilerleme hızı arttığında talaş kalınlığının artış gösterdiği görülmektedir (Bouzakis et al., 2024). Yine yapılan başka bir çalışmada talaş kalınlığına etki eden önemli faktörün ilerleme hızı olarak olduğu hem deneysel hem de istatistiksel olarak belirlenmiştir (Bakır, 2012).

### 3. 2. Talaş oluşumu

Talaş oluşumu ile ilgili farklı yaklaşımlar olmasına rağmen, genel olarak talaşları; sürekli, süreksiz ve segmentli şeklinde gruplandırılabilir (Ginting & Nouari, 2006), (Sutter, 2005). Segmentli talaşların segmentasyon oranı  $G_s$  ile ifade edilmektedir.  $G_s$  oranını hesaplamak için talaş formundan alınan ölçüler ile hesaplanmaktadır.  $h_1$  ve  $h_2$  Şekil 3’de gibi alınarak Eşitlik 1’den segmentasyon oranı hesaplanmaktadır (Bakır, 2012). Paulachon ve Moisan yaptığı çalışmanın sonucunda malzemenin sertliğinin ve kesme hızının talaş segmentasyon oranına en önemli iki etken parametre olduğunu belirtmiştir (Poulachon & Moisan, 2000).



Şekil 3. Segmentasyon oranının hesaplanmasında kullanılan  $h_1$  ve  $h_2$  yüksekliklerinin gösterimi

$$G_s = \frac{(h_1 - h_2)}{(h_1)} \quad (1)$$

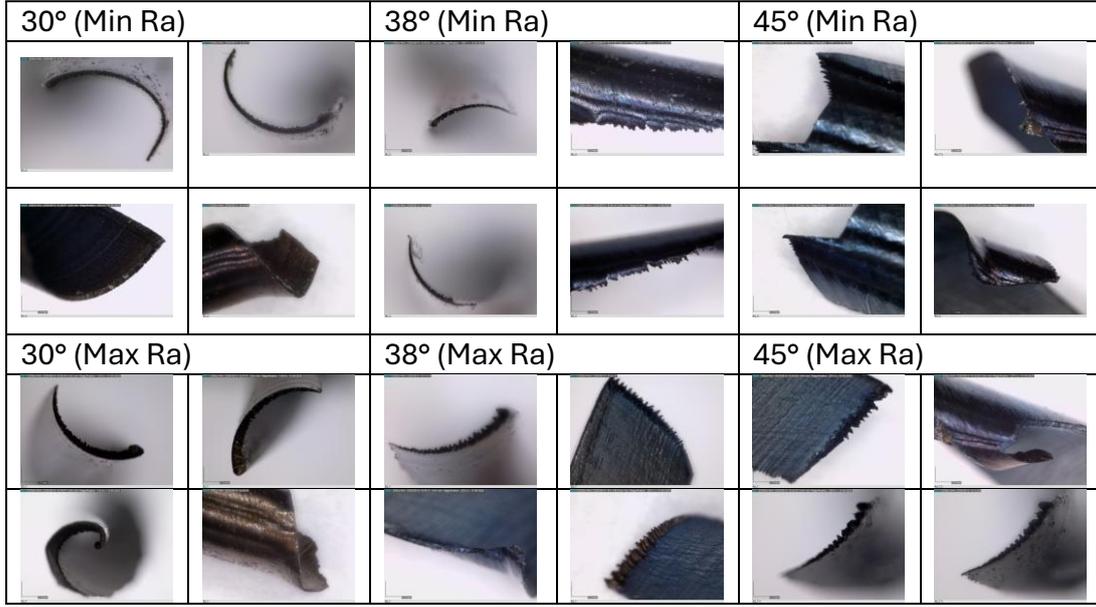
Talaş segmentasyon oranı sıfıra yaklaştıkça ortaya çıkan talaş formunun daha az tırtıklı olduğu ve bu durumun işlenen yüzeyi daha pürüzsüz hale getirdiği görülmüştür. Yapılan benzer çalışma sonuçlarında literatürdeki gibi kesme hızındaki artışın talaş formunu testere forma doğru yönlendirdiği görülmüştür (Ye et al., 2012). Yapılan deneyler neticesinde talaş segmentasyon oranının artışı ile elde edilen yüzeyin gittikçe bozulduğu görülmektedir. Yapılan çalışmada talaş segmentasyon oranı ölçülmüş olup Tablo 5’de gösterilmektedir.

Tablo 5. Talaş segmentasyon oranı ( $G_s$ )

Helis Açısı	30°	38°	45°
$G_s$	0,485	0,371	0.602
Talaş Resimleri			

Her deney operasyonu sonrasında ortaya çıkan talaşlar tezgâh haznesine serilen örtüden alınarak kitli poşetlerde muhafaza edilmiştir. İşlenen parçaların Ra değerleri ölçülerek en düşük Ra ve en yüksek

Ra değerinde ortaya çıkan talaşlar Şekil 4' de gösterilmektedir. Kesme hızının artması ile talaş genişliğinin azaldığı belirlenmiştir. Çalışma literatür ile benzerlik göstermektedir (Sun & Guo, 2008).



Şekil 4. Deneysel çalışmadan elde edilen talaşların fotoğraf görüntüsü

Şekil 2' deki grafikler incelendiğinde bütün helisel açılarda ve kesme hızlarında ilerleme hızının artması ile talaş kalınlıklarında artış olduğu görülmüştür. Deneysel çalışma sonuçları literatürdeki gibi kesme hızındaki artışla beraber talaş testere forma doğru yönelmiştir (Ye et al., 2012).

#### 4. SONUÇLAR

Bu çalışmada endüstride yaygın olarak kullanılan AISI 4140 malzemenin farklı helis açılı parmak frezeler ile farklı kesme parametrelerinde frezeleme işlemi gerçekleştirilerek ortaya çıkan talaşlar incelenmiştir. Elde edilen sonuçlar maddeler halinde sunulmuştur.

Üç farklı helisel açılarda üretilen kesici takımların işleme sırasında ilerleme hızı arttıkça talaş kalınlığında artış olduğu,

En büyük talaş kalınlığı 38° ve 45° helisel parmak frezede 135 m/dak kesme hızı ve 0,15 mm/diş ilerleme hızında olduğu,

En küçük talaş kalınlığı 30° helisel parmak frezede 200 m/dak kesme hızı ve 0,05 mm/diş ilerleme hızında olduğu,

Talaş segmentasyon oranı sıfıra yaklaştıkça ortaya çıkan talaş formunun daha az tırtıklı oluşarak işlenen yüzeyi pürüzsüz hale getirdiği,

Kesme hızındaki artışın talaş formunu testere forma doğru yönlendirdiği,

Talaş segmentasyon oranının artışı ile elde edilen yüzeyin gittikçe bozulduğu,

Kesme hızının artması ile talaş genişliğinin azaldığı,

Bütün helisel açılarda ve kesme hızlarında ilerleme hızının artması ile talaş kalınlıklarında artış olduğu tespit edilmiştir.

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## YAPAY SİNİR AĞI KULLANILARAK YAPIŞTIRICI BAĞLANTI MUKAVEMETİNİN TAHMİNİ

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### ÖZET

Bu çalışmada, yapıştırıcı ile birleştirilmiş tek bindirme bağlantılarının (SLJ) mukavemetini etkileyen en temel parametreler incelenmiştir. Deneyle, AA7075-T6 plakalar yapıştırıcı olarak Araldite 2015 kullanılarak gerçekleştirilmiştir. Bağlantıların mukavemet kontrol parametreleri, bazalt elyaf yüzdesi, ortam sıcaklığı ve yapıştırıcı kalınlığı gibi değişkenlerdir. Bu dinamik koşulların neden olduğu belirsizliği ortadan kaldırmak için, farklı koşullar altında bağlantı mukavemetleri hakkında tahminler üretebilmek hem çok değerli hem de önemlidir. Kayma mukavemeti Yapay Sinir Ağları (ANN) kullanılarak modellenmiştir. ANN modelleme sonuçlarının  $R^2$  ve performans değerleri göz önüne alındığında, modellerin yüksek doğruluk sağladığı görülmüştür.

**Anahtar Kelimeler:** AA7075-T6, Kırılma Yüğü, Kayma Mukavemeti, ANN

## ARTIFICIAL NEURAL NETWORK-BASED PREDICTION OF ADHESIVE BOND STRENGTH

### ABSTRACT

In this study, the most fundamental parameters affecting the strength of adhesive-bonded single lap joints (SLJs) were investigated. The experiments were carried out using AA7075-T6 plates bonded with Araldite 2015 adhesive. The primary factors controlling the joint strength include variables such as the percentage of basalt fiber, ambient temperature, and adhesive thickness. To eliminate the uncertainty caused by these dynamic conditions, it is both valuable and essential to be able to predict the joint strength under various conditions. The shear strength was modeled using Artificial Neural Networks (ANN). Considering the  $R^2$  and performance metrics of the ANN modeling results, it was observed that the models provided high accuracy.

**Keywords:** AA7075-T6, Failure Load, Shear Strength, ANN

### 1. INTRODUCTION

Traditional joining processes generally involve manufacturing operations such as drilling and fastening. However, these operations can induce undesirable thermal and mechanical damages in composite or lightweight alloy materials. Consequently, adhesive bonding techniques have gained prominence as they provide significant advantages over conventional mechanical joining methods (Isbilir and Ghassemieh 2013; Li et al. 2015; Hu et al. 2019). Adhesive joints facilitate the joining of dissimilar materials and components with varying thicknesses, which is often a limitation in traditional mechanical fastening. For instance, aluminum alloys such as those used in this study can form strong galvanic couples when joined using metallic fasteners, leading to electrochemical

corrosion within the aluminum matrix (Mandel and Krüger 2013; Fiore et al. 2017; Håkansson et al. 2017).

Adhesively bonded aluminum alloy joints are extensively employed in structural engineering applications, including automotive body structures, roof frames, and aerospace assemblies (Hamill and Nutt 2018; Sun et al. 2018; Banea et al. 2018; Qin et al. 2018; Liu et al. 2019; Hu et al. 2019). One of the major advantages of adhesive joints is their ability to distribute loads more uniformly and minimize stress concentrations compared to mechanical joints (Kwon et al. 2019; Hu et al. 2019). In addition, adhesive bonding reduces the overall structural weight, enhances fatigue resistance, and provides excellent sealing properties.

The adhesive bonding process comprises several critical stages to ensure high interfacial strength, among which surface preparation plays a key role. Proper surface preparation enhances the surface energy, promotes wettability, and increases mechanical interlocking between the substrate and adhesive. Conventional surface treatments, such as abrasion or surface modification, are essential for achieving reliable and durable adhesive bonds.

Commonly adopted surface preparation techniques to enhance bond strength include mechanical abrasion (e.g., sandblasting, grinding, or abrasive blasting), chemical etching (Håkansson et al. 2017; Hu et al. 2019) and, more recently, hybrid (mechanical + chemical) surface treatments (Zou et al. 2023). Mechanical treatments such as laser texturing (Lim et al. 2020; Wang et al. 2023b; Zou et al. 2023), sandblasting (Wang et al. 2018, 2023c; Safari et al. 2022) and grinding (Hu et al. 2022) modify surface morphology by generating controlled micro-roughness, thereby improving adhesive wetting and mechanical anchoring. Conversely, chemical etching removes the weak oxide layer typically present on aluminum alloys, resulting in a pitted morphology that promotes micro-mechanical interlocking and increases surface reactivity (Abouarkoub et al. 2016; Hu et al. 2019). Therefore, investigating the influence of novel hybrid surface preparation methods on the adhesion performance is of great scientific and practical significance.

In the present study, AA7075-T6 aluminum plates were bonded in a SLJ configuration following the ASTM D5868 standard. Araldite 2015, a high-performance structural epoxy adhesive, was employed as the bonding agent. The effects of basalt powder filler content added to the adhesive on bond strength were experimentally evaluated. Furthermore, the impact of hybrid surface preparation techniques on the interfacial adhesion and shear strength of the joints was systematically investigated. The experimental results were also modeled and predicted using Artificial Neural Networks (ANN), providing a robust data-driven approach for estimating adhesive bond performance under varying processing conditions.

## 2. MATERIALS AND METHODS

### 2.1. Materials

The AA7075-T6 alloy is widely used in the aerospace and automotive industries due to its superior mechanical properties. Its light weight, ease of machinability, high strength, and excellent corrosion resistance are the main reasons for its preference in structural applications. In this study, AA7075-T6 plates with a thickness of 2 mm were used. The particle size of the basalt powder added to the adhesive ranged between approximately 0.1 and 0.7 mm. Basalt powder is frequently used to improve the mechanical performance of epoxy- and polyester-based adhesives. Owing to its high strength and chemical stability, basalt is also widely employed as a reinforcing material in composite structures to enhance their mechanical properties.

## 2.2. Surface Preparation

In this study, AA7075-T6 plates were prepared in accordance with the ASTM D5868 standard, with dimensions of  $125 \times 25 \times 2$  mm. Prior to bonding, surface preparation was carried out to ensure optimal adhesion conditions. The process began with cleaning all specimen surfaces using 99% pure acetone to remove any oil or contaminants.

Subsequently, a hybrid surface treatment was applied to the bonding regions, consisting of mechanical abrasion followed by chemical etching. In the hybrid process, the specimens were first subjected to sandblasting using  $\text{Al}_2\text{O}_3$  abrasive particles with an average grain size of  $5 \mu\text{m}$ . After sandblasting, the surfaces were cleaned again with acetone to remove any remaining dust or oil residues, rinsed with deionized water to eliminate any traces of acetone, and then dried at room temperature.

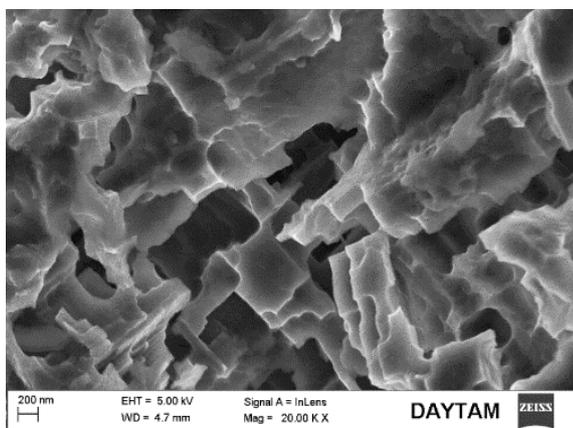
Following the mechanical treatment, chemical etching was performed using a 1 M NaOH solution, following the same cleaning procedure. This treatment removed the weak oxide layer on the surface and produced a more reactive, micro-rough morphology favorable for adhesive bonding. The surface appearances of the AA7075-T6 specimens after the preparation stages are shown in Figure 1.



(b) (c)

**Figure 1.** Surface images of AA7075-T6: a) Untreated surface, b) sandblasted surface as an intermediate treatment, c) surface etched with 1 M NaOH after sandblasting

The SEM images of the surfaces treated by both sandblasting and NaOH etching are presented in Figure 2. On the surfaces treated by sandblasting, micro-pores and cavities generated by the mechanical impact of abrasive particles can be observed, while the surfaces treated by chemical etching exhibit smoother and more rounded morphological features without sharp edges.



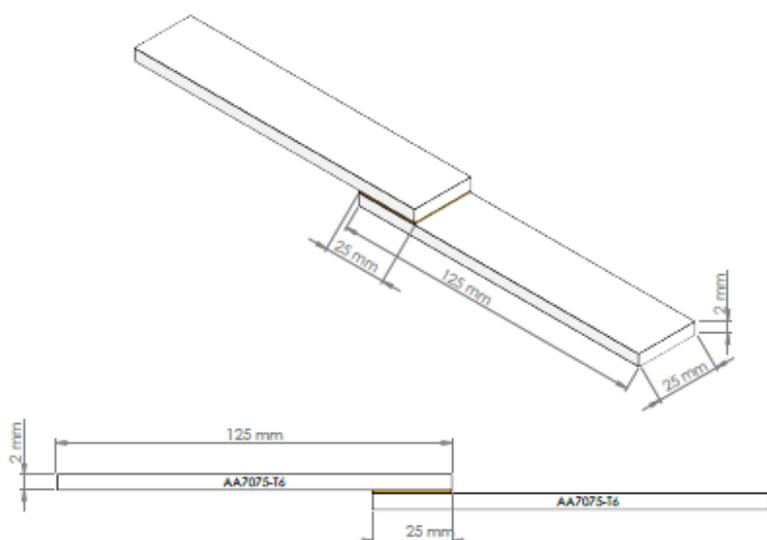
**Figure 2.** SEM image of the surface after hybrid surface treatment

### 2.3. Bonding Process

In this study, the adhesive layer thickness was set to 0.15, 0.20, and 0.25 ± 0.02 mm for different specimen groups. The working time of Araldite 2015 adhesive is approximately 35 minutes at 23 °C. Araldite 2015 is a two-component epoxy-based structural adhesive consisting of a resin and a hardener, which are mixed in a 1:1 ratio by volume to initiate the bonding process.

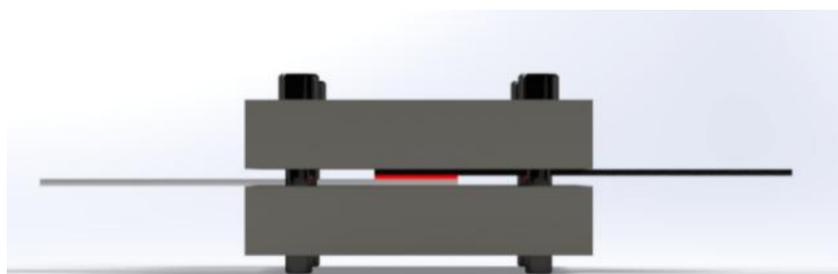
The resin and hardener were first mixed manually for 5 minutes and then blended for an additional 5 minutes using a mechanical stirrer to ensure homogeneity. Subsequently, basalt powder was added as a filler at a weight fraction of 1% and uniformly dispersed within the adhesive mixture.

The SLJs were prepared in accordance with the ASTM D5868 standard, as illustrated in Figure 3. During the bonding process, the adhesive was applied uniformly to the prepared bonding areas, and the adherends were carefully aligned to maintain the desired adhesive thickness. After assembly, the specimens were cured at room temperature (23 ± 2 °C) for 24 hours under slight pressure to ensure uniform bonding and avoid void formation.



**Figure 3.** SLJ configuration of AA7075-T6.

The specimens were prepared using a mold assembly, as shown in Figure 4. The mold was secured at its corners with four round-head screws to ensure proper alignment during bonding. Spacers with known thicknesses were placed between the mold plates to precisely control the adhesive layer thickness.



**Figure 4.** Mold

To investigate the adhesive strength under different temperature conditions, the specimens were placed in an oven at 20°C, 50°C, and 100°C for 24 hours. The mechanical performance of the joints

and the changes in their behavior under these temperature environments were evaluated. The properties and coding of the bonded joints are listed in Table 1, and the experiments were carried out based on these parameters. Adhesion strengths of all specimens were assessed under each condition. The tests were conducted using a BESMAK BMT-E tensile testing machine at a temperature of 20°C, 30% relative humidity, and a crosshead speed of 1 mm/min.

**Table 1.** Experimental parameters of adhesive joints

Parameter	Levels / Values	Description
Basalt fiber content (% by weight)	0, 0.5, 1, 0.15	Amount of basalt fiber powder added to adhesive
Adhesive thickness (mm)	0.15, 0.20, 0.25	Bond line thickness between adherends
Aging temperatures (°C)	20, 50, 100	Temperature environments used to evaluate strength

#### 2.4. Artificial Neural Network (ANN)

Artificial Neural Networks (ANNs) are structures that operate similarly to the biological brain. They consist of a series of interconnected neurons that process information. An ANN is a mathematical and computational data derivation model capable of making predictions. It has the ability to learn from complex, empirical, or statistical data (Onyelowe KC. et. al .2023). ANNs are composed of several interconnected layers, generally consisting of three main layers: the input layer, the hidden layer(s), and the output layer. Problems are solved by sequentially transferring the data through the input layer, then the hidden layer(s), and finally the output layer. The number of hidden layers varies depending on the complexity of the problem and the data (Azimi-Pour M. et.al.2018, Onyelowe KC. et. al.2023, Fabani MP. Et.al. 2020, Golafshani EM.et.al, 2019).

In this study, ANN modeling was conducted to evaluate the effects of basalt fiber content, adhesive thickness, and ambient temperature on the shear strength of adhesive joints. The ANN models were implemented using MATLAB R2020b. A total of 36 experimental data points were randomly included in the model. During the model development process, multiple network architectures were tested through trial and error. Seventy percent of the experimental data were used for training, while the remaining 30% were reserved for testing and validation. The Levenberg–Marquardt algorithm was employed for training. Based on the trial-and-error studies, the model with two hidden layers and ten neurons provided the best results. A Feed-Forward Back Propagation (FFBP) network was selected as the ANN sub-algorithm. TRAINLM was used as the training function, and the Mean Squared Error (MSE) was used as the performance function. The modeling process continued until the highest correlation coefficient (R) was achieved. Figure 5 illustrates the ANN model with the highest R value.

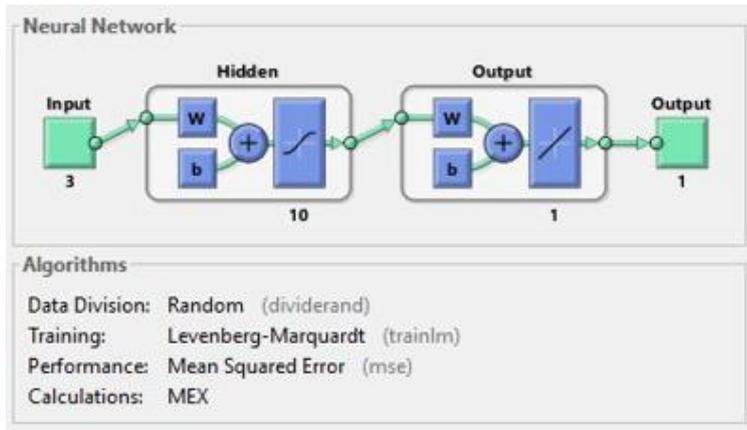


Figure 5. Architecture of the Artificial Neural Network (ANN) model

### 3. RESULTS AND DISCUSSION

#### 3.1 Shear Strenght

Figure 6 presents the shear stress values from 36 experiments conducted with different basalt fiber contents, temperatures, and adhesive thicknesses.

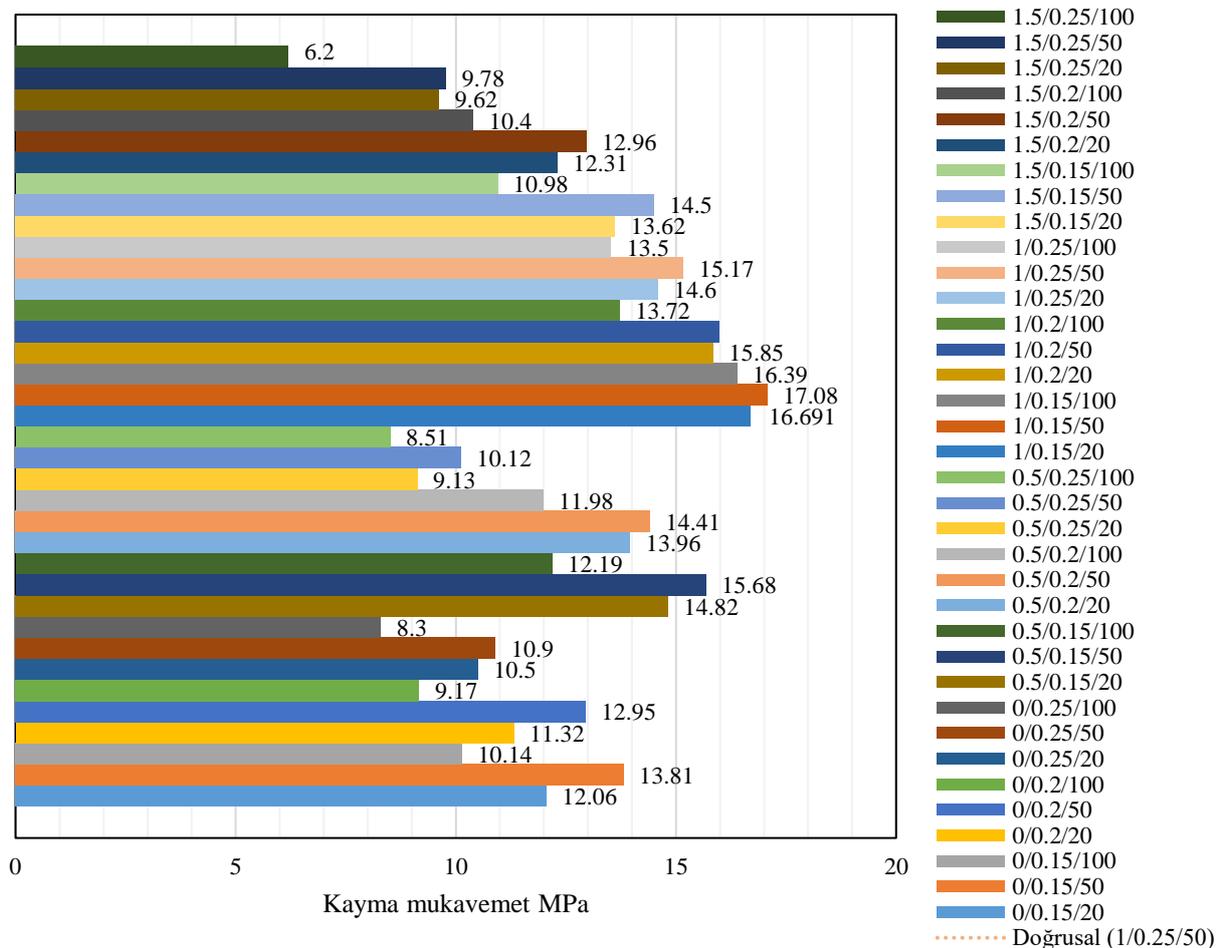


Figure 6. Shear strength values of the specimens.

The shear strength values for all specimens are presented in Figure 6. At 50°C, the highest shear strength was obtained with an adhesive thickness of 0.15 mm and 1% basalt content. At this

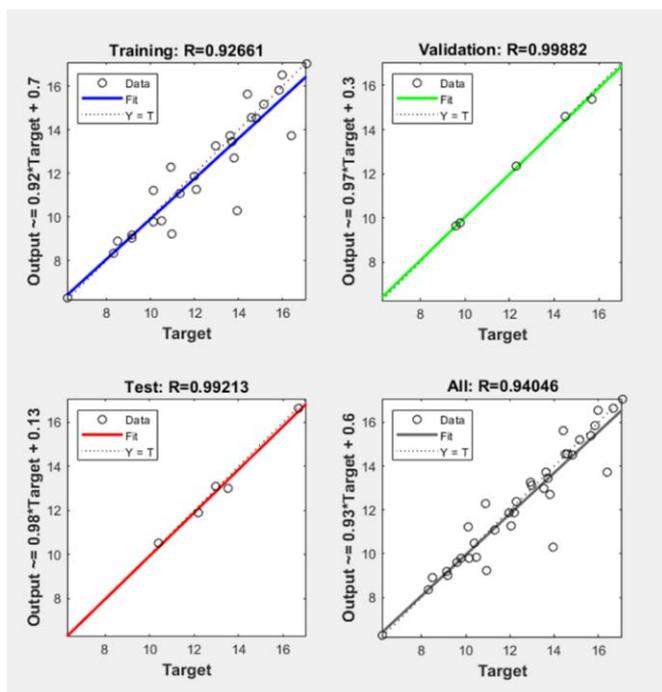
temperature, both unfilled and basalt powder-filled adhesive joints exhibited increased shear strength. This improvement is attributed to the enhanced spreading of the adhesive over a larger surface area and the effective penetration of the basalt powder into the adhesive at elevated temperatures.

When the ambient temperature reached 100°C, it was observed that the adhesive began to lose its bonding properties in all specimens, whether filled or unfilled, and it was concluded that this effect would be completely lost at even higher temperatures. Therefore, the working temperature at which the adhesive joints are produced is of significant importance. As is generally known, increasing adhesive thickness leads to a reduction in strength. Consistently, in this study, adhesive thicknesses of 0.2 mm and 0.25 mm showed lower shear strength compared to the 0.15 mm thickness.

### 3.2. Results of the ANN Model

Artificial Neural Networks (ANNs) are structures that operate similarly to the biological brain. They consist of a series of interconnected neurons that process information. An ANN is a mathematical and computational data derivation model capable of making predictions. It has the ability to learn from complex, empirical, or statistical data. ANNs are composed of several interconnected layers, generally consisting of three main layers: the input layer, the hidden layer(s), and the output layer. Problems are solved by sequentially transferring the data through the input layer, then the hidden layer(s), and finally the output layer. The number of hidden layers varies depending on the complexity of the problem and the data (Azimi-Pour and Eskandari-Naddaf 2018; Golafshani et al. 2020; Fabani et al. 2021; Onyelowe et al. 2023).

In this study, ANN modeling was conducted to evaluate the effects of basalt fiber content, adhesive thickness, and ambient temperature on the shear strength of adhesive joints. The ANN models were implemented using MATLAB R2020b. A total of 36 experimental data points were randomly included in the model. During the model development process, multiple network architectures were tested through trial and error. Seventy percent of the experimental data were used for training, while the remaining 30% were reserved for testing and validation. The Levenberg–Marquardt algorithm was employed for training. Based on the trial-and-error studies, the model with two hidden layers and ten neurons provided the best results. A Feed-Forward Back Propagation (FFBP) network was selected as the ANN sub-algorithm. TRAINLM was used as the training function, and the Mean Squared Error (MSE) was used as the performance function.



Şekil 7. ANN model R values

### 3.3. Statistical Performance Evaluation of the ANN Model

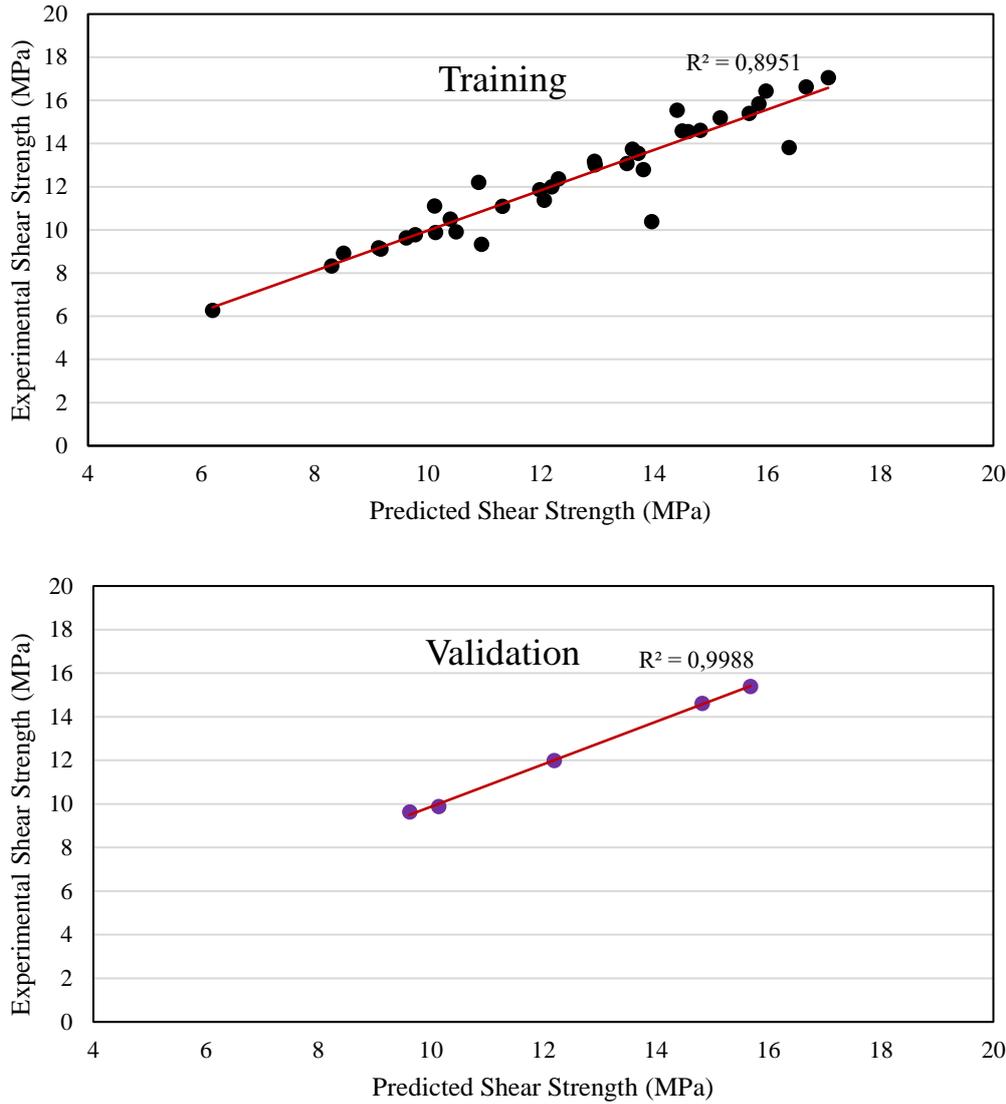
The robustness and reliability of the model were evaluated using the following statistical metrics: MAPE, RMSE, MAE, RSE, NSE, RRMSE, R, and Pi. These statistical performance indicators are presented in Table 8.

Table 2. Performance metric values of shear strength for the GEP and ANN models.

	MAPE	RMSE	MAE	RSE	NSE	RRMSE	R	Pi
ANN (Training)	0.0404	0.9607	0.5171	0.1617	0.836	0.0769	0.927	0.04
ANN (Validation)	0.0151	0.2176	0.1931	0.008	0.992	0.0174	0.99	0.00871

As shown in Table 2, the R values are 0.93 or higher. The MAPE, RMSE, MAE, RSE, and RRMSE values are observed to be quite low. The Pi value being close to 0 indicates a high agreement between the experimental data and the model outputs. In the ANN model, the Pi value is less than 0.05. The NSE values range between 0.836 and 0.99. An NSE value close to 1, similar to high R values, signifies the accuracy of the model. These results demonstrate that the model is highly reliable and successful.

Figure 8 graphically presents the predicted and experimental shear strength values obtained from the ANN modeling. The proximity of the data points to the regression line indicates that the predicted values are very close to the experimental values, confirming the high accuracy of the model (Nazar S.et.al.2023, Golafshani EM. et.al. 2019). The developed ANN model achieved R<sup>2</sup> values greater than 0.9, showing excellent agreement and predictive capability between the experimental data and the predicted results. The models were effectively and efficiently used to predict shear strength for all input parameters. R<sup>2</sup> values approaching 1 indicate a strong correlation between the input and predicted values (Iqbal MF et al 2020).



Şekil 8.  $R^2$  for shear strenght by ANN tarining and validation

#### 4. CONCLUSIONS

The joint strength varies significantly depending on the adhesive thickness, the proportion of basalt powder added to the adhesive, and the ambient temperature. Controlling the strength variations caused by these parameters is challenging. Therefore, determining the optimum conditions and maintaining consistent joint strength is of critical importance. In industrial applications, controlling inappropriate conditions and their effects on strength is often difficult, time-consuming, and costly. Artificial intelligence (AI)-based machine learning (ML) techniques offer the opportunity to identify optimal parameters and predict output values, thereby reducing processing time and overall cost. In this study, two AI-based techniques, namely Artificial Neural Networks (ANN), were employed to predict the shear strength of adhesive joints, and their results were compared.

Experimental results indicate that adhesive thickness, ambient temperature, and basalt powder content significantly affect the strength of AA7075-T6/AA7075-T6 adhesive joints. The highest failure load and shear strength values were obtained at the lowest adhesive thickness. In general, strength values increased at 50°C. The best result was achieved for the specimen with 0.15 mm adhesive thickness and 1% basalt powder at 50°C.

According to statistical performance metrics and  $R^2$  values, the model predicted the shear strength with high accuracy and very low errors. The Pi value was below 0.05 for all models, indicating a strong agreement between the experimental and predicted data.

The ANN model successfully predicts shear strength for new and unseen data.

The use of AI-based machine learning techniques in adhesive joint analysis contributes to eliminating uncertainties, determining optimum parameters, and enhancing environmental sustainability by reducing the number of experiments.

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## ÇİN HİSSE SENEDİ PİYASASI İLE ABD PARA POLİTİKASI BELİRSİZLİĞİ İLİŞKİSİ

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### ÖZET

Finansal piyasaların yapı taşı olan sermaye piyasaları küresel entegrasyon nedeniyle uluslararası piyasalardan oluşan ekonomik değişimlerden kolayca etkilenebilmektedir. Bu nedenle özellikle hisse senedi yatırımcıları uluslararası piyasalarda yatırım kararında bulunurken sadece kendi ülkelerinin ekonomik koşullarını dikkate almayarak çok boyutlu yatırım faaliyetinde bulunurlar. Özellikle gelişmiş ve gelişmekte olan ülkeler yakın ilişki içerisinde oldukları diğer ülkelerin ve/veya dünya ekonomisine etki edebilecek potansiyel güce sahip olan diğer ülkelerin ekonomik durumlarından kolayca etkilenebilmektedirler. Bu nedenle bu çalışmada ABD para politikası belirsizliği ile Çin hisse senedi piyasası arasındaki ilişkiyi inceleyen çalışmada Şangay Composit indeks fiyatları (SSEC), Çin CSI1000 hisse senedi fiyatları (CSI1000), Çin – ABD ticaret savaşı indeksi (UCT) ve Çin yenilenebilir enerji hisse senedi fiyatlarının (RenEw) ABD para politikası (MPU) ilişkisi 2006:06 – 2023:09 aylık dönem verileri kullanılarak ARDL sınır yaklaşımı testi kullanılarak araştırılmıştır. Çalışmadan elde edilen sonuçlara göre MPU indeksi ile UCT, RenEw ve SCI1000 fiyatlarının anlamlı etkiye sahip olduğu belirlenmiştir.

**Anahtar Kelimeler:** ABD para politikası belirsizliği, Çin borsası, ABD-Çin ticaret savaşı, ARDL

### THE RELATIONSHIP BETWEEN THE CHINESE STOCK MARKET AND UNCERTAINTY IN US MONETARY POLICY

### ABSTRACT

Capital markets, which are the building blocks of financial markets, are easily affected by economic changes in international markets due to global integration. For this reason, stock investors in particular engage in multidimensional investment activities when making investment decisions in international markets, taking into account not only the economic conditions of their own countries. Developed and developing countries, in particular, are easily affected by the economic conditions of other countries with which they have close ties and/or other countries with the potential to influence the global economy. Therefore, this study examines the relationship between US monetary policy uncertainty and the Chinese stock market, using the Shanghai Composite Index prices (SSEC), China CSI1000 stock prices (CSI1000), China – US trade war index (UCT), and China renewable energy stock prices (RenEw) are examined using monthly data from 2006:06 to 2023:09 and the ARDL bounds test. The results obtained from the study indicate that the MPU index has a significant effect on UCT, RenEw, and SCI1000 prices.

**Keywords:** USA monetary policy uncertainty, China stock market, USA – China trade conflict, ARDL

## 1. GİRİŞ

Finansal piyasalar işleyişleri ve sahip olduğu araçlar bakımından oldukça karmaşık yapıya sahip olan piyasa türlerinden birisidir. Bunun yanı sıra finansal piyasalar sahip olduğu çeşitli finansal araçları ve kurumları bünyesinde barındırmasından dolayı çok geniş etkiye sahip olmaktadır. Ayrıca, küreselleşme, ülkelerin izlediği serbest ekonomi modelleri ve teknolojinin hızlı bir şekilde ilerlemesi ile birlikte finansal ağın daha da genişlemesine olanak sağlamakta ve gelişmiş ve gelişmekte olan ülkelerin finansal piyasalarının farklı açılardan ve farklı şekillerde etkilenmelerine neden olmaktadır. Finansal piyasalar içerisinde önemli role sahip olan sermaye piyasasının da bu durumlardan etkilenmesi kaçınılmazdır.

Sermaye piyasası uluslararası piyasadaki pek çok yatırımcıyı kendisine çeken hisse senedi piyasasını bünyesinde bulundurmaktadır. Hisse senedi piyasası yatırımcıları hem ulusal hem uluslararası alanlarda politik, siyasi, ekonomik ve jeopolitik göstergelerden etkilenmektedir. Bu göstergelerde meydana gelen belirsizlikler veya riskler yatırımcıların yatırım kararlarını etkileme potansiyeline sahiptir.

Belirsizlik ile risk kavramı çoğu zaman aynı anlama sahip olduğu düşünülse de tanım itibarıyla oldukça farklı özelliklere sahiptirler. Belirsizlik kavramı riski de bünyesinde bulunduran ancak olumlu ve/veya olumsuz bir anlam içermemektedir (Aktaş Şenkardesler, 2016:371). Hisse senedi piyasasında işlem yapan yatırımcılar yatırım kararı alırken belirsizliği ön plana çıkarmaktadırlar. Özellikle şirketlerin politika belirsizliği, ülkelerin ekonomik ve siyasi belirsizliği ile hükümetlerin ve merkez bankalarının maliye ve para politikası belirsizliği yatırım kararlarında etkili olmaktadır. Baker, Bloom ve Davis (2013) tarafından hesaplanan ekonomik politika belirsizliğinin de yine aynı şekilde yatırımcı tercihlerinde etkili olduğu görülmektedir (Tütüncü vd., 2024)

Para politikası belirsizliği (MPU) Amerika için hesaplanan bir indekstir. Bu indeks hesaplanırken gazetelerde ekonomi, kongre, beyaz saray, federal rezerv, açık, belirsiz, belirsizlik, fed, para arzı, açık piyasa işlemleri, FED fon oranı, FED başkanı, iskonto penceresi gibi para politikası ve belirsizliği ifade edebilecek kelimelerin kullanılma sıklığı dikkate alınmaktadır. Para politikası belirsizliği hesaplanırken iki yaklaşım benimsenmektedir.

Şekil 1'e bakıldığında para politikası belirsizliğinin ölçülmesinde kullanılan iki farklı yöntemin olduğu görülmektedir. Bunlardan birincisi dünya çapındaki yüzlerce gazetede yer alan para politikası ve belirsizliği ifade edebilecek kelimelerin kullanılma sıklığı ile hesaplanmaktadır. İkinci hesaplanma yöntemi ise ABD'de yer alan ulusal ve bölgesel 10 büyük gazetede yer alan para politikası ve belirsizliğine yönelik kullanılan kelime sıklığına göre belirlenmektedir.

Şekil 1. Para Politikası Belirsizliği Ölçme Yöntemleri

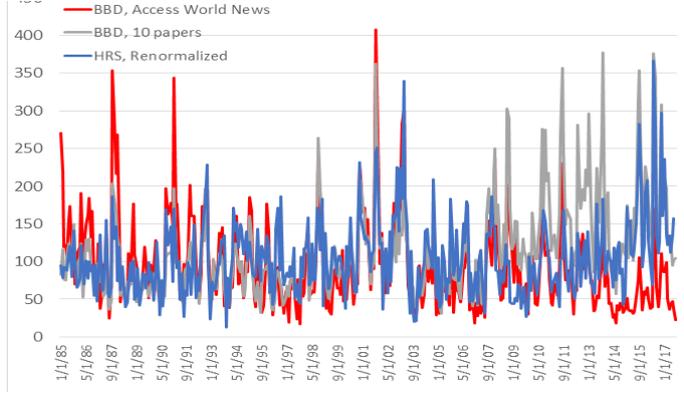


**Kaynak:** Şekil yazar tarafından oluşturulmuştur.

Şekil 2'de ABD para politikası belirsizliğinin belirlenmesinde kullanılan iki hesaplama yönteminin (BBD, Access World News ve BBD, 10 Papers) ve HRS endeksinin göstergeleri yer almaktadır.

Şekilden görüldüğü üzere her endeksin birbiriyle yakın korelasyona sahip olduğu ve bu durumda ele alınan endekslerin farklı sonuç göstermediği anlaşılmaktadır. Bu doğrultuda yapılan çalışmalarda Access World News veya 10 Papers ile çalışmanın sonuçları değiştirmeyeceği ileri sürülmektedir.

Şekil 2. ABD Para Politikası Belirsizliği İndeksi



Kaynak: Economic Policy Uncertainty (2025). Erişim Yeri: [www.policyuncertainty.com/monetary.html](http://www.policyuncertainty.com/monetary.html)

Çalışma 5 aşamadan oluşmaktadır. İkinci aşamada para politikası belirsizliği ile çeşitli hisse senedi piyasaları ilişkisinin ele alındığı literatür taraması bulunmaktadır. Üçüncü kısım araştırmanın yöntem kısmını oluşturmaktadır. Dördüncü kısımda para politikası belirsizliği ile hisse senedi piyasası arasındaki ilişkiyi ortaya koyan analiz kısmı bulunmaktadır. Son kısmı ise sonuç ve tartışma oluşturmaktadır. Çalışmanın literatüre olan katkısı ise birçok açıdan ele alınmaktadır. Birinci katkısı dünya ekonomisinde birbirine rakip olan iki gücün sermaye piyasasında etkilerini ortaya koymaktır. İkincisi Çin sermaye piyasası oldukça güçlü bir piyasadır. Ancak ele alınan çalışmalara bakıldığında literatürün oldukça kısıtlı olduğu görülmektedir. Ayrıca çalışma veri seti aylık verilerden oluştuğu için daha güçlü sonuçlar ortaya koymaktadır.

## 2. LİTERATÜR TARAMASI

Bu bölümde çeşitli para politikası belirsizliklerin hisse senedi piyasalarına olan etkilerini ele alan çalışmalar Tablo 1’de gösterilmektedir.

Tablo 1. Literatür Taraması

Yazar	Dönem	Ülke	Yöntem	Sonuç
Gali ve Gambetti (2015)	1960-2011	ABD	VAR	Para politikası şoklarının pay senedi fiyatlarına içsel tepki vermemektedir.
Gospodinov ve Jamali (2015)	1990-2007	S&P500	VAR-GARCH	Para politikası belirsizliğinin hisse senedi piyasasına etki etmektedir.
Ceylan (2025)	2003-2024	Türkiye	Kantil - Kantil	Para politikaları belirsizliklerinin azalmasının hisse senedi getirilerinin olumsuz etkilediği; belirsizliğin arttığında ise getirilerin pozitif yönde etkilendiğini göstermektedir

Vianez (2020a)	vd.	1990-2014	S&P500 ve NASDAQ	Regresyon	Genişleme dönemlerinde MPU getiri ve oynaklığı etkilerken Durgunluk dönemlerinde MPU likiditeyi etkilemektedir
Vianez (2020b)	vd.	1985-2020	Russell	OLS	MPU özellikle küçük sermayeli hisse senedi getirilerini negatif etkilemektedir
Cai (2018)		1992-2017	Avustralya – Yeni Zelanda	Granger	MPU, dot-com döneminde, Avustralya hisse senedi getirilerini pozitif etkilemektedir 2013'ten itibaren ilişki bulunmamaktadır.
Algahtani (2019)	vd.	2003-2017	Körfez Arap ülkeleri	VAR	MPU'nun GCC ülkelerinde az Bahreyn ve Kuveyt Borsalarına doğru tek yönlü nedensellik tespit edilmiştir.
Chiang (2021)		1998-2019	Kuzey Amerika, Avrupa, Latin Amerika ve Asya ülkeleri	GED-ARCH	MPU Kuzey Amerika, Avrupa, Latin Amerika ve Asya piyasalarının hisse senedi getirilerine negatif etki etmektedir
Wen vd. (2022)		2007-2018	G7-BRICS	Q-Q	MPU hisse senedi getirilerini negatif etkilemektedir.
Arshad (2024)	vd.	2006-2022	Gelişmiş-Gelişmekte olan Asya ülkeleri	Q-Q	Asya ülkeleri hisse senedi piyasalarını önemli ölçüde negatif etkilemektedir.
Si vd. (2021)		2001-2020	Çin	VAR	MPU diğer politika belirsizliklerine göre daha zayıf etkiye sahip olmasına rağmen MPU'nun enerji, finans ve telekomünikasyon sektörlerine etkisi bulunmaktadır.
Lee ve Lee (2023)		1994-2021	Çin	Granger	Pozitif MPU hisse senedi oynaklığına neden olmaktadır.

### 3. EKONOMETRİK YÖNTEM

ABD'de para politikası belirsizliği ile Çin hisse senedi piyasası arasındaki ilişkiyi inceleyen çalışmada Şangay Composit indeks fiyatları (SSEC), Çin CSI1000 hisse senedi fiyatları (CSI1000), Çin – ABD ticaret savaşı indeksi (UCT) ve Çin yenilenebilir enerji hisse senedi fiyatlarının (RenEw) ABD para politikasına (MPU) olan etkisi 2006:06 – 2023:09 aylık dönem verileri kullanılarak araştırılmıştır. Değişkenlere ilişkin tanımlayıcı bilgiler Tablo 2'de gösterilmektedir.

**Tablo 2. Değişkenlere Ait Tanımlayıcı Açıklamalar**

Değişken	Kısaltma	Kaynak
Para Politikası Belirsizliği	MajorMPU	www.policyuncertainty.com
Şangay Borsası	CSI1000	investing.com
Şanghay Kompozit Endeksi	SSEC	investing.com
China Renewable Energy Endeksi	RenEw	investing.com
ABD-Çin tansiyonu	UCT	www.policyuncertainty.com

### 3.1. Ekonometrik Model

ABD para politikası belirsizliği üzerinde Çin – ABD ticaret savaş indeksi, Çin yenilenebilir enerji fiyatları, CSI1000 hisse senedi fiyatı ve SSEC hisse senedi fiyatının etkisini inceleyen çalışmanın ampirik çerçevesini temsil eden form denklem 1'de ifade edilmiştir.

$$MPU_t = f(UCT_t, RenEw_t, CSI1000_t, SSEC_t) \quad (1)$$

Denklem 1'de yer alan değişkenlerin logaritmik versiyonu Denklem 2'de ifade edilmektedir. Denklemde ABD para politikası belirsizliği, Çin – ABD ticaret savaş indeksi, CSI1000 hisse senedi fiyatı ve SSEC hisse senedi fiyatlarının logaritması alınmıştır.

$$LMPU_t = \alpha_0 + \alpha_1 LNUCT_t + \alpha_2 RenEw_t + \alpha_3 LNCSI1000P_t + \alpha_4 LNSSEC_t + \varepsilon_t \quad (2)$$

Denklem 2'de ABD para politikası belirsizliği, Çin – ABD ticaret savaş indeksi, CSI1000 hisse senedi fiyatı ve SSEC hisse senedi fiyatlarının logaritması alınmıştır.

### 2.2. Tahmin Teknikleri (ARDL)

ABD para politikası belirsizliği üzerinde Çin – ABD ticaret savaş indeksi, Çin yenilenebilir hisse senedi fiyatı, CSI1000 hisse senedi fiyatı ve SSEC hisse senedi fiyatlarının etkisini incelemek amacıyla Paseran vd. (2001) tarafından geliştirilen Otoregresif Dağıtılmış Gecikme (ARDL) yöntemi kullanılmıştır. ARDL yöntemi daha küçük örneklemeler üzerinde anlamlı sonuçlar vermesi ve durağanlık seviyelerinin hesaplanmasına gerek duyulmaması nedeniyle geleneksel eşbütünlük tekniklerinden üstün olduğu düşünülmektedir (Chandio vd., 2020). ARDL sınır testi modeli aşağıdaki denklem 3'te ifade edilmiştir.

$$\Delta LNMPU_t = \varphi_0 + \sum_{i=1}^p \varphi_{1i} \Delta LNUCT_{t-i} + \sum_{i=1}^p \varphi_{2i} \Delta RenEw_{t-i} + \sum_{i=1}^p \varphi_{3i} \Delta LCSI1000_{t-i} + \sum_{i=1}^p \varphi_{4i} \Delta LNSSEC_{t-i} + \lambda_1 LNUCT_{t-1} + \lambda_2 RenEw_{t-1} + \lambda_3 LNCSI1000_{t-1} + \lambda_4 LNSSEC_{t-1} + \varepsilon_t \quad (3)$$

ARDL yönteminde değişkenler arasındaki uzun dönem eşbütünlük analizi için Wald testi kullanılmaktadır. Wald testinde Paseran vd. (2001) tarafından ortaya konulan F testi dikkate alınmaktadır. Analiz sonucunda elde edilen f testi alt sınırdan küçükse değişkenler arasında uzun dönem ilişkisi olmadığı anlamına gelirken F testinin değeri üst sınırdan yüksek olması durumunda uzun dönemli ilişki olduğunu göstermektedir (Chandio vd., 2020, s.6).

ARDL hata düzeltme modeli (ECM), değişkenler arasındaki kısa dönemli ilişkiyi tahmin etmek için aşağıdaki denklem 4 ile ifade edilmektedir:

$$\Delta LNMPU_t = \varphi_0 + \sum_{i=1}^{p-1} \varphi_{1i} \Delta LNUCT_{t-i} + \sum_{i=1}^{p-1} \varphi_{2i} RenEw_{t-i} + \sum_{i=1}^{p-1} \varphi_{3i} \Delta LNCSI1000_{t-i} + \sum_{i=1}^{p-1} \varphi_{4i} \Delta LNSSEC_{t-i} + \delta ECT_{t-1} + \varepsilon_t \quad (4)$$

Denklem 4'te  $\delta ECT_{t-1}$  hata düzeltme terimini ve  $\delta$  hata düzeltme katsayısını göstermektedir. Çalışmada ARDL sınır testinde kullanılan değişkenlerin durağanlığı seri korelasyon testi ve değişen varyans testi ile kontrol edilmiştir. Buna karşılık, ARDL modelinin istikrarını araştırmak için CUSUM ve CUSUMSQ testleri kullanılmıştır.

## 4. BULGULAR

Para politikası belirsizliği üzerinde UCT, RenEw, CSI1000 ile SSEC'nin etkilerinin araştırıldığı çalışmada ilk olarak değişkenlerin tanıtıcı istatistikleri Tablo 3'te gösterilmektedir.

**Tablo 3. Pay Endekslerinin İşlem Hacmi Serilerine İlişkin Tanıtıcı İstatistikler**

	MPU	CSI1000 Price	SSEC Price	UCT	RenEw
Mean	4.9357	8.5133	7.9657	21.3382	0.3075
Median	4.8938	8.5696	7.9989	21.1041	0.2300
Maximum	6.1965	9.4747	8.6919	23.0200	1.6640
Minimum	3.8037	7.1775	7.3856	13.9912	0.1140
Std. Dev.	0.4494	0.4412	0.2248	1.3840	0.2212
Skewness	0.1112	-0.9796	-0.0046	-1.4026	2.9414
Kurtosis	2.8576	4.1403	3.6113	7.5523	14.3388
Jarque-Bera	0.6218	45.8231	3.3338	247.8109	1414.215
Probability	0.7327	0.0000	0.1888	0.0000	0.0000

Zaman serilerinin kullanıldığı çalışmalarda durağanlığın belirlenmesi için birim kök testi yapılmalıdır. Para politikası belirsizliği üzerinde Çin piyasasından önemli olan önemli makroekonomik değişkenlerin durağanlığını test etmek amacıyla sıklıkla kullanılan Augmented Dickey-Fuller (ADF) ve Phillips Perron (P.P.) birim kök testleri kullanılmış ve durağanlık sonuçları Tablo 3'te sunulmuştur. Test sonuçlarına göre, MPU, UCT, CSI1000, SSEC ve RenEw değişkenleri seviyesinde durağandır.

**Tablo 4. Değişkenlerin ADF ve PP Birim Kök Test Sonuçları**

Seriler	ADF			PP		
	Sabitli	Sabitli ve trendli	Sabitsiz	Sabitli	Sabitli ve trendli	Sabitsiz
LNMPU I(0)	0.0000***	0.0000***	0.6872	0.0000***	0.0000***	0.6086
UCT I(0)	0.0000***	0.0000***	0.5346	0.0000***	0.0000***	0.5402
LNCSI1000I(O)	0.0395**	0.1842	0.9018	0.0364**	0.1167	0.8841
LNSSEC I(0)	0.0338**	0.1560	0.8183	0.0051***	0.0275**	0.7802
RENEW I(O)	0.0102***	0.0025***	0.0864	0.0280**	0.0704	0.0688

Not:\*\*\* ve \*\* sırasıyla %1 ve %5 anlamlılığı göstermektedir.

#### 4.2. Cointegration Test Sonuçları

Tablo 5, ARDL modelindeki değişkenlerin eşbütünleşme ilişkisini gösteren tahmin sonuçlarını göstermektedir. Buna göre F-testinin tahmini değerleri ile kritik değerler karşılaştırılmış ve hesaplanan F istatistik değerinin (13.4205) kritik değerlerden daha anlamlı olduğu görülmüştür. Bu durumda değişkenler arasında bir eşbütünleşme ilişkisi olduğu yorumu yapılabilir.

**Tablo 5. F İstatistik Test Sonuçları**

K	f-statistic	Lower limit %5	Upper limit %5
4	13.4205	2.56	3.49

#### Uzun ve Kısa Dönem Katsayı Sonuçları

Tablo 6, uzun ve kısa vadeli ARDL modelinin sonuçlarını göstermektedir. Çalışmada bağımlı değişken olarak ABD para politikası belirsizliği kullanılırken bağımsız değişkenler olarak ABD – Çin ticaret indeksi, Çin yenilenebilir enerji fiyatları, CSI1000 hisse senedi fiyatı ve SSEC hisse senedi fiyatları olarak belirlenmiştir.

**Tablo 6. Uzun – Kısa Dönem Sonuçları (1,2,1,1,2)**

<i>Değişkenler</i>	<i>Katsayı</i>	<i>Std.Sapma</i>	<i>T-istatistiği</i>	<i>Olasılık</i>
<i>Uzun Dönem Tahmincisi</i>				
<i>LN(UCT)</i>	<i>-0.109445</i>	<i>0.058593</i>	<i>-1.867903</i>	<i>0.0633*</i>
<i>LN(SSEC)</i>	<i>-0.202017</i>	<i>0.297648</i>	<i>-0.678710</i>	<i>0.4981</i>
<i>LN(CSI1000)</i>	<i>0.317715</i>	<i>0.159509</i>	<i>1.991828</i>	<i>0.0478**</i>
<i>RenEw</i>	<i>0.981427</i>	<i>0.262408</i>	<i>3.740077</i>	<i>0.0002***</i>
<i>Not: *, **, *** sırasıyla %1, %5 ve %10 anlamlılığı göstermektedir.</i>				
<i>Kısa Dönem Tahmincisi</i>				
<i>LN((MPU(-1))</i>	<i>-0.513468</i>	<i>0.057944</i>	<i>-8.861465</i>	<i>0.0000***</i>
<i>LN((UCT(-1))</i>	<i>-0.056197</i>	<i>0.029846</i>	<i>-1.882911</i>	<i>0.0612*</i>
<i>LN((SSEC(-1))</i>	<i>-0.103729</i>	<i>0.153798</i>	<i>-0.674451</i>	<i>0.5008</i>
<i>LN((CSI1000(-1))</i>	<i>0.163136</i>	<i>0.084726</i>	<i>1.925451</i>	<i>0.0556*</i>
<i>RenEw(-1)</i>	<i>0.503931</i>	<i>0.145764</i>	<i>3.457158</i>	<i>0.0007***</i>
<i>LN(UCT)</i>	<i>0.014392</i>	<i>0.021240</i>	<i>0.677592</i>	<i>0.4988</i>
<i>LN((UCT(-1))</i>	<i>0.046709</i>	<i>0.021272</i>	<i>2.195808</i>	<i>0.0293**</i>
<i>LN(SSEC)</i>	<i>0.774795</i>	<i>0.586477</i>	<i>1.321101</i>	<i>0.1880</i>
<i>LN(CSI1000)</i>	<i>-1.212827</i>	<i>0.447770</i>	<i>-2.708595</i>	<i>0.0074***</i>
<i>RenEw</i>	<i>0.132452</i>	<i>0.359629</i>	<i>0.368302</i>	<i>0.7130</i>
<i>ECT(-1)</i>	<i>-0.513468</i>	<i>0.056497</i>	<i>-9.088386</i>	<i>0.0000***</i>
<i>Not: *, **, *** sırasıyla %1, %5 ve %10 anlamlılığı göstermektedir.</i>				

Tablo 6'ya göre uzun dönemde UCT, CSI1000 fiyatları ile RenEw fiyatlarının MPU üzerinde anlamlı etkisi bulunmaktadır. Katsayılarına bakıldığında ise UCT'nin bir birim artış göstermesi MPU üzerinde 0.1 birimlik ve negatif etkisi bulunmaktadır. CSI1000 fiyatlarında meydana gelen bir birimlik değişim MPU'yu 0.31 birim etkiye sahipken RenEw fiyatlarında meydana gelen bir birimlik değişim MPU'yu 0.98 birim etkilemektedir. Çalışma sonucunda elde edilen kısa dönem için Tablo 6'daki hata düzeltme katsayısı (ECT(-1)) sonucu -0,51 olarak bulunmuştur ve istatistiksel olarak anlamlıdır.

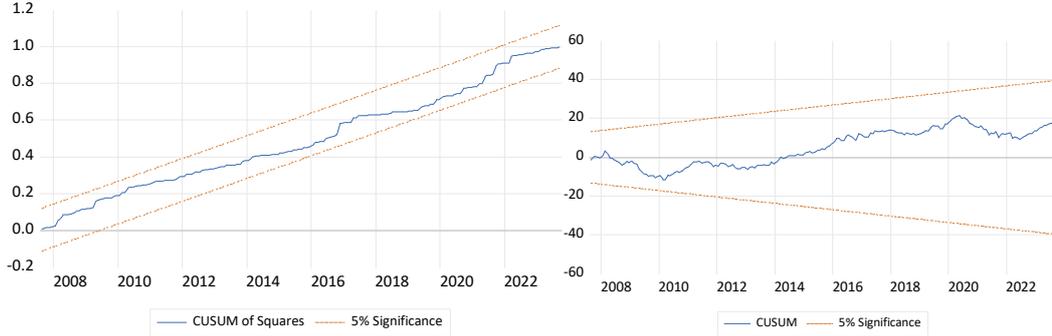
#### 4.4. Diagnostic Tests

Tablo 7, Breusch-Godfrey ve Breusch-Godfrey LM Testlerini içermektedir. Breusch-Godfrey testi değişkenler arasındaki otokorelasyon sorununu araştırırken, Breusch-Godfrey LM testi değişen varyans sorununu araştırmaktadır. Buna göre, her iki testte de sorun olmadığı görülmektedir.

**Tablo 7. Breusch-Godfrey ve Breusch-Godfrey LM Test Sonuçları**

Test	F-istatistiği	Olasılık
Breusch – Godfrey LM Test	2.2546	0.1077
Breusch – Godfrey Test	1.3737	0.1877

Şekil 1'de ardışık hataların kümülatif toplamını ifade eden CUSUM testi ve ardışık hataların kümülatif toplamlarının karesini ifade eden CUSUM of Squares testi ifade edilmektedir. Buna göre parametrelerin %5 anlamlılık düzeyinde kritik sınırlar içerisinde kararlı olduğu söylenebilir.



## SONUÇ ve TARTIŞMA

Finansal piyasaların yapı taşı olan sermaye piyasaları küresel entegrasyon nedeniyle uluslararası piyasalardan oluşan ekonomik değişimlerden kolayca etkilenebilmektedir. Bu nedenle özellikle hisse senedi yatırımcıları uluslararası piyasalarda yatırım kararında bulunurken sadece kendi ülkelerinin ekonomik koşullarını dikkate almayarak çok boyutlu yatırım faaliyetinde bulunurlar. Özellikle gelişmiş ve gelişmekte olan ülkeler yakın ilişki içerisinde oldukları diğer ülkelerin ve/veya dünya ekonomisine etki edebilecek potansiyel güce sahip olan diğer ülkelerin ekonomik durumlarından kolayca etkilenebilmektedirler. Bu nedenle sermaye sahipleri yatırım kararı alırken bu ilişkileri göz önünde bulundurarak çok boyutlu yatırım kararı alabilmektedirler.

Politika belirsizliği karar mekanizmaları ve yatırımcılar üzerinde önemli etkiler yaratan önemli makroekonomik faktörlerden birisidir. Belirsizliğin yüksek olduğu ekonomik ortamlarda özellikle yatırımcılar yatırım kararı verirken geleceğe yönelik risklerini minimize etmeye çalışmaktadırlar. Para politikası belirsizliğinin olduğu ortamlarda ise yatırımcılar yatırım kararlarını erteleyebilmekte, yatırımlarını başka ülkelere aktarabilmekte hatta yatırım yapmaktan vazgeçebilmektedirler. Bu durum ekonomik büyümenin yavaşlamasına hatta durgunluğa neden olabilmektedir.

Literatüre bakıldığında özellikle son dönemlerde popüler hale gelen ekonomik politika belirsizliği ile jeopolitik politika risklerine bakarak yatırımcıların yatırım kararlarının belirlediği görülmektedir. Bu çalışma ABD ve Japonya için hesaplanan para politikası belirsizliğinin literatürde oluşan boşluğu doldurması beklenmektedir. Bu nedenle bu çalışma ABD için hesaplanan para politikası üzerinde Çin'in çeşitli hisse senedi piyasalarının etkilerini araştırmaktadır. Çalışmanın araştırma sorusu ABD ile Çin arasında yaşanan ekonomik gerilimler yatırımcıların hisse senedi piyasasına olan yaklaşımlarını etkileyip etkilemediğinden ortaya çıkmıştır. Bu nedenle Çin hisse senedi piyasasının ABD'de gerçekleşen para politikası belirsizliğine ne denli etki ettiği eşbütünleşme testi ile saptanmaya çalışılmıştır.

Çalışmada 2006:06 – 2024:03 dönemleri arasında ABD para politikası belirsizliği üzerinde Çin – ABD Ticaret savaş, Çin SCI1000 hisse senedi fiyatları, SSCE hisse senedi fiyatları ve Çin yenilenebilir enerji fiyatları arasındaki ilişkiyi tespit etmek amacıyla ARDL eşbütünleşme analizi kullanılmıştır.

Çalışmada ABD para politikası belirsizliği hesaplama yöntemlerinden biri olan 10 Büyük Ulusal ve Bölgesel ABD gazeteleri baz alarak hesaplanan MajorMPU indeksi üzerinde UCT'nin %5 anlamlılık düzeyinde negatif ve anlamlı ilişkiye sahip olduğu belirlenmiştir. Elde edilen sonuca göre Çin – ABD arasında yaşanan gerilimlerin ABD para politikası belirsizliğini azalttığı görülmektedir. Bu durumda yatırımcıların yatırım kararlarında dolaylı olarak Çin yerine ABD'yi tercih ettiği söylenebilir. Tu et al. (2020) ticaret savaş, ABD'nin Çin'den ithalatında tahmini 91,46 milyar dolar ve ABD'den Çin

ithalatında 36,71 milyar dolar önemli bir azalmaya yol açtığını ve ticaretin Meksika, Japonya ve Almanya gibi diğer ülkelere yönlendirilmesine yol açtığını belirtmiştir. Bu yatırımcıların dolaylı olarak ABD ekonomisine pozitif etkide bulunduğunu söylemek mümkündür.

MPU ile SSEC hisse senedi fiyatları arasında anlamlı ilişki saptanmamıştır. Şanghai Kompozit Endeksi Çin'in en önemli borsalarından birisidir ancak para politikası belirsizliği üzerinde anlamlı etkisi olmadığı görülmüştür.

MPU ile CSI1000 hisse senedi fiyatları arasında%5 anlamlılık düzeyinde pozitif ilişki olduğu saptanmıştır. Şanghai Borsası Çin'in en önemli borsalarından birisidir. Çin hisse senedi fiyatlarından MPU'ya doğru oluşan bu ilişki kabul edilebilir. Bunun en önemli nedeni yatırımcılar Çin'e doğru hareket ettikçe, Çin borsa fiyatlarında yukarı yönlü hareket sebebiyet vermektedir. Bu sayede yatırımcıların Çin'e doğru yönelmesi para politikasında belirsizliğin artmasına neden olmaktadır.

MPU ile RenEw hisse senedi fiyatları arasında%1 anlamlılık düzeyinde pozitif ilişki olduğu saptanmıştır. Elde edilen sonuca göre Çin yenilenebilir enerji piyasasına yönelik yatırımların artması Çin yenilenebilir enerji piyasasının fiyatlarının artmasına bu alanda ekonomik güçlerinin derinleşmesine neden olmaktadır. Çin'in ekonomik anlamda büyümesi ABD para politikası belirsizliğini de beraberinde artırmaktadır.

Bu doğrultuda bazı politika önerileri önerilmektedir

- Birincisi, ekonomide önemli yere sahip olan sermaye piyasalarının doğru anlaşılması gerekmektedir. Uluslararası piyasaların bir bütün olarak hareket ettikleri unutulmamalıdır.
- Özellikle ABD ve Çin arasında uzun yıllardır var olan anlaşmazlıklar yatırımcıların yatırım kararı alma sürecinde önemli olmaktadır. Bu nedenle ülkelerin bu durumları kendi lehlerine çevirmeleri için gerekli önlemleri alması gerekmektedir.
- İki ülke yatırımcılarının gürültücü işlemler modeline oldukça yakın olduğu belirlenmiştir. Bu nedenle yatırımcıların ülkeden gitmesini engelleyecek açık ve şeffaf politikalar duyurulmalıdır.

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## SÜRDÜRÜLEBİLİR TURİZM PAZARLAMASINDA YAPAY ZEKA UYGULAMALARININ BİBLİYOMETRİK ANALİZİ

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### ÖZET

Bu araştırma, sürdürülebilir turizm pazarlaması bağlamında yapay zekâ uygulamalarına ilişkin akademik birikimin entelektüel örgüsünü ve zamansal gelişim çizgisini haritalamayı hedeflemektedir. Hızla genişleyen bu disiplinlerarası alanda, alanı kuşatıcı bir perspektifle ele alan kapsamlı bibliyometrik incelemenin eksikliği çalışmanın temel çıkış noktasını oluşturmaktadır. Bu amaç doğrultusunda, Scopus veri tabanından derlenen ve 2011–2025 dönemini kapsayan 124 bilimsel kayıt, R tabanlı bibliometrix ile biblioshiny araçları kullanılarak değerlendirilmektedir. İnceleme kapsamı; tanımlayıcı göstergeler, en üretken yazar/kaynak/ülke profilleri ile anahtar kelimelere dayalı tematik haritalama, birlikte-görülme ağları ve eğilim analizlerini içermektedir. Elde edilen bulgular, alanın yıllık %31,25’lik artışla güçlü ve dinamik bir büyüme sergilediğini; henüz merkezî bir yazar çekirdeğinin oluşmadığını ve yayımların özellikle Çin ile Hindistan odaklı bölgesel kümelerde yoğunlaştığını göstermektedir. Kavramsal mimarinin üç ana eksen etrafında—sürdürülebilirlik, teknoloji ve pazarlama—şekillendiği; araştırma eğilimlerinin ise zaman içerisinde genel çerçeveden “tüketici davranışı” gibi daha uygulamalı ve özgül başlıklara doğru evrildiği görülmektedir. Çalışma, mevcut tabloyu bütüncül biçimde ortaya koyarak literatürdeki boşlukları görünür kılmakta ve gelecek çalışmalar için yönlendirici bir yol haritası sunmaktadır

**Anahtar Kelimeler:** Sürdürülebilir Turizm, Yapay Zeka, Bibliyometrik Analiz, Pazarlama, Biblioshiny.

### A BIBLIOMETRIC ANALYSIS OF ARTIFICIAL INTELLIGENCE APPLICATIONS IN SUSTAINABLE TOURISM MARKETING

### ABSTRACT

This research aims to map the intellectual landscape and temporal development of academic knowledge on artificial intelligence applications in the context of sustainable tourism marketing. The lack of comprehensive bibliometric studies that address this rapidly expanding interdisciplinary field from a comprehensive perspective forms the basis of this study. To this end, 124 scientific records compiled from the Scopus database, covering the period 2011–2025, are evaluated using the R-based tools bibliometrix and biblioshiny.

The scope of the study includes descriptive indicators, thematic mapping based on keywords, co-occurrence networks, and trend analyses, along with profiles of the most productive

authors/sources/country. The findings indicate that the field is exhibiting strong and dynamic growth, with an annual increase of 31.25%; a central core of authors has not yet emerged, and publications are concentrated in regional clusters, particularly focused on China and India. The conceptual architecture is shaped around three main axes—sustainability, technology, and marketing—while research trends have evolved over time from a general framework to more applied and specific topics such as "consumer behavior." The study presents a holistic picture of the current situation, highlighting gaps in the literature and providing a guiding roadmap for future research.

**Keywords:** Sustainable Tourism, Artificial Intelligence, Bibliometric Analysis, Marketing, Biblioshiny.

## GİRİŞ

Sürdürülebilir turizm (ST), doğal ve kültürel kaynakları koruyarak uzun vadeli kalkınmayı hedeflediği için, çevreye duyarlı modern gezginlerin artan beklentilerini karşılamada pazarlaması hayati önem taşımaktadır (İbrahim, 2024; Türkay, 2024). Yapay zekâ (YZ) ise, kişiselleştirme, otomasyon, veri analitiği ve operasyonel verimliliği artırma yetenekleriyle turizm sektöründe dönüştürücü bir rol oynamaktadır. YZ uygulamaları, büyük miktardaki veriyi analiz ederek müşteri tercihlerini ve pazar eğilimlerini anlamak için kritik bir araçtır (Akdeniz vd., 2024; Ercan, 2020). Bu iki alanın kesişimi, "Akıllı Turizm" kavramı bağlamında, YZ algoritmalarının veri analizi kapasitesini sürdürülebilirlik hedefleriyle bütünleştirmesi bakımından dikkate değerdir (Karamustafa & Yılmaz, 2021). Bu sayede turizm işletmeleri, kaynak tahsisini optimize edebilmekte, turist hareketlerini daha doğru öngörebilmekte ve sürdürülebilir turizm ilkelerine uygun, çevre dostu hizmetleri hiperkişiselleştirilmiş deneyimler halinde sunabilmektedir (Ateş vd., 2025). Böyle bir sinerji, işletmelerin hem "yeşil imaj" oluşturarak rekabet avantajı elde etmesine hem de turist memnuniyeti ve sadakatini artırarak uzun vadeli başarıya ulaşmasına katkı sağlamaktadır (Gedik, 2025). Birleşmiş Milletler'in Sürdürülebilir Kalkınma Amaçları (SDG'ler) da turizmin çevresel, ekonomik ve sosyal boyutlarda sorumlu biçimde yönetilmesini küresel bir öncelik olarak vurgulamaktadır (UNWTO, 2017). Bu çerçevede yapay zekâ yalnızca işletmelerin stratejik kararlarında değil, aynı zamanda destinasyonların sürdürülebilirliğini güçlendiren bütüncül politikaların geliştirilmesinde de kritik bir araç konumundadır. Her ne kadar turizmde yapay zekâ kullanımı üzerine giderek artan sayıda araştırma yapılmış olsa da, bu çalışmaların büyük bölümü belirli uygulama örneklerine odaklanmakta; sürdürülebilirlik boyutunu sistematik ve bütüncül şekilde ele almamaktadır (Li et al., 2018; Gretzel et al., 2015). Bu durum, disiplinlerarası bir perspektifin zorunlu olduğunu ve alandaki literatür boşluğunu açıkça ortaya koymaktadır. Dolayısıyla, bu çalışmanın temel amacı bibliyometrik bir yaklaşım kullanarak sürdürülebilir turizm pazarlaması ve yapay zekâ kesişimindeki akademik literatürü sistematik biçimde incelemek, alanın entelektüel yapısını haritalandırmak ve gelecekteki araştırmalar için yol gösterici bir çerçeve sunmaktır. Bu yaklaşım, hem literatürdeki dağınıklığın giderilmesine hem de yeni araştırma yönelimlerinin belirlenmesine katkı sağlayacaktır.

Bu bağlamda, çalışma aşağıdaki temel araştırma sorularına yanıt aramaktadır:

AS1: Sürdürülebilir turizm pazarlamasında yapay zeka uygulamaları alanındaki bilimsel yayınların küresel trendi nedir?

AS2: Bu trend dikkate alındığında, literatürde hangi kavramsal boşluklar ve yeterince araştırılmamış alanlar bulunmaktadır?

AS3: Bu alandaki gelecekteki araştırmalar için potansiyel yönelimler ve öncelikli konular nelerdir?

Bu sorular çerçevesinde, bu bibliyometrik analizin temel amacı, Scopus veri tabanından elde edilen 124 adet bilimsel yayını analiz ederek alanın entelektüel yapısını ortaya koymak; en etkili yazarları, dergileri, ülkeleri ve anahtar kelime eğilimlerini belirlemek; ve gelecekteki çalışmalar için bir yol haritası sunmaktır.

## ARAŞTIRMA VE BULGULAR

### Veri Toplama Süreci

Bu çalışmanın veri seti, alanın önde gelen multidisipliner hakemli yayın indeksi olan Scopus veri tabanından elde edilmiştir. Veri toplama işlemi, konuyu kapsamlı bir şekilde temsil etmek amacıyla üç temel kavramsal bloğu (sürdürülebilir turizm, yapay zeka, pazarlama) birleştiren sistematik bir arama sorgusu ile gerçekleştirilmiştir. Arama, yayınların başlık, özet ve anahtar kelime (TITLE-ABS-KEY) alanlarında yapılmıştır. Kullanılan nihai arama sorgusu aşağıdaki gibidir:

```
TITLE-ABS-KEY(( "sustainable tourism" OR "green tourism" OR "responsible tourism"  
OR "ecotourism" ) AND ( "artificial intelligence" OR "AI" OR "machine learning" OR  
"deep learning" OR "chatbot*" OR "recommender system*" OR "big data" OR "robot*"  
) AND ( "marketing" OR "promotion" OR "customer engagement" OR "tourist  
behavior" OR "personalization" OR "customer experience" ))
```

Araştırma kapsamı, alanın gelişimini gözlemlemek amacıyla 2011 ile 2025 yılları arasında yayımlanmış makaleler ile sınırlandırılmıştır. Yapılan bu arama stratejisi sonucunda, analiz için uygun görülen toplam 124 adet yayından oluşan nihai veri seti elde edilmiştir.

### Veri Analizi

Verilerin analizi ve görselleştirilmesi için açık kaynaklı R programlama dili ve bu dilin bilimsel haritalama için geliştirilmiş kapsamlı paketi olan bibliometrix kullanılmıştır. Özellikle, analiz bulgularının (yıllık bilimsel üretim, en etkili kaynaklar, yazar ve ülke iş birlikleri, kavramsal yapı haritaları vb.) üretilmesi ve yorumlanmasını kolaylaştıran interaktif web arayüzü biblioshiny'den aktif olarak yararlanılmıştır (Aria & Cuccurullo, 2017).

### Tanımlayıcı Bibliyometrik Analiz (Descriptive Bibliometric Analysis)

Sürdürülebilir turizm pazarlamasında yapay zeka uygulamaları üzerine yapılan bu çalışma, Scopus veri tabanından elde edilen ve 2011-2025 yılları arasını kapsayan toplam 124 dokümanı analiz etmektedir. Veri setinin temel bibliyometrik göstergeleri, doküman içerikleri, yazarlık ve iş birliği örüntüleri ile doküman türlerine ilişkin detaylı bilgiler Tablo 1'de sunulmuştur.

**Tablo 1.** Tanımlayıcı Bibliyometrik Analiz Verileri

<i>Açıklama</i>	<i>Sonuç</i>
<b>TEMEL BİLGİLER</b>	
<i>İncelenen Zaman Aralığı (Timespan)</i>	2011-2025
<i>Kaynak Sayısı (Sources)</i>	55
<i>Doküman Sayısı (Documents)</i>	124
<i>Yıllık Büyüme Oranı (Annual Growth Rate %)</i>	31.25
<i>Dokümanların Ortalama Yaşı (Document Average Age)</i>	1.72
<i>Doküman Başına Ortalama Atıf (Average citations per doc)</i>	7.726
<b>DOKÜMAN İÇERİKLERİ</b>	
<i>Yazar Anahtar Kelimeleri (Author's Keywords - DE)</i>	890

<i>Sistem Tarafından Atanan Anahtar Kelimeler (Keywords Plus - ID)</i>	593
<b>YAZARLAR VE İŞ BİRLİĞİ</b>	
<i>Toplam Yazar Sayısı (Authors)</i>	351
<i>Tek Yazarlı Doküman Sayısı (Single-authored docs)</i>	28
<i>Doküman Başına Ortak Yazar Sayısı (Co-Authors per Doc)</i>	2.99
<i>Uluslararası Ortak Yazarlık Oranı (International co-authorships %)</i>	27.42
<b>DOKÜMAN TÜRLERİ</b>	
<i>Makale (Article)</i>	62
<i>Kitap Bölümü (Book Chapter)</i>	21
<i>Konferans Bildirisi (Conference Paper)</i>	17
<i>Konferans Değerlendirmesi (Conference Review)</i>	9
<i>Kitap (Book)</i>	6
<i>Derleme (Review)</i>	6

Tablo 1'de sunulan güncel bulgular, incelenen araştırma alanının oldukça dinamik ve hızla büyüyen bir yapıya sahip olduğunu teyit etmektedir. Yıllık %31.25'lik büyüme oranı, konunun akademik alanda ne denli artan bir ilgiyle karşılandığının güçlü bir göstergesidir. Analiz edilen 124 dokümanın 62'sini (%50) makaleler oluşturmakta, bunu kitap bölümleri ve konferans bildirileri takip etmektedir. Bu dağılım, alanın bir yandan hakemli dergiler aracılığıyla akademik olgunluğa eriştiğini, diğer yandan konferanslar gibi platformlarda güncel tartışmalarla gelişmeye devam ettiğini göstermektedir.

Yazarlık ve iş birliği örüntüleri incelendiğinde, alanın hem bireysel hem de kolektif araştırma çabalarını barındırdığı görülmektedir. Toplam 124 dokümanın 28'i (%22.5) tek bir yazar tarafından kaleme alınmışken, geriye kalan büyük çoğunluğu (%77.5) ortak yazarlıdır. Doküman başına düşen ortak yazar sayısının 2.99 olması, bu alandaki çalışmaların genellikle küçük ve odaklanmış araştırma grupları tarafından yürütüldüğünü göstermektedir. Bu durum, sürdürülebilir turizm ve yapay zeka gibi disiplinlerarası bir alanda ekip çalışmasının önemini koruduğunu, ancak bireysel katkıların da alanda önemli bir yer tuttuğunu ortaya koymaktadır. %27.42'lik uluslararası ortak yazarlık oranı ise, iş birliklerinin önemli bir bölümünün küresel ölçekte devam ettiğini ve alanın uluslararası bir araştırma ağına sahip olduğunu doğrulamaktadır.

### En Çok Yayın Yapan Kaynaklar Analizi (Most Relevant Sources Analysis)

Analiz edilen 124 dokümanın yayınlandığı 55 farklı kaynak incelendiğinde, belirli dergi ve konferans serilerinin alana öncülük ettiği görülmektedir. Alandaki en üretken 10 kaynak Tablo 2'de listelenmiştir.

**Tablo 2.** En Çok Yayın Yapan Kaynaklar Analiz Verileri

<i>Kaynak Adı (Source)</i>	<i>Kaynak Sayısı (Articles)</i>
<i>SUSTAINABILITY (SWITZERLAND)</i>	11
<i>SPRINGER PROCEEDINGS IN BUSINESS AND ECONOMICS</i>	6
<i>SMART INNOVATION, SYSTEMS AND TECHNOLOGIES</i>	4
<i>CURRENT ISSUES IN TOURISM</i>	3
<i>GEOJOURNAL OF TOURISM AND GEOSITES</i>	3
<i>JOURNAL OF SUSTAINABLE TOURISM</i>	3
<i>WORLDWIDE HOSPITALITY AND TOURISM THEMES</i>	3

<i>ACM INTERNATIONAL CONFERENCE PROCEEDING SERIES</i>	2
<i>HELIYON</i>	2
<i>INTERNATIONAL TRANSACTIONS ON ELECTRICAL ENERGY SYSTEMS</i>	2

Tablo 2'nin de ortaya koyduğu gibi, Sustainability (Switzerland) dergisi, 11 yayın ile bu alandaki en üretken ve merkezi kaynak olarak öne çıkmaktadır. Bu durum, sürdürülebilir turizm ve yapay zeka kesişimindeki çalışmaların temel motivasyonunun geniş bir "sürdürülebilirlik" perspektifi olduğunu göstermektedir. Listenin devamında, Journal of Sustainable Tourism, Current Issues in Tourism gibi doğrudan turizm odaklı dergilerin yanı sıra, Springer Proceedings in Business and Economics, Smart Innovation, Systems and Technologies ve ACM International Conference Proceeding Series gibi teknoloji, inovasyon ve bilgisayar bilimleri alanlarına ait konferans serilerinin ve kitap serilerinin varlığı dikkat çekmektedir. Bu kaynak çeşitliliği, konunun disiplinlerarası doğasını bir kez daha teyit etmektedir. Araştırmalar, hem turizm ve otelcilik alanındaki teorik tartışmalara katkı sunmakta hem de teknoloji ve mühendislik alanlarındaki pratik uygulamalar ve yenilikler üzerinden şekillenmektedir. Bu durum, alandaki bilginin sadece geleneksel turizm dergilerinde değil, aynı zamanda teknoloji odaklı yayın platformlarında da geliştiğini göstermektedir.

### En Çok Yayın Yapan Yazarlar (Most Relevant Authors)

Bu bölümde, sürdürülebilir turizm pazarlamasında yapay zeka alanına en çok katkıda bulunan yazarlar incelenmektedir. Tablo 3, yayın sayısına göre en üretken yazarları sıralamaktadır.

**Tablo 3.** *En Çok Yayın Yapan Yazarlar Analiz Verileri*

<i>Yazar (Author)</i>	<i>Makale Sayısı (Articles)</i>
<i>AL-ROMEEDY, BASSAM SAMIR</i>	2
<i>HASSAN, AZIZUL</i>	2
<i>LIASIDOU, SOTIROULA</i>	2
<i>PIPYROS, KOSMAS</i>	2
<i>ALRAHMAN, ABDELBASET AHMAD ALABED</i>	1
<i>FAN, HUANHUAN</i>	1
<i>GIL-CRUZ, MAR</i>	1
<i>JIANG, LI</i>	1
<i>KOC, ERDOGAN</i>	1
<i>KOUROUPI, NANSY</i>	1

Yazar üretkenliği analizi, bu araştırma alanının oldukça dağınık (fragmented) ve merkezi olmayan bir yapıya sahip olduğunu ortaya koymaktadır. Tablo 3'te görüldüğü üzere, alandaki en üretken yazarların her biri yalnızca 2'şer yayına sahiptir. Hiçbir yazarın diğerlerine göre belirgin bir üstünlüğünün olmaması, bu alanda henüz yerleşik bir "düşünce lideri" veya uzmanlaşmış bir çekirdek yazar grubunun oluşmadığını göstermektedir. Bu dağılım, alanın henüz başlangıç veya "doğuş" (nascent) aşamasında olduğunu güçlü bir kanıttır. Olgunlaşmış araştırma alanlarının aksine, burada birkaç kilit yazarın öncülük ettiği bir yapı yerine, çok sayıda farklı araştırmacının alana genellikle bir veya iki yayımla sınırlı, benzer düzeyde katkılar sunduğu görülmektedir. Bu durum, bilginin tek bir merkezden yayılmak yerine, birçok farklı noktadan eş zamanlı olarak geliştiği, dinamik ve keşfe açık bir akademik ortama işaret etmektedir.

### Anahtar Kelime Analizi (Conceptual Structure: Keyword Analysis)

Bu bölümde, araştırma alanının entelektüel temelini oluşturan en önemli kavramları belirlemek amacıyla yazar anahtar kelimeleri (Author's Keywords) analiz edilmiştir. En sık tekrar eden anahtar kelimeler, alanın odak noktalarını ve temel araştırma temalarını ortaya koymaktadır.

Tablo 4, frekanslarına göre ilk 20 anahtar kelimeyi listelemektedir. Şekil 1 (Kelime Bulutu) ve Şekil 2 (Ağaç Haritası) ise bu kelimelerin önemini görsel olarak sunmaktadır.

**Tablo 4.** *En Sık Kullanılan Yazar Anahtar Kelimeleri*

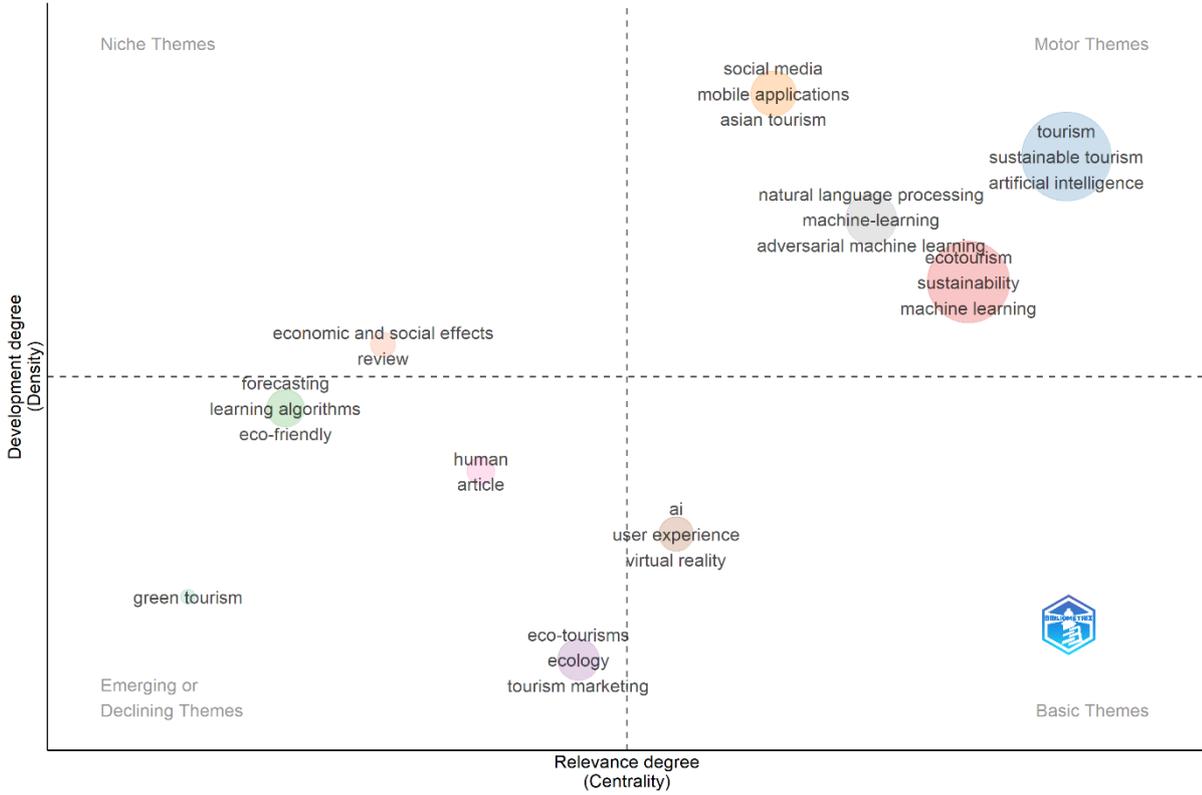
<i>Anahtar Kelime (Keyword)</i>	<i>Frekans (Frequency)</i>
<i>tourism</i>	46
<i>sustainable tourism</i>	45
<i>artificial intelligence</i>	37
<i>ecotourism</i>	32
<i>marketing</i>	23
<i>big data</i>	21
<i>sustainability</i>	20
<i>machine learning</i>	18
<i>sustainable development</i>	17
<i>tourist behavior</i>	15
<i>commerce</i>	12
<i>tourism development</i>	12
<i>tourism industry</i>	12
<i>tourist destination</i>	12
<i>leisure industry</i>	10
<i>tourism management</i>	10
<i>leisure</i>	9
<i>innovation</i>	8
<i>smart tourism</i>	8
<i>tourism sectors</i>	8

Anahtar kelime analizi, alanın üç temel kavramsal sütun etrafında şekillendiğini açıkça göstermektedir. Şekil 1 ve Şekil 2'de de görsel olarak vurgulandığı gibi, "tourism" (46), "sustainable tourism" (45) ve "artificial intelligence" (37), bu araştırma alanının kavramsal çekirdeğini oluşturmaktadır. Bu üç anahtar kelimenin baskınlığı, çalışmanın kapsamını doğrulamaktadır. Bu çekirdek etrafında ise birbiriyle ilişkili üç ana tema kümesi belirginleşmektedir:

**Sürdürülebilirlik Teması:** "Sustainable tourism" anahtar kelimesinin yanı sıra, "ecotourism" (32), "sustainability" (20) ve "sustainable development" (17) gibi terimlerin yüksek frekansı, araştırmaların güçlü bir çevresel, sosyal ve ekonomik sürdürülebilirlik odağına sahip olduğunu göstermektedir. Bu alandaki çalışmaların sadece teknoloji uygulamalarına değil, aynı zamanda bu uygulamaların gezegen ve toplum üzerindeki etkilerine de odaklandığını kanıtlamaktadır.

**Teknoloji ve Veri Teması:** "Artificial intelligence" (37) liderliğindeki bu küme, "big data" (21), "machine learning" (18), "smart tourism" (8) ve "deep learning" (7) gibi terimleri içermektedir. Bu,



**Tematik Harita Analizi (Thematic Map Analysis)****Şekil 3. Tematik Harita**

Şekil 3'teki tematik harita incelendiğinde, alanın yapısal dinamikleri açıkça görülmektedir:

**Motor Temalar:** Sağ üst köşede yer alan temalar, bu araştırma alanının lokomotifidir. Görüldüğü gibi, "tourism", "sustainable tourism" ve "artificial intelligence" kelimelerinden oluşan küme, alanın en merkezi ve en gelişmiş konusudur. Bu, beklendiği gibi, alanın temelini oluşturmaktadır. Bununla birlikte, "machine learning", "ecotourism" ve "sustainability" gibi kavramları içeren ikinci bir motor tema kümesi daha bulunmaktadır. Bu durum, makine öğrenmesi uygulamalarının, sürdürülebilir turizm ve ekoturizm problemlerini çözmede anahtar bir rol oynadığını göstermektedir.

**Niş Temalar:** Sol üst köşede, "forecasting" (tahminleme) ve "learning algorithms" (öğrenme algoritmaları) gibi daha özel konular yer almaktadır. Bu temalar kendi içlerinde gelişmiş olsalar da, alanın diğer konularıyla daha az bağlantılıdır ve belirli bir uzmanlık alanını temsil etmektedirler.

**Temel Temalar:** Sağ alt köşede, "user experience" (kullanıcı deneyimi) ve "virtual reality" (sanal gerçeklik) gibi konuların yer aldığı görülmektedir. Bu konular, motor temaların gelişiminde kullanılan temel yapı taşlarıdır ancak henüz kendi başlarına olgunlaşmış birer araştırma teması haline gelmemişlerdir.

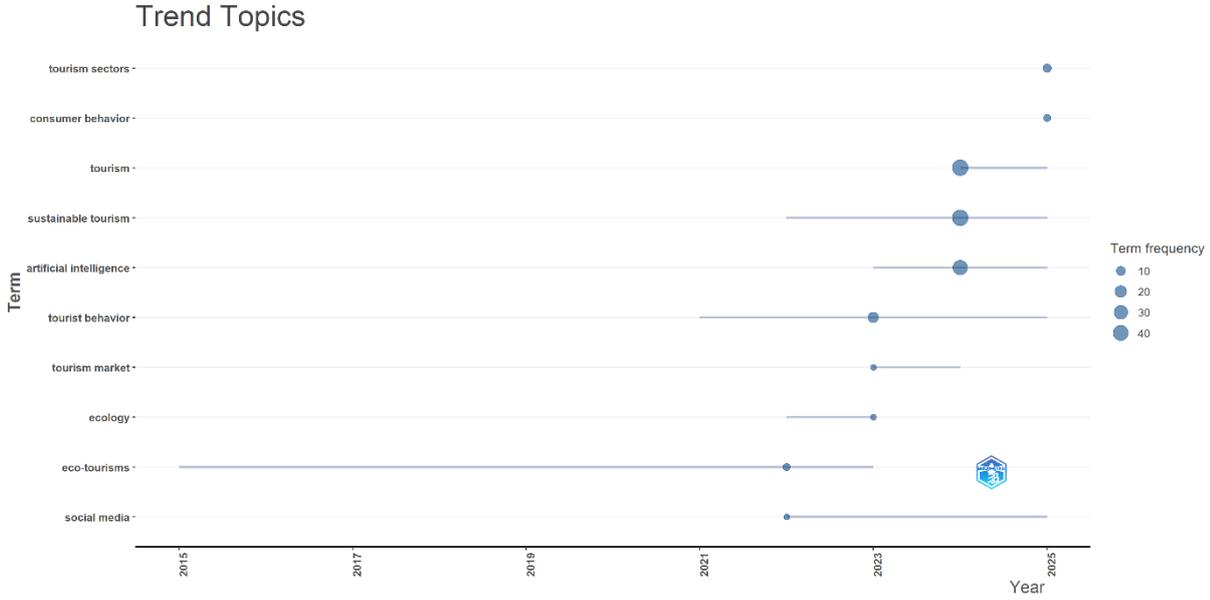
**Gelişen veya Gerileyen Temalar:** Sol alt köşe, alanın gelecekteki potansiyel yönelimleri hakkında önemli ipuçları vermektedir. Özellikle "tourism marketing" (turizm pazarlaması) ve "ecology" (ekoloji) gibi konuların burada yer alması, bu konuların alanda henüz yeni filizlenmekte olduğunu ve gelecekte önem kazanma potansiyeli taşıdığını düşündürmektedir.

**Birlikte-Görülme Ağı Analizi (Co-occurrence Network Analysis)**



## Trend Konular Analizi (Trend Topics Analysis)

Şekil 5. Trend Konular Grafiği.



Şekil 5'teki trend grafiği, araştırma alanının kavramsal gelişiminin belirli aşamalardan geçtiğini göstermektedir. Analiz, konuların zaman içinde genel ve temel kavramlardan daha spesifik ve uygulamalı alanlara doğru evrildiğini ortaya koymaktadır:

**Temellerin Atılması (2022 ve öncesi):** Grafiğe göre, alanın ilk tartışmaları "eco-tourisms" ve "social media" gibi kavramlar etrafında başlamıştır. Bu konular, alanın temelini oluşturan ilk çalışmaları temsil etmektedir.

**Çekirdek Alanın Olgunlaşması (2023-2024):** Araştırmanın en yoğun dönemi, en büyük frekanslara sahip anahtar kelimelerin toplandığı 2023 ve 2024 yıllarıdır. Bu dönemde, alanın ana direkleri olan "sustainable tourism" ve "artificial intelligence" kavramları zirveye ulaşmıştır. Bu, alanın temel teorik ve kavramsal çerçevesinin bu yıllarda sağlamlaştırıldığını göstermektedir.

**Yeni ve Yükselen Trendler (2025):** Grafiğin en sağ tarafında konumlanan 2025 yılı, alanın gelecekteki yönelimleri hakkında önemli ipuçları vermektedir. Bu dönemde "consumer behavior" (tüketici davranışı) ve "tourism sectors" (turizm sektörleri) gibi daha spesifik konuların ortaya çıktığı görülmektedir. Bu durum, araştırmanın odağının, geniş kavramsal tartışmalardan, yapay zeka ve sürdürülebilirlik ilkelerinin belirli turizm sektörleri ve tüketici davranışları üzerindeki etkilerini inceleyen daha niş ve uygulamalı çalışmalara doğru kaydığını göstermektedir. Bu, alanın olgunlaşarak daha derinlemesine analizlere yöneldiğinin bir işaretidir.

## Ülke Analizi (Country Analysis)

Bu bölümde, sürdürülebilir turizm pazarlamasında yapay zeka alanındaki bilimsel yayınların coğrafi dağılımı ve ülkeler arası bilimsel iş birliği ağları incelenmektedir.

Şekil 6'daki dünya haritası ve Şekil 7'deki işbirliği ağı, alandaki bilimsel üretimin belirli ülkelerde yoğunlaştığını göstermektedir. Düğüm büyüklüklerine göre Çin, bu alandaki en üretken ülke olarak öne çıkmaktadır. Çin'i Hindistan, Birleşik Krallık, Malezya ve ABD gibi diğer önemli aktörler takip etmektedir.

İşbirliği ağı (Şekil 7), ülkelerin farklı coğrafi ve bilimsel eksenlerde kümelenildiğini ortaya koymaktadır. Analizde birkaç belirgin araştırma kümesi tespit edilmiştir:

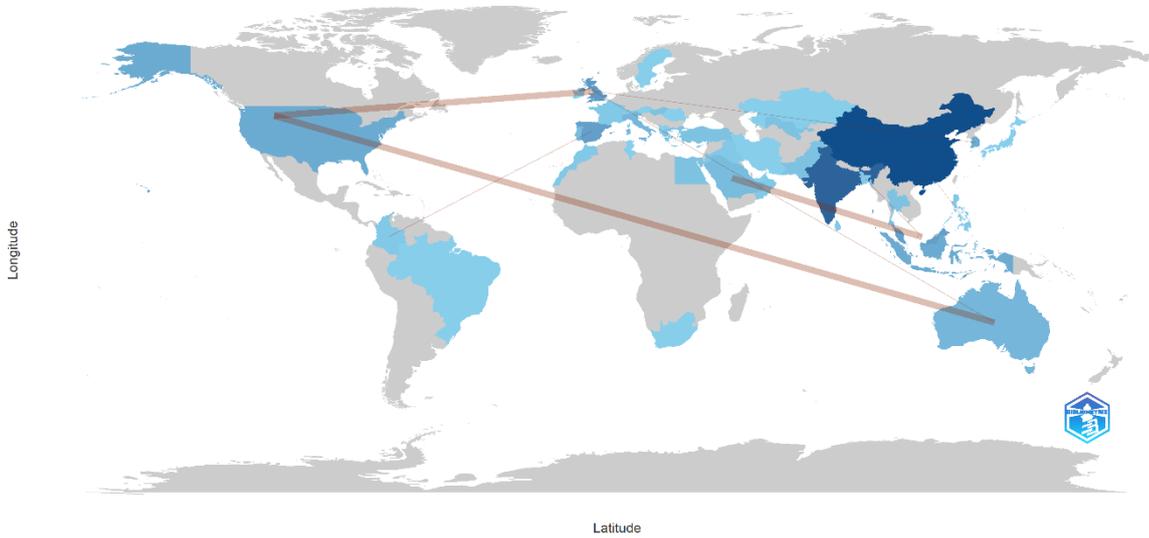
Asya-Pasifik Ağı (Yeşil Küme): Çin'in liderliğindeki bu küme, en büyük ve en bağlantılı ağı oluşturmaktadır. Malezya, Japonya, Endonezya ve Bangladeş gibi ülkeleri içeren bu ağ, alanın gelişiminde Asya-Pasifik bölgesinin ne kadar merkezi bir rol oynadığını göstermektedir.

Güney/Batı Asya ve Doğu Avrupa Ağı (Kırmızı Küme): Hindistan'ın merkezinde olduğu bu küme; Pakistan, Irak, Türkiye ve Romanya gibi ülkeler arasında güçlü bir bölgesel iş birliği olduğunu göstermektedir.

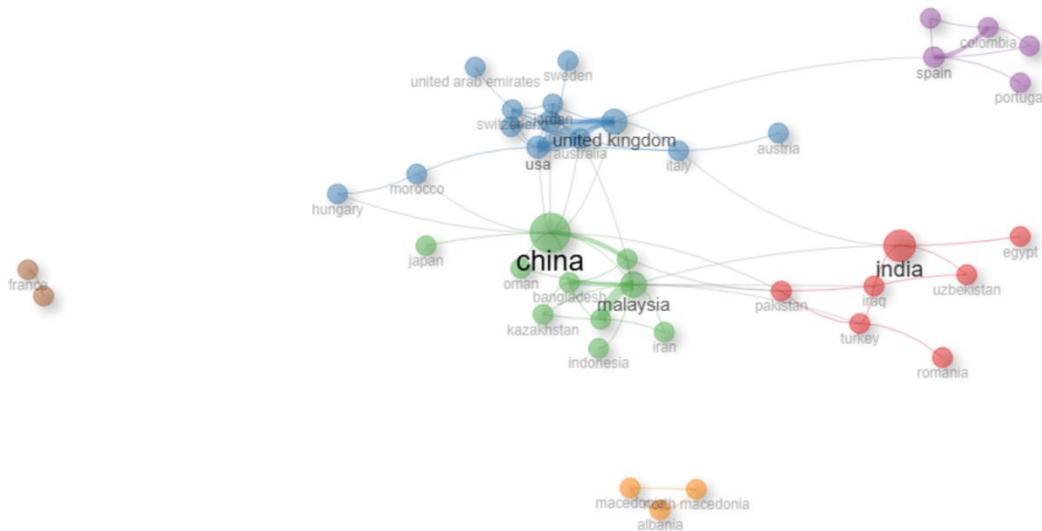
Batı Araştırma Ağı (Mavi Küme): Bu küme, Birleşik Krallık ve ABD'nin öncülüğünde Avustralya, İsveç, İsviçre gibi Batılı ülkeleri bir araya getirmektedir.

Bu bölgesel ağlar arasında küresel bağlantıyı sağlayan köprü ülkeler de dikkat çekmektedir. Özellikle Birleşik Krallık ve Avustralya, Batı araştırma ağı (mavi) ile Asya-Pasifik ağı (yeşil) arasında önemli bir köprü görevi görerek küresel bilgi akışını kolaylaştırmaktadır.

Şekil 6. Ülkeler Arası İşbirliği Haritası



Şekil 7. Ülke İşbirliği Ağı



## TARTIŞMA VE SONUÇ

Bu bibliyometrik analiz, sürdürülebilir turizm pazarlamasında yapay zeka uygulamaları alanının hızla büyüyen, dinamik ve disiplinlerarası bir yapıya sahip olduğunu ortaya koymuştur. Araştırma, henüz yerleşik bir yazar ağına sahip olmayan, merkezi olmayan bir yapıda ilerlemekte ve özellikle Çin ile Hindistan'ın liderliğindeki bölgesel iş birliği ağları tarafından yönlendirilmektedir. Kavramsal olarak alan; sürdürülebilirlik, teknoloji ve pazarlama olmak üzere üç ana tema etrafında şekillenmekte ve zamanla genel konulardan "tüketici davranışı" gibi daha spesifik ve uygulamalı alanlara doğru evrilmektedir.

Bu çalışma, en başta belirlenen araştırma sorularına şu yanıtları sunmaktadır:

AS1: Sürdürülebilir turizm pazarlamasında yapay zeka uygulamaları alanındaki bilimsel yayınların küresel trendi nedir?

Bulgular, yıllık %31.25'lik bir büyüme oranıyla alanın son derece dinamik bir yükseliş trendinde olduğunu göstermektedir. Trend analizi, alanın 2022 öncesinde temellerinin atıldığını, özellikle 2023-2024 yıllarında "sürdürülebilir turizm" ve "yapay zeka" gibi temel kavramların olgunlaştığını ve 2025 itibarıyla daha niş konulara yönelimin başladığını ortaya koymuştur. Bu, alanın hızla evrilen ve olgunlaşan bir yapıya sahip olduğunu göstermektedir.

AS2: Bu trend dikkate alındığında, literatürde hangi kavramsal boşluklar ve yeterince araştırılmamış alanlar bulunmaktadır?

Tematik harita analizi, "turizm pazarlaması" ve "ekoloji" gibi konuların henüz alanın merkezinde yer almayan ve "gelişen" temalar olduğunu ortaya koymuştur. Benzer şekilde, Trend Konular analizi, "tüketici davranışı" gibi uygulamalı konuların ancak 2025 itibarıyla yükselişe geçtiğini göstermiş, bu da önceki dönemlerde bu spesifik alanda bir boşluk olduğuna işaret etmiştir. Bu bulgular, literatürün henüz teknoloji ve sürdürülebilirlik kavramlarının pazarlama ve tüketici psikolojisi üzerindeki derinlemesine etkilerini tam olarak keşfetmediğini göstermektedir.

AS3: Bu alandaki gelecekteki araştırmalar için potansiyel yönelimler ve öncelikli konular nelerdir?

Analizler, alanın geleceğinin daha niş ve uygulamalı konulara yöneleceğini göstermektedir. Özellikle "tüketici davranışı" ve "belirli turizm sektörleri" üzerine yapılacak çalışmalar, yükselen trendler olarak öne çıkmaktadır. Araştırmacılar, yapay zeka destekli sürdürülebilirlik mesajlarının farklı tüketici segmentleri üzerindeki etkisini veya bu teknolojilerin konaklama, ulaşım gibi alt sektörlerde nasıl uygulanabileceğini inceleyebilir. Ayrıca, Tematik Harita'da "gelişen tema" olarak belirlenen "turizm pazarlaması"nın, yapay zeka ve sürdürülebilirlik entegrasyonu açısından önemli bir potansiyel taşıdığı ve gelecekteki araştırmalar için öncelikli bir alan olduğu söylenebilir.

Bu bulgular ışığında, gelecekteki araştırmalar için birkaç somut yönelim önerilebilir: YZ tabanlı kişiselleştirilmiş sürdürülebilirlik mesajlarının farklı demografik ve psikografik özelliklere sahip turist grupları üzerindeki davranışsal etkileri nicel ve nitel yöntemlerle incelenebilir. Araştırmalar, YZ uygulamalarının konaklama, yeme-içme veya ulaşım gibi belirli turizm alt sektörlerinde sürdürülebilir pazarlama stratejilerini nasıl dönüştürdüğünü vaka analizleri yoluyla derinlemesine ele alabilir. Temel temalar arasında yer alan "kullanıcı deneyimi" ve "sanal gerçeklik" gibi teknolojilerin, turistlerin sürdürülebilirliğe yönelik tutumlarını ve satın alma niyetlerini nasıl şekillendirdiği deneysel çalışmalarla araştırılabilir. Son olarak, "ekoloji" ve "turizm pazarlaması" gibi gelişen temalar, YZ'nin ekolojik ayak izini azaltan operasyonel verimlilikleri pazarlama iletişimine nasıl entegre edebileceği konusunda yeni araştırma alanları sunmaktadır.

Bu çalışmanın bazı sınırlılıkları bulunmaktadır. Öncelikle, analiz yalnızca Scopus veri tabanından elde edilen yayınları kapsamaktadır. Web of Science gibi diğer önemli veri tabanlarının dahil edilmesi, sonuçların kapsamını genişletebilir. İkinci olarak, sonuçlar seçilen arama sorgusuna bağlıdır; farklı anahtar kelimelerle yapılacak bir arama, farklı bir yayın setini ortaya çıkarabilir.

Son olarak, bibliyometrik analiz doğası gereği nicel bir yöntemdir ve makalelerin içeriğini derinlemesine veya kalitatif olarak değerlendirmez; yalnızca yayın meta verileri üzerinden bir haritalama yapar.

Sonuç olarak, bu çalışma, sürdürülebilir turizm pazarlamasında yapay zeka uygulamaları gibi yeni ve hızla büyüyen bir alanda gerçekleştirilen ilk kapsamlı bibliyometrik analizlerden birini sunmaktadır. Analiz, alanın mevcut entelektüel yapısını, ana temalarını, kilit aktörlerini ve gelişim yörüngesini ortaya koyarak dağınık haldeki literatürü sistematik bir çerçeveye oturtmuştur. Bu harita, alanda çalışan mevcut ve gelecekteki araştırmacılar için literatürdeki boşlukları ve potansiyel araştırma fırsatlarını belirlemede değerli bir rehber niteliğindedir.

## KAYNAKÇA

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## DİJİTAL HALKLA İLİŞKİLERDE EDEBİ ANLATININ GÜCÜ: THY’NİN DİJİTAL KAMPANYALARINDA HİKÂYE, METAFOR VE KÜLTÜREL KODLAR

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### ÖZET

Bu çalışma, dijital halkla ilişkiler bağlamında edebi anlatının işlevini inceleyerek, markaların hikâye, metafor ve kültürel kodlar aracılığıyla kimlik inşa süreçlerini nasıl yürüttüklerini ortaya koymayı amaçlamaktadır. Çalışmada Türk Hava Yolları (THY), hem ulusal kimliği temsil eden hem de küresel pazarda faaliyet gösteren bir marka olarak vaka çalışması kapsamında ele alınmıştır. Araştırma, nitel araştırma yaklaşımı çerçevesinde tasarlanmış ve seçilmiş kampanyaların söylem analizi ile çözümlenmesine dayanmaktadır. Özellikle “Widen Your World” kampanyası ile 29 Ekim Cumhuriyet Bayramı’na yönelik dijital kampanya, hikâye anlatı biçimleri, metafor kullanımı ve kültürel kodların temsili açısından ayrıntılı olarak incelenmiştir.

Elde edilen bulgular, THY’nin küresel kampanyalarda bireysel özgürlük, keşif ve kişisel gelişim temalarını; ulusal kampanyalarda ise topluluk kimliği, dayanışma ve ulusal aidiyet temalarını ön plana çıkardığını göstermektedir. Hikâye ve metaforların stratejik kullanımı, tüketicilerin bireysel ve kolektif düzeyde markayla özdeşleşmesine olanak tanımaktadır. Kültürel kodlar ise markanın bir yandan Türkiye’nin tarihsel ve kültürel mirasını yansıtan, diğer yandan da uluslararası alanda kültürlerarası köprü işlevi gören bir özne olarak algılanmasına katkı sağlamaktadır. Bu bulgular, literatürde markaların yalnızca ürün ya da hizmet sağlayıcı değil, aynı zamanda kültürel anlam üreten aktörler olduğuna yönelik görüşleri desteklemektedir.

Sonuç olarak çalışma, edebi anlatı stratejilerinin dijital halkla ilişkilerde marka imajının inşasında kritik bir rol üstlendiğini ortaya koymaktadır. THY örneği, anlatının salt estetik bir unsur değil hem ulusal aidiyeti pekiştiren hem de küresel prestiji güçlendiren stratejik bir iletişim aracı olduğunu göstermektedir. Bu bağlamda çalışma, halkla ilişkiler literatürüne anlatı temelli bir perspektif kazandırırken, uygulayıcılar için de dijital kampanyalarda edebi anlatının kullanılmasının stratejik önemini vurgulamaktadır.

**Anahtar Kelimeler:** Dijital Halkla İlişkiler, Hikâye Anlatıcılığı, Metafor, Kültürel Kodlar, Marka İletişimi, Türk Hava Yolları, Vaka Çalışması

### THE POWER OF LITERARY NARRATIVE IN DIGITAL PUBLIC RELATIONS: STORYTELLING, METAPHORS, AND CULTURAL CODES IN TURKISH AIRLINES’ DIGITAL CAMPAIGNS

### ABSTRACT

This study aims to examine the function of literary narrative within the context of digital public relations, focusing on how brands construct their identities through stories, metaphors, and cultural codes. Turkish Airlines (THY) is analyzed as a case study, as it represents both a national identity and a global brand in the international market. The research was designed within a qualitative framework and employed discourse analysis of selected campaigns. In particular, the “Widen Your World”

campaign and the digital campaign produced for the Republic Day of October 29 were analyzed in detail in terms of narrative structures, metaphorical expressions, and representations of cultural codes.

The findings reveal that THY emphasizes themes of individual freedom, discovery, and personal growth in its global campaigns, while highlighting collective identity, solidarity, and national belonging in its domestic campaigns. The strategic use of narratives and metaphors enables consumers to identify with the brand both on an individual and collective level. Cultural codes, on the other hand, contribute to the perception of the brand as not only reflecting Turkey's historical and cultural heritage but also functioning as a cultural bridge in the international sphere. These findings support existing literature that positions brands not merely as providers of products or services but as cultural actors that produce and disseminate meaning.

In conclusion, the study demonstrates that literary narrative strategies play a crucial role in shaping brand image within digital public relations. The case of THY illustrates that narrative is not simply an aesthetic component but a strategic communication tool that reinforces national identity while simultaneously enhancing global prestige. Accordingly, the study contributes a narrative-based perspective to the public relations literature and underscores for practitioners the strategic importance of employing literary narrative in digital campaigns.

**Keywords:** Digital Public Relations, Storytelling, Metaphor, Cultural Codes, Brand Communication, Turkish Airlines, Case Study

## GİRİŞ

Günümüz iletişim ortamında dijitalleşme, halkla ilişkiler uygulamalarını köklü biçimde dönüştürmüş; markaların hedef kitleleriyle etkileşim biçimlerini yeniden tanımlamıştır. Geleneksel halkla ilişkiler stratejilerinin ötesine geçen dijital halkla ilişkiler, yalnızca bilgilendirme ve tanıtım işleviyle sınırlı kalmamakta, aynı zamanda kültürel, duygusal ve sembolik boyutları da içeren çok katmanlı bir iletişim pratiği olarak öne çıkmaktadır (Breakenridge, 2008; Macnamara, 2016). Bu bağlamda, markaların dijital mecralarda farklılaşabilmesi ve kalıcı bir imaj inşa edebilmesi için, salt rasyonel bilgi aktarımından ziyade, hedef kitleyle duygusal bağ kurmaya yönelik anlatı stratejilerine yöneldiği görülmektedir.

Hikâye anlatıcılığı, modern iletişim çalışmalarında en çok vurgulanan yöntemlerden biridir. Anlatılar, yalnızca bilgiyi aktaran bir araç değil, aynı zamanda anlamı inşa eden, değerleri taşıyan ve bireylerin kimlik algısını şekillendiren bir yapı sunar (Fisher, 1984; Polletta, Chen, Gardner & Motes, 2011). Halkla ilişkiler bağlamında hikâye, markaların kendi varoluş gerekçelerini, toplumsal rollerini ve hedef kitlelerine sundukları değerleri dramatize ederek görünür kılmasına imkân tanır (Fog, Budtz, Munch & Blanchette, 2010). Bu nedenle hikâye anlatımı, markaların yalnızca ürün ya da hizmetlerini değil, aynı zamanda kültürel konumlarını ve ideolojik duruşlarını da inşa ettikleri önemli bir araçtır.

Metafor kullanımı da marka iletişimde önemli bir rol üstlenmektedir. Lakoff ve Johnson'ın (1980) ortaya koyduğu bilişsel metafor kuramına göre, metaforlar yalnızca dilsel bir süsleme değil, bireylerin dünyayı algılayış biçimlerini yapılandıran zihinsel kategorilerdir. Dolayısıyla markaların dijital kampanyalarında kullandıkları metaforlar, tüketicilerin marka ile kurduğu bilişsel ve duygusal bağların temelini oluşturmaktadır. Örneğin uçuşun "özgürlük", yolculuğun "hayat serüveni", Türkiye'nin ise "kültürler arası köprü" olarak metaforlaştırılması, yalnızca bir hizmetin değil, aynı zamanda bir yaşam tarzının ve kültürel kimliğin temsilini mümkün kılar.

Kültürel kodlar da markaların dijital halkla ilişkiler uygulamalarında anlatıyı güçlendiren diğer bir boyut olarak öne çıkmaktadır. Barthes'ın (1972) göstergebilim yaklaşımıyla ele alınabilecek kültürel kodlar; milli semboller, tarihi göndermeler, geleneksel motifler ya da popüler kültür unsurları aracılığıyla tüketicilere anlamlı bağlamlar sunar. Böylelikle marka, yalnızca ticari bir aktör olarak değil, aynı zamanda kültürel bir özne olarak toplumsal belleğe yerleşir (Holt, 2004). Özellikle

uluslararası faaliyet gösteren markalar için kültürel kodların yerel değerlerle küresel hedefler arasında köprü kurma işlevi, marka iletişiminin başarısını doğrudan etkileyen bir faktördür.

Türk Hava Yolları (THY) bu bağlamda dikkat çekici bir örnek oluşturmaktadır. Hem ulusal kimliğin taşıyıcısı hem de küresel ölçekte bir aktör olarak konumlanan THY, dijital halkla ilişkiler kampanyalarında sıklıkla hikâye, metafor ve kültürel kodlara başvurmaktadır. “Globally Yours” ve “Widen Your World” gibi uluslararası kampanyaların yanı sıra, milli bayramlarda veya toplumsal olaylarda yayımladığı dijital içerikler, markanın hem küresel yolculuk anlatısını hem de Türkiye’nin kültürel kimliğini harmanlayarak sunduğunu göstermektedir. Bu strateji, THY’nin yalnızca bir havayolu şirketi olarak değil, aynı zamanda kültürel bir marka elçisi olarak algılanmasını mümkün kılmaktadır (Uztuğ, 2013; İspir & Aydemir, 2018).

Bu çalışma, dijital halkla ilişkilerde edebi anlatının gücünü tartışmaya açarak, THY’nin dijital kampanyalarını vaka çalışması olarak ele almakta ve hikâye, metafor ile kültürel kodların marka iletişimine nasıl katkı sunduğunu incelemeyi amaçlamaktadır. Böylelikle hem halkla ilişkiler literatürüne anlatı temelli bir perspektif kazandırmak, hem de markaların dijital ortamlarda kültürel değerleri nasıl yeniden ürettiğini ortaya koymak hedeflenmektedir. Bu doğrultuda araştırmanın soruları şu şekilde belirlenmiştir:

1. THY’nin dijital kampanyalarında hangi hikâye anlatı biçimleri öne çıkmaktadır?
2. Marka iletişimde hangi metaforlar kullanılmaktadır ve bu metaforlar nasıl bir anlam inşa etmektedir?
3. Kampanyalarda kullanılan kültürel kodlar marka algısını nasıl etkilemektedir?
4. Bu anlatı stratejileri tüketiciler ile marka arasında nasıl bir duygusal bağ kurmaktadır?

## Teorik Çerçeve

### 1. Hikâye Anlatıcılığı Kuramı

İletişim çalışmalarında hikâye anlatıcılığı, yalnızca estetik bir tercih değil, aynı zamanda toplumsal anlam inşasının temel araçlarından biri olarak kabul edilmektedir. Fisher’in (1984) geliştirdiği Narrative Paradigm, insan iletişiminin rasyonel argümanlardan ziyade anlatılar etrafında şekillendiğini vurgular. Bu yaklaşıma göre bireyler, karşılaştıkları mesajları “anlatı olasılığı” ve “anlatı tutarlılığı” ölçütleriyle değerlendirirler. Dolayısıyla bir markanın hedef kitle üzerinde ikna edici olabilmesi, ilettiği hikâyelerin gerçekçi bulunmasına ve duygusal bağ kurabilmesine bağlıdır (Green & Brock, 2000).

Marka iletişimde hikâyeler, ürün ve hizmetlerin ötesinde, tüketicilere belirli değerleri, yaşam biçimlerini ve idealleri sunar (Fog, Budtz, Munch & Blanchette, 2010). Hikâyeler aracılığıyla markalar, toplumsal kimlikler inşa eder, hedef kitlelerini duygusal olarak harekete geçirir ve onları uzun vadeli bir bağlılığa yönlendirir (Escalas, 2004). Özellikle dijital halkla ilişkilerde hikâye anlatıcılığı, sosyal medya ve çevrimiçi platformların görsel-işitsel olanakları sayesinde daha etkileşimli ve katılımcı bir forma kavuşmuştur (Lundqvist, Liljander, Gummerus & van Riel, 2013).

THY örneğinde hikâye, yalnızca bir uçuş deneyiminin aktarımı değil, aynı zamanda “keşif”, “birlik” ve “dünya vatandaşlığı” gibi temalar etrafında inşa edilen bir marka anlatısıdır. “Widen Your World” kampanyasında öne çıkan yolculuk anlatısı, tüketicilere yeni ufuklar açmayı vaat eden bir yaşam hikâyesi kurgulamaktadır. Bu noktada hikâye anlatıcılığı, markanın hem küresel hem de yerel düzeyde kimlik inşasına katkı sunan bir stratejiye dönüşmektedir.

## 2. Metafor Kuramı

Metaforlar, dilin ötesinde, bireylerin dünyayı algılama ve kavramsallaştırma biçimlerini şekillendiren zihinsel modellerdir. Lakoff ve Johnson'ın (1980) ortaya koyduğu Bilişsel Metafor Kuramı, metaforların yalnızca bir anlatım aracı değil, aynı zamanda düşüncenin temel yapıları olduğunu savunur. Dolayısıyla marka iletişimde kullanılan metaforlar, tüketicilerin markaya dair algılarının oluşumunda kritik bir rol üstlenmektedir (Forceville, 2008).

Metaforlar aracılığıyla soyut kavramlar somut deneyimlere bağlanır. Örneğin uçuş, “özgürlük” metaforu üzerinden anlatıldığında yalnızca bir ulaşım hizmeti değil, sınırları aşma ve bireysel potansiyeli gerçekleştirme deneyimi olarak sunulur. Benzer şekilde yolculuk, hayatın kendisine dair bir metafor olarak işlendiğinde, marka yalnızca bir aracı değil, bireyin yaşam serüveninin ayrılmaz bir parçası haline gelir (Charteris-Black, 2011).

THY kampanyalarında metaforlar hem küresel hem de yerel bağlamda işlev görmektedir. Gökyüzü “sınırsız olanaklar” metaforu ile küresel ufukları temsil ederken, Türkiye'nin kültürel mirası “köprü” metaforu üzerinden farklı kültürleri buluşturan bir merkez olarak konumlandırılmaktadır. Bu metaforlar, markanın yalnızca hizmet sunan bir aktör değil, aynı zamanda değer üreten ve kimlik inşa eden bir özne olarak algılanmasını sağlamaktadır.

## 3. Kültürel Kodlar ve Göstergebilim

Kültürel kodlar, markaların mesajlarını yerel ve küresel bağlamlarda anlamlı kılan sembolik unsurlardır. Barthes'ın (1972) göstergebilim yaklaşımı, gündelik söylemlerdeki mitlerin ve sembollerin ideolojik işlevlerini açığa çıkararak, kültürel kodların toplumsal anlam üretimindeki rolünü vurgulamaktadır. Halkla ilişkiler ve marka iletişimi bağlamında kültürel kodlar, markaların belirli değerlerle özdeşleşmesini ve toplumsal bellekte yer edinmesini sağlar (Holt, 2004).

Kültürel kodların dijital halkla ilişkilerdeki önemi, özellikle küresel ölçekte faaliyet gösteren markaların yerel değerleri evrensel mesajlarla bütünleştirme ihtiyacından kaynaklanmaktadır (Robertson, 1995). Milli semboller, bayrak, müzik, renkler veya geleneksel motifler, tüketicilerin markayla kurduğu duygusal bağı güçlendiren göstergelere dönüşür.

THY kampanyalarında kültürel kodların stratejik biçimde kullanıldığı görülmektedir. Örneğin milli bayramlarda hazırlanan dijital içeriklerde Türk bayrağı, tarihsel göndermeler ve toplumsal dayanışma temaları ön plana çıkmaktadır. Uluslararası kampanyalarda ise İstanbul'un tarihi yapıları ya da Anadolu kültürünün simgesel öğeleri, markanın “küresel ama yerel” konumunu güçlendiren kodlar olarak sunulmaktadır. Bu bağlamda THY, kültürel kodlar aracılığıyla hem ulusal kimliğin temsilcisi hem de küresel bir marka elçisi olarak kendisini konumlandırmaktadır.

## 4. Dijital Halkla İlişkiler ve Anlatı

Dijitalleşme, halkla ilişkilerde iki yönlü iletişim ve etkileşim süreçlerini güçlendirmiştir (Macnamara, 2016). Breakenridge'in (2008) “PR 2.0” kavramıyla tanımladığı bu dönüşüm, markaların hedef kitleleriyle doğrudan, hızlı ve katılımcı bir iletişim kurmasına olanak tanımaktadır. Dijital halkla ilişkilerde anlatı, yalnızca tek yönlü bir mesaj değil, kullanıcıların katılımıyla yeniden üretilen dinamik bir süreçtir (Kent & Taylor, 2002).

Bu bağlamda markaların dijital platformlarda ürettikleri hikâyeler, metaforlar ve kültürel kodlar, yalnızca marka tarafından inşa edilmez; kullanıcıların etkileşimleri, paylaşımları ve yorumlarıyla yeniden anlam kazanır. THY'nin sosyal medya kampanyalarında tüketicilerin katılımını teşvik eden içerikler, bu etkileşimli anlatının bir parçası olarak değerlendirilebilir.

## YÖNTEM

### Araştırma Deseni

Bu çalışma, nitel araştırma yaklaşımı çerçevesinde tasarlanmış olup, vaka çalışması (case study) deseni benimsenmiştir. Yin'e (2018) göre vaka çalışmaları, karmaşık toplumsal olguların kendi bağlamı içinde derinlemesine incelenmesine imkân tanır. Halkla ilişkiler alanında vaka çalışmaları, belirli bir markanın veya kampanyanın iletişim stratejilerinin ayrıntılı biçimde analiz edilmesine olanak sağlayarak, alan yazına hem kuramsal hem de uygulamalı katkı sunar (Tellis, 1997). Bu doğrultuda araştırma, Türk Hava Yolları'nın (THY) seçilmiş dijital kampanyalarını incelemeye odaklanmaktadır.

### Örneklem ve Veri Seçimi

Araştırmanın örneklemi, THY'nin son on yıl içinde dijital mecralarda gerçekleştirdiği kampanyalar arasından seçilen örnekler oluşturmaktadır. Özellikle küresel çapta yürütülen "Widen Your World" kampanyası ile milli bayramlara ve toplumsal olaylara ilişkin sosyal medya içerikleri (ör. 29 Ekim Cumhuriyet Bayramı, 23 Nisan Ulusal Egemenlik ve Çocuk Bayramı kampanyaları) çalışma kapsamına dâhil edilmiştir. Bu seçim, kampanyaların hem uluslararası hedef kitleye ulaşma hem de yerel değerleri temsil etme işlevlerini karşılaştırmalı olarak inceleme olanağı sağlamaktadır.

Veri seti;

THY'nin resmi YouTube kanalında yayımlanan reklam filmleri,

Twitter (X) ve Instagram hesaplarında paylaşılmış görsel ve video içerikleri,

Resmî internet sitesinde kampanyalara ilişkin basın bültenleri ve tanıtım metinlerinden oluşmaktadır.

Bu içerikler, amaçlı örnekleme yöntemiyle belirlenmiştir. Amaçlı örnekleme, araştırmanın amacına en uygun verilerin seçilmesini sağlayarak olgunun derinlemesine incelenmesine imkân tanır (Patton, 2002).

### Veri Toplama Yöntemi

Çalışmada ikincil veriler (dijital kampanya içerikleri) kullanılmış, herhangi bir deneysel müdahaleye başvurulmamıştır. Seçilen veriler araştırmacı tarafından sistematik biçimde arşivlenmiş ve incelenmiştir. Dijital halkla ilişkilerde kullanılan metinler, görseller ve videolar hem söylemsel düzeyde hem de sembolik-kültürel düzeyde değerlendirilmiştir.

### Veri Analizi

Araştırmada, nitel söylem analizi yöntemi benimsenmiştir. Van Dijk'in (1993) söylem analizi yaklaşımı, metinlerin yalnızca dilsel düzeyde değil, aynı zamanda toplumsal ve kültürel bağlamları içinde çözümlenmesini önerir. Bu doğrultuda analiz süreci üç aşamada yürütülmüştür:

Hikâye Anlatısı Çözümlemesi:

Fisher'in (1984) Narrative Paradigm çerçevesinde kampanya içerikleri "anlatı tutarlılığı" ve "anlatı olasılığı" ölçütleriyle değerlendirilmiştir. Ayrıca Greimas'ın (1987) anlatı şeması kullanılarak hikâye yapılarındaki aktörler, roller ve dönüşüm süreçleri incelenmiştir.

Metafor Analizi:

Lakoff ve Johnson'ın (1980) Bilişsel Metafor Kuramı temelinde kampanya metinlerinde ve görsellerinde kullanılan metaforlar belirlenmiş ve sınıflandırılmıştır. Özellikle "uçuş = özgürlük",

“Türkiye = köprü”, “seyahat = keşif” gibi temel metaforların marka algısına katkısı değerlendirilmiştir.

Kültürel Kodların Göstergibilimsel Çözümü:

Barthes’in (1972) göstergibilim yaklaşımı doğrultusunda kampanyalardaki semboller (bayrak, İstanbul silüeti, geleneksel motifler, renkler vb.) çözümlenmiş; bu göstergelerin hangi kültürel mitlere referans verdiği ve nasıl bir toplumsal anlam ürettiği incelenmiştir.

Analiz sürecinde ayrıca Braun ve Clarke’ın (2006) önerdiği tematik analiz aşamalarından yararlanılmıştır. Bu kapsamda:

Verilere aşinalık sağlanmış,

Kodlama yapılmış,

Temalar (hikâye, metafor, kültürel kod) belirlenmiş,

Bulgular literatürle ilişkilendirilerek yorumlanmıştır.

Geçerlik ve Güvenirlik

Nitel araştırmalarda geçerlik ve güvenilirlik, sürecin şeffaflığı ve veri analizinin tutarlılığı ile sağlanır (Lincoln & Guba, 1985). Bu çalışmada;

Veriler doğrudan markanın resmî dijital mecralarından elde edilmiştir. Analiz süreci sistematik olarak belgelenmiş ve temalar açık biçimde tanımlanmıştır. Bulgular, mevcut literatürle karşılaştırılarak üçgenleme (triangulation) sağlanmıştır.

## Sınırlılıklar

Araştırmanın temel sınırlılığı, yalnızca belirli kampanyalara ve dijital mecralara odaklanmasıdır. THY’nin tüm iletişim stratejilerini kapsamak yerine seçilmiş örnekler üzerinden inceleme yapılmıştır. Ayrıca nitel söylem analizi, araştırmacının yorumlarını da içereceği için bulguların genellenebilirliği sınırlı kalabilir. Bununla birlikte, çalışma derinlemesine analiz imkânı sunduğu için anlatı, metafor ve kültürel kodların işlevini anlamada önemli bir katkı sağlamaktadır.

## BULGULAR / ANALİZ

### 1. Hikâye Anlatı Biçimleri

“Widen Your World” Kampanyası:

Türk Hava Yolları’nın 2014 yılında başlattığı “Widen Your World” kampanyası, marka iletişimde hikâye anlatısının merkezde olduğu bir örnek teşkil etmektedir. Kampanyada birey, sıradan bir yolcudan çok daha fazlası olarak resmedilir; yeni ufuklara açılan, farklı kültürlerle karşılaşan ve bu deneyim sonucunda dönüşüm yaşayan bir kahraman figürü olarak sunulur. Fisher’in (1984) Narrative Paradigm yaklaşımına göre bu tür anlatılar, yüksek anlatı tutarlılığı ve olasılığı sergileyerek hedef kitleyi içine çekmektedir. Yolculuk, yalnızca mekânsal bir hareketlilik değil, aynı zamanda bireyin kendini gerçekleştirmesine imkân veren bir yaşam yolculuğu olarak kurgulanmıştır. Bu bağlamda kampanya, tüketiciye “sınırları aşma” ve “kendini geliştirme” gibi evrensel temalar üzerinden hitap etmektedir.

29 Ekim Cumhuriyet Bayramı Kampanyası:

THY’nin 2022 yılında hazırladığı 29 Ekim Cumhuriyet Bayramı kampanyası ise hikâye anlatımında kolektif kimliği ön plana çıkarmaktadır. Burada hikâye, tek bir bireyin yolculuğu değil, ulusun ortak geçmişi ve geleceği üzerine inşa edilmektedir. Cumhuriyet’in ilanı, “yolculuğun başlangıcı” metaforu

ile dramatize edilmekte; gelecek ise “açık bir ufuk” olarak betimlenmektedir. Bu anlatı biçimi, ulusal kimliği güçlendiren ve toplumsal aidiyet duygusunu pekiştiren bir yapı sunmaktadır. Escalas’ın (2004) vurguladığı gibi tüketicilerin markalarla özdeşleşmeleri, paylaşılan hikâyeler aracılığıyla gerçekleşir. Bu kampanyada bireyler, Cumhuriyet’in parçası olarak konumlandırılarak markayla daha güçlü bir özdeşleşme yaşamaktadır.

“Widen Your World” bireysel kahramanlık ve kişisel dönüşüm hikâyesi üretirken; 29 Ekim kampanyası kolektif kahramanlık ve ulusal dayanışma hikâyesi üretmektedir. THY böylece farklı bağlamlarda farklı hikâye anlatı biçimlerini kullanarak hem küresel hem yerel ölçekte çok katmanlı bir marka imajı inşa etmektedir.

## 2. Metaforların Kullanımı

“Widen Your World” Kampanyası:

Bu kampanyada kullanılan metaforlar, bireysel özgürlüğün ve potansiyelin açığa çıkarılmasına yöneliktir. Gökyüzü “özgürlük” metaforunu, yolculuk ise “hayatın kendisi” metaforunu taşır. Lakoff ve Johnson’ın (1980) Bilişsel Metafor Kuramı bağlamında bu kullanım, soyut değerlerin somut deneyimler üzerinden kavramsallaştırılmasıdır. Uçuş, yalnızca bir ulaşım değil, bireyin sınırlarını aşarak yeni deneyimlere ulaşmasının simgesi haline gelir. Kampanyanın temel sloganı olan “Widen Your World”, metaforik olarak yalnızca fiziksel dünyanın değil, zihinsel ve duygusal ufukların da genişlemesini ifade etmektedir.

29 Ekim Cumhuriyet Bayramı Kampanyası:

Bu kampanyada metaforlar ulusal kimliğe dayalı kolektif bir anlatı oluşturur. Cumhuriyet “bir yolculuğun başlangıcı” olarak metaforlaştırılmış, gelecek ise “ufukta beliren yeni bir dünya” imgesiyle aktarılmıştır. Barthes’ın (1972) mit çözümlemeleriyle de okunabilecek bu metaforlar, Cumhuriyet’in yalnızca tarihsel bir olgu değil, geleceğe dair sürekli yeniden üretilen bir yolculuk olduğunu vurgulamaktadır. Burada kullanılan metaforlar, bireysel potansiyeli öne çıkaran küresel kampanyalardan farklı olarak, ortak aidiyet ve ulusal birlik duygusunu besleyen sembolik bir işlev görmektedir.

“Widen Your World” metaforları bireysel kimlik ve özgürlük ekseninde inşa edilirken, 29 Ekim kampanyasının metaforları kolektif kimlik ve ulusal aidiyet üzerinden kurgulanmaktadır. Bu ikili yapı, THY’nin marka stratejisinde hem bireysel hem de toplumsal düzeyde anlam üretmesine olanak tanımaktadır.

## 3. Kültürel Kodların Temsili

“Widen Your World” Kampanyası:

Bu kampanyada kültürel kodlar, Türkiye’nin küresel ölçekte tanıtımına katkı sunacak şekilde seçilmiştir. İstanbul’un simgesel mekânları (Ayasofya, Boğaziçi Köprüsü, Kapalıçarşı) kültürlerarası buluşmayı ve Türkiye’nin “Doğu ile Batı arasında köprü” rolünü pekiştirmektedir. Holt’un (2004) “kültürel markalaşma” yaklaşımıyla okunabilecek bu strateji, THY’nin yalnızca bir havayolu değil, aynı zamanda Türkiye’nin kültürel elçisi olarak konumlandırılmasına hizmet etmektedir. Robertson’un (1995) “glokalleşme” kavramı bağlamında, yerel kültürel kodların evrensel bir anlatıya entegre edilmesi markanın küresel kimliğini güçlendirmektedir.

29 Ekim Cumhuriyet Bayramı Kampanyası:

Bu kampanyada kültürel kodlar daha çok ulusal kimliği pekiştirmeye yöneliktir. Türk bayrağı, milli marş dizeleri, Atatürk’ün sözlerine göndermeler ve çocukların görüntüleri, Barthes’ın (1972) mit

kavramıyla açıklanabilecek biçimde toplumsal belleği harekete geçiren güçlü sembollerdir. Bu kodlar, markayı yalnızca ticari bir aktör değil, aynı zamanda ulusal değerlerin taşıyıcısı olarak konumlandırmaktadır.

“Widen Your World” kampanyasında kültürel kodlar Türkiye’yi küresel bir medeniyetler buluşma noktası olarak tanıtırken, 29 Ekim kampanyası Türkiye’yi ulusal kimlik ve bağımsızlık idealleri üzerinden konumlandırmaktadır. Böylece THY, aynı anda hem evrensel hem de yerel düzeyde kültürel kod üretmektedir.

#### 4. Duygusal Bağ ve Marka Algısı

“Widen Your World” Kampanyası:

Bu kampanyada izleyiciler, bireysel özgürlük ve keşif duygusu üzerinden markayla özdeşleşmeye davet edilmektedir. Escalas’ın (2004) çalışmalarında vurguladığı gibi tüketicilerin markalarla bağ kurması, kendi yaşam hikâyelerini marka anlatısıyla ilişkilendirmeleriyle gerçekleşir. THY, bireyleri “dünyalarını genişletmeye” çağırarak, markayı kişisel gelişimin ve dönüşümün aracı haline getirmektedir. Bu da tüketiciyle duygusal bir bağ kurulmasını sağlamaktadır.

29 Ekim Cumhuriyet Bayramı Kampanyası:

Burada ise duygusal bağ ulusal kimlik üzerinden kurulmaktadır. Cumhuriyet’in kazanımlarına yapılan vurgu, izleyicide gurur, aidiyet ve toplumsal sorumluluk duygularını harekete geçirmektedir. Böylece marka, yalnızca hizmet sağlayıcı değil, ulusal değerlerin temsilcisi olarak algılanmaktadır.

“Widen Your World” bireysel duyguları (özgürlük, keşif, kişisel gelişim) harekete geçirirken, 29 Ekim kampanyası kolektif duyguları (ulusal aidiyet, gurur, dayanışma) beslemektedir. THY’nin marka stratejisi, bu iki farklı düzeyde duygusal bağ kurarak marka algısını güçlendirmektedir.

Genel bir değerlendirmeye gidilecek olursa yapılan çözümler, Türk Hava Yolları’nın dijital halkla ilişkiler kampanyalarında edebi anlatı unsurlarını sistematik biçimde kullandığını ortaya koymaktadır. Özellikle incelenen iki kampanya -“Widen Your World” ve 29 Ekim Cumhuriyet Bayramı- farklı anlatı stratejileri aracılığıyla markanın hem küresel hem de yerel düzeyde kendisini yeniden inşa ettiğini göstermektedir.

Öncelikle hikâye anlatısı bağlamında, THY’nin küresel kampanyalarda bireysel yolculuk ve keşif temalarını merkeze aldığı, ulusal kampanyalarda ise topluluk ve dayanışma temalarını ön plana çıkardığı görülmektedir. Bu, markanın hedef kitleye yalnızca ulaşım hizmeti sunmadığını, aynı zamanda farklı ölçeklerde anlam üreten bir “hikâye anlatıcısı” olarak konumlandığını göstermektedir. Anlatılar, bireyleri ya kişisel bir kahramanlık yolculuğuna davet etmekte ya da onları ulusal bir kimliğin parçası haline getirerek toplumsal aidiyet hissini pekiştirmektedir. Dolayısıyla THY, hikâye anlatımını çok katmanlı bir marka kimliği inşasının temel mekanizması olarak kullanmaktadır.

Metafor analizi, markanın hem bireysel hem de kolektif düzeyde güçlü sembolik anlamlar ürettiğini ortaya koymaktadır. Küresel ölçekte “uçuş = özgürlük”, “yolculuk = hayat” metaforları bireyin sınırları aşmasını temsil ederken; yerel ölçekte “Cumhuriyet = yolculuğun başlangıcı” metaforu tarihsel sürekliliği ve toplumsal kimliği yeniden üretmektedir. Bu durum, Lakoff ve Johnson’ın (1980) vurguladığı metaforların kavramsal işlevine uygun biçimde, tüketicilerin dünyayı markanın sunduğu zihinsel çerçeveler üzerinden algılamasına yol açmaktadır. Böylelikle THY, farklı bağlamlarda değişen metaforik anlatılar aracılığıyla hem bireysel hem de kolektif düzeyde anlam üretme kapasitesine sahiptir.

Kültürel kodların analizi, markanın “glokalleşme” stratejisi izlediğini göstermektedir. “Widen Your World” kampanyasında İstanbul’un simgesel mekânları, Türkiye’nin “Doğu ile Batı arasında köprü” işlevini vurgularken; 29 Ekim kampanyasında bayrak, marş ve ulusal kahramanlara yapılan

göndermeler, ulusal kimliği pekiştiren semboller olarak öne çıkmaktadır. Bu kodlar, Barthes'ın (1972) göstergebilim yaklaşımı bağlamında yalnızca görsel semboller değil, aynı zamanda toplumsal mitlerdir. Böylece THY, hem uluslararası pazarda kültürel zenginliği temsil eden bir marka, hem de ulusal düzeyde aidiyet ve gururun taşıyıcısı olarak algılanmaktadır.

Duygusal bağ boyutunda, kampanyaların tüketicilerle farklı türde özdeşleşmeler kurduğu görülmektedir. “Widen Your World” bireysel özgürlük ve potansiyel üzerinden duygusal bağ kurarken, 29 Ekim kampanyası toplumsal aidiyet ve gurur duygularını harekete geçirmektedir. Escalas'ın (2004) belirttiği gibi tüketicilerin markalarla ilişkisi, anlatılarla kurdukları özdeşleşme düzeyine bağlıdır. THY'nin farklı anlatı stratejileriyle hem bireysel hem de toplumsal düzeyde özdeşleşmeyi mümkün kılması, markanın çok boyutlu bir duygusal etki alanı oluşturduğunu göstermektedir.

Genel olarak değerlendirildiğinde, THY'nin dijital halkla ilişkiler stratejisi, edebi anlatı unsurlarını (hikâye, metafor, kültürel kod) yalnızca estetik bir unsur olarak değil, stratejik bir iletişim aracı olarak kullandığını ortaya koymaktadır. Bu strateji, markanın hem küresel hem yerel pazarlarda güçlü bir konum elde etmesini sağlamaktadır. Küresel kampanyalar evrensel değerler (özgürlük, keşif, bireysel gelişim) üzerinden evrensel bir izleyici kitlesine hitap ederken; yerel kampanyalar ulusal değerler (bağımsızlık, Cumhuriyet, dayanışma) üzerinden kolektif kimliği güçlendirmektedir. Böylece marka, farklı bağlamlarda farklı anlam ağları üreterek kendisini “hem dünya vatandaşı hem de ulusal kimlik taşıyıcısı” olarak konumlandırmaktadır.

Bu bulgular, literatürde sıklıkla vurgulanan “markaların yalnızca ürün değil, anlam üreten kültürel aktörler olduğu” (Holt, 2004) yaklaşımını desteklemektedir. THY örneği, dijital halkla ilişkilerde edebi anlatının, markaların çok katmanlı kimlik inşasında vazgeçilmez bir araç olduğunu göstermektedir.

## TARTIŞMA

Bu çalışmada Türk Hava Yolları'nın dijital halkla ilişkiler kampanyaları edebi anlatı unsurları (hikâye, metafor, kültürel kodlar) bağlamında incelenmiş ve elde edilen bulgular mevcut literatürle karşılaştırmalı olarak tartışılmıştır. Bulgular, dijital halkla ilişkilerde anlatının stratejik bir iletişim aracı olduğunu ve markaların kimlik inşasında merkezi bir rol oynadığını doğrulamaktadır.

Hikâye anlatısı bağlamında, THY'nin küresel kampanyalarında bireysel kahramanlık ve kişisel gelişim temaları, ulusal kampanyalarında ise kolektif kimlik ve dayanışma anlatıları öne çıkmıştır. Bu durum, Fisher'ın (1984) Narrative Paradigm kuramı ile uyumludur; zira anlatıların ikna gücü, hedef kitlenin bu hikâyelerle özdeşleşme düzeyine bağlıdır. Lundqvist ve arkadaşlarının (2013) marka hikâyelerinin tüketici deneyimini güçlendirdiğini ortaya koyan çalışmaları, THY kampanyalarının izleyiciye yalnızca bilgi değil, anlam sunduğunu desteklemektedir.

Metafor kullanımı, hem bireysel hem de kolektif düzeyde güçlü sembolik yapılar üretmiştir. “Uçuş = özgürlük” ve “yolculuk = hayat” gibi bireysel metaforlar, Lakoff ve Johnson'ın (1980) bilişsel metafor kuramıyla örtüşmektedir. Cumhuriyet'in “yolculuğun başlangıcı” olarak metaforlaştırılması ise Barthes'ın (1972) mit çözümlemelerinde işaret ettiği gibi tarihsel bir olgunun sürekli yeniden üretilen sembolik bir anlatıya dönüşmesini göstermektedir. Forceville'in (2008) görsel metaforlar üzerine çalışmaları da THY'nin görsel kampanya dilinde metaforların kavramsal işlevini doğrulamaktadır.

Kültürel kodlar açısından, bulgular Holt'un (2004) “kültürel markalaşma” yaklaşımıyla uyumludur. THY, hem yerel (bayrak, milli marş, Atatürk göndermeleri) hem de küresel (İstanbul'un simgesel mekânları, kültürlerarası köprü vurgusu) kodları kullanarak kendisini kültürel bir özne olarak konumlandırmaktadır. Bu durum Robertson'un (1995) “glokalleşme” kavramını somutlaştırmakta; markanın hem yerel hem küresel anlam evrenlerinde varlık göstermesine imkân tanımaktadır.

Duygusal bağ boyutunda, çalışma Escalas'ın (2004) tüketicilerin markalarla kurdukları anlatı temelli özdeşleşmelerin bağlılığı artırdığı yönündeki bulgularını desteklemektedir. “Widen Your World” bireysel özdeşleşmeyi, 29 Ekim kampanyası ise kolektif özdeşleşmeyi harekete geçirmiştir. Bu da markanın çok boyutlu bir duygusal etki alanı oluşturduğunu göstermektedir.

Bu çalışma, dijital halkla ilişkiler literatürüne edebi anlatının işlevine odaklanarak hem kuramsal hem de uygulamalı açıdan önemli katkılar sunmaktadır. Kuramsal açıdan, hikâye, metafor ve kültürel kodların yalnızca estetik unsurlar değil, aynı zamanda marka iletişiminin temel yapıtaşları olduğunu ortaya koyarak anlatı temelli yaklaşımlara yeni bir derinlik kazandırmaktadır. Bulgular, Robertson'un (1995) glokalleşme kuramını iletişimsel bir boyutta somutlaştırmakta; markaların aynı anda hem küresel hem de yerel anlam evrenlerinde var olabileceğini göstermektedir. Ayrıca, bireysel ve kolektif düzeyde özdeşleşmenin aynı kampanyalar aracılığıyla sağlanabileceği yönündeki bulgular, Escalas'ın (2004) anlatı temelli tüketici-marka ilişkisi yaklaşımını genişleterek çok katmanlı bir özdeşleşme imkânına işaret etmektedir. Uygulama boyutunda ise çalışma, markalar için dijital halkla ilişkilerde anlatı kullanımının stratejik önemini göstermekte; doğru seçilmiş hikâyeler, metaforlar ve kültürel kodların yalnızca marka imajını güçlendirmekle kalmayıp tüketiciyle kalıcı duygusal bağlar kurduğunu kanıtlamaktadır. THY örneği, ulusal değerlerin kampanya anlatılarına entegre edilmesinin markaya güçlü bir aidiyet zemini sunduğunu ve küresel ölçekte kültürel zenginliği temsil etmesinin de uluslararası pazarda rekabet avantajı yarattığını ortaya koymaktadır. Dolayısıyla bu çalışma hem akademik araştırmacılar hem de iletişim uygulayıcıları için dijital halkla ilişkilerde anlatı temelli stratejilerin kuramsal ve pratik önemini vurgulamaktadır.

## SONUÇ

Bu çalışma, Türk Hava Yolları'nın dijital halkla ilişkiler kampanyalarını edebi anlatı unsurları bağlamında inceleyerek, hikâye, metafor ve kültürel kodların marka iletişimde nasıl işlev gördüğünü ortaya koymuştur. Bulgular, markaların dijital platformlarda salt bilgi aktaran kurumlar olmaktan öte, kültürel anlam üreten aktörler haline geldiğini göstermektedir. Özellikle THY örneği, dijital halkla ilişkilerde edebi anlatının marka kimliğinin inşasında ve hedef kitleyle duygusal bağ kurmada vazgeçilmez bir strateji olduğunu kanıtlamaktadır.

Analizler, THY'nin küresel ölçekte bireysel keşif ve özgürlük hikâyelerini, yerel ölçekte ise ulusal aidiyet ve dayanışma anlatılarını stratejik biçimde harmanladığını göstermiştir. Böylece marka, Robertson'un (1995) glokalleşme kavramıyla açıklanabilecek bir biçimde, hem evrensel değerleri hem de yerel kimliği aynı anda temsil eden çok katmanlı bir söylem üretmektedir. Bu strateji, yalnızca markanın uluslararası rekabet gücünü artırmakla kalmamakta, aynı zamanda ulusal kimliği güçlendiren sembolik bir rol üstlenmesini de mümkün kılmaktadır.

Metaforların kullanımı da bu sürecin ayrılmaz bir parçasıdır. “Uçuşun özgürlük” ya da “Cumhuriyetin yolculuğun başlangıcı” olarak metaforlaştırılması, Lakoff ve Johnson'ın (1980) bilişsel metafor kuramının işaret ettiği gibi tüketicilerin algı dünyasını biçimlendirmekte ve markanın sunduğu değerleri içselleştirmelerine olanak tanımaktadır. Benzer şekilde kültürel kodların (bayrak, marş, tarihi mekânlar, çocuk figürleri) sistematik biçimde kullanılması, Barthes'ın (1972) göstergebilim perspektifinden değerlendirildiğinde, THY'nin yalnızca bir hizmet sağlayıcı değil, toplumsal belleğin taşıyıcısı konumuna yükseldiğini göstermektedir.

Bu bağlamda çalışma, dijital halkla ilişkiler alanında üç temel sonuca işaret etmektedir. Birincisi, anlatı temelli stratejiler, markaların hedef kitleleriyle daha güçlü duygusal bağlar kurmasını sağlamaktadır. İkincisi, markalar aynı anda hem bireysel hem de kolektif düzeyde özdeşleşme üreterek çok boyutlu bir marka algısı inşa edebilmektedir. Üçüncüsü, ulusal ve küresel kodların birlikte kullanımı, markalara hem yerel aidiyet hem de uluslararası prestij kazandırmaktadır.

Sonuç olarak, Türk Hava Yolları örneği, dijital halkla ilişkilerde edebi anlatının yalnızca bir estetik tercih değil, stratejik bir zorunluluk haline geldiğini göstermektedir. Çalışma, literatürdeki “markaların kültürel aktörler olduğu” (Holt, 2004) tezini desteklemekte ve dijital ortamda anlatı stratejilerinin, markaların kimlik, değer ve ideolojilerini görünür kılmada kritik bir rol üstlendiğini ortaya koymaktadır. Gelecek araştırmaların, farklı sektörlerdeki markaları karşılaştırmalı olarak incelemesi ve kullanıcı etkileşimlerini de analize dâhil etmesi, dijital halkla ilişkilerde anlatının çok boyutlu doğasını daha kapsamlı biçimde ortaya çıkaracaktır.

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## AŞI KARŞITLIĞI VE DEMOGRAFİK FAKTÖRLER ARASINDAKİ İLİŞKİ: BİR KESİTSEL ARAŞTIRMA

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### ÖZET

Bu araştırma, ebeveynlerin sosyo-demografik özellikleri ile aşı karşıtlığı arasındaki ilişkiyi belirlemek amacıyla yapılmıştır. Tanımlayıcı ve ilişki arayıcı tipteki bu kesitsel çalışma, 30 Aralık 2024–30 Temmuz 2025 tarihleri arasında Karabük ilinde bir Aile Sağlığı Merkezi'ne başvuran 126 kadın ile yürütülmüştür. Örneklem büyüklüğü korelasyon katsayısı ( $r=0,30$ ), %95 güven aralığı ve %90 güç dikkate alınarak hesaplanmıştır. Veriler araştırmacılar tarafından geliştirilen “Kişisel Bilgi Formu” ile yüz yüze görüşme yöntemiyle toplanmıştır. İstatistiksel analizlerde tanımlayıcı testler ve Ki-kare testleri kullanılmış, anlamlılık düzeyi  $p<0,05$  olarak kabul edilmiştir. Katılımcıların yaş ortalaması  $33,44\pm 5,64$  yıl olup, babaların yaş ortalaması  $36,47\pm 5,97$  yıl olarak bulunmuştur. Kadınların ortalama gebelik sayısı  $1,87\pm 0,95$ , yaşayan çocuk sayısı ise  $1,68\pm 0,76$ 'dır. Annelerin %67,5'i, babaların ise %67,5'i üniversite mezunudur. Annelerin %57,9'u, babaların %94,4'ü gelir getirici bir işte çalışmaktadır. Katılımcıların %89,7'si çocukluk çağı aşıları hakkında bilgi sahibi olduğunu belirtmiş, bilgi kaynağı olarak en sık sağlık çalışanları (%77,0) ifade edilmiştir. Katılımcıların %11,1'i en az bir aşığı yaptırmadığını bildirmiştir. Aşı yaptırmama nedenleri arasında en sık “aşuların yan etkileri hakkındaki endişeler” (%50,0) yer almıştır. Aşı yaptırmama kararını çoğunlukla anneler (%78,6) vermiştir. Anne ve babanın eğitim ve çalışma durumları ile aşı yaptırmama arasında istatistiksel olarak anlamlı bir ilişki saptanmamıştır ( $p>0,05$ ). Ayrıca özel aşılar hakkında bilgi sahibi olduğunu belirtenlerin oranı %74,6'dır. Araştırma bulguları, aşı karşıtlığının düşük düzeyde olmakla birlikte ebeveynlerin kaygıları, güven algıları ve dini inançları gibi faktörlerden etkilendiğini göstermektedir. Sosyo-demografik özellikler ile aşı karşıtlığı arasında anlamlı bir ilişki saptanmamıştır.

**Anahtar kelimeler:** Aşı karşıtlığı, aşı reddi, demografik faktörler.

## THE RELATIONSHIP BETWEEN VACCINE HESITANCY AND DEMOGRAPHIC FACTORS: A CROSS-SECTIONAL STUDY

### ABSTRACT

This study was conducted to determine the relationship between parents' socio-demographic characteristics and vaccine hesitancy. This descriptive and correlational cross-sectional study was carried out with 126 women who applied to a Family Health Center in Karabük between December 30, 2024, and July 30, 2025. The sample size was calculated based on a correlation coefficient ( $r = 0.30$ ), with a 95% confidence interval and 90% power. Data were collected through face-to-face interviews using the "Personal Information Form" developed by the researchers. Descriptive tests and Chi-square tests were used for statistical analyses, and the level of significance was set at  $p < 0.05$ . The mean age of the participants was  $33.44 \pm 5.64$  years, while the mean age of the fathers was  $36.47 \pm 5.97$  years. The women's mean number of pregnancies was  $1.87 \pm 0.95$ , and the mean number of living children was  $1.68 \pm 0.76$ . Among the participants, 67.5% of the mothers and 67.5% of the fathers were university graduates. Additionally, 57.9% of the mothers and 94.4% of the fathers were employed in income-generating jobs. A total of 89.7% of the participants stated that they had knowledge about childhood vaccinations, with healthcare professionals being the most frequently reported source of information (77.0%). A total of 11.1% of the participants reported that they had not received at least one vaccine. The most common reason for not vaccinating was concerns about vaccine side effects (50.0%). In most cases, the decision not to vaccinate was made by the mothers (78.6%). No statistically significant relationship was found between the parents' education and employment status and vaccination refusal ( $p > 0.05$ ). Additionally, 74.6% of the participants reported having knowledge about optional vaccines. The findings indicate that, although vaccine hesitancy was generally low, it was influenced by factors such as parental concerns, perceived safety, and religious beliefs. No significant relationship was observed between socio-demographic characteristics and vaccine hesitancy.

**Keywords:** Vaccine hesitancy, vaccine refusal, demographic factors.

### 1. GİRİŞ

Aşının geliştirilmesi, insanlık tarihindeki en önemli bilimsel gelişmelerden biridir. 20. yüzyılın başından itibaren bulaşıcı hastalıkların yol açtığı morbidite ve mortaliteyi önemli ölçüde azaltarak, ortalama yaşam süresini uzatmıştır. Dünya üzerinde, her yıl 2-3 milyon ölümün engellenmesini sağlamaktadır (Kurt vd. 2023; Zhang vd. 2024). Bu başarı, aşıların sağlık alanındaki önemini ve insanlık üzerindeki etkisini açıkça göstermektedir. Aşılama, bulaşıcı hastalıklarla mücadelede temel bir halk sağlığı aracıdır ve düşük maliyetli, kolay uygulanabilir olmasıyla öne çıkar (Termrungruangelert vd. 2024). Ancak aşı karşıtlığı, aşılarla duyulan güvensizlik, tereddüt veya reddetme şeklinde ortaya çıkarak aşılama programlarını tehdit etmektedir. Gelişmiş ve gelişmekte olan ülkelerde %90'dan fazlası aşı tereddüdü yaşamaktadır. Dünya Sağlık Örgütü (WHO), aşı tereddüdünü küresel bir sağlık tehdidi olarak tanımlamaktadır. Aşı reddinin artması, salgın riskini yükseltir (Dubé vd. 2021). Aşı karşıtlığının nedenleri oldukça çeşitlidir ve bireylerin farklı inanç, deneyim ve dünya görüşlerinden kaynaklanabilir. Bu nedenler arasında, geçmişte aşılarla veya sağlık sistemiyle ilgili yaşanan olumsuz deneyimler, aşıların güvenliği veya etkinliği konusundaki şüpheler, alternatif tıp yaklaşımlarına duyulan inanç, dini veya felsefi inançlar, özgürlük veya hükümete duyulan güvensizlik gibi faktörler yer alabilir. Ayrıca, aşı üreticilerinin çıkar çatışmaları da önemli bir rol oynayabilir (Bianco vd. 2019). Sağlık profesyonelleri, toplumlar ve hükümetler, aşılamaı teşvik etmek ve aşı reddini azaltmak için çeşitli stratejiler geliştiriyor. Bu çalışmalara ek olarak, rutin aşıların ebeveynler tarafından reddedilmesiyle ilgili argümanlar sistematik olarak inceleniyor ve

sınıflandırılıyor. Amaç, aşı politikalarını ve uygulamalarını daha iyi bilgilendirerek, daha etkili bir aşı kampanyası yürütmek ve toplum sağlığını korumaktır (Güngör ve Koparan 2023).

Türkiye'de ilk sistematik bağışıklama çalışmaları 1930'da çiçek hastalığına karşı başlamıştır. 1931'de ilk verem aşısı üretilmiştir. Günümüzde çocukluk çağı aşı takviminde difteri, boğmaca, tetanoz, çocuk felci, hepatit B ve A, H. influenza tip b, tüberküloz, kızamık, kabakulak, kızamıkçık, suçiçeği ve pnömokok dahil olmak üzere 13 hastalığa karşı rutin aşı uygulaması yapılmaktadır. Aşı takvimi, Sağlık Bakanlığı tarafından belirlenir ve düzenli olarak güncellenir (Özen vd. 2024).

Bu çalışma, Türkiye'deki ebeveynlerin çocukları için aşı takviminde yer alan aşılardan reddetme eğilimlerini ve nedenlerini araştırmayı hedeflemektedir. Türkiye'de ve dünya genelinde, aşı reddi veya aşı tereddüdü üzerine düzenli olarak anketler yapılmaktadır. Bu anketler, ebeveynlerin aşı konusundaki tutumlarını, endişelerini ve aşı reddine yol açan faktörleri anlamayı amaçlar. Bu tür araştırmalar, aşı karşıtı söylemlerin yaygınlığını, etkisini ve halk sağlığı üzerindeki potansiyel etkilerini değerlendirmek için önemlidir. Elde edilen bulgular, aşılamaı teşvik etmek ve aşı tereddüdünü azaltmak için stratejiler geliştirmede kullanılabilir.

## 2. GEREÇ VE YÖNTEM

**2.1. Araştırmanın tipi:** Bu araştırma tanımlayıcı nitelikte bir ilişki çalışmasıdır.

**2.2. Araştırmanın yeri ve zamanı:** Araştırmanın verileri, 30.12.2024- 30.07.2025 tarihleri arasında Karabük ilinde bir Aile Sağlığı Merkezine başvuru yapan kadınlar ile yüz yüze toplanmıştır.

**2.3. Araştırmanın evreni ve örnekleme:** Araştırmanın evrenini, 30.12.2024- 30.07.2025 tarihleri arasında Karabük ilinde bulunan Kartaltepe Aile Sağlığı Merkezi'ne başvuru yapan kadınlar oluşturdu. Araştırmanın örnekleminin belirlenmesinde korelasyon katsayısı dikkate alınarak hesaplama yapılmıştır. İstatistiksel hesaplama sonucunda  $r= 0.30$  korelasyon katsayısı baz alınarak %95 güven aralığında, 0.90 istatistiksel analiz güç öngörülerek araştırmaya en az 112 katılımcının alınması gerektiği hesaplanmıştır. Çalışma gönüllülük esasına dayalı 126 katılımcı ile sonlandırılmıştır.

**2.4. Veri Toplama Araçları:** Araştırma verileri, araştırmacılar tarafından geliştirilmiş olan "Kişisel Bilgi Formu" kullanılarak toplanmıştır.

**2.5. Etik İlkeler:** Çalışmanın uygulanabilmesi için Karabük Üniversitesi Sosyal ve Beşeri Bilimler Araştırmaları Etik Kurulu'ndan etik kurul onayı alınmıştır (Tarih 27.12.2024, Karar No: 2024/10). Çalışma kapsamındaki tüm kadınlardan gönüllü katılımlarına dair yazılı ve sözlü onay alınmıştır.

**2.6. Verilerin analizi:** İstatistiksel analizler, SPSS 27.0 paket programı kullanılarak yapıldı. Çalışmadan elde edilen sürekli veriler ortalama standart sapma; kategorik veriler yüzde dağılım biçiminde özetlendi. Değişkenler arası ilişkilerin değerlendirilmesinde ise Pearson Korelasyon Analizi ve Continuity Correction analizi kullanıldı. İstatistiksel anlamlılık sınır değeri  $p<0.05$  olarak kabul edildi.

### 3. BULGULAR VE TARTIŞMA

**Table 1.** Ebeveynlerin sosyo-demografik özellikleri

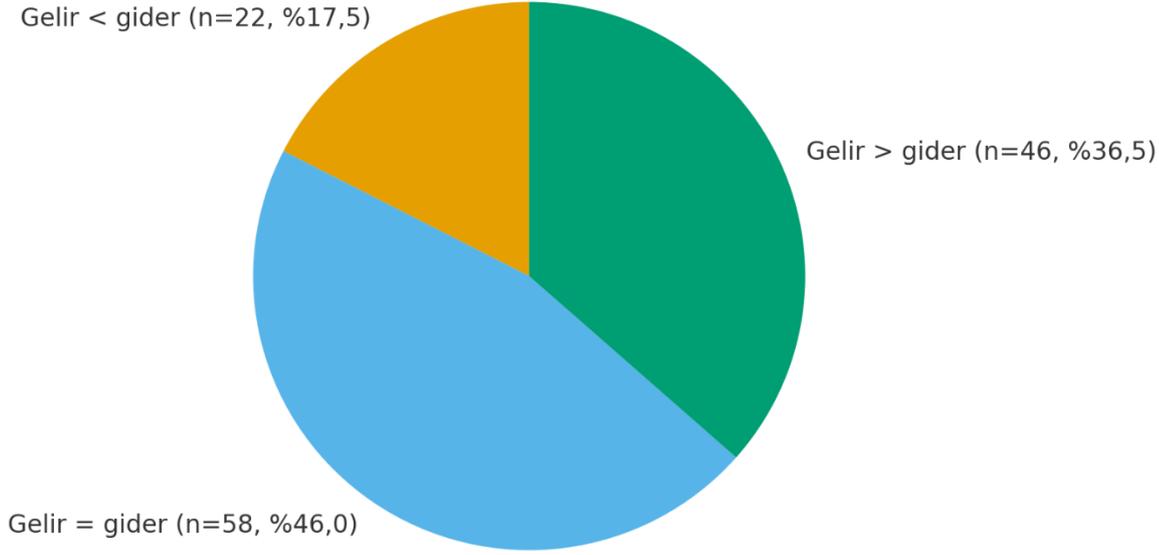
Değişken	Ort±SS	min-maks
<b>Yaş</b>		
<b>Anne</b>	33.44±5.64	19-48
<b>Baba</b>	36.47±5.97	21-50
<b>Toplam gebelik sayısı</b>	1.87±0.95	0-5
<b>Yaşayan çocuk sayısı</b>	1.68±0.76	1-4
	<b>Anne / n (%)</b>	<b>Baba / n (%)</b>
<b>Eğitim durumu</b>		
<b>Elementary school</b>	5 (4.0)	6 (4.8)
<b>Middle school</b>	12 (9.5)	8 (6.3)
<b>High school</b>	24 (19.0)	27 (21.4)
<b>University</b>	85 (67.5)	85 (67.5)
<b>Çalışma durumu</b>		
<b>Yes</b>	73 (57.9)	119 (94.4)
<b>No</b>	53 (42.1)	7 (5.6)

Ort: Ortalama, SS: Standart Sapma, min: Minimum, maks: Maksimum

Ebeveynlerin sosyo-demografik özellikleri incelendiğinde; annelerin yaş ortalamasının 33,44±5,64, babaların yaş ortalamasının ise 36,47±5,97 yıl olduğu belirlenmiştir. Kadınların toplam gebelik sayısı ortalaması 1,87±0,95, yaşayan çocuk sayısı ortalaması 1,68±0,76 olarak belirlenmiştir. Ebeveynlerin eğitim durumları incelendiğinde, annelerin %19,0'ı lise düzeyinde eğitim seviyesine sahipken, babaların %19,0'ü lise düzeyine eğitim seviyesine sahip bulundu. Son olarak annelerin %57,9'u herhangi bir gelir getiren işte çalıştığını belirtirken babaların %94,4'ü gelir getiren işte çalıştığını belirtti (Tablo 1).

Ebeveynlerin ekonomik durumlarına ilişkin bulgular değerlendirildiğinde; %17,5'inin gelirinin giderinden az olduğu, %46,0'ının gelirinin giderine eşit olduğu ve %36,5'inin gelirinin giderinden fazla olduğu belirlendi (Şekil 1).

## Ebeveynlerin Ekonomik Durumu



**Şekil 1.** Ebeveynlerin ekonomik durumlarına yönelik bulguların dağılımı

Çocukluk çağı aşılama ile ilgili kadınların bilgi durumları incelendiğinde, katılımcıların %89,7'sinin (n=113) çocukluk çağı aşılı hakkında bilgi sahibi olduğu, %10,3'ünün (n=13) ise bilgi sahibi olmadığı belirlendi. Bilgi kaynağına bakıldığında, ebeveynlerin %77,0'nun (n=97) bilgiyi sağlık çalışanlarından edindiği, %10,3'ünün (n=13) herhangi bir bilgi kaynağı bulunmadığı, %7,1'inin (n=9) internetten, %3,2'sinin (n=4) yakın akrabalarından, %2,4'ünün (n=3) ise arkadaşlarından bilgi aldığı saptandı.

Katılımcılara aşı takvimindeki aşılardan yaptırmadıkları olup olmadığı sorulduğunda %11,1'inin (n=14) en az bir aşıyı yaptırmadığı, %88,9'unun (n=112) ise tüm aşıları yaptırdığı görüldü. Aşı yaptırmama nedenleri incelendiğinde, ebeveynlerin %50,0'ı (n=7) aşıların yan etkileri hakkında endişeleri olduğunu, %21,4'ü (n=3) aşıları güvenli bulmadığını, %21,4'ü (n=3) dini görüşlerine uygun olmadığını, %7,2'si (n=1) ise doğal bağışıklığın daha iyi olduğunu düşündüğünü ifade etti. Aşı reddine karar veren kişi olarak %78,6 oranında (n=11) annelerin, %21,4 oranında (n=3) babaların öne çıktığı belirlendi. İstanbul'da yapılan bir çalışmada, okul çağı aşılama sırasında ailelerin onam vermeme düzeyi %30 olarak bulunmuştur. Araştırmacı bunun olası nedeninin, onam formunun veliye ulaştırılmadan doldurulması olduğunu düşündüğünü belirtmiştir (Duman 2017). Suudi Arabistanda yapılan bir çalışmada her 7 kişiden birinin aşı tereddütü yaşadığı, ailelerin %2,5'nin ise aşıyı reddettiği tespit edilmiştir (Al- Saeed vd. 2018).

Son olarak, özel aşılar hakkındaki bilgi durumları değerlendirildiğinde, katılımcıların %74,6'sının (n=94) özel aşılar hakkında bilgi sahibi olduğu, %25,4'ünün (n=32) ise bilgi sahibi olmadığı saptandı (Tablo 2).

**Table 2.** Kadınların aşılama yönelik sorulan sorulara verdikleri yanıtlar

Değişken	n	%
<b>Çocukluk çağı aşılama hakkında bilgi durumu</b>		
Var	113	89.7
Yok	13	10.3
<b>Bilgi kaynağı</b>		
Sağlık çalışanı	97	77.0
Yakın akraba	4	3.2
Arkadaş	3	2.4
İnternet	9	7.1
Bilgi kaynağı yok	13	10.3
<b>Aşı takvimindeki aşılarından yaptırmadığınız oldu mu?</b>		
Evet	14	11.1
Hayır	112	88.9
<b>Aşı yaptırmama nedeni nedir? (n=14)</b>		
Aşıları güvenli bulmuyorum	3	21.4
Aşıların yan etkileri hakkında endişelerim var	7	50.0
Dini görüşüme uygun değil	3	21.4
Doğal bağışıklığım daha iyi olduğunu düşünüyorum	1	7.2
<b>Aşı reddine karar veren kişi kim? (n=14)</b>		
Anne	11	78.6
Baba	3	21.4
<b>Özel aşılar hakkında bilginiz var mı?</b>		
Evet	94	74.6
Hayır	32	25.4

Annenin eğitim durumu ve aşı yaptırmama durumu arasındaki ilişki karşılaştırıldığında; aşı yaptırmayanların %0'ı ilkokul, %14,3'ü ortaokul, %21,4'ü lise, %64,3'ü üniversite ve üzeri mezunu annelere sahipti. Aşı yaptıranlarda ise bu oranlar sırasıyla %4,5, %8,9, %18,8 ve %67,9 idi. Gruplar arasındaki fark istatistiksel olarak anlamlı bulunmadı ( $\chi^2=1,070$ ;  $p=0,784$ ) (Tablo 3).

Babanın eğitim durumu ve aşı yaptırmama durumu arasındaki ilişki karşılaştırıldığında; Aşı yaptırmayanların %0'ı ilkokul, %7,1'i ortaokul, %14,3'ü lise, %78,6'sı üniversite ve üzeri mezunu babalara sahipti. Aşı yaptıranlarda ise bu oranlar sırasıyla %5,4, %6,3, %22,3 ve %66,1 olarak bulundu. Gruplar arasındaki fark istatistiksel olarak anlamlı değildi ( $\chi^2=1,429$ ;  $p=0,699$ ) (Tablo 3). Ülkemizde de Diyarbakır ve İstanbul'da yapılan çalışmalarda düşük eğitim düzeyi ile eksik aşı uygulaması arasında bir ilişki olduğu saptanmıştır (Gülgün vd. 2014).

**Tablo 3.** Ebeveynlerin aşı yaptırmama durumları ile eğitim durumları arasındaki ilişki

Aşı yaptırmama durumu		Annenin eğitim durumu				Test İstatistiği	
		İlkokul	Ortaokul	Lise	Üniversite ve ↑		
<b>Evet</b>	n	0	2	3	9	X <sup>2</sup> =1,070 <sup>a</sup> p=0,784	
	%	0,0	14,3	21,4	64,3		
<b>Hayır</b>	n	5	10	21	76		
	%	4,5	8,9	18,8	67,9		
<b>Toplam</b>	n	5	12	24	85		
	%	4,0%	9,5%	19,0%	67,5%		
Aşı yaptırmama durumu		Baba eğitim durumu					Test İstatistiği
		İlkokul	Ortaokul	Lise	Üniversite ve ↑		
<b>Evet</b>	n	0	1	2	11	X <sup>2</sup> =1,429 <sup>a</sup> p=0,699	
	%	0,0	7,1	14,3	78,6		
<b>Hayır</b>	n	6	7	25	74		
	%	5,4	6,3	22,3	66,1		
<b>Toplam</b>	n	6	8	27	85		
	%	4,8	6,3	21,4	67,5		

a: Pearson Chi-Square test

Annenin çalışma durumu ve aşı yaptırmama durumu arasındaki ilişki karşılaştırıldığında; aşı yaptırmayanların %57,1'i çalışan, %42,9'u çalışmayan annelere sahipti. Aşı yaptıranlarda ise oranlar %40,2 çalışan, %59,8 çalışmayan anne şeklindeydi. Gruplar arasındaki fark istatistiksel olarak anlamlı bulunmadı ( $\chi^2=0,856$ ;  $p=0,355$ ) (Tablo 4).

Babanın çalışma durumu ve aşı yaptırmama durumu arasındaki ilişki karşılaştırıldığında; aşı yaptırmayan çocukların %100'ünün babası çalışmıyordu, çalışan baba grubunda hiç aşı yaptırmama görülmedi. Aşı yaptıranlarda ise %6,2'si çalışmayan, %93,8'i çalışan babaya sahipti. Gruplar arasındaki fark istatistiksel olarak anlamlı değildi ( $\chi^2=0,118$ ;  $p=0,731$ ) (Tablo 4).

**Tablo 4.** Ebeveynlerin aşı yaptırmama durumları ile çalışma durumları arasındaki ilişki

Aşı yaptırmama durumu		Annenin çalışma durumu		Test İstatistiği	
		Evet	Hayır		
<b>Evet</b>	n	8	6	X <sup>2</sup> =0,856 <sup>b</sup> p=0,355	
	%	57,1	42,9		
<b>Hayır</b>	n	45	67		
	%	40,2	59,8		
<b>Toplam</b>	n	53	73		
	%	42,1	57,9		
Aşı yaptırmama durumu		Baba çalışma durumu			Test İstatistiği
		Evet	Hayır		
<b>Evet</b>	n	0	14	X <sup>2</sup> =0,118 <sup>b</sup> p=0,731	
	%	0,0	100,0		
<b>Hayır</b>	n	7	105		
	%	6,2	93,8		
<b>Toplam</b>	n	7	119		
	%	5,6	94,4		

b: Continuity Correction Test

#### 4. Sonuç

Bu çalışmada, ebeveynlerin sosyo-demografik özellikleri ile aşı karşıtlığı arasındaki ilişki incelenmiştir. Elde edilen bulgular, aşı karşıtlığının toplumda sınırlı düzeyde görüldüğünü, ancak özellikle annelerin karar verme sürecinde daha etkin olduğunu ortaya koymaktadır. Aşı yaptırmama gerekçelerinin başında aşılardan yan etkilerine ilişkin kaygılar ve güvenlik endişeleri gelmektedir. Bununla birlikte, anne ve babaların eğitim ve çalışma durumları ile aşı yaptırmama arasında anlamlı bir ilişki bulunmamıştır. Bu durum, aşı karşıtlığının yalnızca demografik özelliklerle açıklanamayacağını, daha çok bireysel inanç, tutum ve bilgi kaynaklarıyla ilişkili olduğunu düşündürmektedir.

Sonuç olarak, ebeveynlerin aşı konusundaki bilgi ve tutumlarının geliştirilmesi için sağlık profesyonellerinin danışmanlık ve eğitim faaliyetlerini artırmaları önemlidir. Özellikle annelere yönelik bilgilendirme programları ve topluma güven verici kampanyalar, aşı karşıtlığının azaltılmasına katkı sağlayabilir. Ayrıca gelecekte yapılacak daha geniş kapsamlı araştırmaların, aşı karşıtlığını etkileyen psikososyal ve kültürel faktörleri derinlemesine incelemesi önerilmektedir.

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## OTİZM SPEKTRUM BOZUKLUĞU OLAN ÇOCUKLARDA DİYETİN BAĞIRSAK MİKROBİYATASI ÜZERİNE ETKİSİ: GÜNCEL BULGULARIN DERLENMESİ

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### ÖZET

Otizm Spektrum Bozukluğu (OSB), sosyal iletişimde güçlükler ve tekrarlayıcı davranışlarla karakterize nörogelişimsel bir bozukluktur. Son yıllarda Otizm Spektrum Bozukluğu (OSB) olan bireylerde gastrointestinal sorunlar ve bağırsak mikrobiyotasındaki dengesizlikler dikkat çekmektedir. Bağırsak-beyin eksenini aracılığıyla mikrobiyota, nörotransmitter üretimi, bağışıklık yanıtları ve metabolitler üzerinden merkezi sinir sistemi fonksiyonlarını etkilemektedir. Bu durum, OSB semptomlarının şiddetini artırabilmekte ve davranışsal zorluklarla ilişkili olabilmektedir.

Bu derleme çalışmasının amacı, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda diyetin bağırsak mikrobiyotası üzerindeki etkilerini güncel bulgular ışığında değerlendirmektir. Literatürde probiyotik ve prebiyotiklerin, glutensiz-kazeinsiz, ketojenik ve GAPS gibi spesifik diyet modellerinin mikrobiyotayı modüle ederek gastrointestinal ve davranışsal belirtiler üzerinde iyileştirici etkiler gösterebileceği bildirilmiştir. Prebiyotik ve probiyotik destekleri bağırsak bariyerini güçlendirmekte, inflamasyonu azaltmakta ve kısa zincirli yağ asitlerinin üretimini artırarak nörolojik fonksiyonları desteklemektedir. Bununla birlikte, mevcut bulgular heterojen olup, etkinlik ve güvenilirlik açısından daha geniş örneklemli, uzun dönemli klinik araştırmalara ihtiyaç vardır.

Sonuç olarak, bağırsak mikrobiyotası OSB'nin patofizyolojisinde kritik bir rol oynamakta ve diyet temelli müdahaleler potansiyel bir tamamlayıcı tedavi seçeneği sunmaktadır. Kişiselleştirilmiş beslenme yaklaşımlarının geliştirilmesi, OSB semptomlarının yönetiminde yeni bir perspektif kazandırabilir.

**Anahtar Kelimeler:** Otizm Spektrum Bozukluğu, Bağırsak Mikrobiyotası, Diyet, Probiyotik, Prebiyotik

## THE EFFECT OF DIET ON GUT MICROBIOTA IN CHILDREN WITH AUTISM SPECTRUM DISORDER: A REVIEW OF CURRENT EVIDENCE

### Abstract

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by deficits in social communication and repetitive behaviors. In recent years, gastrointestinal problems and imbalances in gut microbiota have been increasingly reported in individuals with ASD. Through the gut-brain axis, microbiota influence central nervous system functions via neurotransmitter

production, immune regulation, and microbial metabolites. These alterations may exacerbate ASD symptoms and contribute to behavioral difficulties.

The aim of this review is to evaluate the effects of diet on gut microbiota in children with ASD based on current scientific findings. Evidence from the literature suggests that probiotics, prebiotics, and specific dietary models such as gluten-free/casein-free, ketogenic, and GAPS diets may modulate gut microbiota and improve both gastrointestinal and behavioral outcomes. Prebiotic and probiotic interventions have been shown to strengthen the intestinal barrier, reduce inflammation, and increase the production of short-chain fatty acids, thereby supporting neurological functions. However, existing findings remain heterogeneous, and further large-scale, long-term clinical studies are needed to establish efficacy and safety.

In conclusion, gut microbiota play a critical role in the pathophysiology of ASD, and diet-based interventions represent a promising complementary therapeutic strategy. Developing personalized nutritional approaches may provide a novel perspective for managing ASD symptoms and improving quality of life.

**Keywords:** Autism Spectrum Disorder, Gut Microbiota, Diet, Probiotics, Prebiotics

## GİRİŞ

### Otizm Spektrum Bozukluğu (OSB) Tanımı ve Önemi

Otizm spektrum bozukluğu (OSB), sosyal etkileşim ve iletişimde zorlukların yanı sıra kısıtlı veya tekrarlayıcı davranışlarla karakterize bir grup nörogelişimsel durumdur (Kamp-Becker, 2024).

Semptomlar bireyler arasında geniş bir yelpazede değişiklik gösterir ve bu durum, OSB'nin "spektrum" olarak tanımlanmasına yol açmıştır (Issac et al., 2025).

OSB'nin kesin nedeni bilinmemekle birlikte, genetik ve çevresel faktörlerin etkileşimi sonucu ortaya çıktığı düşünülmektedir. Son yıllarda yapılan çalışmalar, OSB'nin nörogelişimsel süreçlerdeki farklılıklarla ilişkili olduğunu ve bireylerin gelişimsel yolculuklarının erken dönemlerden itibaren şekillendiğini göstermektedir (Blaxill, Rogers, & Nevison, 2022)

Son çalışmalar hem ulusal düzeyde hem de belirli alt gruplar içinde zaman içinde sürekli bir artış olduğunu bildirmektedir (Zeidan et al., 2022).

Hastalık Kontrol ve Önleme Merkezleri'nin Otizm ve Gelişimsel Engellilikler İzleme Ağı'nın tahminlerine göre, yaklaşık 44 çocuktan 1'ine otizm spektrum bozukluğu (OSB) teşhisi konuyor (Malwane et al., 2022).

Otizm Spektrum Bozukluğu, ABD'de 8 yaş üstü çocukların yaklaşık %2,3'ünü ve yetişkinlerin yaklaşık %2,2'sini etkilemektedir. Birinci basamak tedavi davranışsal müdahalelerden oluşurken, anksiyete veya saldırganlık gibi eş zamanlı psikiyatrik durumlar özel davranış terapisi veya ilaçlarla tedavi edilebilir (Hirota & King, 2023).

Dünya genelinde OSB'nin prevalansı artış göstermektedir. Amerika Birleşik Devletleri'nde, 8 yaşındaki çocuklar arasında OSB prevalansı 36'da 1 olarak bildirilmiştir. Bu artış, daha geniş tanı kriterleri, gelişmiş tarama yöntemleri ve artan farkındalık gibi faktörlerle ilişkilendirilmektedir. Ancak, bazı bölgelerde, özellikle Orta Doğu ve Kuzey Afrika'da, sosyal damgalanma ve sınırlı tanı kaynakları nedeniyle OSB prevalansı daha düşük rapor edilmektedir (Akomolafe et al., 2025).

Otizm spektrum bozukluğunun temel özellikleri iyi belirlenmiş olsa da etkilenen bireylerde beslenme bozuklukları, gastrointestinal sorunlar ve bağırsak mikrobiyotasındaki değişikliklerin varlığı giderek daha fazla kabul görmektedir (Viviers et al., 2020).

Gıda seçiciliğinin temel bileşenlerinden biri gıda neofobisidir (FN). FN, yeni gıdaları denemeye karşı isteksizlik veya hatta korku olarak tanımlanır (Łoboś & Januszewicz, 2019).

### **Derlemenin Amacı ve Kapsamı**

Bu derlemenin amacı, otizm spektrum bozukluğu (OSB) olan çocuklarda diyetin bağırsak mikrobiyotası üzerindeki etkilerini güncel bilimsel bulgular ışığında incelemektir. Bağırsak mikrobiyotasının nörogelişimsel süreçler ve davranışsal semptomlar üzerindeki rolü giderek artan bir ilgi görmekte olup, diyet müdahaleleri OSB semptomlarının yönetiminde potansiyel bir tedavi yöntemi olarak değerlendirilmektedir. Derleme, mikrobiyota-bağırsak-beyin eksenini mekanizması doğrultusunda, farklı diyet modellerinin ve besin takviyelerinin bağırsak mikrobiyotasını nasıl modüle ettiğini ve bunun OSB üzerindeki etkilerini kapsamlı biçimde değerlendirmeyi hedeflemektedir. Ayrıca, bireysel farklılıkların ve çevresel faktörlerin diyet ve mikrobiyota etkileşimindeki rolü göz önünde bulundurularak, gelecekteki araştırmalar ve tedavi stratejileri için öneriler sunulmaktadır.

### **Bağırsak Mikrobiyotası ve GUT-Brain Axis Kavramı**

İnsan bağırsak mikrobiyotası, trilyonlarca bakteri, virüs ve mantar gibi mikroorganizmanın oluşturduğu son derece karmaşık ve bireysel bir ekosistemdir. Bu topluluk, bağışıklık sistemini düzenler, besinlerin sindirimini ve metabolizmayı destekler, vitamin (ör. B vitaminleri, K vitamini) sentezler ve antioksidan etki gösterir (Wadan, Abd El-Aziz, & Ellakwa, 2025).

Faydalı mikroorganizmalar, kısa zincirli yağ asitleri (SCFAs) gibi metabolitler üretir; bu moleküller hem bağırsak sağlığını hem de sinir sistemi fonksiyonlarını olumlu yönde etkiler (Barrio, Arias-Sánchez, & Martín-Monzón, 2022).

Dengesizlik, yani dysbiosis, bağırsak geçirgenliğini artırarak (“leaky gut”) toksinlerin kana geçmesine neden olur; bu durum sistemik iltihaba yol açarak hem metabolik hem de nöropsikiyatrik hastalıklarla ilişkilendirilmektedir (Barrio, Arias-Sánchez, & Martín-Monzón, 2022).

Gut-brain eksenini, merkezi sinir sistemi ve gastrointestinal sistem arasında çift yönlü iletişim sağlayan çok kanallı bir ağdır. Bu iletişimin yolları arasında sinirsel (örneğin vagus siniri aracılığıyla), hormonal (HPA eksenini gibi), immün ve metabolik (neurotransmitterler, SCFA’lar ve mikrobiyal metabolitler) mekanizmalar yer alır (Osadchiy, Martin, & Mayer, 2019).

Örneğin, bazı bakteri türleri dopamin, GABA, serotonin gibi nörotransmitterlerin sentezine katkı sağlayarak beyne sinyal gönderebilir (Barrio, Arias-Sánchez, & Martín-Monzón, 2022).

Bağırsak kaynaklı metabolitler doğrudan veya immün ya da vagal yol aracılığıyla beyin fonksiyonlarını etkileyebilir (Osadchiy, Martin, & Mayer, 2018).

Klinik ve deneysel bulgular, bu iletişim hattındaki bozulmaların depresyon, anksiyete, otizm spektrum bozukluğu ve nörodejeneratif hastalıklar gibi ruhsal ve nörolojik durumlarla bağlantılı olduğuna işaret etmektedir (Ullah et al., 2023).

### **Diyetin Mikrobiyota ve Nörogelişimsel Bozukluklar Üzerindeki Rolü**

Bağırsak mikrobiyotası ve nörogelişimsel bozukluklar arasındaki ilişki, son yıllarda yapılan bilimsel çalışmalarda önemli bir araştırma konusu olmuştur. Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, bağırsak mikrobiyomunun farklılıkları ve diyetin bu mikrobiyotadaki etkileri üzerine yapılan araştırmalar, bu ilişkinin daha iyi anlaşılmasına katkı sağlamaktadır (Fang et al., 2025).

Özellikle probiyotik ve prebiyotiklerin kullanımı, bağırsak mikrobiyotasını modüle ederek OSB semptomlarını iyileştirme potansiyeline sahiptir. Ancak, bu tedavi yöntemlerinin etkinliği konusunda

yapılan çalışmaların sonuçları karışıktır ve daha fazla araştırmaya ihtiyaç duyulmaktadır. Diyetin mikrobiyota üzerindeki etkileri, bireysel farklılıklar ve çevresel faktörler gibi etmenlerden etkilenebilir. Bu nedenle, kişiye özel tedavi yaklaşımlarının geliştirilmesi önemlidir (Yang et al., 2024).

Sonuç olarak, bağırsak mikrobiyotası ve nörogelişimsel bozukluklar arasındaki ilişki, karmaşık ve çok faktörlü bir etkileşimdir. Diyetin bu ilişkideki rolünü anlamak, gelecekte daha etkili ve kişiye özel tedavi yöntemlerinin geliştirilmesine katkı sağlayacaktır (Lewandowska-Pietruszka, Figlerowicz, & Mazur-Melewska, 2023).

## ARAŞTIRMA VE BULGULAR

### Otizm Spektrum Bozukluğu ve Bağırsak Mikrobiyotası İlişkisi OSB'de Mikrobiyota Profili ve Disbiyozis

Otizm Spektrum Bozukluğu (OSB) olan bireylerde, bağırsak mikrobiyotasının genellikle sağlıklı bireylerden farklı olduğu gözlemlenmiştir. Bu farklılıklar, bağırsakta bulunan mikroorganizma çeşitliliği ve sayısı ile ilgilidir. Özellikle, bazı çalışmalar, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, daha düşük bakteri çeşitliliği ve bazı yararlı mikroorganizmaların azalması ile disbiyozis (mikrobiyota dengesizliği) arasında bir ilişki olduğunu göstermektedir (Strati et al. 2017)

Bu durumu açıklamak için bağışıklık sistemi ve merkezi sinir sistemi arasındaki karmaşık etkileşimler incelenmektedir. Disbiyozisin, OSB belirtilerini etkileyebileceği ve semptomların şiddetini artırabileceği öne sürülmektedir (De Angelis et al., 2020).

Bağırsak mikrobiyotası, OSB'nin patofizyolojisinde önemli bir rol oynayan ve sinir sistemi fonksiyonlarını etkileyebilen bir faktör olarak kabul edilmektedir. Özellikle, bağırsakta bulunan Firmicutes, Bacteroidetes gibi bakteriyel gruplar ile OSB arasında bir ilişki olduğu düşünülmektedir. Firmicutes grubundaki bazı bakteriler, kısa zincirli yağ asitleri üretirken, bu asitler sinir sistemi üzerinde etkili olabilir ve otizmle ilişkili davranışsal belirtileri etkileyebilir (Hughes et al.2013).

Bağırsak mikrobiyotasında meydana gelen değişikliklerin, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, gastrointestinal semptomları da tetikleyebileceği, bu semptomların davranışsal zorluklara yol açabileceği ve bu kısır döngünün OSB belirtilerini daha da şiddetlendirebileceği ortaya konmuştur (Cryan et al., 2019). Bu bulgular, OSB'nin tedavi yaklaşımlarında mikrobiyota odaklı stratejilerin önemini artırmaktadır.

### Bağırsak Mikrobiyotasının Bağışıklık Sistemi ve Nörogelişimsel Etkileri

Bağırsak mikrobiyotası, bağışıklık sisteminin gelişimi ve fonksiyonu üzerinde kritik bir rol oynar. Bağırsakta yaşayan mikroorganizmalar, bağışıklık hücrelerinin farklılaşmasını ve bağışıklık yanıtlarının düzenlenmesini etkiler. Mikrobiyota, vücutta bulunan T hücrelerinin sayısını ve türünü modüle eder ve bununla birlikte, inflamasyonun kontrol edilmesinde önemli bir rol oynar (Schirmer et al., 2016).

Mikrobiyotanın dengesizliği (disbiyozis), inflamasyon seviyelerinin artmasına yol açarak, bağışıklık sisteminin normal işleyişini bozabilir. Bu durum, özellikle otoimmün hastalıklar ve alerjik reaksiyonlar gibi bağışıklık sistemi kaynaklı bozuklukların gelişmesine zemin hazırlayabilir. Aynı zamanda mikrobiyota, merkezi sinir sistemiyle etkileşimde bulunarak nörolojik ve nörogelişimsel süreçlere etki edebilir. Bu etkileşim, mikropların bağışıklık hücrelerini aktive ederek, beyin gelişimini ve fonksiyonlarını modüle etmesini sağlar (Sampson & Mazmanian, 2015).Bağırsak mikrobiyotası ile nörogelişimsel hastalıklar arasındaki ilişki giderek daha fazla araştırılmaktadır. Mikrobiyota, sinir sistemi üzerinde etki gösteren nörotransmitterlerin üretimini etkiler, bu da özellikle otizm spektrum

bozukluğu (OSB) gibi nörogelişimsel bozuklukların semptomlarının şiddetini artırabilir. Mikrobiyotanın, beyinde nöroinflamasyonu ve oksidatif stres seviyelerini etkileyebileceği düşünülmektedir. Bu süreçler, nörogelişimsel bozuklukların patofizyolojisinde önemli bir rol oynar. Örneğin, bağırsak mikrobiyotasındaki değişiklikler, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, davranışsal ve sosyal etkileşim bozukluklarını kötüleştirebilir (Hu et al., 2020). Ayrıca, bağışıklık sisteminin düzensiz yanıtları, mikrobiyotayla etkileşerek, beyin gelişimini olumsuz yönde etkileyebilir ve nörogelişimsel hastalıkların seyrini değiştirebilir. Bu bulgular, mikrobiyotaya odaklı tedavi yaklaşımlarının nörogelişimsel hastalıklar üzerindeki potansiyel faydalarını araştıran yeni bir araştırma alanını işaret etmektedir.

### **GUT-Brain Axis ve Otizmdeki Önemi**

Gut-brain axis (GBA), bağırsak mikrobiyotası ile merkezi sinir sistemi arasındaki karşılıklı iletişimi tanımlayan bir terimdir. Bağırsak mikrobiyotası, bağırsaklarda bulunan mikroorganizmaların merkezi sinir sistemiyle doğrudan ve dolaylı yollarla etkileşim kurmasını sağlar. Bu etkileşimler, beyin fonksiyonları, davranışlar ve duygusal durumlar üzerinde belirleyici bir rol oynayabilir (Collins et al., 2019). Mikrobiyotaya, sinir sistemi üzerinde çeşitli yollarla etkili olabilir: Sinirsel yollar, metabolitler (özellikle kısa zincirli yağ asitleri gibi) ve bağışıklık yanıtları bu etkileşimde önemli bir rol oynar. GBA üzerindeki bu etkileşimler, otizm spektrum bozukluğu (OSB) gibi nörogelişimsel hastalıkların patofizyolojisinde kritik bir unsur olarak öne çıkmaktadır. Çeşitli araştırmalar, OSB olan bireylerde bağırsak mikrobiyotasının normalden farklı olduğunu ve bu farklılıkların beyin gelişimi ve fonksiyonları üzerinde etkili olabileceğini göstermektedir (Kang et al., 2017).

Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, bağırsak-beyin ekseninin bozulmuş işleyişi, özellikle gastrointestinal semptomlarla ilişkilendirilmiştir. OSB' olan bireylerin büyük bir kısmı, mide-bağırsak sorunları yaşamakta ve bu sorunlar, sosyal etkileşim ve davranışsal semptomlarla ilişkilendirilebilmektedir. Bağırsak mikrobiyotasında görülen dengesizliklerin, beyin gelişimi üzerinde uzun vadeli etkiler yapabileceği ve otizm semptomlarını şiddetlendirebileceği düşünülmektedir. Örneğin, bağırsakta üretilen bazı metabolitler, merkezi sinir sistemi üzerinde nöroinflamasyon yaratabilir ve otizmde sıkça gözlemlenen davranışsal bozuklukları tetikleyebilir (Luczynski et al., 2017). Ayrıca, GBA'nın işleyişindeki bozulmalar, beyin sosyal, bilişsel ve duygusal işlevleriyle ilişkili bölgelerinin gelişimini etkileyebilir. Bunun sonucunda, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, sosyal etkileşim, dil gelişimi ve empati gibi becerilerde zorluklar yaşanabilir. Bu bulgular, bağırsak mikrobiyotasına yönelik tedavi yaklaşımlarının otizm tedavisinde potansiyel bir strateji olarak değerlendirilmesini desteklemektedir.

### **Diyetin Bağırsak Mikrobiyotası Üzerindeki Etkileri**

#### **Genel Diyet Alışkanlıklarının Mikrobiyota Üzerindeki Rolü**

Otizm spektrum bozukluğu (OSB) olan bireylerde beslenme bozuklukları yaşamın erken dönemlerinde, hatta emzirme döneminde bile başlayabilir. Bu dönemdeki yaygın zorluklar arasında, çocuk tok olsa bile devam eden düzensiz ve şiddetli emme yer alır (Lucas & Cutler, 2015).

Provost ve arkadaşları tarafından yapılan bir araştırma, Otizm spektrum bozukluğu (OSB) olan çocukların genellikle çeşitli ortamlarda yemek yemekte zorlandığını, yarısından fazlasının normal restoranlarda yemek yemede zorluk çektiğini ve arkadaşlarının evinde yemek yerken zorluklarla karşılaştığını ortaya koymuştur (Provost et al., 2010).

Yemeye ilgili zorlukların bir diğer kategorisi, genellikle üç alanla tanımlanan yiyecek seçiciliğidir (FS): yiyecek reddi, sınırlı yiyecek çeşitliliği ve yüksek sıklıkta tek bir yiyecek alımı (Page et al., 2022).

Yapılan bir araştırmalar, diyetin bağırsak mikrobiyotası üzerindeki etkisinin daha derinlemesine incelendiğini göstermektedir. Özellikle, diyetin mikrobiyota çeşitliliğini nasıl şekillendirdiği ve bunun insan sağlığı üzerindeki uzun vadeli etkileri konusunda önemli bulgular elde edilmiştir. 2019'da yayınlanan bir çalışma, bitkisel bazlı diyetlerin, bağırsak mikrobiyotasının çeşitliliğini artırarak Firmicutes ve Bacteroidetes türleri arasındaki dengeyi iyileştirdiğini ortaya koymuştur (Ticinesi et al., 2019). Yüksek lifli diyetler, özellikle meyve, sebze ve tam tahılların, bağırsak mikrobiyotasında faydalı bakteri türlerinin çoğalmasına katkıda bulunurken, aynı zamanda sindirim sisteminin sağlığını desteklemektedir (O'Keefe, 2018). Bunun yanı sıra, yüksek yağlı ve işlenmiş gıdalardan zengin diyetler, bağırsak mikrobiyotasındaki dengeyi bozarak inflamasyona yol açabilir ve bağışıklık sistemini olumsuz etkileyebilir (Ticinesi et al., 2019).

Yapılan bir diğer önemli araştırma, prebiyotik ve probiyotiklerin mikrobiyota üzerindeki etkilerini daha ayrıntılı şekilde incelemiştir. Prebiyotikler, bağırsaklarda faydalı bakterilerin çoğalmasına yardımcı olan liflerdir ve son yıllarda yapılan çalışmalarda prebiyotiklerin, bağırsak mikrobiyotasının kompozisyonunu iyileştirerek sindirim sağlığını ve bağışıklık fonksiyonlarını artırdığı gözlemlenmiştir (Scherer et al., 2021). Özellikle, probiyotikler ve prebiyotiklerle zenginleştirilmiş diyetlerin, mikrobiyota üzerinde olumlu etkiler yarattığı ve bağışıklık sisteminin düzgün çalışmasını desteklediği bulunmuştur. Bununla birlikte, düşük lifli ve zengin işlenmiş gıdalardan oluşan batı tarzı diyetler, Bacteroidetes ve Firmicutes bakterileri arasındaki oranı bozarak bağırsak mikrobiyotasında dengesizliklere yol açabilir ve bu da bağışıklık tepkilerini negatif yönde etkileyebilir (O'Keefe, 2018; Scherer et al., 2021). Bu bulgular, sağlıklı bir bağırsak mikrobiyotasını desteklemek için diyetin kritik bir rol oynadığını ve beslenme düzenindeki değişikliklerin mikrobiyota üzerindeki etkilerini düzelterek sağlık üzerinde olumlu sonuçlar doğurabileceğini vurgulamaktadır.

### **Prebiyotik ve Probiyotiklerin Mikrobiyota Modülasyonundaki Etkisi**

Prebiyotikler ve probiyotikler, bağırsak mikrobiyotasını düzenleyen ve sağlık üzerinde önemli etkiler yaratan iki bileşiktir. Prebiyotikler, bağırsakta yaşayan faydalı bakterilerin büyümesini teşvik eden, vücut tarafından sindirilemeyen bileşiklerdir. Prebiyotiklerin bağırsak sağlığını iyileştirdiği ve bağışıklık fonksiyonlarını artırdığı gösterilmiştir. 2021'de yapılan bir çalışma, inulin ve frukto-oligosakkaritlerin (FOS) prebiyotiklerin, bağırsak mikrobiyotasındaki Bifidobacterium ve Lactobacillus türlerini artırarak, bağırsak sağlığını iyileştirdiğini ve bağışıklık sisteminin yanıtını optimize ettiğini ortaya koymuştur. Prebiyotikler, aynı zamanda kısa zincirli yağ asitleri (SCFA'lar) üretimini artırarak bağırsak bariyerini güçlendirir ve inflamasyonu azaltır. Bu etki, sindirim sağlığını iyileştirmenin yanı sıra, nörolojik sağlığı destekleyebilir, çünkü SCFA'lar, beyinde inflamasyonu azaltmaya yardımcı olabilir (González-González et al., 2022).

Probiyotikler, bağırsaklara doğrudan eklenen canlı mikroorganizmalardır ve genellikle Lactobacillus ve Bifidobacterium türleri gibi yararlı bakterileri içerir. Probiyotiklerin, mikrobiyota üzerinde doğrudan etkisi olduğu ve birçok gastrointestinal bozukluğun tedavisinde faydalı olduğu bulunmuştur. 2020'de yapılan bir çalışma, probiyotiklerin, inflamatory bowel disease (IBD) gibi hastalıkların tedavisinde etkinliğini artırdığını ve bağışıklık tepkilerini düzenlediğini göstermiştir (Hidalgo et al., 2020). Ayrıca, probiyotiklerin beyin-gut eksenini (GBA) üzerindeki etkileri de giderek daha fazla araştırılmaktadır. Probiyotiklerin, nörogelişimsel hastalıklar ve nörolojik bozuklukların semptomlarını iyileştirdiği düşünülmektedir. Özellikle Lactobacillus rhamnosus türü, otizm spektrum bozukluğu (OSB) ve anksiyete gibi durumlarda davranışsal iyileşme sağlamakta faydalı olabilmektedir (Ng, et al., 2021)

Prebiyotikler ve probiyotikler birlikte kullanıldığında, sinerjik etkiler göstererek bağırsak mikrobiyotasını modüle etmede daha büyük bir etki yaratabilirler. 2021 yılında yapılan bir çalışmada, prebiyotik ve probiyotiklerin kombinasyonunun, bağırsak mikrobiyotasının çeşitliliğini artırdığı, bağışıklık fonksiyonlarını iyileştirdiği ve inflamasyonu azalttığı gösterilmiştir (Qiao et al., 2021). Bu

sinerjik etki, bağışıklık sistemi üzerinde güçlendirici bir etki sağlarken, aynı zamanda sinir sistemi üzerinde olumlu değişikliklere de yol açabilir. Mikrobiyota ile beyin arasındaki etkileşimlerin daha fazla keşfi, prebiyotik ve probiyotiklerin nörolojik sağlık üzerindeki potansiyel faydalarını daha iyi anlamamıza olanak tanımaktadır.

### **Spesifik Diyet Modellerinin (Glutensiz-Kazeinsiz, Ketojenik vb.) Mikrobiyota Üzerindeki Etkisi**

Son yıllarda, belirli diyet modellerinin bağırsak mikrobiyotası üzerindeki etkileri dikkatle araştırılmaktadır. Bu diyetler, özellikle nörogelişimsel ve metabolik hastalıkların tedavisinde önemli bir rol oynamaktadır. Glutensiz-Kazeinsiz (GFCF) diyetler, Ketojenik diyeti ve GAPS (Gut and Psychology Syndrome) diyeti, bağırsak mikrobiyotasını modüle etmek ve nörolojik semptomları iyileştirmek amacıyla popüler seçenekler arasında yer alır. Bu diyetlerin mikrobiyota üzerindeki etkileri, bağışıklık sisteminin düzenlenmesinden inflamasyonun azaltılmasına kadar geniş bir etki yelpazesi sunmaktadır.

#### **Glutensiz-Kazeinsiz (GFCF) Diyetler**

Gluten ve kazein, sırasıyla buğday ve süt ürünlerinde bulunan proteinlerdir ve özellikle otizm spektrum bozukluğu (OSB) gibi nörogelişimsel hastalıklarla ilişkilendirilen semptomların yönetiminde glutensiz-kazeinsiz (GFCF) diyetler sıklıkla tercih edilmektedir. Bu diyetin mikrobiyota üzerindeki etkileri son yıllarda yapılan çalışmalarda ele alınmıştır. 2020 yılında yapılan bir çalışmada, GFCF diyetlerinin Bacteroidetes türlerinin artışı ve Firmicutes türlerinin azalmasını sağladığı gözlemlenmiştir (Keller, et al., 2021). Bu değişiklikler, mikrobiyota dengesini iyileştirerek, bağırsak sağlığını ve bağışıklık fonksiyonlarını destekleyebilir. Ayrıca, GFCF diyetleri, bağırsakta kısa zincirli yağ asitleri (SCFA'lar) üretimini artırarak, nörolojik sağlık üzerinde de olumlu bir etki yapabilir. SCFA'lar, özellikle butirat ve asetat, bağırsak bariyerini güçlendirir ve beyin-gut eksenini aracılığıyla nöroinflamasyonu azaltabilir.

#### **Ketojenik Diyetler**

Ketojenik diyet, yüksek yağ, düşük karbonhidrat içeren ve protein oranı kontrolü sağlayan bir diyettir. Bu diyet, enerji kaynağı olarak keton cisimlerinin kullanılmasını teşvik eder ve nörolojik hastalıkların yönetiminde sıklıkla tercih edilir. Ketojenik diyetin bağırsak mikrobiyotasındaki etkileri üzerine yapılan araştırmalar, ketojenik diyeti uygulayan bireylerde Firmicutes türlerinin artışı ve Bacteroidetes türlerinin azalması gibi mikrobiyota değişiklikleri gözlemlenmiştir (Rew et al., 2022). Bu değişiklik, bağırsak bariyerinin güçlenmesine ve bağışıklık fonksiyonlarının iyileşmesine yardımcı olabilir. 2023'de yapılan bir başka araştırmada, ketojenik diyeti uygulayan bireylerin mikrobiyotasındaki bu tür değişikliklerin, nörolojik hastalıklar ve inflamasyonun yönetiminde etkili olabileceği belirtilmiştir (Li et al., 2023).

Ketojenik diyet, bağırsaklarda butirat gibi kısa zincirli yağ asitlerinin üretimini artırarak inflamasyonu azaltabilir ve beyin-gut eksenini aracılığıyla nörolojik sağlığı iyileştirebilir. Ayrıca, ketojenik diyetin otizm, depresyon ve epilepsi gibi nörolojik bozukluklarda potansiyel faydalar sağladığı düşünülmektedir.

#### **GAPS Diyeti**

GAPS (Gut and Psychology Syndrome) Diyeti, bağırsak sağlığını iyileştirmeyi ve psikiyatrik hastalıkların semptomlarını hafifletmeyi amaçlayan özel bir beslenme modelidir. Bu diyet, bağırsak mikrobiyotası üzerinde önemli değişiklikler yaratmak amacıyla, gluten, kazein, şeker, nişasta ve

işlenmiş gıdalardan kaçınmayı, kemik suyu, sebzeler, et, balık ve sağlıklı yağlar gibi besinleri vurgular. GAPS diyeti, bağırsak florasındaki disbiyozisi düzeltmeye ve beyin-gut eksenini aracılığıyla psikiyatrik semptomları iyileştirmeye yardımcı olabilir.

2020 yılında yapılan bir çalışmada, GAPS diyeti uygulayan bireylerin bağırsak mikrobiyotasında pozitif değişiklikler ve psikiyatrik semptomlarda belirgin bir iyileşme gözlemlenmiştir (Holsinger et al., 2020). Bu diyeti uygulayan bireylerde, özellikle Bifidobacterium ve Lactobacillus türlerinin artışı gözlemlenmiş ve bu bakteriler bağırsak bariyerinin güçlenmesine, inflamasyonun azalmasına ve bağışıklık fonksiyonlarının düzenlenmesine katkı sağlamıştır. Ayrıca, butirat gibi kısa zincirli yağ asitlerinin üretimi de bu diyetin olumlu etkileri arasında sayılabilir.

GAPS diyeti, özellikle otizm spektrum bozukluğu (OSB), depresyon, anksiyete gibi psikiyatrik rahatsızlıkların tedavisinde faydalı olabileceği düşünülmektedir. 2019'da yapılan bir araştırma, GAPS diyeti uygulayan bireylerde davranışsal ve bilişsel iyileşmelerin yanı sıra bağırsak mikrobiyotasındaki dengeyi de iyileştirdiğini göstermiştir (Holsinger et al., 2019).

### **Sonuç ve Potansiyel Tedavi Seçenekleri**

Glutensiz-Kazeinsiz (GFCF), ketojenik ve GAPS gibi spesifik diyet modellerinin bağırsak mikrobiyotası üzerinde önemli etkileri olduğu anlaşılmaktadır. Bu diyetler, mikrobiyota çeşitliliğini artırarak, inflamasyonu azaltabilir, bağışıklık fonksiyonlarını iyileştirebilir ve nörolojik sağlık üzerinde olumlu etkiler yapabilir. Özellikle nörogelişimsel ve psikiyatrik bozukluklar için, bu diyetler alternatif tedavi seçenekleri sunabilir. Bununla birlikte, bu diyetlerin uzun dönem etkileri ve her birey üzerindeki etkisi kişiselleştirilmiş yaklaşımlar gerektirmektedir.

### **Diyet ve Mikrobiyota Değişimlerinin Nörogelişimsel ve Davranışsal Sonuçları Mikrobiyota Değişiminin Sosyal Davranış ve Bilişsel Fonksiyonlara Etkisi**

Bağırsak mikrobiyotası, son yıllarda, yalnızca sindirim sistemi sağlığı ile değil, aynı zamanda nörogelişimsel ve davranışsal sağlık ile de doğrudan ilişkili olduğu bir alan olarak dikkat çekmiştir. Özellikle otizm spektrum bozukluğu (OSB) gibi nörogelişimsel bozukluklar üzerinde yapılan araştırmalar, mikrobiyota değişimlerinin, sosyal davranışlar, bilişsel fonksiyonlar ve nörolojik semptomlar üzerinde önemli etkiler yaratabileceğini göstermektedir. Bu bölümde, diyet ve mikrobiyota değişimlerinin, sosyal etkileşimler, bilişsel gelişim ve davranışsal semptomlar üzerindeki etkileri ele alınacaktır.

Mikrobiyota modülasyonu ile ilgili yapılan araştırmalar, probiyotik ve prebiyotik takviyelerinin, özellikle Lactobacillus ve Bifidobacterium türlerinin, sosyal etkileşimleri iyileştirebileceğini ortaya koymuştur. 2025'de yapılan bir çalışmada, probiyotik takviyelerinin Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, sosyal becerilerde belirgin iyileşmelere yol açtığı gösterilmiştir (Nugent et al., 2024). Probiyotiklerin, bağışıklık sistemini düzenleyerek ve beyin-gut eksenini modüle ederek sosyal davranışları iyileştirmesi beklenmektedir.

### **Mikrobiyota Değişiminin Bilişsel Fonksiyonlara Etkisi**

Mikrobiyota, yalnızca davranışsal bozuklukları değil, aynı zamanda bilişsel fonksiyonları da etkileyebilir. Bağırsak mikroflorasındaki değişiklikler, öğrenme yeteneklerini, hafızayı ve genel bilişsel işlevleri etkileyebilir. Yapılan çalışmalar, özellikle Lactobacillus ve Bifidobacterium türlerinin, beyin gelişimini ve bilişsel fonksiyonları iyileştirdiğini göstermektedir. Bu türler, bağırsaklardan beynimize giden sinyalleri iyileştirerek, nörolojik sağlığı optimize eder.

2018 yılında yayımlanan bir araştırmada, farelerde probiyotik takviyeleri uygulandıktan sonra, bilişsel testlerde belirgin bir iyileşme gözlemlenmiştir (Zhou et al., 2018). Bu çalışmada, probiyotiklerin hafıza ve öğrenme üzerinde olumlu etkiler yaratmasının yanı sıra, kognitif işlevlerin iyileşmesine de katkı sağladığı bulunmuştur. Mikrobiyota ve bilişsel fonksiyon arasındaki bu ilişki, özellikle nörogelişimsel bozuklukların tedavisinde mikrobiyota modülasyonunun önemini vurgulamaktadır.

Bağırsak mikrobiyotası, serotonin, dopamin ve GABA gibi nörotransmitterlerin sentezi üzerinde etkili olabilir. Bu nörotransmitterler, öğrenme ve hafıza gibi bilişsel işlevleri doğrudan etkileyen maddelerdir. Mikrobiyota, bağırsak ve beyin arasında bu kimyasalları düzenleyerek, bilişsel işlevlerin iyileşmesini teşvik edebilir. 2020’de yapılan bir başka çalışmada, probiyotik takviyelerinin, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, bilişsel ve dil becerilerini geliştirmeye yardımcı olabileceği öne sürülmüştür (Harris et al., 2020).

### **Mikrobiyota ve Davranışsal Sonuçlar**

Mikrobiyota değişikliklerinin, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, davranışsal semptomlar üzerindeki etkisi, mikrofloranın nöroinflamasyon, sinirsel gelişim ve beyin kimyası üzerindeki modülatör etkisiyle bağlantılıdır. Bağırsak mikrobiyotası, beyin gelişiminde kritik bir rol oynayabilir; dolayısıyla mikrobiyotadaki bozukluklar, anksiyete, depresyon, hiperaktivite, saldırganlık gibi davranışsal semptomların şiddetini artırabilir.

Mikrobiyota modülasyonu, bağırsak ve beyin arasındaki iletişimi iyileştirerek, nöroinflamasyonu azaltabilir ve serotonin, dopamin gibi nörotransmitter seviyelerini optimize edebilir. Yapılan çalışmalarda, probiyotik ve prebiyotik takviyelerinin, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, anksiyete, saldırganlık ve dikkat eksikliği gibi semptomlarda önemli iyileşmeler sağladığı gözlemlenmiştir (Santocchi et al., 2020). Probiyotiklerin mikrobiyota dengesini iyileştirerek, davranışsal bozuklukları ve anksiyeteyi azaltma potansiyeli, bu alanda yapılan araştırmaların temel odaklarından biridir.

### **Sonuçlar ve Gelecek Perspektifleri**

Bağırsak mikrobiyotası ve beyin-gut ekseninin, sosyal davranışlar, bilişsel fonksiyonlar ve davranışsal semptomlar üzerindeki etkileri, otizm gibi nörogelişimsel bozuklukların tedavisinde önemli bir araştırma alanı oluşturmuştur. Mikrobiyota modülasyonu, sosyal etkileşimleri iyileştirebilir, bilişsel fonksiyonları güçlendirebilir ve davranışsal semptomları azaltabilir. Bununla birlikte, bu etkilerin daha iyi anlaşılması için daha fazla klinik çalışmaya ve uzun dönemli araştırmalara ihtiyaç vardır. Mikrobiyota ve nörogelişimsel bozukluklar arasındaki ilişkiyi derinlemesine incelemek, kişiselleştirilmiş tedavi yaklaşımlarının geliştirilmesine yardımcı olabilir.

### **Bağırsak Sağlığı ve OSB Belirtileri Arasındaki İlişki**

Bağırsak sağlığı ve Otizm Spektrum Bozukluğu (OSB) arasındaki ilişki, son yıllarda yapılan araştırmalarla giderek daha fazla gündeme gelmiştir. Otizm Spektrum Bozukluğu (OSB) olan bireylerde, gastrointestinal (GI) problemler ve bağırsak mikrobiyotasındaki dengesizlikler yaygın olarak gözlemlenmektedir. Çalışmalar, bağırsak mikrobiyotası ile OSB belirtileri arasında belirgin bir ilişki olduğunu göstermektedir. Özellikle Bacteroides ve Firmicutes gibi bakteri türlerinin dengesizlikleri, bağırsaklardaki inflamasyonu artırabilir ve beyin fonksiyonlarını olumsuz etkileyebilir (Finegold et al., 2017). Ayrıca, bağırsak mikrobiyotası ile merkezi sinir sistemi arasındaki etkileşimleri açıklayan gut-brain eksenini teorisi, OSB’nin nörolojik ve davranışsal semptomlarını anlamada önemli bir çerçeve sunmaktadır (Gürbüz et al., 2021).

Bağırsak mikrobiyotası, yalnızca sindirim sistemi sağlığını değil, aynı zamanda nörolojik sağlığı da etkileyebilecek bir faktördür. Otizm spektrum bozukluğu (OSB) ile ilişkili bazı bağırsak mikrobiyota değişiklikleri, merkezi sinir sisteminin gelişimini ve davranışsal semptomları etkileyebilir. Yapılan bir çalışmada, bağırsak mikrobiyotasındaki disbiyozisin, Otizm Spektrum Bozukluğu (OSB) bireylerde artan anksiyete, sosyal beceri zorlukları ve dikkat eksikliği gibi belirtilerle ilişkili olduğu bildirilmiştir (Jiang et al., 2015). Mikrobiyota dengesizlikleri, sinirsel inflamasyonu tetikleyerek beyin fonksiyonlarını bozar ve bu durum, özellikle Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, sosyal etkileşim zorluklarını artırabilir (Sivieri et al., 2021).

Bağırsak sağlığı, sosyal davranışları doğrudan etkileyebilen önemli bir faktördür. Bağırsak mikroflorası, beyin gelişimini ve davranışsal düzenlemeleri etkileyen nörotransmitterlerin üretimini modüle eder. Özellikle serotonin ve dopamin gibi nörotransmitterlerin bağırsakta üretilmesi, ruh hali ve sosyal etkileşimler üzerinde önemli bir rol oynar. Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, bağırsak mikrobiyotasındaki disbiyozisin, sosyal etkileşimlerdeki güçlükleri artırabileceği öne sürülmektedir. Probiyotiklerin, bağırsak sağlığını iyileştirerek sosyal becerileri artırabileceği konusunda bazı olumlu bulgular vardır (Santocchi et al. 2020), probiyotik takviyelerinin, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, sosyal becerileri ve genel davranışları iyileştirmeye yardımcı olabileceğini belirtmiştir.

Bağırsak mikrobiyotasındaki değişiklikler, bilişsel işlevler üzerinde de etkili olabilir. Bağırsak mikroflorası, beyin sağlığını etkileyen nörolojik metabolitlerin üretimini artırabilir. Özellikle kısa zincirli yağ asitleri (SCFA'lar), bağırsakta üretilerek merkezi sinir sistemi üzerinde iyileştirici etki yapar. Butirat gibi SCFA'lar, nöroinflamasyonu azaltarak beyin gelişimini ve bilişsel fonksiyonları iyileştirebilir. 2020'de yapılan bir çalışmada, bağırsak mikrobiyotasındaki dengesizliklerin Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, bilişsel bozuklukları tetikleyebileceği, bunun da mikroflora modülasyonu ile iyileştirilebileceği belirtilmiştir (Liu et al., 2020). Bu, bağırsak sağlığının bilişsel işlevler üzerinde doğrudan bir etkisi olduğunu gösteren önemli bir bulgudur.

Bağırsak sağlığındaki bozulmalar, özellikle Otizm Spektrum Bozukluğu (OSB) olan bireylerde davranışsal semptomları kötüleştirir. Gastrointestinal (GI) sorunlar, anksiyeteyi ve stres seviyelerini artırarak, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, davranışsal bozuklukları tetikleyebilir. Bağırsak-beyin eksenini üzerinden yapılan etkileşimler, sinirsel inflamasyonu artırabilir ve bu da davranışsal semptomların şiddetlenmesine yol açabilir. Yapılan bir çalışma, probiyotik ve prebiyotik takviyelerinin, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, aşırı hareketlilik, saldırganlık ve diğer olumsuz davranışları azalttığını bulmuştur (Kozielecka et al., 2021). Bu bulgular, bağırsak sağlığının, davranışsal düzenlemeleri ve genel yaşam kalitesini iyileştirme potansiyeline sahip olduğunu göstermektedir.

Bağırsak sağlığı ve Otizm Spektrum Bozukluğu arasındaki ilişki, giderek daha fazla araştırılan önemli bir konu olmuştur. Bağırsak mikrobiyotası ve gastrointestinal problemler, sosyal etkileşimler, bilişsel fonksiyonlar ve davranışsal semptomlar ile doğrudan ilişkilidir. Bağırsak sağlığının iyileştirilmesi ve mikrobiyota modülasyonu, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, belirtilerin hafifletilmesine yardımcı olabilir. Gelecekte, mikrobiyota ve OSB arasındaki ilişkinin daha iyi anlaşılması, tedavi yaklaşımlarının kişiye özel hale getirilmesine katkı sağlayacaktır.

### **Klinik Bulgular ve Literatürden Örnekler**

Bağırsak mikrobiyotasındaki dengesizlikler ve gastrointestinal sorunlar, Otizm Spektrum Bozukluğu (OSB) olan bireylerde sıkça gözlemlenen ve klinik olarak önemli bulgulardır. Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, genellikle sindirim sistemi problemleri (kabızlık, şişkinlik, ishal) yaşamaktadır ve bu durumların, otizmin temel belirtilerine benzer şekilde nörogelişimsel bozuklukları şiddetlendirdiği düşünülmektedir. (Chistolini et al., 2020), bağırsak mikrobiyotasındaki

disbiyozisin, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, davranışsal değişikliklere ve özellikle sosyal etkileşim sorunlarına yol açabileceğini ortaya koymuşlardır. Ayrıca, (Santocchi, et al., 2020), gastrointestinal semptomların, çocuklarda otizmle ilişkili sosyal becerilerin zayıflamasına yol açtığını belirtmiştir. Bu bulgular, bağırsak sağlığı ile davranışsal ve sosyal fonksiyonlar arasındaki güçlü ilişkiyi desteklemektedir. Bağırsak mikrobiyotasındaki bozulmaların, sosyal etkileşim, dil gelişimi ve davranışsal semptomların şiddetini artırdığı, klinik gözlemlerle de desteklenmektedir.

Günümüzde yapılan araştırmalar, bağırsak mikrobiyotasının modülasyonunun Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, semptomların iyileşmesinde potansiyel bir tedavi aracı olabileceğini göstermektedir. (Song et al., 2023), probiyotik ve prebiyotik takviyelerinin Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, gastrointestinal semptomları azaltabileceğini ve sosyal etkileşim becerilerini iyileştirebileceğini ortaya koymuştur. ( Fukui et al., 2021), mikrobiyota modülasyonunun, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, sinirsel ve davranışsal gelişimi iyileştirdiğini rapor etmiştir. Bağırsak sağlığındaki iyileşme ile bilişsel ve sosyal davranışların geliştiği gözlemlenmiş ve bu durum, Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, yaşam kalitesini artırmaya yönelik potansiyel tedavi yaklaşımlarını işaret etmektedir.

## Güncel Araştırmalar ve Gelecek Perspektifler

### Mevcut Literatürdeki Boşluklar

Son yıllarda, Otizm Spektrum Bozukluğu (OSB) ve bağırsak mikrobiyotası arasındaki ilişki üzerine yapılan araştırmalar önemli bir ivme kazanmıştır. Ancak, mevcut literatürde hala bazı boşluklar ve eksiklikler bulunmaktadır. Çoğu çalışma, mikroorganizma türleri arasındaki dengenin ve bağırsak-beyin ekseninin OSB semptomlarını nasıl etkilediğine dair sınırlı bilgi sunmaktadır. Örneğin, mikrobiyota değişikliklerinin farklı otizm alt gruplarında nasıl farklılıklar gösterdiği veya spesifik bağırsak patojenlerinin OSB üzerindeki uzun vadeli etkileri hakkında daha fazla araştırma yapılması gerekmektedir. OSB'deki mikrobiyota değişimlerinin klinik semptomlarla olan ilişkisini belirlemede kullanılan yöntemlerin heterojenliğine dikkat çekmiş ve daha tutarlı veri setlerinin oluşturulmasının gerekliliğini vurgulamıştır. Ayrıca, bağırsak mikrobiyotasının nörolojik gelişim üzerindeki etkileri hakkında daha fazla etkileşimli ve prospektif çalışmaların yapılması gerektiği ifade edilmiştir.

Bir diğer eksiklik ise, bağırsak mikrobiyotasındaki değişimlerin tedavi süreçlerine entegrasyonu konusundadır. Bugüne kadar yapılan çalışmalarda probiyotikler ve prebiyotiklerin otizm semptomlarını iyileştirmeye yönelik potansiyeli gösterilmiş olsa da bu tedavi yöntemlerinin etkinliği ve güvenliği hakkında kesin sonuçlar çıkarılmamıştır (He et al., 2024), mikrobiyota modülasyonunun tedavi süreçlerindeki rolüne dair sınırlı sayıda klinik çalışma bulunduğunu belirtmiş ve gelecekte daha fazla randomize kontrollü çalışmanın yapılması gerektiğini önermiştir. Ayrıca, bağırsak sağlığının iyileştirilmesiyle elde edilecek potansiyel davranışsal ve bilişsel faydaların her bireyde farklılık gösterebileceği, bu nedenle kişiye özel tedavi yaklaşımlarının önem kazanacağı vurgulanmıştır. Bu boşlukları gidermek, otizm tedavisinde mikrobiyota odaklı yenilikçi ve etkili stratejiler geliştirilmesine olanak tanıyacaktır.

### Gelecekteki Araştırma Yönelimleri

Gelecekteki araştırmalar, Otizm Spektrum Bozukluğu (OSB) ve bağırsak mikrobiyotası arasındaki ilişkinin daha derinlemesine anlaşılmasına odaklanmalıdır. İlk olarak, bağırsak mikrobiyotasının çeşitli alt gruplardaki bireylerdeki rolü ve bunun OSB'nin klinik semptomlarıyla nasıl etkileşime girdiği konusunda daha fazla veri toplanması gerekmektedir. Yapılan bir çalışmada, mikrobiyota değişimlerinin otizm alt gruplarına göre farklılıklar gösterebileceği vurgulanmış ve kişiye özel tedavi yaklaşımlarının geliştirilmesi gerektiği ifade edilmiştir. Gelecekte, mikrobiyota profillemesi ve

biyomarkers kullanılarak, her bireyin mikrobiyota yapısının özelleştirilmesi ve buna dayalı kişiselleştirilmiş tedavi yaklaşımlarının geliştirilmesi önem kazanacaktır (Tye et al., 2023)

Bir diğer önemli araştırma yönelimi, bağırsak mikrobiyotası ile merkezi sinir sistemi arasındaki etkileşimlerin daha ayrıntılı bir şekilde incelenmesidir (Młynarska et al., 2025) Bağırsak mikroflorasındaki dengesizliklerin, merkezi sinir sistemi üzerinde inflamatuvar bir yanıt başlatarak Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, nörolojik gelişimsel bozuklukları tetikleyebileceğini öne sürmüştür. Bu bağlamda, gut-brain axis üzerine yapılacak daha fazla araştırma, bağırsak sağlığının beyin gelişimi, bilişsel fonksiyonlar ve davranışsal düzenlemeler üzerindeki etkilerini anlamamıza yardımcı olacaktır. Ayrıca, bağırsak mikrobiyotasının nörotransmitter üretimi, bağışıklık sistemi aktivasyonu ve nöroinflamasyon üzerindeki etkileri daha ayrıntılı bir şekilde incelenmelidir.

Bir diğer potansiyel araştırma alanı, mikrobiyota modülasyonuna dayalı tedavi yöntemlerinin uzun dönemli etkilerinin incelenmesidir. Şu anda, probiyotikler, prebiyotikler ve özel diyetlerin otizm semptomları üzerindeki etkisi üzerine çeşitli çalışmalar yapılmıştır, ancak bu tedavi yöntemlerinin uzun süreli etkileri hala netleşmemiştir (Shen et al., 2021). Bu tür tedavi yöntemlerinin etkinliğini ve güvenliğini değerlendiren daha kapsamlı ve uzun vadeli klinik çalışmalara ihtiyaç duyulduğunu belirtmiştir. Ayrıca, mikrobiyota modülasyonunun Otizm Spektrum Bozukluğu (OSB) olan çocuklarda, bilişsel, sosyal ve davranışsal gelişimini iyileştirme potansiyelinin her birey için farklılık gösterebileceği göz önünde bulundurulmalıdır.

Son olarak, genetik, çevresel ve mikrobiyal etkileşimlerin birlikte ele alınarak daha bütünsel bir yaklaşım geliştirilmesi gerektiği vurgulanmaktadır (Alharthi et al., 2022). Genetik faktörlerin ve çevresel etkenlerin, mikrobiyota üzerinde nasıl etkiler yaratabileceğini ve bunun OSB'nin gelişimiyle nasıl ilişkilendirilebileceğini araştırmanın önemli bir yönü olduğunu belirtmişlerdir. Bağırsak mikrobiyotası ile OSB arasındaki etkileşimlerin genetik ve çevresel faktörlerle nasıl şekillendiğini anlamak, gelecekteki tedavi yaklaşımlarını daha etkili ve bireye özel hale getirebilir.

### **Diyet ve Mikrobiyota Temelli Tedavilerin Potansiyeli**

Bağırsak mikrobiyotası, otizm spektrum bozukluğu (OSB) olan çocuklarda gastrointestinal semptomlar ve davranışsal belirtiler üzerinde etkili bir hedef olarak değerlendirilmektedir. Prebiyotik, probiyotik ve sinbiyotik kullanımına yönelik sistematik incelemeler, bu yaklaşımların mikrobiyota bileşimini olumlu yönde değiştirebileceğini; gastrointestinal rahatsızlıkları hafifletip bazı OSB ilişkili davranışlarda iyileşme sağlayabileceğini öne sürmektedir Bununla birlikte, bu kanıtlar daha çok başlangıç seviyesinde olup, mevcut çalışmaların çoğu küçük örneklem hacmine sahip, metodolojik olarak heterojen ve uzun vadeli etkileri net olarak ortaya koyamamaktadır (Milani et al., 2021).

### **Mikrobiyota Transferi ve Ketojenik Diyet Yaklaşımları**

Mikrobiyota transferi (FMT) yöntemine ilişkin açık etiketli çalışmalar hem gastrointestinal hem de otizme özgü davranışsal belirtilerde önemli iyileşmeler olduğunu göstermiştir. Bu iyileşmenin tedavi sonrası takipte de sürdürülebildiği bildirilmektedir. Öte yandan ketojenik diyet (KD) temelinde yürütülen pilot çalışmalar, uygulama sürecinde inflamatuvar belirteçlerde azalma, butirat kinaz ekspresyonunda artış ve bazı mikrobiyal gen aktivitelerinde değişiklikler gibi olumlu mikrobiyota etkileri göstermiştir. Bununla birlikte, bu diyetlerin sürdürülebilirliği, beslenme dengesine etkisi ve uzun dönemli sonuçlarıyla ilgili daha fazla kontrollü araştırmaya ihtiyaç duyulmaktadır (Shen, Liu, & Ji, 2021).

### **Mekanizma ve Kişiselleştirme Perspektifi**

Prebiyotik ve probiyotik müdahalelerin etkileri, özellikle bağırsak–beyin eksenini aracılığıyla, spesifik mikrobiyal metabolitlerin (örneğin kısa zincirli yağ asitleri - SCFA’lar) ve immün sistem regülasyonunun modülasyonu üzerinden etki gösterebilir (Adams et al., 2011; Gupta & Nair, 2021). SCFA dengesizlikleri ve triptofan metabolitlerindeki değişiklikler, OSB’nin bazı nörobiyolojik patolojileriyle ilişkilendirilmiştir. Ayrıca, farklı probiyotik suşları farklı mekanizmalarla etki gösterebilir; örneğin *Lactobacillus rhamnosus* GG immün sistemi düzenlerken, *Bifidobacterium longum* vagus siniri üzerinden nörotransmitter sentezini etkileyebilir. Bu bağlamda, bireysel mikrobiyota profili, genetik yapı ve çevresel faktörlerle birlikte değerlendirildiğinde, kişiselleştirilmiş mikrobiyota temelli tedavi stratejilerinin geliştirilmesi büyük önem taşımaktadır .

## SONUÇ

Son yıllarda yapılan çeşitli çalışmalar, otizm spektrum bozukluğu (OSB) olan bireylerde görülen sindirim sistemi sorunları ile davranışsal belirtiler arasında güçlü bir ilişki olduğunu ortaya koymuştur. Bu kapsamda, probiyotikler, prebiyotikler, sinbiyotikler ve dışkı mikrobiyota transplantasyonu (FMT) gibi müdahaleler ile bağırsak mikrobiyotasının düzenlenmesinin OSB semptomlarını hafifletme potansiyeli taşıdığı öne sürülmektedir. Bazı klinik araştırmalarda bu müdahalelerin, sosyal etkileşim, iletişim becerileri ve davranış düzenleme gibi alanlarda iyileşmelere yol açtığı rapor edilmiştir. Bununla birlikte, farklı çalışmalarda kullanılan yöntemlerin, müdahale sürelerinin ve mikrobiyal suşların çeşitliliği nedeniyle elde edilen sonuçlar arasında tutarsızlıklar gözlemlenmektedir.

Mikrobiyotaya yönelik tedavilerin, bağışıklık sistemi yanıtları, nörotransmitter dengeleri ve vagus siniri üzerinden beyin-bağırsak eksenini aracılığıyla etki ettiği düşünülmektedir. Ancak bu mekanizmaların tam olarak nasıl işlediği hâlâ net değildir. Ayrıca, mevcut çalışmaların birçoğu küçük örneklem gruplarına ve kısa süreli izleme periyotlarına dayanmaktadır. Bu nedenle, bağırsak mikrobiyotasını hedef alan yaklaşımların OSB tedavisindeki rolünü daha iyi anlayabilmek için, daha büyük ölçekli, kontrollü ve uzun vadeli çalışmalar yapılması gerekmektedir.

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## DİRENÇ EGZERSİZİ ÖNCESİ KAFEİN TÜKETİMİNİN EGZERSİZ SONRASI TOPARLANMA SÜRECİNDE KALP ATIM HIZI DEĞİŞKENLİĞİNE ETKİLERİ: SİSTEMATİK BİR DERLEME

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### ÖZET

Bu derlemenin amacı, direnç egzersizi öncesi kafein tüketiminin egzersiz sonrası toparlanma sürecinde kalp atım hızı değişkenliği (HRV) üzerine etkilerini inceleyen mevcut literatürü değerlendirmektir. Çalışma, PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) yönergeleri dikkate alınarak yürütülmüştür. PubMed, Google Scholar ve Web of Science veri tabanlarında resistance training, resistance exercise, caffeine, ergogenic aid, heart rate variability, cardiac autonomic modulation, autonomic recovery, parasympathetic activation, sympathetic activation olmak üzere 9 İngilizce anahtar kelimeleri kullanılarak tarama yapılmıştır. PRISMA protokolü dahilinde 2254 çalışmadan yinelenen çalışmalar çıkarılmış, başlık ve özet incelemesi sonrası 15 tam metin makale değerlendirmeye alınmıştır. Nihai olarak dahil etme kriterlerini karşılayan 2 makale analize dâhil edilmiştir. Çalışmalar, makale, katılımcı, kafein protokolü, egzersiz protokolleri, HRV ölçüm yöntemleri ve bulgular açısından değerlendirilmiştir. Bir çalışmada, 4.21 mg/kg kafein tüketiminin ardından uygulanan yüksek hacimli direnç egzersizi sonrası 30dk süresince parasempatik yeniden aktivasyonun geciktiği ve sempatik baskınlığın daha uzun sürdüğü bulunmuştur. Buna karşılık, diğer çalışmada 3 mg/kg ve 6 mg/kg kafein dozlarının egzersiz sonrası HRV parametreleri üzerinde anlamlı bir etkisi olmadığı bildirilmiştir. Ancak bu çalışmada egzersiz sonrası HRV'nin ne kadar süreyle takip edildiğinin belirtilmemesi, sonuçların yorumlanmasında önemli bir kısıtlılık oluşturmuştur. Sonuç olarak, mevcut literatürde, direnç egzersizi öncesi kafein tüketiminin egzersiz sonrası toparlanma sürecinde HRV üzerindeki etkileri çelişkilidir. Çalışmaların bulgularındaki tutarsızlıklar nedeni olarak metodolojik farklılıklar, farklı kafein dozları, katılımcı özellikleri, egzersiz protokolleri ve ölçüm süreleri olduğu düşünülmektedir. Bu konuda, standartlaştırılmış protokoller ve uzun süreli HRV takipleri içeren metodolojik olarak güçlü çalışmalara ihtiyaç duyulmaktadır.

**Anahtar kelimeler:** Kafein, direnç egzersizi, toparlanma, kalp atım hızı değişkenliği, otonom sinir sistemi

### EFFECTS OF CAFFEINE CONSUMPTION BEFORE RESISTANCE EXERCISE ON HEART RATE VARIABILITY DURING POST-EXERCISE RECOVERY: A SYSTEMATIC REVIEW

#### ABSTRACT

The aim of this review is to evaluate the current literature examining the effects of caffeine consumption prior to resistance exercise on heart rate variability (HRV) during the post-exercise recovery period. The review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. A comprehensive search was conducted in the PubMed, Google Scholar, and Web of Science databases using nine English

keywords: resistance training, resistance exercise, caffeine, ergogenic aid, heart rate variability, cardiac autonomic modulation, autonomic recovery, parasympathetic activation, and sympathetic activation. Duplicates were removed from 2254 studies within the PRISMA protocol, and 15 full-text articles were evaluated after title and abstract review. Two articles that met the inclusion criteria were ultimately included in the analysis. The studies were evaluated in terms of publication details, participants, caffeine protocols, exercise protocols, HRV measurement methods, and findings. One study reported that following the ingestion of 4.21 mg/kg of caffeine, high-volume resistance exercise delayed parasympathetic reactivation and prolonged sympathetic dominance during the 30-minute recovery period. In contrast, the other study found no significant effects of 3 mg/kg and 6 mg/kg caffeine doses on HRV parameters following resistance exercise. However, the lack of information regarding the duration of HRV monitoring in this study represents a significant limitation in interpreting the results. In conclusion, the effects of pre-exercise caffeine consumption on HRV during the post-exercise recovery period remain inconclusive. Methodological differences, varying caffeine doses, participant characteristics, exercise protocols, and monitoring durations appear to contribute to these inconsistencies. Future studies employing standardized protocols and extended HRV monitoring are warranted to provide more definitive insights into this area.

**Keywords:** Caffeine, resistance exercise, recovery, heart rate variability, autonomic nervous system

## GİRİŞ

Kafein, kahve, çay ve kakao gibi bitkilerden doğal olarak elde edilen ve dünya genelinde en yaygın tüketilen psikoaktif maddelerden biridir. Özellikle enerji içeceklerine eklenmesiyle birlikte kafein tüketimi son yıllarda önemli ölçüde artış göstermiştir. Günümüzde kafein en çok kahve, çay ve gazlı içecekler aracılığıyla tüketilmekte olup, bu eğilim küresel ölçekte yaygındır (Spriet vd., 2014). Sporcular arasında ise kafein, doping listesinde yer almaması ve doğal kaynaklardan temin edilebilmesi nedeniyle uzun yıllardır performans artırıcı bir destek olarak kullanılmaktadır. Dünya Anti-Doping Ajansı'nın 2004 yılında kafeini yasaklı maddeler listesinden çıkarması, sporcularda kafein kullanımının yaygınlaşmasına zemin hazırlamıştır. Nitekim, gerçekleştirilen doping kontrollerinde analiz edilen idrar örneklerinde 2004-2008 arası %70,1, 2008 ve 2015 yılları arasında %75,7 kafein tespit edilmiştir (Aguilar-Navarro vd., 2019). Bu durum, kafeinin spor performansındaki yaygın kullanımını açıkça ortaya koymaktadır.

Kafeinin egzersiz performansını artırmadaki temel mekanizması, merkezi sinir sistemi üzerindeki etkileridir. Adenozin A1 ve A2A reseptörlerinin seçici olmayan antagonisti olarak görev yapan kafein, norepinefrin ve dopamin salınımını artırarak uyanıklığı ve dikkati güçlendirir, algılanan eforu ve ağrıyı azaltır; böylece egzersiz sırasında merkezi sinir sistemi aktivitesini artırabilir (Goldstein vd., 2010; Gonzala vd., 2017; Barcelos vd., 2020). Bu nedenle kafein, dünya genelinde spor performansını artırma, bilişsel fonksiyonları destekleme ve termojenik etki sağlama amaçlarıyla yaygın biçimde kullanılmaktadır. Kafeinin kardiyovasküler sistem üzerindeki etkileri, sempatik otonom sinir sisteminin aktivasyonu ve adenozin reseptörlerinin inhibisyonu gibi mekanizmalarla ortaya çıkar (Barcelos vd., 2020). Ayrıca, riyanodin reseptörlerine bağlanarak kalsiyum akışını tetiklemesi, pozitif inotropik etkiler ve potansiyel aritmilere yol açabilir (Des Georges vd., 2016; Neyroud vd., 2019). Bu bağlamda, kalp atım hızı değişkenliği (HRV) kardiyak otonom fonksiyonun non-invaziv bir göstergesi olarak önem kazanmakta ve egzersiz sonrası kardiyoprotektif adaptasyonların değerlendirilmesinde yaygın olarak kullanılmaktadır (Shaffer ve Ginsberg, 2017). Ancak, kafein alımı HRV parametrelerini etkileyerek parasempatik sinir sisteminin egzersiz sonrası yeniden aktivasyonunu geciktirebilir ve bu durum olumsuz kardiyak sonuçlara yol açabilir (Peçanha vd., 2017). HRV'nin egzersiz sonrası toparlanma süreci, kardiyovasküler risklerin ve mortalitenin öngörülmesinde güvenilir bir yöntem olarak kabul edilmektedir. Kafein, bu toparlanma yanıtını bozabilmekte; özellikle parasempatik vagal aktivitenin gecikmesi, aritmi ve kardiyovasküler stres

riskini artırma potansiyeline sahiptir (Turnbull vd., 2017). Literatürde kafeinin HRV üzerindeki etkileri, doz, tüketim zamanı ve alınış şekline bağlı olarak değişkenlik göstermekte ve genellikle HRV'de azalma ile ilişkilendirilmektedir (Bunsawat vd., 2015; Thomas vd., 2017; Sarshin vd., 2020). Ancak, mevcut çalışmaların metodolojik sınırlılıkları ve kafeinin diğer maddelerle birlikte kullanıldığı durumlar, bu konuda kesin sonuçlar elde edilmesini zorlaştırmaktadır.

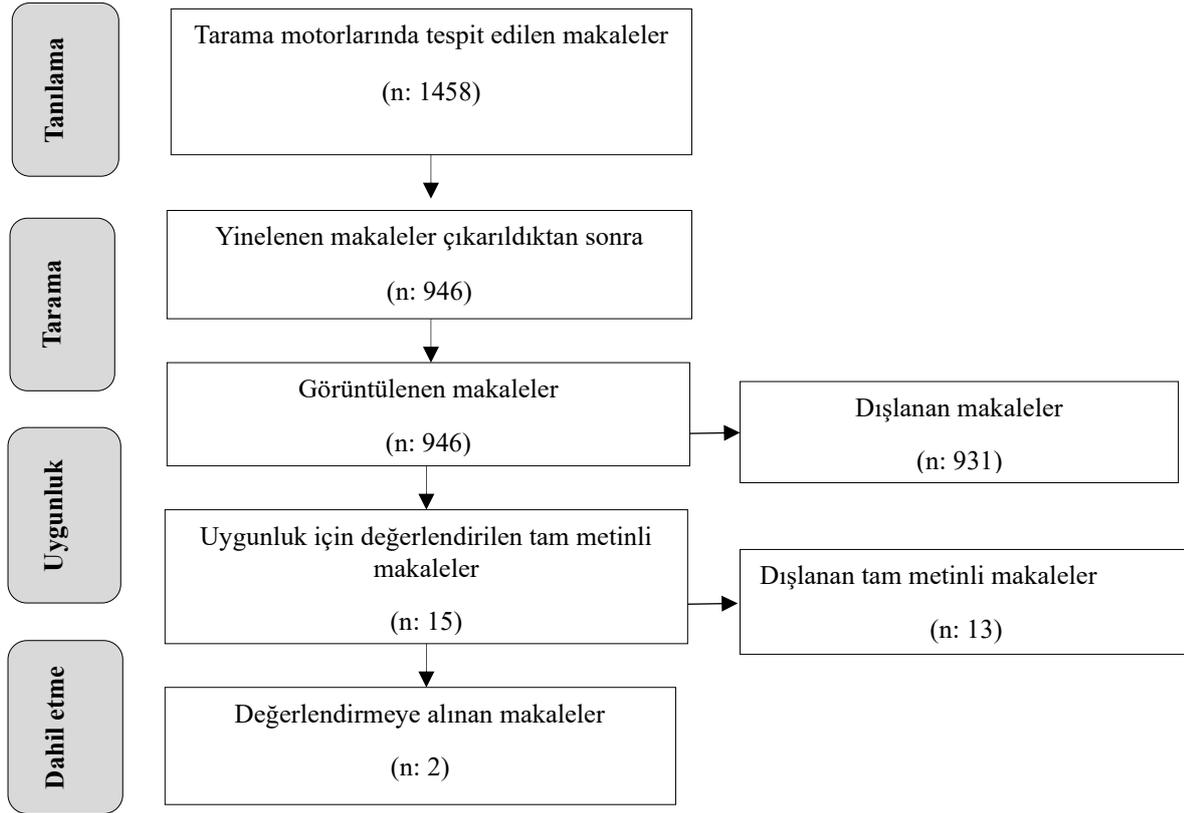
Literatürde, direnç antrenmanı öncesi kafein tüketiminin performans ve otonom toparlanmaya etkilerini araştıran sınırlı sayıda çalışma bulunmaktadır ve bu çalışmaların bulguları kafein hakkında doğru bilgilere ulaşmada henüz netlik kazanmamıştır. Özellikle, direnç egzersizlerinin kendine özgü metabolik ve kardiyovasküler stresinin, kafeinin otonom sinir sistemi üzerindeki etkileriyle nasıl etkileştiğine dair bilgiler oldukça sınırlıdır. Bu doğrultuda, direnç egzersizleri öncesi alınan kafeinin egzersiz sonrası kalp atım hızı değişkenliği üzerindeki etkilerinin araştırılması hem sporcu sağlığı hem de performans yönetimi açısından önem taşımaktadır. Bu kapsamda, bu çalışmanın amacı, direnç egzersizi öncesi kafein tüketiminin egzersiz sonrası HRV parametrelerine etkilerini belirlemektir.

## YÖNTEM

Literatür 18-20 Ağustos 2025'de "PubMed, Google Scholar ve Web of Science" veri tabanları kullanılarak taranmıştır. Veri tabanlarında 2000 ve 2025 yılları arasında yayınlanmış, sadece İngilizce dili ile yazılmış makaleler taranmıştır. Bilimsel konferanslardan alıntılar hariç tutulmuştur.

### *Araştırma Stratejisi*

Literatür taraması, Sistemik İncelemeler ve Metaanalizler için Tercih Edilen Raporlama Maddeleri (PRISMA) kılavuzlarına uygun olarak gerçekleştirilmiştir (şekil 1), (Moher vd., 2009). Her veri tabanında başlık, özet ve anahtar sözcük arama alanları taranmıştır. Boole operatörleri (AND/OR) ile birlikte aşağıda belirtilen anahtar kelimeler kullanılmıştır. ("Resistance training" OR "resistance exercise") AND ("caffeine" OR "ergogenic aid" OR "heart rate variability" OR "cardiac autonomic modulation" OR "autonomic recovery" OR "parasympathetic activation" OR "sympathetic activation"). Başka ek bir filtre veya arama taraması kullanılmamıştır. Taranan makalelerin içeriğinde konu ile ilgili benzer makaleler tespit edildiğinde, ek makale için tarama yapılmıştır.



Şekil 1. Arama stratejisinin akış şeması ve makale seçimi.

#### Dahil Etme Kriterleri

Çalışmalar, aşağıdaki dahil edilme kriterlerine göre uygunluk açısından değerlendirilmiştir. a) İngilizce hakemli bir dergide yayınlanan deneysel bir çalışma b) egzersiz öncesi kafein tüketimi olan direnç egzersiz çalışmaları, c) bilinen kronik hastalığı veya yaralanması olmayan insan katılımcılar, e) 18-30 yaş arası katılımcıların olduğu çalışmalar.

#### Veri Çıkarma

Araştırmada tam metin makaleler değerlendirilmiş ve önceden tanımlanmış bir form kullanarak veri çıkarımı gerçekleştirilmiştir. Makale (yazar ve yayın yılı), Katılımcılar (kişi sayısı, antrenman tecrübesi, cinsiyet, yaş), Kafein Protokolü (kafein, plasebo), Egzersiz Protokolü (egzersizler, set, tekrar ve dinlenme süreleri) Ölçülen HRV Parametreleri (RMSSD, SDNN, LF, HF, LF/HF oranı) Bulgular (gruplar arası farklılıklar veya benzerlikler) ile ilgili veriler toplanmıştır.

## BULGULAR

Elektronik veri tabanı aramasının ilk sonuçlarına göre toplam 1458 çalışma değerlendirildi; yinelenen makalelerin kaldırılmasından sonra bu sayı 946'ya düşmüştür. Özetleri uygunluk açısından inceledikten sonra, 15 tam metinli makale ayrıntılı inceleme için uygun görülmüştür. Ayrıntılı incelemelerden sonra 2 çalışma dahil etme kriterlerini karşılamıştır (tablo 1). Hariç tutulan tam metinli 13 makale aşağıda belirtilen özelliklerden en az birine sahipti. a) akut olmayan çalışmalar, b) belirli

bir hastalığa sahip grup içermesi, c) kafeinle birleştirilmiş başka supplementler, d) sadece egzersiz sonrası HRV takibi yapan çalışmaları.

**Tablo 1:** Dahil etme kriterlerini karşılayan çalışmaların özellikleri.

Makale (Yazar ve yayın yılı)	Katılımcılar (Kişi sayısı, antrenman tecrübesi, cinsiyet, yaş)	Kafein Protokolü (Kafein, plasebo, Tüketim süresi)	Egzersiz Protokolü (Egzersizler, set, tekrar ve dinlenme süreleri)	Ölçülen HRV Parametreleri (RMSSD, SDNN, LF, HF, LF/HF oranı)	Bulgular (Gruplar arası farklılıklar veya benzerlikler)
Benjamin vd., 2021	- 30 antrene erkek - Yaş: 22.3 ± 2,1 yıl	- 45dk önce - 4.21 mg/kg kafein - plasebo	- 4 direnç egzersizi: leg press, squat, abductor chair, extensor chair. - %75 1RM, - 4 set × 10 tekrar - Setler arası din. 3dk	- Egzersiz sonrası 30dk toparlanma - RMSSD - SDNN - HF - LF	•Kafein, egzersiz sonrası parasempatik yeniden aktivasyonu geciktirdi. • RMSSD, SDNN ve HF değerlerinde toparlanma daha yavaştı. • Sempatik baskınlık (LF) kafein koşulunda daha uzun sürdü.
Karayiğit vd., 2021	- 17 antrene kadın - Yaş: 23.5 ± 1.8 yıl	- 60 dk önce - 3 mg/kg - 6 mg/kg kafein - plasebo	- Bench press + squat; - 1RM nin %40, - Kas tükenme noktasına kadar, - Set arası din. 2 dk	- Egzersiz sonrası 30dk - RMSSD - SDNN - HF - LF - LF/HF oranı	- Egzersiz öncesi kafein tüketiminin egzersiz sonrası HRV toparlanması üzerinde anlamlı bir etkisi bulunmadı.

## TARTIŞMA

Bu derlemede, direnç egzersizi öncesi kafein tüketiminin egzersiz sonrası toparlanma sürecinde HRV üzerine etkilerini inceleyen sınırlı sayıda çalışma değerlendirilmiştir. Bulgular, kafeinin otonom sinir sistemi yanıtlarını etkileyebileceğini, ancak bu etkinin egzersiz protokolü, dozaj, katılımcı özellikleri ve HRV ölçüm zamanlamasına bağlı olarak değişkenlik gösterdiğini ortaya koymaktadır.

Egzersiz sonrası toparlanma sürecinde otonom sinir sisteminin yeniden dengelenmesi, sporcu sağlığı ve performansın sürdürülebilirliği açısından kritik öneme sahiptir. HRV, bu süreci değerlendirmek için kullanılan duyarlı bir belirteç olup, özellikle parasempatik yeniden aktivasyonun hızı, toparlanmanın kalitesine dair önemli bilgiler sağlar (Stanley vd., 2013). Egzersiz sonrası HRV'nin hızlı bir şekilde eski seviyelere dönmesi, kardiyovasküler stresin daha etkin bir şekilde yönetildiğini ve otonom dengenin daha hızlı sağlandığını gösterir. Buna karşılık, HRV parametrelerinin baskılanması veya toparlanmanın gecikmesi, sempatik baskınlığın uzadığına ve toparlanma

kapasitesinin kısıtlandığına işaret edebilir (Michael vd., 2017). Bu bağlamda, kafein tüketiminin egzersiz sonrası HRV toparlanması üzerine etkilerini inceleyen çalışmalar sınırlı sayıda olmakla birlikte, mevcut bulgular farklı sonuçlar ortaya koymaktadır. Benjamin vd. (2021), tarafından yürütülen çalışmada, direnç egzersizinden 45 dakika önce 4.21 mg/kg kafein tüketen antrene erkeklerde, egzersiz sonrası 30 dakikalık toparlanma süresince parasempatik yeniden aktivasyonun belirgin şekilde geciktiği rapor edilmiştir. Çalışmada, RMSSD, SDNN ve HF parametreleri kafein koşulunda daha yavaş toparlanırken, LF değerlerinin yüksek kalmaya devam etmesi sempatik baskınlığın uzadığını göstermiştir. Bu bulgu, kafeinin egzersiz sonrası kardiyak otonom regülasyonu baskılayabileceğini ve toparlanmayı geciktirebileceğini düşündürmektedir.

Buna karşılık, Karayığit vd. (2021) tarafından gerçekleştirilen çalışmada, 3 mg/kg ve 6 mg/kg kafein dozlarının direnç egzersizi sonrası HRV parametreleri üzerinde anlamlı bir etkisi bulunmamıştır. Ancak bu çalışmada, egzersiz sonrası HRV ölçümlerinin takip süresinin belirtilmemesi, sonuçların yorumlanabilirliğini önemli ölçüde kısıtlamaktadır. Çünkü toparlanma sürecinin değerlendirilmesinde, ölçüm zamanlaması kritik bir faktördür. Özellikle Benjamin vd.'nin 30 dakikalık takip süresi ile Karayığit vd.'nin belirsiz zamanlaması, çalışmalar arasındaki farklılığı açıklayabilecek önemli bir metodolojik unsurdur. Bu farklı bulgular, kafeinin dozajına, katılımcı özelliklerine (ör. cinsiyet, antrenman düzeyi), uygulanan direnç egzersizi protokollerine ve ölçüm sürelerine bağlı olabileceğini düşündürmektedir. Literatürde, kafeinin merkezi sinir sistemi üzerinden adozin reseptör antagonizması yoluyla sempatik aktiviteyi artırdığı, kalp atım hızı ve kan basıncını yükseltebildiği bildirilmiştir (Porto vd., 2022). Bu fizyolojik mekanizma, özellikle yüksek hacimli direnç egzersizleri sonrasında parasempatik toparlanmanın gecikmesine katkıda bulunabilir. Öte yandan, kafeinin etkisinin bireysel tolerans düzeyi, genetik faktörler ve egzersiz tipine göre değişkenlik gösterebileceği de göz ardı edilmemelidir.

Sonuç olarak, mevcut bulgular kafein tüketiminin direnç egzersizi sonrası HRV toparlanması üzerindeki etkilerine dair kesin bir yargıya varmak için yetersizdir. Bununla birlikte, özellikle Benjamin vd. (2021), çalışmasının bulguları, yüksek doz kafeinin toparlanma sürecinde otonom sinir sistemi yanıtını modüle edebileceğine işaret etmektedir. Bu durum, antrenman planlamasında, toparlanma stratejilerinde ve kafein kullanımına ilişkin önerilerde dikkate alınması gereken önemli bir noktadır. Gelecekte yapılacak çalışmaların; kafein dozajı (düşük, orta, yüksek düzeyler), cinsiyet ve antrenman geçmişi gibi katılımcı özellikleri, egzersiz protokollerinin standardizasyonu, HRV ölçüm sürelerinin uzatılması (örneğin 60 dakika veya daha uzun) gibi faktörleri kontrol ederek daha bütüncül bir değerlendirme sağlaması önerilmektedir.

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## HİDROTERAPİ İLE ELEKTROTERAPİ ALAN HASTALARIN TEDAVİ ETKİNLİĞİNİN VE TATMİN DÜZEYLERİNİN İNCELENMESİ

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### ÖZET

Turizm, günümüzde yalnızca bireysel rekreasyon aracı olmanın ötesinde, ekonomik kalkınma, kültürel etkileşim ve çevresel sürdürülebilirlik açısından stratejik bir rol üstlenmektedir. Alternatif tıp alanında özellikle son dönemlerdeki planlı yenileşme hareketleri, turizmin sağlık koluna hareket katmıştır. Nitekim sağlık turizmi giderek büyüyen bir hizmet sektörü olarak öne çıkmaktadır. Son yıllarda sağlık turizmi alanında önemli bir ivme kazanan Türkiye, kalite odaklı hizmet anlayışıyla küresel ölçekte öne çıkan destinasyonlar arasında yer bulma yarışında kendini göstermektedir. Bu bağlamda suyun tedavi edici gücünden yararlanılarak uygulanan tedaviler (elektroterapi + hidroterapi) ile yalnız elektroterapi desteği alan hastaların tedavilerinden tatmin düzeylerinin belirlenmesi araştırmanın ana problemidir. Bu kapsamda araştırma, hidroterapi ile birlikte elektroterapi alan hastaların tedavi etkinliğinin ve tatmin düzeyinin sadece elektroterapi alan hastalarla karşılaştırılması amacıyla yapılmıştır. Tanımlayıcı ve kesitsel tipteki bu araştırma yüz yüze anket tekniği kullanılarak gerçekleştirilmiştir. Sıcak Çermik Fizik Tedavi ve Rehabilitasyon Merkezi'nden 60 hasta, Sivas Numune Hastanesi fizik tedavi bölümünde yatarak tedavi gören 60 hasta, toplamda 120 hasta araştırmanın örneklemini oluşturmaktadır. Araştırmada veriler; demografik veriler, ağrı skalası ve hastaların tatmin düzeyi ölçeği kullanılarak toplanmıştır. Katılımcıların %69'u kadınlardan oluşmakta, %55'i ilköğretim düzeyinde eğitime sahip, %80,8'i evli, %70,8'i gelir gider dengesine sahiptirler. Hastaların fizik tedavi almalarındaki en önemli sebepler olarak bel ve diz ağrıları gelmektedir. Tedavi öncesi ve sonrası ağrı skalasında, medeni durum ve cinsiyet açısından görülen farklılığın önemsiz olduğu belirlenmiştir. Katılımcıların tatmin düzeylerinin Elektroterapi+hidroterapi alanlar lehine daha yüksek olduğu, kadınların erkeklere nazaran ve bekar olan hastaların evlilere nazaran tatmin düzeylerinin yüksek olduğu bu farklılıkların ise istatistiksel olarak anlamlı olduğu belirlenmiştir. Yapılan analizler sonucunda, sadece elektroterapi alan hastaların tedavi öncesi ağrı skoru  $8,43 \pm 1,93$  iken, tedavi sonrası ağrı skoru 3,9 birim düşerek  $4,53 \pm 2,84$  puana gerilemiştir. Bu durum istatistiksel olarak da anlamlı bulunmuştur. Buna göre elektroterapi ile birlikte hidroterapinin fiziksel ağrıları tedavi etmede etkin bir tedavi yöntemi olduğu görülmektedir. Bu sonuçlar ışığında sağlık turizminin etkin bir şekilde uygulanmasının gerek topluma gerekse ülkenin refah düzeyine olumlu etki edeceği gözler önüne serilmiştir.

**Anahtar kelimeler:** Hidroterapi, Elektroterapi, Ağrı, Fizik tedavi

### EXAMINATION OF TREATMENT EFFECTIVENESS AND SATISFACTION LEVELS OF PATIENTS RECEIVING HYDROTHERAPY AND ELECTROTHERAPY

## ABSTRACT

Tourism today plays a strategic role beyond being merely a means of individual recreation, contributing significantly to economic development, cultural interaction, and environmental sustainability. Recent planned renewal initiatives in the field of alternative medicine have injected new momentum into the health tourism sector. Indeed, health tourism is emerging as a rapidly growing service sector. Turkey, which has gained significant momentum in the field of health tourism in recent years, is demonstrating its position in the race to become one of the leading destinations on a global scale with its quality-focused service approach. In this context, the main problem of the research is to determine the satisfaction levels of patients receiving treatments utilising the healing power of water (electrotherapy + hydrotherapy) compared to those receiving only electrotherapy support. Within this scope, the research was conducted to compare the treatment effectiveness and satisfaction levels of patients receiving electrotherapy alongside hydrotherapy with those receiving only electrotherapy. This descriptive and cross-sectional study was conducted using a face-to-face survey technique. A total of 120 patients formed the sample for the study: 60 patients from the Sıcak Çermik Physical Therapy and Rehabilitation Centre and 60 patients receiving inpatient treatment at the physical therapy department of Sivas Numune Hospital. Data were collected using demographic data, a pain scale, and a patient satisfaction level scale. Sixty-nine per cent of participants were women, 55 per cent had primary education, 80.8 per cent were married, and 70.8 per cent had a balanced income and expenditure. The most important reasons for patients receiving physiotherapy were back and knee pain. It was determined that there was no significant difference in the pain scale before and after treatment in terms of marital status and gender. It was determined that the satisfaction levels of participants were higher in favour of those receiving electrotherapy + hydrotherapy, that women had higher satisfaction levels than men, and that single patients had higher satisfaction levels than married patients, and that these differences were statistically significant. The analyses revealed that the pre-treatment pain score for patients receiving only electrotherapy was  $8.43 \pm 1.93$ , while the post-treatment pain score decreased by 3.9 points to  $4.53 \pm 2.84$ . This situation has also been found to be statistically significant. Accordingly, it has been observed that hydrotherapy combined with electrotherapy is an effective treatment method for physical pain. In light of these results, it has been demonstrated that the effective implementation of health tourism will have a positive impact on both society and the country's level of prosperity.

**Keywords:** Hydrotherapy, Electrotherapy, Pain, Physical Therapy

## GİRİŞ

İnsanlık tarihi boyunca dinlenme, keşfetme, yeni kültürler tanıma ve sağlığına kavuşma gibi çeşitli ihtiyaçlar, bireyleri buldukları yerlerden farklı destinasyonlara seyahat etmeye yönlendirmiştir. Bu hareketliliğin organize bir yapıya kavuşmasıyla ortaya çıkan turizm, günümüzde yalnızca bireysel bir faaliyet olmaktan çıkıp, küresel boyutta sosyal, ekonomik, kültürel ve çevresel etkiler doğuran çok yönlü bir sektör haline gelmiştir (Uçar vd., 2012: 78). Turizmin bu çok katmanlı yapısı, bölgesel kalkınma hedeflerine katkı sağlamasının yanı sıra, ülkeler arasındaki kültürel etkileşimi de artırarak dünya barışına hizmet eden bir araç haline gelmiştir (Çeken, 2008: 298).

Turizm, katılımcı özelliklerine, seyahat amaçlarına, gidilen destinasyona ve sosyo-ekonomik farklılıklara göre çok çeşitli alt türlere ayrılmaktadır. Bu bağlamda; katılan kişi sayısına göre bireysel ve grup turizmi, ziyaret edilen yere göre iç ve dış turizm, katılımcıların amaçlarına göre kültürel, sportif, eğlence, sağlık ya da dini turizm, katılımcıların yaşına göre gençlik veya yaşlılık turizmi gibi sınıflandırmalar yapılmaktadır. Bu türler, turist profillerine göre özelleşmiş hizmetler sunulmasını mümkün kılmakta ve sektördeki çeşitliliği artırmaktadır. Bu çeşitlilik içerisinde sağlık turizmi, son yıllarda hem gelişmiş hem de gelişmekte olan ülkelerin öncelikli alanlarından biri haline gelmiştir. Sağlık turizmi, bireylerin fiziksel, ruhsal veya estetik ihtiyaçlarını karşılamak amacıyla tedavi almak

ya da sağlıklarını korumak için kendi ülkeleri dışına yaptıkları seyahatleri kapsamaktadır. Günümüzde artan yaşam süresi, kronik hastalıkların yaygınlığı, yaşlanan nüfus, sağlık teknolojilerindeki ilerlemeler ve sağlık hizmet maliyetlerindeki farklılıklar; bireyleri daha uygun, kaliteli ve erişilebilir sağlık hizmeti arayışına itmektedir kapsamaktadır (Edinsel ve Adıgüzel 2014: 172). Bu eğilim, küresel sağlık turizmi pazarının büyümesini hızlandırmaktadır.

Sağlık turizminin tarihsel gelişimi, Antik Yunan ve Roma dönemlerindeki kaplıca ziyaretlerinden modern medikal seyahatlere kadar uzanmaktadır (Bulut ve Şengül 2019: 49). Özellikle son yirmi yılda sağlık turizmi; medikal turizm, termal turizm, yaşlı ve engelli turizmi, spa, wellness turizmi gibi birçok alt alanda hizmet sunarak sağlık sistemlerinin bir tamamlayıcısı haline gelmiştir. Bu alanların her biri farklı türde sağlık ihtiyacına hitap etmekte olup, çeşitli destinasyonların öne çıkmasını sağlamaktadır. Sağlık turizmi, yalnızca bireylerin sağlığını değil, ülkelerin ekonomik kalkınma süreçlerini de doğrudan etkileyen stratejik bir alan olarak değerlendirilmektedir (Gülenç 2023: 176)

Dünya genelinde sağlık turizmine yönelen hasta trafiği incelendiğinde; Tayland, Hindistan, Güney Kore, Macaristan ve Türkiye gibi ülkeler, ileri düzey sağlık teknolojileri, eğitilmiş sağlık personeli ve uygun maliyet avantajlarıyla öne çıkmaktadır (Muzaffar ve Hussain 2007: 217). Türkiye ise coğrafi konumu, hizmet kalitesi, doğal kaynakları ve termal potansiyeli sayesinde son yıllarda sağlık turizmi destinasyonu olarak dikkat çekmektedir. Özellikle kamu-özel sektör iş birlikleri, devlet teşvikleri ve altyapı yatırımları ile Türkiye, medikal ve termal turizm alanlarında güçlü bir oyuncu konumuna gelmiştir (Çetin, 2022: 641).

Termal turizmin bir alt dalı olan hidroterapi, sağlık turizmi içerisinde hem geleneksel hem de modern bir uygulama olarak yer almaktadır. Suyun fiziksel özelliklerinden faydalanarak çeşitli sağlık sorunlarının giderilmesini amaçlayan hidroterapi, yüzyıllardır kullanılan bir tedavi yöntemidir (Gautham ve Devi 2020: 257). Tarihsel olarak Antik Roma hamamlarından günümüz modern spa merkezlerine kadar uzanan bu uygulama, özellikle kas-iskelet sistemi hastalıkları, dolaşım bozuklukları, stres temelli rahatsızlıklar ve doğum sürecinde kullanımıyla dikkat çekmektedir (Cowan, Hale, Horrigan ve Koren 2017: 123). Doğumda hidroterapi kullanımı, doğum sancılarını hafifletici, annenin rahatlamasını sağlayıcı ve doğum sürecini kolaylaştırıcı etkileri nedeniyle alternatif bir yöntem olarak önem kazanmıştır (Güneş, 2021: 17).

Hidroterapinin etki mekanizması, suyun ısı, basınç ve hareket özelliklerinin insan fizyolojisi üzerindeki olumlu etkilerine dayanmaktadır (Becker, 2009: 854). Suya maruz kalma, kas gevşemesi, ağrı eşliğinin yükselmesi, dolaşımın hızlanması ve psikolojik rahatlama gibi etkiler yaratmaktadır. Ancak hidroterapi uygulamalarının güvenli ve etkili olabilmesi için belirli temel ilkelere uyulması ve uygulamaların uzman kişiler tarafından yapılması gerekmektedir (Yiğitbaşı, 2023: 6-7).

Modern tıbbın bir diğer tamamlayıcısı olan elektroterapi de fiziksel tıp ve rehabilitasyon alanlarında sıkça kullanılmaktadır. Elektrik akımı kullanılarak sinir ve kas sistemini uyaran elektroterapi, özellikle ağrı yönetimi ve fonksiyonel iyileştirme amaçlı tercih edilmektedir (Aytemur, 2020: 26). Hidroterapi ile birlikte değerlendirildiğinde, elektroterapi, sağlık turizmi kapsamında sunulan fizik tedavi ve rehabilitasyon hizmetlerinin kapsamını genişletmektedir

### Turizm Kavramı ve Önemi

Turizm, doğrudan insana yönelik hizmet sunan ve insan emeğine en fazla ihtiyaç duyan ekonomik sektörlerden bir tanesidir. Bu nedenle bugüne kadar turizmin genellikle ekonomik katkıları ön planda değerlendirilmiştir (İçöz, 1991: 15). Oysa turizmin ortaya çıktığı ve geliştiği bir mekân – ister doğal ister kültürel çevre olsun – bulunmaktadır. Turistik hizmetler bu mekân üzerinden sağlanmakta, gelir bu kaynaklardan elde edilmekte ve turizmin sürdürülebilirliği de bu alanların doğru ve dengeli kullanımına bağlıdır (Soykan, 1999: 67).

Turizm, günümüzde hem ekonomik kalkınmanın hem de kültürel-kırsal bölgelerde sürdürülebilir gelişimin temel bileşenlerinden birisi haline gelmiştir. Kırsal turizm özelinde ele alındığında, tarımsal

alanlarda istihdam yaratma, bölgesel refahın artması ve kırsal kalkınmanın desteklenmesi açısından büyük katkı sağladığı vurgulanmaktadır (Kadanalı ve Yazgan 2012: 98). Bununla birlikte, turizm faaliyetlerinin sosyo-ekonomik yapılar üzerindeki etkileri incelendiğinde, konaklama, ulaşım ve tanıtım gibi sektörlere pozitif durumlar yaratarak istihdamı ve gelir düzeyini artırmaktadır. Ayrıca bölgesel gelir adaletsizliklerinin giderilmesine katkı sunduğu görülmektedir (Uçar vd., 2012: 78). Bu çerçevede, turizm yalnızca bireysel rekreasyon amaçlı bir faaliyet olmaktan ziyade aynı zamanda hem yerel hem ulusal ölçekte ekonomik büyüme, kültürel etkileşim ve çevresel sürdürülebilirlik için stratejik bir araç olması ile de önem kazanmaktadır.

Çevresel boyutta, turizm doğal kaynakların korunması ve çevre bilincinin artmasını teşvik edilmesi oldukça önemlidir. Korunan alanlardaki ziyaretlerin doğru yönetilmesi, altyapının geliştirilmesi ve çevre eğitimi, halkın yaşam kalitesini yükselten bir etkiye sahip olabilmektedir (Kadanalı ve Yazgan 2012: 98). Ancak bu faydalar, plansız turizm faaliyetleri sonucu su kaynaklarının tükenmesi, ekolojik bozulma ve ekosistemlerin zarar görmesi gibi risklerle de barındırmaktadır (Karadağ, 2021: 164–165). Bu nedenle sürdürülebilir turizm ve ekoturizm uygulamaları hem toplum hem de çevre yararına stratejik önem taşımaktadır (Kaypak, 2010: 93). Özellikle mülk sahipleri ve inşaat sektöründe faaliyet gösteren girişimciler bu süreçten önemli kazançlar sağlarken, yerel halk artan kira ve hizmet fiyatları nedeniyle kendisini ekonomik baskı altında hissedebilmektedir. Turizmin sağladığı faydalar toplum içinde eşit dağılmadığı gibi, bazı sosyal gruplar için avantaj teşkil eden unsurlar, başka gruplar için yaşam kalitesini olumsuz etkileyecek potansiyeli de içerisinde barındırmaktadır. Otel ve restoran işletmecileri bu süreçten ekonomik kazanç elde ederken, aynı bölgede ikamet eden yerel halk yoğun kalabalık, çevre kirliliği, gürültü artışı ve kültürel değişim gibi sorunlardan rahatsızlık duyabilirler. Bu bağlamda, turizm gelişiminin planlı ve dengeli şekilde yürütülmesi; ekonomik, çevresel ve sosyal etkilerinin birlikte değerlendirilmesini zorunlu kılmaktadır (Korkmaz 1990: 395). Olumsuzluklara rağmen turizmin çevreye dair olumlu etkileri de bulunmaktadır. Turizm sektörü, doğru şekilde planlandığında ve yönetildiğinde, kısa sürede gelişme gösterebilecek güçlü bir potansiyele sahiptir. Bu sektörün temel niteliklerini doğal güzellikler, tarihsel miras, kültürel değerler ve coğrafi çeşitlilik gibi zenginlikler oluşturmaktadır. Bu nedenle bir bölgedeki turizmin sürekliliği, sahip olunan bu doğal ve kültürel kaynakların korunması ile doğrudan ilişkisi bulunmaktadır.

### **Sağlık Turizmi ve Termal Turizm**

Sağlık turizmi farklı kategorilere ayrılmakla birlikte, genel kabul gören sınıflandırmaya göre bu alan; yaşlılara yönelik turizm (geriatrik turizm), medikal turizm, termal turizm (spa ve wellness uygulamaları dahil) ve engelli bireylere yönelik turizm olmak üzere dört temel başlık altında incelenmektedir. Bu ayırım hem sunulan hizmetlerin içeriği hem de hedeflenen kullanıcı grupları bakımından sağlık turizmi faaliyetlerinin daha etkin yönetilmesini sağlamaktadır (Topuz Gürcan, 2025: 6).

Termal Turizm, çeşitli doğal unsurların tedavi amaçlı kullanıldığı sağlık turizmi alt alanlarından biridir. Termal turizm, termomineral su banyoları, içme kürleri, inhalasyon, çamur banyoları gibi doğrudan uygulamaların yanı sıra; iklim terapisi, fizik tedavi, rehabilitasyon, egzersiz, psikoterapi ve diyet gibi destekleyici sağlık hizmetlerinin bütünleşik biçimde sunulduğu bir tedavi süreci olarak değerlendirilmektedir (Edinsel ve Adıgüzel 2014: 173). Bununla birlikte, termal kaynakların eğlence ve rekreasyon amaçlı kullanımı da bu turizm türü içerisinde yer almakta ve fiziksel iyileşmenin yanında psikolojik rahatlama hedeflenmektedir (Şengül ve Bulut 2019: 52).

### Araştırmanın Amacı

Bu araştırma hidroterapi ile birlikte elektroterapi alan hastaların tedavi etkinliğinin ve tatmin düzeyinin sadece elektroterapi alan hastalarla karşılaştırılması amacıyla yapılmıştır. Bu bağlamda araştırma problemleri ve hipotezleri şu şekilde belirlenmiştir:

P1: Elektroterapi alan hastaların tatmin düzeyi nedir?

P2: Elektroterapi ile birlikte hidroterapi alan hastaların tatmin düzeyi nedir?

P3: Hidroterapi tedavi etkinliğini artırmakta mıdır?

H<sub>1</sub>: Tedavi öncesi ve sonrası ağrı skorları çeşitli değişkenlere göre farklılık göstermektedir.

H<sub>1a</sub>: Tedavi öncesi ve sonrası ağrı skorları cinsiyet değişkenine göre farklılık göstermektedir.

H<sub>1b</sub>: Tedavi öncesi ve sonrası ağrı skorları medeni durum değişkenine göre farklılık göstermektedir.

H<sub>1c</sub>: Tedavi öncesi ve sonrası ağrı skorları tedavi alma nedenine göre farklılık göstermektedir.

H<sub>2</sub>: Hastaların tatmin düzeyi çeşitli değişkenlere göre farklılık göstermektedir.

H<sub>2a</sub>: Elektroterapi ile birlikte hidroterapi alan hastaların tatmin düzeyi sadece elektroterapi alan hastalara göre daha yüksektir.

H<sub>2b</sub>: Hastaların tatmin düzeyi cinsiyet değişkenine göre farklılık göstermektedir.

H<sub>2c</sub>: Hastaların tatmin düzeyi medeni durum değişkenine göre farklılık göstermektedir.

H<sub>2d</sub>: Hastaların tatmin düzeyi eğitim durumu değişkenine göre farklılık göstermektedir.

H<sub>2e</sub>: Hastaların tatmin düzeyi gelir düzeyi değişkenine göre farklılık göstermektedir.

H<sub>2f</sub>: Hastaların tatmin düzeyi tedavi alma nedenine göre farklılık göstermektedir.

H<sub>3</sub>: Elektroterapi ile birlikte hidroterapi alan hastaların tedavi etkinliği sadece elektroterapi alan hastalara göre daha yüksektir.

### Araştırmanın Önemi

Hidroterapi kelimesi Latince'den türetilmiş olup "su tedavisi" anlamına gelmektedir. Hidroterapide suyun fiziksel özellikleri ön plandadır. Hidroterapi ağrıyı, tutukluğu azaltmak, postürü iyileştirmek, eklem hareket açıklığını arttırmak, dolayısıyla yaşam kalitesini iyileştirmek için geleneksel ve tamamlayıcı tedavi olarak kullanılmaktadır. Günümüzde hidroterapi yaygınlaşmakta ve bu da uygulanma oranını arttırmaktadır. Hidroterapi, sağlığın önlenmesi ve hastalıkların tedavisi amacıyla suyun sıvı, buz ve buhar halinde sıcak veya soğuk uygulamalarla kullanılmasıdır. Elektrik akımının fiziksel etkilerinden tedavi amacıyla yararlanılmasına ise elektroterapi denilmektedir.

Sağlık turizminin giderek arttığı ülkemizde, termal suyun tedaviye etkinliğinin tespit edilmesi gerek sağlık turizmini canlandırması gerekse tedavi sürecine olumlu katkısı bağlamında önem arz etmektedir. Bu çalışmanın sonuçları sağlık kurumu yöneticilerinin farkındalığını artırması, tedavi yöntemlerinin geliştirilmesi ve toplum sağlığı açısından önem arz etmektedir. Ayrıca daha önce Türkiye'de benzer araştırmaya rastlanmaması da araştırmayı özgün ve önemli kılmaktadır.

### Veri Toplama Aracı

Araştırmanın verileri; demografik veriler, ağrıya ilişkin sorular, ağrı skalası ve hastaların tatmin düzeyi ölçeği kullanılarak toplanmıştır.

**Ağrı Skalası:** Ağrının şiddetini ölçmek için kullanılan, 0 ile 10 arası puanlanan bir skaladır. Burada ağrının şiddetini belirleyen hastanın kendi algısıdır. Ağrı yok 0 puan, hafif ağrı 1-3 puan, orta şiddetli ağrı 4-6 puan, şiddetli ağrı ise 7-10 puan arasındadır.

**Hastaların Tatmin Düzeyi Ölçeği:** Hastaların tatmin düzeyini ölçmek için Yaltagil (2019) tarafından geliştirilmiş, 6 madde tek faktörden oluşan “Hastaların Tatmin Düzeyi” ölçeği kullanılmıştır. Ölçek memnuniyet, beklentilerin karşılanması, kurumdan yeniden hizmet almaya isteklilik durumlarını ölçmektedir. “Hastaların Tatmin Düzeyi Ölçeği” maddeleri 1’den 5’e kadar değişen likert tipi puanlama ile derecelendirilmektedir. Derecelendirme; 1= Kesinlikle Katılmıyorum, 2= Katılmıyorum, 3= Ne Katılıyorum Ne De Katılmıyorum, 4= Katılıyorum, 5= Kesinlikle Katılıyorum şeklindedir. Ölçekten alınan en düşük puan 6 ve en yüksek puan 30’ dur. Ölçek puanının yüksek olması, hastanın tatmin düzeyinin yüksek olduğunu, ölçek puanının düşük olması hastanın tatmin düzeyinin düşük olduğunu göstermektedir.

### Verilerin Analizi

Araştırmada elde edilen verilerin analizinde “SPSS” programı kullanılmıştır. Veriler değerlendirilirken tanımlayıcı istatistiksel metotlarının yanı sıra, “güvenilirlik analizi” ve normallik analizi yapılmıştır. Demografik verilerle ağrı skalası ve ölçek yargı ifadelerinin ilişkilerini ölçen non-parametrik testler (Mann Whitney U Testi, Kruskal Wallis H Testi) yapılmıştır. Ağrı skalası soruları sorulup cevaplandırıldıktan sonra tedavi bitiminde (15 fizik seans tedavi) yeniden ağrı skalası soruları sorulup yalnızca elektroterapi alan grup ile hidroterapi ve elektroterapi alan grup arasında ağrı skalasında azalma oranı Wilcoxon Eşlenik-Çift Testi ile karşılaştırılmıştır.

### Bulgular

Tablo 1. Tanımlayıcı İstatistikler

Cinsiyet	n	%	Medeni Durum	n	%
Kadın	83	69,2	Evli	97	80,8
Erkek	37	30,8	Bekar	23	19,2
Eğitim Durumu	n	%	Gelir Düzeyi	n	%
Okur yazar değil	10	8,3	Gelir giderden az	19	15,8
İlköğretim	66	55,0	Gelir gidere eşit	85	70,8
Lise	24	20,0	Gelir giderden fazla	16	13,3
Ön lisans	6	5,0			
Lisans	14	11,7	Toplam	120	100

\*Yaş: Min:18- Max: 74 Ortalama: 51,80

Araştırmaya katılmayı kabul eden 120 hastanın çoğunluğunu kadınlar oluşturmaktadır. Evrenin de ağırlıklı olarak kadın olması bu durumu etkilemektedir. Hastaların yaş ortalaması yüksektir. Eğitim

durumu ise düşüktür. Büyük çoğunluğu evlidir. Katılımcıların çoğunluğu gelirlerinin giderlerine eşit olduğunu ifade etmiştir.

Tablo 2. Hastaların Fizik Tedavi Alma Nedenleri

Fizik Tedavi Alma Nedeni	n	%
Diz Ağrısı	30	25.0
Bel Ağrısı	24	20.0
Bel-Kalça-Diz Çoklu Ağrı	21	17.5
Boyun Ağrısı	15	12.5
Boyun-Sırt-Kol Çoklu Ağrı	10	8.3
Sırt Ağrısı	8	6.7
Omuz Ağrısı	7	5.8
Kalça Ağrısı	5	4.2
Toplam	120	100.0

Hastaların fizik tedavi alma nedenleri incelendiğinde, ilk sıralarda diz ve bel ağrısının geldiği görülmektedir. Onu çoklu ağrıların takip ettiği görülmektedir.

Tablo 3. Ağrının Özelliği (Hastanın Kendi İfadesi)

Ağrının Özelliği	n*	Ağrının Özelliği	n*
Acı veren	73	Basınç Hissi	24
Uyuşuk	58	Yanıcı	15
Zonklayıcı	52	Ezici	14
Keskin	46	Elektrik çarpması	14
Sürekli	44	Kolik	13
Kramp tarzında	43	Dolgunluk	6
Derin	31	Künt	6
Sıkıştırıcı	28	<i>*Birden fazla cevap</i>	

Hastaların ağrıları tanımlamaları istediğinde verilen cevaplar tabloda görülmektedir. Buna göre ağrı şekillerinin, en fazla acı veren tarzda, uyuşuk ve zorlayıcı olduğunu ifade etmişlerdir.

Tablo 4. Ağrının Şiddetlenme Nedeni

Ağrının Şiddetlenme Nedeni	n*
Hareket	77
Pozisyon	55
Soğuk	42
Stres-Yorgunluk	5
Sıcak	4

\*Birden fazla cevap

Hastaların, hangi durumlarda ağrının daha fazla şiddetlendiği sorusuna cevapları incelendiğinde, en fazla hareket ve pozisyon cevapları verilmiştir. Soğuktan etkilendiği ifade eden hasta ise 42 kişidir. Stres ve yorgunluk cevabını veren hasta sayısı düşüktür.

Araştırmada kullanılan memnuniyet ölçeğine ilişkin güvenilirlik analizi, ortalama değerler ve normallik analizi Tablo 5'te verilmiştir. Ağrı skalasına ilişkin ortalama değerler ise Tablo 6'da sunulmuştur.

Tablo 5. Memnuniyet Ölçeğine İlişkin Genel İstatistikler

Cronbach's Alpha	Minimum	Maximum	Ortalama	Sd	Skewness	Kurtosis
0,917	6,00	30,00	25,93	5,396	-2,050 ,221	3,887 ,438

Ölçeğin Cronbach's Alpha değeri 0,917 ile yüksek çıkmıştır. Ölçekten alınan en düşük puan 6 iken en yüksek puan 30'dur. Buna göre memnuniyet puan ortalaması yüksek ( $25,93 \pm 5,39$ ) bulunmuştur. Yapılan normal dağılım analizi sonucunda memnuniyet ölçeğinin normal dağılımdan gelmediği, basıklık ve çarpıklık değerlerinin  $\pm 1,5$  arasında olmadığı sonucuna varılmıştır. Bu sebeple analizlere non-parametrik testlerle devam edilmiştir.

Tablo 6. Ağrı Skalasına İlişkin İstatistikler

	n	Min.	Max.	Orta.	Sd
Tedavi Öncesi Ağrı Skalası	120	2,00	10,00	8,48	1,767
Tedavi Sonrası Ağrı Skalası	120	,00	10,00	4,22	2,574

Hastaların fizik tedavi almadan önce ve fizik tedavi aldıktan sonra ağrı puanları genel olarak incelendiğinde tedavi öncesi Ort. $\pm 8,48$  olan ağrı skorunun tedavi sonrası Ort. $\pm 4,22$ 'ye düştüğü görülmektedir. Buna göre tedavinin ağrılara oldukça iyi geldiği söylenebilir.

Tablo 7. Tedavi Öncesi ve Sonrası Ağrı Skalasının Cinsiyet ve Medeni Durum Değişkenlerine Göre Farklılaşma Durumu (Mann Whitney U)

Değişkenler		n	Orta.	Sıra Orta.	U	z	p
Tedavi Öncesi Ağrı	Kadın	83	8,55	62,75	1348,50	-1,11	,266
	Erkek	37	8,32	55,45			
Tedavi Sonrası Ağrı	Kadın	83	4,39	62,92	1335,00	-1,14	,251
	Erkek	37	3,83	55,08			
Tedavi Öncesi Ağrı	Evli	97	8,52	61,06	1061,50	-,37	,706
	Bekar	23	8,30	58,15			
Tedavi Sonrası Ağrı	Evli	97	4,26	61,36	1032,50	-,55	,577
	Bekar	23	4,04	56,89			

Hastaların tedavi öncesi ve sonrası ağrı skorlarının cinsiyet ve medeni durum değişkenleri ile istatistiksel olarak anlamlı bir değişiklik göstermediği görülmektedir ( $p>0,05$ ). Bu sonuçlara göre,  $H_{1a}$ : “Tedavi öncesi ve sonrası ağrı skorları cinsiyet değişkenine göre farklılık göstermektedir.” ve  $H_{1b}$ : “Tedavi öncesi ve sonrası ağrı skorları medeni durum değişkenine göre farklılık göstermektedir.” hipotezleri reddedilmiştir.

Tablo 8. Tedavi Öncesi ve Sonrası Ağrı Skalasının Tedavi Alma Nedenine Göre Farklılaşma Durumu (Kruskall Wallis H)

Tedavi Alma Nedeni	n	Ortalama		Sıra Ortalaması		H	df	p
		Tedavi Öncesi	Tedavi Sonrası	Tedavi Öncesi	Tedavi Sonrası			
Bel Ağrısı	24	8,16	3,91	51,81	55,63			
Sırt Ağrısı	8	8,37	6,62	60,88	91,31	Tedavi Öncesi	7	Tedavi Öncesi
Diz Ağrısı	30	8,73	4,36	65,52	62,22	3,107		,875
Boyun Ağrısı	15	8,40	4,00	64,97	57,20	Tedavi Sonrası		Tedavi Sonrası
Omuz Ağrısı	7	8,28	3,42	58,57	51,14	8,414		,298
Kalça Ağrısı	5	9,00	3,60	66,50	53,50			
Boyun-Sırt-Kol Çoklu Ağrı	10	8,40	4,60	54,80	66,40			

Bel-Kalça-Diz Çoklu Ağrı	21	8,57	3,85	61,86	56,21
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Hastaların tedavi öncesi ve sonrası ağrı skorlarının tedavi alma nedeni ile istatistiksel olarak anlamlı bir değişiklik göstermediği görülmektedir ( $p>0,05$ ). Bu sonuçlara göre,  $H_{1c}$ : “Tedavi öncesi ve sonrası ağrı skorları tedavi alma nedenine göre farklılık göstermektedir.” hipotezi reddedilmiştir.

Tablo 9. Tatmin Düzeyinin Çeşitli Değişkenlere Göre Farklılaşma Durumu (Mann Whitney U)

Değişkenler	n	Ortalama	Sıra Orta.	U	z	p
Elektroterapi	60	24,06	49,09	1115,50	-3,63	,000
Elektroterapi+hidroterapi	60	27,80	71,91			
Kadın	83	26,74	66,23	1059,50	-2,7	006*
Erkek	37	24,10	47,64			
Evli	97	25,75	60,62	1103,50	-,08	,935
Bekar	23	26,69	59,98			

Hastaların çeşitli değişkenlere göre tatmin düzeyleri incelendiğinde; Elektroterapi ile birlikte hidroterapi alan hastaların tatmin düzeylerinin ( $\pm 27,80$ ) Elektroterapi alanlara ( $\pm 24,06$ ) göre daha yüksek olduğu ve bu farkın istatistiksel olarak anlamlı olduğu görülmektedir ( $p<0,05$ ). Buna göre,  $H_{2a}$ : “Elektroterapi ile birlikte hidroterapi alan hastaların tatmin düzeyi sadece elektroterapi alan hastalara göre daha yüksektir.” hipotezi kabul edilmiştir. Kadınların tatmin düzeylerinin ( $\pm 26,74$ ) erkeklere ( $\pm 24,10$ ) göre daha yüksek olduğu ve bu farkın istatistiksel olarak anlamlı olduğu görülmektedir ( $p<0,05$ ). Buna göre,  $H_{2b}$ : “Hastaların tatmin düzeyi cinsiyet değişkenine göre farklılık göstermektedir.” hipotezi kabul edilmiştir. Bekarların tatmin düzeylerinin ( $\pm 26,69$ ) evlilere ( $\pm 25,75$ ) göre daha yüksek olduğu fakat bu farkın istatistiksel olarak anlamlı olmadığı görülmektedir ( $p>0,05$ ). Buna göre,  $H_{2c}$ : “Hastaların tatmin düzeyi medeni durum değişkenine göre farklılık göstermektedir.” hipotezi reddedilmiştir.

Tablo 10. Tatmin Düzeyinin Çeşitli Değişkenlere Göre Farklılaşma Durumu

Değişkenler	n	Orta	Sıra Orta	H	df	p
Eğitim Düzeyi						
Okur yazar değil	10	27,10	56,50	9,622	4	,047*
İlk Öğretim	66	26,30	66,92			
Lise	24	24,29	41,94			
Ön Lisans	6	25,16	62,00			

Lisans	14	26,50	64,25			
Gelir Düzeyi						
Gelir giderden az	19	26,05	58,16	0,160	2	923
Gelir gidere eşit	85	26,11	61,29			
Gelir giderden fazla	16	24,81	59,09			
Tedavi Alma Nedeni						
Bel Ağrısı	24	24,50	60,69			
Sırt Ağrısı	8	26,12	53,31			
Diz Ağrısı	30	26,06	55,50			
Boyun Ağrısı	15	26,33	59,10	2,895	7	,895
Omuz Ağrısı	7	27,00	63,71			
Kalça Ağrısı	5	24,60	63,30			
Boyun-Sırt-Kol Çoklu Ağrı	10	25,30	58,40			
Bel-Kalça-Diz Çoklu Ağrı	21	27,28	70,43			

Hastaların çeşitli değişkenlere göre tatmin düzeyleri incelendiğinde; eğitim durumuna göre tatmin düzeyinin farkının istatistiksel olarak anlamlı olduğu görülmektedir ( $p < 0,05$ ). Buna göre,  $H_{2d}$ : “Hastaların tatmin düzeyi eğitim durumu değişkenine göre farklılık göstermektedir.” hipotezi kabul edilmiştir.

Hastaların tatmin düzeylerinin, gelir durumuna ve tedavi alma nedenlerine göre ise istatistiksel olarak anlamlı olmadığı görülmektedir ( $p > 0,05$ ). Buna göre,  $H_{2e}$ : “Hastaların tatmin düzeyi gelir düzeyi değişkenine göre farklılık göstermektedir.” ve  $H_{2f}$ : “Hastaların tatmin düzeyi tedavi alma nedenine göre farklılık göstermektedir.” hipotezleri reddedilmiştir. Hastaların aldıkları tedavi türünün (Elektroterapi ile Elektroterapi + Hidroterapi) etkinliğini ölçen Wilcoxon Testi sonuçları Tablo 11’de verilmiştir.

Tablo 11. Tedavi Türüne Göre Tedavi Etkinliğinin Karşılaştırılması

	Elektroterapi + Hidroterapi	Elektroterapi	
	Ortalama	Ortalama	
Tedavi Öncesi Ağrı	8,53±1,59	Tedavi Öncesi Ağrı	8,43±1,93
Tedavi Sonrası Ağrı	3,91±2,24	Tedavi Sonrası Ağrı	4,53±2,84
Z	-6,466	Z	-5,905

p 0,000 p 0,000

Yapılan Wilcoxon Testine göre elektroterapi ile birlikte hidroterapi alan hastaların tedavi öncesi ağrı skoru  $8,53 \pm 1,59$  iken, tedavi sonrası ağrı skoru 4,62 birim düşerek  $3,91 \pm 2,24$  puana gerilemiştir. Sadece elektroterapi alan hastaların ise tedavi öncesi ağrı skoru  $8,43 \pm 1,93$  iken, tedavi sonrası ağrı skoru 3,9 birim düşerek  $4,53 \pm 2,84$  puana gerilemiştir. Bu durum istatistiksel olarak da anlamlı bulunmuştur ( $p < 0,05$ ). Buna göre elektroterapi ile birlikte hidroterapinin fiziksel ağrıları tedavi etmede etkin bir tedavi yöntemi olduğu görülmektedir. Bu sonuçlar ışığında,  $H_3$ : “Elektroterapi ile birlikte hidroterapi alan hastaların tedavi etkinliği sadece elektroterapi alan hastalara göre daha yüksektir.” hipotezi kabul edilmiştir.

## SONUÇ

Turizm, günümüzde yalnızca bireysel rekreasyon aracı olmanın ötesinde, ekonomik kalkınma, kültürel etkileşim ve çevresel sürdürülebilirlik açısından stratejik bir rol üstlenmektedir. Bu bağlamda, turizmin tanımı, tarihsel gelişimi ve toplumlar üzerindeki etkileri değerlendirilerek hem bireysel hem de toplumsal düzeydeki önemine dikkat çekilmektedir. Turizm, çevresel açıdan doğal kaynakların korunması ve çevre bilincinin artırılmasında önemli bir rol oynamaktadır. Doğru yönetilen ziyaretler, altyapı geliştirmeleri ve çevre eğitimi, yerel halkın yaşam kalitesini olumlu yönde etkileyebilmektedir. Sağlık turizmi, bireylerin tedavi, rehabilitasyon ya da sağlıklı yaşam hizmetlerinden yararlanmak amacıyla kendi yerleşim yerleri dışına yaptıkları seyahatleri kapsamakta ve giderek büyüyen bir hizmet sektörü olarak öne çıkmaktadır. Bu alanda; termal turizm, medikal turizm, SPA ve Wellness turizmi, ileri yaş ve engelli turizmi gibi farklı alt türler bulunmaktadır. Her bir sağlık turizmi türü, sunulan hizmetin niteliğine ve hedef kitlenin ihtiyaçlarına göre farklılaşmakta; bu durum, hizmet sağlayıcı ülkeler açısından stratejik planlamaları da zorunlu kılmaktadır.

Küresel sağlık turizmi piyasasında yaşanan gelişmeler, Türkiye'nin konumu da avantaj sağlamak açısından ön planda görülmesine katkı sağlamıştır. Türkiye, sahip olduğu doğal kaynaklar, nitelikli sağlık personeli, jeotermal zenginlikler, uluslararası akreditasyona sahip sağlık kuruluşları ve uygun maliyetli hizmet sunumu ile sağlık turizmi alanında rekabet gücü yüksek ülkeler arasında yer almaktadır. Türkiye, sağlık turizmi açısından stratejik konumu, gelişmiş altyapısı, nitelikli sağlık hizmetleri ve ulaşılabilirliği artıran teşvik ve yapısal politikalarıyla önemli bir potansiyele sahiptir. Son yıllarda sağlık turizmi alanında önemli bir ivme kazanan Türkiye, kalite odaklı hizmet anlayışıyla küresel ölçekte öne çıkan destinasyonlar arasında yer almaktadır. Türkiye’de sağlık turizmi kapsamında değerlendirilebilecek tamamlayıcı ve destekleyici tedavi yöntemlerinden biri olan hidroterapiye ilişkin avantajlı turizm bölgelerinden söz etmek mümkündür. Suyun tedavi edici gücünden yararlanılarak uygulanan hidroterapinin tarihsel gelişimi, çeşitli hastalık gruplarındaki kullanım alanları, doğum sürecindeki yeri ve etki mekanizması analiz edilmiştir. Ayrıca, hidroterapi uygulamalarının güvenli ve etkin bir şekilde gerçekleştirilebilmesi için dikkate alınması gereken temel ilkeler açıklanmıştır. Benzer şekilde, elektroterapi uygulamaları da sağlık turizmi bağlamında ele alınmıştır. Elektroterapi, rehabilitasyon ve klinik ortamlarda kas kuvvetini artırma, motor kontrolü geliştirme, ağrıyı hafifletme, periferik dolaşımı destekleme, ödemi azaltma ve doku iyileşmesini hızlandırma gibi çeşitli amaçlarla kullanılan çok yönlü bir tedavi yöntemidir ve bu yöntemin fizyoterapi ve rehabilitasyon alanlarındaki yeri, kullanım amaçları ve etki prensipleri değerlendirilmiştir.

Çalışma, hidroterapi ile birlikte elektroterapi uygulanan hastaların tedavi etkinliği ve memnuniyet düzeylerinin, yalnızca elektroterapi alan hastalarla karşılaştırılması amacıyla gerçekleştirilen bu araştırma sonucunda öne çıkan sonuçlar şu şekilde sıralanmıştır.

Katılımcıların büyük bir bölümü evli kadınlardan oluşmaktadır ve eğitim düzeyi büyük çoğunlukta ilköğretim düzeyindedir. Fizik tedavi alma sebepleri ise, diz ve bel ağrısının yanı sıra çoklu ağrılar

sebebiyle olduğu görülmüştür. Hastaların ağrılarının genelde, acı veren uyuşukluk ve zonklama tarzında yoğunlaştığı, hareket edilmesi durumunda ağrının çoğaldığı belirlenmiştir. Katılımcıların memnuniyet düzeylerinin iyi sayılacak seviyede olduğu belirlenmiştir (Tablo 5; min = 6; Max = 30; ort = 25.93). Ağrı skalasından aldıkları ağrı puanlarının ise tedavi öncesi ve sonrasında yarı yarıya azaldığı şeklindedir. Tedavi öncesin ağrı durumlarının cinsiyete göre farklılığı önemsiz olarak görülmüştür. Yine benzer şekilde tedavi öncesi ve sonrası ağrı düzeylerinin medeni duruma göre farklılığının önemsiz olduğu belirlenmiştir. Yine benzer şekilde, tedavi öncesi ve sonrasında tedavi alma niyetine göre farklılığının önemsiz olduğu belirlenmiştir.

Tatmin olma düzeylerinin alınan tedavi türüne göre farklılığı önemli bulunmuştur. Elektroterapi + hidroterapi alan hastaların tatmin düzeyinin, yalnızca elektroterapi alanlara göre daha yüksek olduğu belirlenmiştir. Kadınların erkeklere nazaran daha fazla tatmin oldukları belirlenmiştir. Hastaların tatmin olma düzeylerinin eğitim durumu açısından farklılığının da önemli olduğu belirlenmiş, okur yazar olmayanların lise düzeyinde eğitim alanlara nazaran daha fazla tatmin olduğu belirlenmiştir. Elektroterapi + hidroterapi alan hastaların tedavi öncesi ve sonrası arasındaki farklılığın önemli olduğu belirlenmiştir. Önemli ölçüde ağrının azaldığı belirlenmiştir. Yine benzer şekilde elektroterapi alan hastaların da tedavi öncesinde ve sonrasında ağrı skalası puanlarında önemli bir düşüş olduğu bu düşüşün ise önemli olduğu belirlenmiştir.

Sonuç itibarıyla, çalışmada hem turizm alanının genel bir çerçevesi çizilmiş hem de sağlık turizmi özelinde Türkiye'nin potansiyeli ve gelişim alanları kapsamlı bir şekilde ortaya konulmuştur. Sağlık turizminin yalnızca ekonomik bir faaliyet olarak değil, aynı zamanda toplum sağlığını geliştirme ve sürdürülebilir kalkınmaya katkı sağlama potansiyeline sahip çok boyutlu bir alan olduğu sonucuna ulaşılmıştır. Yapılan analiz sonuçlarında ise her iki yöntemle tedavi alan hastaların tedavi sonrasında ağrı düzeylerinde ve tatminlerinde bir artışın olduğu belirlenmiştir. Demografik özelliklerden, cinsiyet, medeni durumun ağrı düzeyinde göre farklılığının önemsiz olduğu belirlenmiştir.

## KAYNAKÇA

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## GROOMING'İN ANATOMİSİ: ÇOCUKLARIN DİJİTAL TEHLİKELERE MARUZİYETİ

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### ÖZET

Günümüzde bilgi ve iletişim teknolojilerinin hızla gelişmesi, interneti çocuklar için sadece bir eğlence ve iletişim aracı olmaktan çıkarıp, öğrenme ve eğitim kaynaklarıyla bütünleşmiş vazgeçilmez bir mecra hâline getirmiştir. Ancak bu imkânların ebeveyn denetimi olmadan kullanılması, çocukların ve gençlerin sanal ortamlarda çeşitli risklerle karşılaşmasına yol açmaktadır. Özellikle çevrimiçi çocuk istismarı, istismarcı ile mağdur arasında kurulan sosyal ilişkiler üzerinden cinsel içerikli mesaj ve görsellerle tehdidi, manipülasyonu ve çocukların uygunsuz cinsel davranışlara zorlanmasını içeren ciddi bir sorun olarak öne çıkmaktadır. Sosyal medya ve diğer dijital platformların yaygın kullanımı, çocukların sanal ortamda maruz kaldığı bu riski artırmakta ve konunun toplumsal boyutunu giderek daha görünür hâle getirmektedir. Bu bağlamda, çevrimiçi çocuk istismarı yalnızca bireysel değil, aynı zamanda sosyal ve hukuki açıdan da önemli bir problem olarak değerlendirilmektedir.

Çevrimiçi grooming'e maruz kalan çocuklar, hem ruhsal hem de bedensel açıdan olumsuz durumlar yaşayabilmektedir. Ruhsal olarak, bu süreç çocuklarda sürekli endişe, korku, utanç ve kendine güven eksikliği gibi durumların oluşmasına neden olabilir. Çocuğun güven duygusunun zedelenmesi, arkadaş ilişkilerinde çekingenliğe ve sosyal izolasyona yol açabilir. Ayrıca, uzun süreli yaşanan bu deneyimler, stres ve kaygının kalıcı hâle gelmesine, duygusal dalgalanmaların artmasına sebep olabilir. Bedensel açıdan ise çocuklarda uyku düzeninde bozulmalar, iştah değişiklikleri ve stresin yol açtığı çeşitli rahatsızlıklar gözlemlenebilir. Bu etkiler, çocuğun günlük yaşamını, eğitimini ve sosyal ilişkilerini olumsuz etkileyerek, uzun vadede genel sağlık durumunda kalıcı sorunlar oluşturabilir.

Bu çalışmanın amacı, çocukların çevrimiçi ortamlarda karşılaştığı grooming risklerini ve bu süreçte maruz kaldıkları psikolojik ile fizyolojik etkileri analiz etmek, faillerin yöntemlerini anlamak ve önleyici stratejiler geliştirmektir. Ayrıca, ailelere ve eğitimcilere, çocukların güvenli çevrimiçi davranışlar kazanmasını destekleyecek somut ve uygulanabilir öneriler sunulması hedeflenmektedir. Bu yaklaşım, çocukların sanal ortamdaki güvenliğini artırırken, bilinçli ve sorumlu dijital kullanım kültürünün yaygınlaşmasına da katkı sağlamaktadır.

**Anahtar kelimeler:** Çocuk istismarı, Çevrimiçi Grooming, İnternet, Önleme Stratejileri

## THE ANATOMY OF GROOMING: CHILDREN'S EXPOSURE TO DIGITAL RISKS

### ABSTRACT

Today, the rapid development of information and communication technologies has transformed the internet for children from merely a tool for entertainment and communication into an indispensable platform integrated with learning and educational resources. However, using these opportunities without parental supervision exposes children and adolescents to various risks in virtual environments. In particular, online child abuse emerges as a serious issue, involving threats, manipulation, and coercion of children into inappropriate sexual behaviors through social relationships established between the abuser and the victim, often via sexual messages and images. The widespread use of social media and other digital platforms increases the risk children face online and makes the societal dimension of this issue increasingly visible. In this context, online child abuse is recognized not only as an individual problem but also as a significant social and legal concern.

Children exposed to online grooming may experience adverse effects both psychologically and physically. Psychologically, this process can lead to persistent anxiety, fear, shame, and a lack of self-confidence. Damage to the child's sense of trust can result in social withdrawal and reluctance in peer interactions. Moreover, prolonged exposure to such experiences may lead to chronic stress and anxiety, as well as intensified emotional fluctuations. Physically, children may exhibit sleep disturbances, changes in appetite, and various stress-related health issues. These effects can negatively impact the child's daily life, education, and social relationships, potentially causing long-term consequences for overall health.

The aim of this study is to analyze the grooming risks children encounter in online environments, as well as the psychological and physiological effects they experience, to understand the methods employed by offenders, and to develop preventive strategies. Additionally, the study seeks to provide families and educators with concrete and practical recommendations to support children in developing safe online behaviors. This approach not only enhances children's online safety but also contributes to promoting a conscious and responsible digital usage culture.

**Keywords:** Child Abuse, Online Grooming, Internet, Prevention Strategies

### GİRİŞ

Grooming terimi, ilk olarak 1995 yılında Salter tarafından ağırlıklı olarak duygusal manipülasyon sürecini tanımlamak amacıyla kullanılmış olup, çocuk istismarının yeni bir türü olarak literatürde kendisine yeni yeni yer bulmaya başlamıştır (Pasca vd., 2022). Kavramın literatüre yeni girmesi nedeniyle, tanımları arasında farklılıklar gözlemlenebilmektedir. Öte yandan, bilgi ve iletişim teknolojilerindeki hızlı dönüşüm, çocukluk olgusunu sosyal, bilişsel ve duygusal boyutlarıyla yeniden şekillendirmiştir. İnternet, günümüzde yalnızca bir eğlence veya iletişim aracı olmanın ötesine geçerek, öğrenme, araştırma ve sosyal etkileşim için temel bir platform hâline gelmiştir (Livingstone & Helsper, 2007). Çocukların erken yaşlardan itibaren dijital ortamlarda etkin bir biçimde yer alması gelişim süreçlerine olumlu katkılar sağlasa da, çevrimiçi ortamların denetimsiz ve bilinçsiz kullanımı çocukları çok yönlü risklerle karşı karşıya bırakmaktadır. Özellikle sosyal medya ağları ve çevrim içi oyun platformları, çocukların çevrimiçi istismar, siber zorbalık ve grooming gibi tehditlere maruz kalma olasılığını artırmakta, böylece dijital çağda çocukluğun hem fırsatlar hem de ciddi tehlikeler barındıran ikili bir yapıya sahip olduğunu göstermektedir (Whittle et al., 2013).

Son yıllarda yapılan araştırmalar, çevrimiçi ortamların sunduğu imkânların yanı sıra önemli tehditler de barındırdığını ortaya koymaktadır. Çevrimiçi grooming, fail ile çocuk arasında güven ilişkisi kurulmasıyla başlayan ve zamanla manipülasyon, tehdit ve istismar süreçlerine evrilen karmaşık bir

olgu olarak tanımlanmaktadır (Craven, Brown, & Gilchrist, 2006). Bu süreç, çocukların psikolojik, sosyal ve akademik yaşamlarını olumsuz yönde etkileyebilmekte ve uzun vadede kalıcı travmalara yol açabilmektedir. Literatürde çevrimiçi istismarın bireysel, toplumsal ve hukuki boyutları giderek daha görünür hâle gelmekte, bu durum konuya yönelik kapsamlı inceleme ve önleme stratejilerinin geliştirilmesini gerekli kılmaktadır (Kloess, Seymour, & Hamilton-Giachritsis, 2014). Bu bağlamda, bu çalışmanın temel amacı, çocukların dijital ortamlarda maruz kaldığı grooming risklerini ele almak, sürecin etkilerini analiz etmek ve çocuk güvenliğini artırmaya yönelik koruyucu stratejilerin geliştirilmesine katkı sunmaktır.

### **Grooming'in Anatomisi**

Çevrimiçi grooming, yetişkin faillerin çocuklarla çevrimiçi platformlarda güven ilişkisi kurarak onları manipüle etmesiyle başlayan karmaşık bir süreçtir. Bu süreç genellikle dört aşamada ilerler: güven kazanma, gizlilik oluşturma, manipülasyon ve sömürü (Craven, Brown, & Gilchrist, 2006). Grooming sürecinde failler, öncelikle savunmasız durumda olan çocukları hedef alarak süreci başlatmaktadır. Bu noktada, çocukların yalnızlık duyguları, güvensizlikleri veya çeşitli duygusal ve sosyal ihtiyaçları istismarcı tarafından dikkatle tespit edilmektedir. Fail, bu zayıf noktaları kullanarak çocuk üzerinde kontrol kurmakta ve manipülasyon yoluyla güven ilişkisi geliştirmektedir. Ardından, psikolojik baskı yöntemleri devreye sokularak çocuğun karar verme özgürlüğü kısıtlanmakta ve istismarcının yönlendirmelerine boyun eğmesi sağlanmaktadır. Daha sonra, fail çocuğun duygusal veya maddi ihtiyaçlarını karşılayarak ona bağımlılık duygusu yaratır; hediyeler, övgüler ve destek sunma gibi davranışlarla çocukla bağ kurulur (Kloess, Seymour, & Hamilton-Giachritsis, 2017).

Sürecin ilerleyen aşamalarında çocuk, ailesi ve arkadaşlarından uzaklaştırılarak sosyal izolasyona tabi tutulur ve yalnızca failin güvenine dayalı bir ilişki geliştirmesi sağlanır. Bu durum, psikolojik baskı ve kontrol mekanizmalarını güçlendirir (Whittle, Hamilton-Giachritsis, & Beech, 2014). Ardından fail, ilişkiyi cinsel içerikli konuşmalar ve davranışlarla cinselleştirir; bu aşama fiziksel cinsel istismar riskini de beraberinde getirir (Whittle et al., 2013). Son olarak, fail tehdit, suçluluk duygusu ve korkutma stratejileriyle çocuğu kontrol altında tutmaya devam eder; çocuk, istismarı açığa çıkarmaması için psikolojik ve sözel baskıya maruz bırakılır (Craven et al., 2006; Kloess et al., 2017). Böylece grooming, çok aşamalı ve manipülatif bir süreç olarak, çocuğun güvenliği ve psikolojik bütünlüğü üzerinde derin etkiler bırakmaktadır. Bu nedenle grooming, yalnızca bireysel bir etkileşim değil, sistematik olarak işleyen bir istismar mekanizmasıdır.

### **Dijital Platformlar ve İstismarın Görünmez Yüzü**

Failler, çevrimiçi grooming süreçlerinde en sık sosyal medya uygulamaları, anlık mesajlaşma yazılımları ve çevrim içi oyun platformlarını kullanmaktadır (Whittle, Hamilton-Giachritsis, Beech, & Collings, 2013). Bu mecralar, çocukların günlük yaşamlarında yoğun olarak kullandıkları alanlar olduğundan, istismarcılar için erişimi kolaylaştırmaktadır. Özellikle çok oyunculu oyunlar ve anonim mesajlaşma uygulamaları, failin kimliğini gizleyerek manipülasyonu daha etkin hâle getirmektedir (Hamilton-Giachritsis, Hanson, Whittle, & Beech, 2017).

Avrupa Çevrimiçi Çocuk Araştırması'na (2020) göre, Türkiye'de çocukların %46'sı interneti kişisel bilgilerinin herkese açık olarak paylaşmakta ve %37,6'sı tanımadıkları kişilerle çevrim içi iletişim kurmaktadır. Bu durum, çevrimiçi platformları yalnızca sosyalleşme alanı olmaktan çıkarıp, çocukların güvenliği açısından ciddi riskler barındıran bir ortam hâline getirmektedir (Avrupa Çevrimiçi Çocuk Araştırması, 2020). Bu veriler, istismarcıların manipülasyon sürecini kolaylaştıran etkenlerden biri olarak değerlendirilmektedir ve çocukların dijital okuryazarlık ve güvenlik farkındalığının artırılmasının önemini ortaya koymaktadır.

## Çocukların Savunmasızlığı: Risk Faktörleri

Çocukların çevrimiçi cinsel istismara karşı savunmasızlığı, bireysel, sosyal ve ailevi faktörlerin etkileşimiyle şekillenmektedir. Araştırmalar, kız çocuklarının erkek çocuklarına kıyasla daha yüksek risk altında olduğunu göstermektedir; ancak erkek çocukların da tamamen korunmuş olmadığı vurgulanmaktadır (Finkelhor et al., 2005). Ergenlik döneminde gençler, sosyal etkileşim ve bağımsız kimlik geliştirme ihtiyacıyla birlikte, onaylanma, ilgi görme ve beğenilme arayışı içindedir; bu gelişimsel eğilimler, ergenlerin çevrimiçi ortamlarda tanımadıkları kişilerle iletişim kurma olasılığını artırmakta ve istismarcılar için fırsatlar yaratmaktadır (Quayle, Vaughan, & Taylor, 2012). Sosyal medya ve çevrim içi platformlar, gençlere hızlı geri bildirim ve sosyal kabul deneyimi sunarken, aynı zamanda savunmasızlıklarını da açığa çıkarmaktadır ve bu durum, dijital ortamlarda riskli davranışlarda bulunma olasılıklarını yükseltmektedir. Bireysel özellikler, özellikle düşük özsaygı, yalnızlık, sosyal izolasyon ve kendine güvensizlik, çocukların çevrimiçi istismara karşı kırılganlığını artıran kritik faktörler arasında yer almaktadır (De Graaf & Vanwesenbeeck, 2006). Ayrıca aile yapısı ve ebeveyn davranışları da risk üzerinde belirleyici rol oynamaktadır; parçalanmış aileler, ebeveyn-çocuk çatışmaları ve ebeveynlerin madde kullanımına bağlı ihmalkârlık, çocukların çevrimiçi istismara maruz kalma olasılığını artırmaktadır (Berger, Slack, Waldfogel, & Bruch, 2010). Bu çok boyutlu etkileşimler, çocukların dijital ortamda istismara karşı savunmasızlığını derinleştirmekte ve güvenli çevrimiçi deneyimlerin sağlanmasını zorlaştırmaktadır.

## Grooming'in Çocuklar Üzerindeki Yansımaları

Çevrimiçi grooming, çocukların dijital ortamlarda tanımadıkları kişilerle kurdukları ilişkiler aracılığıyla manipülasyon ve istismar süreçlerine tabi tutulmalarını ifade eder. Bu süreç, çocukların psikolojik ve sosyal gelişimlerini olumsuz yönde etkileyerek kalıcı travmalara yol açabilir.

Birleşik Krallık'ta yapılan bir araştırma, 2017 ile 2023 yılları arasında yaklaşık 34.000 çevrimiçi grooming vakasının kaydedildiğini ortaya koymuştur. Bu vakaların %83'ü kız çocuklarına yönelikken, 12 yaş altındaki çocuklar arasında vakaların dörtte biri görülmüştür (NSPCC, 2023). Benzer şekilde, Avustralya'da yapılan bir çalışmada, 18 yaşından önce çevrimiçi cinsel istismara uğrayan kız çocuklarının oranı %26,3 iken, erkek çocuklarında bu oran %7,6 olarak belirlenmiştir (Walsh et al., 2025). Psikolojik etkiler açısından, çevrimiçi grooming mağduru çocuklar arasında depresyon, anksiyete ve travma sonrası stres bozukluğu (TSSB) gibi durumların prevalansı yüksektir. Örneğin, Avustralya'da yapılan bir araştırma, çevrimiçi cinsel istismara uğrayan çocukların %17,7'sinin bu tür psikolojik sorunlar yaşadığını bildirmiştir (Walsh et al., 2025). Ayrıca, çevrimiçi grooming mağdurlarının %73,9'u yardım aradığını belirtmiş, ancak bunların yalnızca %26,1'i destek alabilmiştir (Walsh et al., 2025). Sosyal etkiler açısından, grooming mağduru çocuklar arasında sosyal izolasyon, okul başarısında düşüş ve aile içi ilişkilerde bozulmalar gibi durumlar gözlemlenmektedir. Ayrıca, bu çocuklar akran ilişkilerinde güvensizlik geliştirebilir, arkadaş gruplarından uzaklaşabilir ve sosyal etkileşimlerde kaygı ve çekingenlik yaşayabilirler (Whittle, Hamilton-Giachritsis, & Beech, 2014).

Uzun vadede, bu olumsuz sosyal deneyimler, çocukların özsaygı ve kendine güven duygusunu zayıflatarak, ilerleyen yaşlarda sosyal uyum ve ilişki kurma becerilerini olumsuz yönde etkileyebilir. Eğitim ortamında yaşanan başarısızlıklar, sadece akademik performansı değil, aynı zamanda motivasyon, katılım ve gelecek planlarını da etkileyerek, çocukların genel yaşam kalitesini düşürebilmektedir (Montiel, Vega, & Soto, 2016).

Türkiye özelinde ise, Edinburgh Üniversitesi Childlight Küresel Çocuk Güvenliği Enstitüsü ve Sidney New South Wales Üniversitesi'nin ortaklaşa yürüttüğü *Into the Light* raporuna göre, çocukların yaklaşık %13'ü rıza dışı cinsel görüntülerin paylaşılmasıyla karşı karşıya kalmaktadır (Çocuk Odaklı Habercilik Kütüphanesi, 2024). Ayrıca, Türkiye'de 11-17 yaş arası çocukların

%46'sının çevrimiçi etkinliklerini ailelerinden gizlediği, %52'sinin ise internette şiddet içerikli içeriklerle karşılaştığı bildirilmiştir (Kaspersky, 2023a; Kaspersky, 2023b). Ailelerin %31'inin çocuklarının çevrimiçi yaşamı nedeniyle çatışma yaşadığı da dikkate alındığında (Kaspersky, 2023c), çevrimiçi risklerin yalnızca bireysel değil aile içi ilişkileri de etkilediği görülmektedir. Adalet Bakanlığı verilerine göre ise, 2023 yılında çocuklara yönelik cinsel istismar suçuna ilişkin 66.138 dosya savcılıklara intikal etmiş ve 14.919 dava açılmıştır (Adalet Bakanlığı, 2023; Cumhuriyet, 2024). Bu veriler, Türkiye'de çevrimiçi grooming ve genel olarak çocuk istismarının ciddi bir toplumsal sorun olduğunu ve uluslararası bulgularla benzer şekilde çocukların güvenliğini tehdit eden yaygın bir problem oluşturduğunu göstermektedir.

### Toplumsal ve Hukuki Çerçeve

Çevrimiçi grooming yalnızca bireysel bir sorun değil, aynı zamanda toplumsal ve hukuki boyutları olan bir problemdir. Türkiye'de 5237 sayılı Türk Ceza Kanunu çocuk istismarını düzenleyen hükümler içerse de, çevrimiçi grooming'e yönelik özel düzenlemeler sınırlıdır (Kara, 2020). Uluslararası düzeyde ise Avrupa Konseyi'nin *Lanzarote Sözleşmesi* ve Avrupa Birliği'nin dijital güvenlik stratejileri bu alanda önemli çerçeveler sunmaktadır (Council of Europe, 2007). *Lanzarote Sözleşmesi*, çevrimiçi grooming'i açıkça suç olarak tanımlayarak devletlere hem önleyici tedbirler alma hem de mağdurlara destek hizmetleri sağlama yükümlülüğü getirmektedir. Avrupa Birliği'nin dijital güvenlik stratejileri ve *Dijital Hizmetler Yasası* (Digital Services Act) ise, çevrimiçi platformların çocukların güvenliğini sağlamak amacıyla içerik denetimi, şeffaflık ve sorumluluk mekanizmaları kurmasını zorunlu kılmaktadır (European Commission, 2020). Bu düzenlemeler, hem çocukların korunmasını hem de failerin cezalandırılmasını hedeflemektedir.

### Koruyucu ve Önleyici Yaklaşımlar

Çevrimiçi grooming'in önlenmesi, yalnızca bireysel farkındalık veya teknik çözümlerle sınırlı değildir; sosyal, eğitimsel ve sağlık temelli yaklaşımların bütüncül bir şekilde ele alınması gerekmektedir. Sosyal düzeyde, çocuklara dijital farkındalık kazandırılması, ailelerin bilinçli denetim mekanizmaları geliştirmesi ve çocuklarla açık, güven temelli iletişim kurması kritik öneme sahiptir (Livingstone, Davidson, & Bryce, 2017). Bu bağlamda, ailelerin çocukların çevrimiçi etkinliklerini izlemesi, internet kullanım kuralları belirlemesi ve dijital riskler konusunda çocuklarla sürekli diyalog halinde olması, grooming gibi çevrimiçi istismar türlerini önlemede temel stratejiler arasında yer almaktadır. Eğitim kurumları, çocuklara dijital okuryazarlık becerileri kazandırarak internet ortamındaki riskleri fark etmelerini sağlayabilir; ayrıca çocukların güvenli dijital davranışlar geliştirmesi ve şüpheli durumları raporlaması için rehberlik edebilir. Teknik çözümler olarak yazılım tabanlı ebeveyn kontrol araçları, filtreleme sistemleri ve çevrimiçi ihbar mekanizmaları da çevrimiçi risklerin azaltılmasına katkı sağlayan önemli araçlardır.

Bununla birlikte, bu önleyici yaklaşımlar yalnızca sosyal ve teknik boyutlarla sınırlı değildir; sağlık profesyonelleri, özellikle pediatri hemşireleri, çocuk sağlığını koruma kapsamında kritik bir rol üstlenmektedir. Pediatri hemşireleri, ailelere çevrimiçi riskler ve çocukların güvenli internet kullanımı konusunda danışmanlık sunarak ebeveynlerin bilinç düzeyini artırabilir (Çalışkan & Tuncay, 2021). Ayrıca hemşireler, ebeveynlerin çocuklarıyla açık ve destekleyici iletişim kurmalarını sağlayacak eğitim programları düzenleyebilir ve çocukların dijital farkındalıklarının artırılmasına yardımcı olabilir. Bu tür girişimler, çocukların kendilerini riskli durumlarda koruma becerilerini güçlendirirken, ailelerin de çocuklarının güvenli internet kullanımına aktif şekilde katılımını teşvik eder. Pediatri hemşirelerinin rolü, sadece bireysel aileleri desteklemekle sınırlı kalmaz; aynı zamanda toplum düzeyinde koruyucu sağlık hizmetlerinin etkinliğini artırır ve çocukların dijital ortamda güvenli bir şekilde gelişmesine katkıda bulunur. Bu kapsamda, hemşireler toplumsal farkındalık

yaratmak, ebeveynleri bilgilendirmek ve çocukların çevrimiçi güvenliğini sağlamak için eğitim, danışmanlık ve rehberlik sağlayan önemli bir köprü işlevi görmektedir (Sakellari et al., 2021). Sonuç olarak, çocukların dijital dünyada güvenliğini sağlamada sosyal, teknik ve hemşirelik odaklı önleyici yaklaşımların birlikte uygulanması, çocukların psikososyal sağlığının korunması ve çevrimiçi grooming gibi risklere karşı dirençli hâle gelmelerinde kritik bir stratejidir.

## Sonuç

Çevrimiçi grooming, çocukların güvenlik ve mahremiyet algısını derinden sarsan ve toplumsal etkileri olan ciddi bir problemdir. Bu nedenle, soruna yalnızca bireysel düzeyde değil, aile ve eğitim kurumlarının iş birliğiyle bütüncül bir yaklaşım geliştirilmesi gerekmektedir. Ebeveynler, çocukların internet kullanımını izlemek için aile filtreleri veya ebeveyn kontrol yazılımları kullanabilir ve onları güvenli internet davranışları konusunda bilinçlendirebilir. Örneğin, sosyal medya platformlarının gizlilik ayarlarını düzenlemek, çocukların kişisel bilgilerini paylaşmasını sınırlamak ve çevrim içi arkadaş listelerini gözden geçirmek somut adımlar arasında yer almaktadır. Eğitim kurumları ise çocuklara dijital okuryazarlık ve çevrim içi güvenlik eğitimi sunarak riskli durumları tanıma ve bildirme becerilerini geliştirebilir; örneğin, okul tabanlı atölyeler ve interaktif seminerler bu amaçla uygulanabilir. Ayrıca, çocukların çevrimiçi platformlarda karşılaştıkları şüpheli durumları kolayca rapor edebilecekleri güvenli iletişim kanalları oluşturulması da önem taşımaktadır.

Buna ek olarak, pediatri hemşireleri çocuk sağlığının korunmasında merkezi bir rol üstlenir. Hemşireler, ailelere çevrimiçi riskler hakkında danışmanlık sağlayarak, çocukların güvenli internet kullanımı ve dijital farkındalık becerilerini geliştirmelerine yardımcı olabilir. Hemşireler, okul tabanlı atölye ve seminerlerde veya bireysel danışmanlık oturumlarında ebeveynleri bilinçlendirerek, çocuklarla açık iletişim kurulmasını destekleyebilir ve potansiyel istismar durumlarını erken fark etmelerine katkıda bulunabilir. Bu bütüncül yaklaşım, yalnızca risklerin azaltılmasını sağlamakla kalmaz, aynı zamanda çocukların güvenli, bilinçli ve sorumlu bir dijital kullanım kültürü geliştirmelerine olanak tanır. Sonuç olarak, pediatri hemşireleri, aileler ve eğitimciler iş birliğiyle yürütülen bu önleyici ve eğitici uygulamalar, çocukların çevrimiçi ortamlarda güvenli ve sağlıklı bir şekilde gelişmesini mümkün kılmaktadır.

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## TÜRKİYE SÜPER LİGİ'NDE İÇ VE DIŞ SAHA MAÇLARINDAKİ KOŞU MESAFELERİNİN KARŞILAŞTIRILMASI

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### ÖZET

Maç koşu performansı, profesyonel futbolda fiziksel yükün ve performansın önemli bir göstergesidir ve maçın oynandığı saha koşulları performansı etkileyebilir. Türkiye Süper Ligi takımlarının iç saha ve deplasman maçlarındaki toplam koşu mesafesi, yüksek şiddetli koşu (HSR) ve sprint mesafeleri arasındaki farklara ilişkin kanıtlar sınırlıdır. Bu çalışma, Süper Lig takımlarının iç saha ve deplasman maçlarındaki koşu performansını karşılaştırmayı amaçlamaktadır. Sezon boyunca toplam 356 maç analiz edilmiş; toplam mesafe (m), yüksek şiddetli koşu (>19,8 km/s) ve sprint (>25,2 km/s) mesafeleri ölçülmüştür. İç saha ve deplasman performansları arasındaki farklar eşleştirilmiş örneklem t-testi (Paired Samples T-Test) ile değerlendirilmiş ve etki büyüklükleri Cohen's d ile hesaplanmıştır. Analiz sonuçları, toplam mesafe açısından iç saha ve deplasman arasında anlamlı bir fark olmadığını göstermiştir ( $t(355) = 1.281$ ,  $p = .201$ ,  $d = 0.068$ ). HSR mesafesi iç saha lehine bir eğilim sergilemiş, ancak fark istatistiksel olarak anlamlı bulunmamıştır ( $t(355) = 1.945$ ,  $p = .053$ ,  $d = 0.103$ ). Sprint mesafesi ise iç sahada anlamlı olarak yüksek bulunmuştur ( $t(355) = 2.255$ ,  $p = .025$ ,  $d = 0.120$ ). Tüm değişkenlerde etki büyüklükleri düşük düzeydedir. Bulgular, toplam koşu performansının saha durumundan etkilenmediğini, ancak sprint mesafelerinin iç sahada biraz daha yüksek olduğunu göstermektedir; bu durum saha avantajı, taraftar desteği veya taktik yaklaşımlarla ilişkili olabilir. Antrenörler ve performans ekibi, antrenman yüklerini ve maç hazırlıklarını planlarken bu farkları göz önünde bulundurmalıdır.

**Anahtar kelimeler:** Türkiye Süper Ligi, İç saha, Deplasman, Koşu Mesafeleri

### COMPARISON OF RUNNING DISTANCES IN HOME AND AWAY MATCHES IN THE TURKISH SUPER LEAGUE

#### ABSTRACT

Match running performance is an important indicator of physical load and performance in professional football, and pitch conditions can influence performance. Evidence regarding differences in total distance, high-speed running (HSR), and sprint distances between home and away matches in the Turkish Süper Lig is limited. This study aimed to compare the running performance of Süper Lig teams in home and away matches. A total of 356 matches across the season were analyzed; total distance (m), high-speed running (>19.8 km/h), and sprint (>25.2 km/h) distances were measured. Differences between home and away performances were assessed using paired-samples t-tests, and effect sizes were calculated using Cohen's d. Results indicated no significant difference in total distance between home and away matches ( $t(355) = 1.281$ ,  $p = .201$ ,  $d = 0.068$ ). HSR distance showed a trend in favor of home matches but was not statistically significant ( $t(355) = 1.945$ ,  $p = .053$ ,  $d = 0.103$ ). Sprint distance was significantly higher at home ( $t(355) = 2.255$ ,  $p = .025$ ,  $d = 0.120$ ). Effect sizes for all variables were small. These findings suggest that overall running performance is not affected by match location, although sprint distances are slightly higher at home, potentially due to

home advantage, crowd support, or tactical approaches. Coaches and performance staff should consider these differences when planning training loads and match preparations.

**Keywords:** Turkish Super League, Home, Away, Running Distances

## 1. GİRİŞ

Ev sahibi avantajı (home advantage) olgusu, spor bilimlerinde en kapsamlı biçimde araştırılan performans fenomenlerinden biri olarak kabul edilmektedir. Kavram, 20. yüzyılın ortalarından itibaren sistematik olarak tanımlanmış ve özellikle futbol, basketbol ve beyzbol gibi takım sporlarında ev sahibi takımların kendi sahalarında rakiplerine göre daha yüksek kazanma oranlarına sahip oldukları tekrarlanan biçimde rapor edilmiştir (Courneya & Carron, 1992). Pollard (1986) tarafından “takımın kendi sahasında oynadığı maçlarda deplasman maçlarına göre daha yüksek başarı oranı elde etme eğilimi” şeklinde tanımlanan bu fenomen, farklı liglerde ve dönemlerde yapılan çok sayıda çalışmada tutarlı biçimde doğrulanmıştır (Pollard, 2006; Goumas, 2014; Sánchez et al., 2021).

Ev sahibi avantajı, tek bir faktörle açıklanamayacak kadar çok boyutlu bir yapıya sahiptir. Seyirci desteği, saha koşullarına aşinalık, seyahat yorgunluğunun azlığı, çevresel faktörler, taktiksel tercihler ve hakem kararları gibi unsurların etkileşimi bu olgunun temel bileşenleri olarak tanımlanmaktadır (Nevill & Holder, 1999; Lago-Peñas & Lago-Ballesteros, 2011). Bu etkenler arasında özellikle seyirci varlığı, hem psikolojik hem de fizyolojik mekanizmalar üzerinden performansı etkileyen en güçlü belirleyici olarak öne çıkmaktadır. Yoğun taraftar desteği, oyuncuların motivasyonunu artırmakla kalmaz, aynı zamanda hakem kararlarını bilinçdışı düzeyde etkileyerek ev sahibi lehine karar olasılığını yükseltebilir (Nevill et al., 2002).

COVID-19 pandemisi sırasında dünya genelinde karşılaşmaların seyircisiz oynanması, ev sahibi avantajının doğasına ilişkin benzersiz bir doğal deney ortamı sunmuştur. Bilalić (2021) ve Bryson et al. (2022), seyircisiz dönemde ev sahibi takımların galibiyet oranlarının belirgin biçimde azaldığını ve bu farkın bazı liglerde neredeyse ortadan kalktığını göstermiştir. Bu bulgular, ev sahibi avantajının yalnızca çevresel veya taktiksel unsurlardan değil, seyirci varlığının tetiklediği psikososyal süreçlerden de güçlü biçimde etkilendiğini ortaya koymuştur.

Bununla birlikte, ev sahibi avantajına ilişkin literatürün büyük bölümü sonuç odaklı değişkenlere, örneğin galibiyet oranı, gol farkı veya hakem kararlarına odaklanmıştır. Modern futbolda performansın belirleyici bileşenlerinden biri olan fiziksel yüklenme düzeyi ve koşu profilleri ise görece daha az araştırılmıştır. Gelişen GPS tabanlı izleme teknolojileri, toplam koşu mesafesi, yüksek hızda koşu (>19.8 km/h), sprint mesafesi (>25.2 km/h), hızlanma ve yavaşlama gibi parametrelerin objektif biçimde analiz edilmesini mümkün kılmıştır (Akenhead & Nassis, 2016). Bu tür veriler, günümüz profesyonel futbolda performansın değerlendirilmesi, antrenman yüklerinin planlanması ve sakatlık riskinin yönetilmesi açısından kritik öneme sahiptir.

Buna karşın, ev sahibi avantajının fiziksel performans göstergeleri üzerindeki etkisini doğrudan inceleyen çalışmalar son derece sınırlıdır. Mevcut literatürdeki çoğu çalışma, takım davranışı ve taktiksel yaklaşımlar üzerine odaklanmış, oyuncuların maç içi koşu yükleri arasındaki farklılıkları sistematik olarak analiz etmemiştir. Rampinini et al. (2007), yüksek hızda koşu mesafesinin takım başarısıyla ilişkili olduğunu belirtmesine rağmen, bu ilişkinin ev sahibi–deplasman bağlamında nasıl değiştiği net biçimde ortaya konmamıştır.

Türkiye Süper Ligi, farklı iklim bölgelerini, değişken seyahat mesafelerini, yoğun seyirci desteğini ve yüksek rekabet düzeyini bir arada barındırması nedeniyle ev sahibi avantajının fiziksel boyutunun incelenmesi açısından uygun bir örneklem sunmaktadır. Avrupa'nın beş büyük liginde (Premier League, La Liga, Serie A, Bundesliga, Ligue 1) bu konu üzerine çok sayıda araştırma yürütülmüş olmasına karşın, Türkiye Süper Ligi özelinde fiziksel performans parametrelerinin karşılaştırmalı biçimde incelendiği çalışmalar oldukça sınırlıdır.

Bu bağlamda, mevcut çalışma Türkiye Süper Ligi'nde yer alan takımların iç saha ve deplasman maçlarındaki koşu performanslarını karşılaştırmayı amaçlamaktadır. Analize dahil edilen değişkenler toplam koşu mesafesi, yüksek şiddetli koşu mesafesi ( $>19.8$  km/h) ve sprint mesafesi ( $>25.2$  km/h) olup, oyuncuların maç boyunca sergiledikleri fiziksel efor düzeylerini nesnel biçimde temsil etmektedir. Çalışmanın temel varsayımı, ev sahibi takımların saha tanıdıklığı, kısa seyahat süresi ve seyirci desteği gibi avantajlardan faydalanarak deplasman takımlarına kıyasla daha yüksek fiziksel performans sergileyecekleridir. Buna karşılık, deplasman takımlarının seyahat yorgunluğu, çevresel koşulların değişimi ve psikolojik baskı gibi faktörler nedeniyle fiziksel yüklenme düzeylerinde azalma yaşayabileceği öngörülmektedir.

Sonuç olarak, bu araştırma ev sahibi avantajını yalnızca skor veya taktiksel çıktılarla değil, fiziksel performans perspektifinden ele alarak literatürdeki önemli bir boşluğu doldurmayı hedeflemektedir. Türkiye Süper Ligi verileri üzerinden yürütülen bu analiz, antrenörler, performans analistleri ve spor bilimciler için saha konumuna bağlı fiziksel yük farklılıklarını anlamada değerli bilgiler sunabilir. Ayrıca, bulguların antrenman planlaması ve yük yönetimi stratejilerinin optimize edilmesine katkı sağlaması beklenmektedir.

## 2. YÖNTEM

### 2.1 Araştırma Tasarımı

Bu çalışma, Türkiye Süper Ligi'nde yer alan profesyonel futbol takımlarının 2023–2024 sezonu boyunca oynadığı maçlardan elde edilen koşu performans verilerinin retrospektif ve karşılaştırmalı analizine dayalı olarak tasarlanmıştır. Araştırma, iç saha ve deplasman müsabakalarındaki fiziksel yüklenme farklılıklarını nesnel koşu mesafesi parametreleri üzerinden incelemeyi amaçlayan nicel bir gözlemsel çalışma niteliğindedir.

### 2.2 Katılımcılar ve Veri Seçimi

Analize Türkiye Süper Ligi'nde yer alan 20 profesyonel takım dâhil edilmiştir. Sezon boyunca oynanan tüm maçlar taranmış, eksik GPS kaydı veya erken oyuncu değişikliği nedeniyle tamamlanmamış veriler dışlanmıştır. Bu kriterler doğrultusunda toplam 356 maç gözlemi değerlendirmeye alınmıştır. Kaleciler analize dâhil edilmemiştir. Tüm değerler takım bazında ortalama koşu performansları olarak hesaplanmıştır.

### 2.3 Veri Toplama Prosedürü

Maç verileri, Türkiye Süper Ligi kulüplerinin performans departmanlarında kullanılan Sportbase veritabanı sisteminden elde edilmiştir. Bu sistem; toplam koşu mesafesi, yüksek şiddetli koşu (HSR) ve sprint mesafesi gibi değişkenleri yüksek doğrulukla kaydetmektedir.

Her müsabakadan sonra video kamera sisteminden alınan veriler, manuel doğrulama ve filtreleme işlemleri sonrası araştırma veri setine aktarılmıştır. Elde edilen ham veriler aşağıdaki değişkenlere göre sınıflandırılmıştır: Toplam koşu mesafesi (m): Oyuncuların maç boyunca kat ettiği toplam mesafe; Yüksek şiddetli koşu (HSR, m): 19.8 km/h üzerindeki koşu hızlarında kat edilen toplam mesafe; Sprint mesafesi (m): 25.2 km/h üzerindeki hızlarda koşulan toplam mesafe.

### 2.4 Veri Düzenleme ve İstatistiksel Analiz

Veriler Microsoft Excel 2021 ortamında düzenlenmiş ve istatistiksel analizler için JASP (v0.18) yazılımına aktarılmıştır. Öncelikle değişkenlerin normal dağılım varsayımı Shapiro–Wilk testi ile test

edilmiştir. Normallik koşulunun sağlandığı durumlarda, iç saha ve deplasman koşu performanslarını karşılaştırmak için eşleştirilmiş örneklem t-testi (Paired Samples t-test) uygulanmıştır. Her değişken için tanımlayıcı ve karşılaştırmalı istatistiksel analizler gerçekleştirilmiştir. Bu kapsamda ortalama (Mean), standart sapma (SD), ortalama fark (Mean Difference), %95 güven aralığı (CI), t değeri, serbestlik derecesi (df) ve p değeri raporlanmıştır. Ayrıca farkların büyüklüğünü değerlendirmek amacıyla etki büyüklüğü (Cohen's d) hesaplanmıştır. Etki büyüklüklerinin yorumlanmasında Cohen (1988) tarafından önerilen sınıflandırma ölçütleri esas alınmıştır:  $d < 0.2$  çok küçük etki,  $0.2 \leq d < 0.5$  küçük etki,  $0.5 \leq d < 0.8$  orta etki ve  $d \geq 0.8$  büyük etki olarak değerlendirilmiştir. Tüm istatistiksel analizlerde anlamlılık düzeyi  $p < 0.05$  olarak belirlenmiştir.

### 3. BULGULAR

Araştırmada toplam 356 maç gözlemine ait koşu performansı verileri analiz edilmiştir. Futbolculardan elde edilen ortalama toplam koşu mesafesi, yüksek şiddetli koşu mesafesi ve sprint mesafesi değişkenleri için iç saha ve deplasman performansları karşılaştırılmıştır. Analizlerde eşleştirilmiş örneklem t-testi uygulanmış, ayrıca etki büyüklükleri Cohen's d katsayısı ile hesaplanmıştır.

Elde edilen bulgulara göre, toplam koşu mesafesi iç saha maçlarında ( $M = 113.669 \pm 4.704$  m) deplasman maçlarına ( $M = 113.266 \pm 4.872$  m) kıyasla daha yüksek olmasına rağmen, bu fark istatistiksel olarak anlamlı bulunmamıştır,  $t(355) = 1.28$ ,  $p = .201$ ,  $d = 0.068$ , 95% CI  $[-0.036, 0.172]$  (Tablo 1). Bu sonuca göre, toplam koşu mesafesinde iç saha ve deplasman maçları arasında anlamlı bir fark olmadığı ve etki büyüklüğünün çok küçük düzeyde olduğu söylenebilir (Grafik 1).

**Tablo 1.**

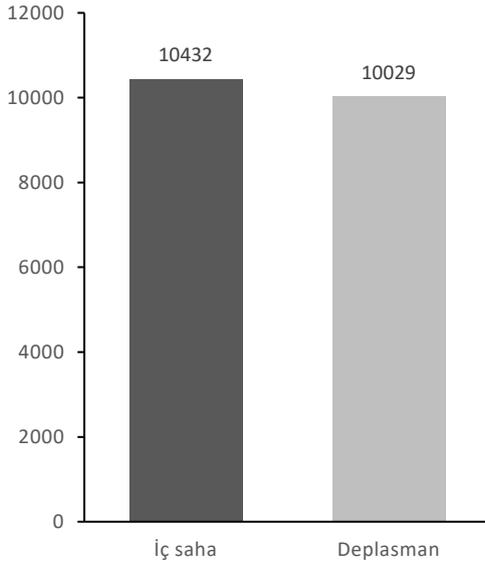
İç Saha ve Deplasman Maç Koşu Performanslarına Ait Betimsel İstatistikler ve Eşleştirilmiş Örneklem t-Testi Sonuçları

Değişken	İç Saha Ortalama (SS)	Deplasman Ortalama (SS)	t	sd	p	Cohen's d	95% CI
Toplam Mesafe (m)	113.669 (4.704)	113.266 (4.872)	1.28	355	.201	0.068	[-0.036, 0.172]
Yüksek Şiddetli Koşu (m)	8.247 (1.002)	8.115 (1.028)	1.95	355	.053	0.103	[-0.001, 0.207]
Sprint Mesafesi (m)	1.965 (0.416)	1.901 (0.362)	2.26	355	.025	0.120	[0.015, 0.224]

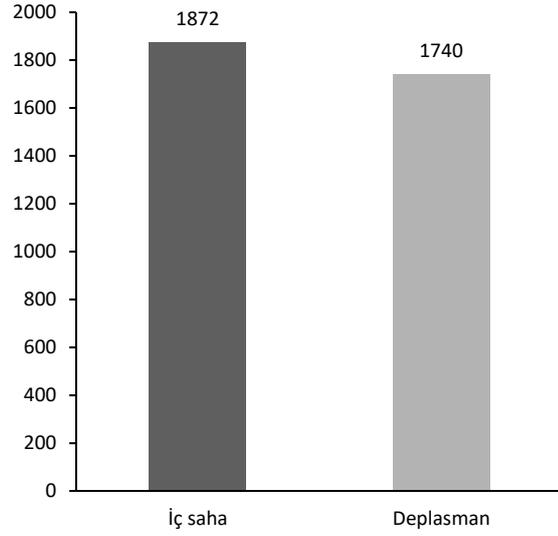
SS = standart sapma; CI = güven aralığı. Cohen's d etki büyüklüğü yorumları: 0.2 = küçük, 0.5 = orta, 0.8 = büyük etki.  $P < 0.05$

Yüksek şiddetli koşu mesafesi değişkeninde ise iç saha ortalaması ( $M = 8.247 \pm 1.002$  m), deplasman ortalamasına ( $M = 8.115 \pm 1.028$  m) göre daha yüksek bulunmuştur. Bu fark sınırda istatistiksel anlamlılık göstermiştir,  $t(355) = 1.95$ ,  $p = .053$ ,  $d = 0.103$ , 95% CI  $[-0.001, 0.207]$  (Tablo 1). Etki büyüklüğünün düşük düzeyde olduğu ve farkın anlamlılık sınırına yakın olduğu görülmektedir (Grafik 2).

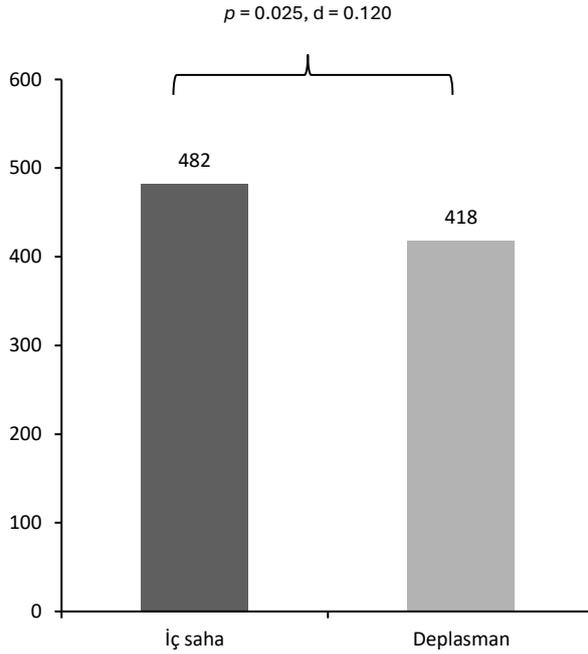
Sprint mesafesi açısından iç saha maçlarında ( $M = 1.965 \pm 0.416$  m) elde edilen değerler, deplasman maçlarına ( $M = 1.901 \pm 0.362$  m) kıyasla anlamlı derecede daha yüksek bulunmuştur,  $t(355) = 2.26$ ,  $p = .025$ ,  $d = 0.120$ , 95% CI  $[0.015, 0.224]$  (Tablo 1). Bu fark küçük düzeyde bir etki büyüklüğüyle desteklenmiştir (Grafik 3).



**Grafik 1.** Toplam Koşu Mesafesi Mesafesi



**Grafik 2.** Yüksek Şiddetli Koşu



**Grafik 3.** Sprint Mesafesi

#### 4. TARTIŞMA ve SONUÇ

Bu çalışmanın amacı, Türkiye Süper Ligi takımlarının iç saha ve deplasman maçlarındaki koşu performanslarını karşılaştırarak ev sahibi avantajının fiziksel yansımalarını incelemektir. Elde edilen bulgular, ev sahibi takımların toplam koşu mesafesi ve yüksek şiddetli koşu mesafesi bakımından deplasman takımlarına göre yalnızca sınırlı düzeyde üstünlük gösterdiğini; buna karşın sprint mesafesi değişkeninde anlamlı bir fark bulunduğunu ortaya koymuştur. Bu sonuçlar, ev sahibi

avantajının futbol performansına yalnızca teknik-taktik veya psikolojik düzeyde değil, fiziksel performans bileşenleri açısından da belirli ölçüde yansımaları göstermektedir.

Bulgular, ev sahibi takımların daha yüksek sprint mesafesi kat ettiğini bildiren önceki araştırmalarla kısmen tutarlıdır. Örneğin, Rampinini ve arkadaşları (2007) takım başarısının yüksek hızda koşu ve sprint performansı ile ilişkili olduğunu belirtmiştir. Benzer şekilde, Lago-Peñas ve Lago-Ballesteros (2011), ev sahibi takımların özellikle hücum fazında daha agresif koşu profili sergilediklerini göstermiştir. Mevcut çalışmada da sprint mesafesindeki anlamlı fark, ev sahibi takımların hücumda daha proaktif davranma eğilimini yansıtıyor olabilir. Bu durum, taktiksel tercihlerin ve psikolojik motivasyonun fiziksel çıktılara doğrudan yansımaları şeklinde yorumlanabilir (Pollard, 2006; Nevill & Holder, 1999).

Buna karşın, toplam koşu mesafesi ve yüksek şiddetli koşu mesafesinde gözlenen farkların istatistiksel olarak anlamlı düzeyde olmaması, ev sahibi avantajının fiziksel yüklenme üzerindeki etkisinin sınırlı olabileceğini düşündürmektedir. Özellikle modern futbolda deplasman takımlarının kondisyonel düzeylerinin ve seyahat koşullarının iyileşmesi, bu farkın azalmasına neden olmuş olabilir (Sánchez et al., 2021). Ayrıca GPS teknolojilerinin yaygın kullanımıyla antrenman planlamasının daha hassas hale gelmesi, deplasman maçlarında da yüksek fiziksel çıktının sürdürülebilmesini kolaylaştırmıştır (Akenhead & Nassis, 2016).

Ev sahibi avantajına ilişkin geleneksel açıklamalardan biri olan seyirci desteği faktörü (Nevill et al., 2002), fiziksel performans üzerinde motivasyonel etkiler yaratabilir. Bununla birlikte, mevcut bulgular seyirci desteğinin koşu performansını dramatik biçimde artırmadığını göstermektedir. COVID-19 pandemisi sürecinde seyircisiz maçlarda ev sahibi avantajının büyük ölçüde ortadan kalktığını bildiren çalışmalar (Bilalić, 2021; Bryson et al., 2022) da bu sonucu destekler niteliktedir. Bu bağlamda, psikolojik faktörlerin maç sonucuna etkisi fiziksel performans değişkenlerinden daha belirgin olabilir.

Çalışmanın bulguları, ev sahibi avantajının fiziksel performans göstergeleri üzerindeki etkisinin küçük ama sistematik olabileceğini göstermektedir. Özellikle sprint mesafesi farkının istatistiksel olarak anlamlı bulunması, maçın kritik anlarında (örneğin hücum geçişlerinde) ev sahibi takımların daha yüksek efor düzeyine ulaşabildiğini işaret edebilir. Bu bulgu, antrenörler açısından da pratik bir öneme sahiptir. İç saha maçlarında oyuncuların yüksek hız ve sprint yüklerinin doğal olarak artabileceği göz önünde bulundurularak, antrenman yüklemesinin bu duruma göre planlanması önerilebilir.

Bununla birlikte, bu çalışmada gözlenen farkların etki büyüklükleri oldukça düşük düzeydedir ( $d = 0.068-0.120$ ). Bu durum, istatistiksel anlamlılık elde edilse bile, saha içi performans üzerindeki pratik etkilerin sınırlı olabileceğine işaret etmektedir. Dolayısıyla, ev sahibi avantajının fiziksel performans üzerindeki etkisi, diğer faktörlerle (taktiksel organizasyon, oyuncu kalitesi, maçın dinamiği) etkileşim içinde değerlendirilmelidir.

Gelecekteki araştırmaların, ev sahibi avantajını yalnızca koşu mesafesiyle değil, hız zonu dağılımı, hızlanma/yavaşlama yoğunluğu, metabolik güç veya pozisyon bazlı yüklenme gibi daha kapsamlı parametrelerle incelemesi önerilmektedir. Ayrıca, farklı iklim bölgeleri ve seyahat mesafeleri gibi çevresel faktörlerin de modele dahil edilmesi, sonuçların genellenebilirliğini artırabilir.

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## AI-DRIVEN PSYCHOMETRIC TESTING: ENHANCING ACCURACY, ADAPTABILITY, AND INSIGHT

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### Abstract

Psychometric testing has long been a cornerstone in evaluating cognitive skills, personality traits, and behavioral tendencies across education, clinical practice, and organizational development. Traditional approaches, however, are limited by static design, lengthy administration, and the risk of subjective bias in interpretation. With the advent of Artificial Intelligence (AI), psychometric testing is undergoing a paradigm shift toward greater accuracy, adaptability, and deeper insights.

This paper examines how AI enhances psychometric assessments through machine learning algorithms that identify subtle response patterns, natural language processing (NLP) that interprets open-ended responses, and adaptive testing frameworks that dynamically adjust difficulty based on real-time performance. By integrating AI-driven analytics, psychometric evaluations can provide more precise predictions of job performance, learning potential, and emotional resilience.

Nevertheless, the use of AI introduces challenges related to fairness, data privacy, and algorithmic transparency. Ensuring that AI-driven psychometric systems are ethical, inclusive, and explainable is essential to maintaining credibility and trust.

The study concludes that AI-driven psychometric testing represents a transformative leap from traditional static tools to intelligent, adaptive systems capable of offering personalized insights. When implemented responsibly, it can significantly improve decision-making in education, employment, and mental health contexts.

**Keywords:** Psychometric Testing, Artificial Intelligence, Machine Learning, Adaptive Assessment, Behavioral Analytics, Ethical AI

### 1. Introduction

Psychometric testing has been central to educational measurement, psychological assessment, and recruitment practices for over a century. Rooted in **Classical Test Theory (CTT)** and later **Item Response Theory (IRT)**, these assessments aim to infer latent psychological traits from observable responses. Traditional methods, while scientifically rigorous, are often **static, time-consuming, and vulnerable to cultural biases**.

Artificial intelligence offers a way to **reimagine psychometrics** as dynamic, adaptive systems that personalize test delivery, uncover subtle response patterns, and generate richer interpretive insights. This paper explores how AI enhances traditional testing methods, addresses ethical and legal implications, and highlights emerging applications across education, clinical contexts, and talent management.

## 2. Traditional Psychometric Testing: Foundations and Limitations

### 2.1 Foundations

Traditional psychometrics is anchored in fixed-form tests designed to estimate latent constructs such as intelligence, aptitude, or personality traits. CTT assumes each observed score is the sum of a true score and random error, emphasizing reliability and validity. IRT refines this by modeling the probability of a correct response as a function of a person's ability and item parameters. These frameworks have enabled standardized tests, diagnostic assessments, and selection tools to be widely adopted.

### 2.2 Limitations

Despite their utility, several limitations persist:

- **Static Forms:** Fixed item sets for all examinees, leading to inefficiencies and ceiling/floor effects.
- **Calibration Burden:** Large item banks are expensive to build and maintain.
- **Limited Sensitivity:** Static designs may miss intra-individual variability.
- **Cultural Bias:** Differential item functioning can disadvantage minority groups.
- **Restricted Formats:** Reliance on multiple-choice or Likert scales suppresses narrative richness.
- **Interpretive Constraints:** Traditional scoring focuses on raw or scaled scores, overlooking nuanced behavioral patterns.

These gaps motivate the integration of **AI techniques** to improve efficiency, adaptivity, and interpretive power.

## 3. AI-Driven Enhancements in Psychometrics

AI contributes to psychometric innovation in multiple dimensions — from **machine learning pattern detection** to **adaptive testing** and **automatic item generation**.

### 3.1 Machine Learning for Pattern Detection

Machine learning models analyze high-dimensional response data to uncover latent patterns invisible to classical models. They can detect unusual response times, inconsistent patterns, or strategic guessing, helping flag misfitting items or disengaged respondents. Clustering techniques reveal subgroups with distinct response trajectories, supporting refined trait interpretation.

### 3.2 Natural Language Processing for Open-Ended Responses

NLP enables scoring of narrative responses—something historically difficult to standardize. By analyzing emotional tone, lexical diversity, and thematic content, NLP can infer psychological constructs such as openness or resilience from free-text answers (Pellert, 2024). This broadens assessment beyond rigid multiple-choice formats, enhancing validity.

### 3.3 Adaptive Testing and Dynamic Difficulty

AI-driven adaptive testing goes beyond IRT-based CATs by incorporating **response times**, **confidence indicators**, and **previous trajectories** to select optimal next items. Recent studies show that **ML-enhanced adaptive tests** can halve item counts while maintaining measurement precision (Colledani et al., 2025).

### 3.4 Predictive Analytics and Outcome Forecasting

Using psychometric data as inputs, AI models predict downstream outcomes—such as academic performance, job success, or mental health trajectories—through nonlinear, data-rich modeling. This enables personalized recommendations and targeted interventions.

### 3.5 Automatic Item Generation

AI can generate new items through templates or language models, ensuring **continuous replenishment of item banks** and mitigating exposure risks (Automatic item generation, n.d.).

### Comparison of Traditional vs AI-Enhanced Psychometric Testing

Aspect	Traditional Methods	AI-Enhanced Methods
Test Design	Fixed-form, pre-calibrated	Dynamic, data-driven, adaptive
Adaptivity	Same items for all examinees	Real-time adjustment to ability
Response Analysis	Raw scores & IRT	ML on patterns, latencies, clusters
Item Generation	Manual, expert-driven	Automated item generation (AIG)
Scoring	Rule-based	Predictive modeling, NLP for open-ended responses
Interpretation	Norm-referenced	Rich multidimensional profiles
Efficiency	Long, less tailored	Fewer items, higher precision

Table 1 compares key aspects of traditional versus AI-driven psychometric testing approaches.

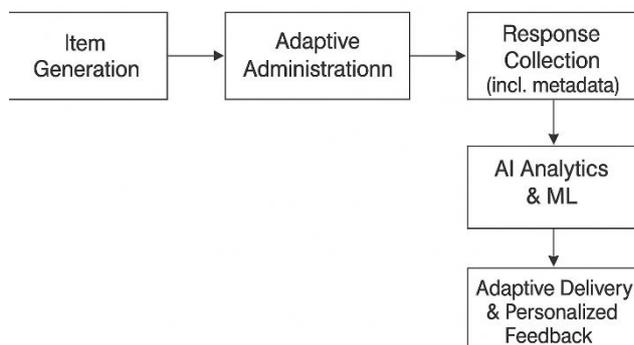


Figure 1. AI Integration Points in Psychometric Assessment

Figure 1 depicts key integration points for AI within the psychometric assessment pipeline.

## 4. Ethical, Legal, and Social Considerations

### 4.1 Algorithmic Bias

Training data often encode demographic biases, potentially amplifying group disparities. Auditing for **differential item functioning** and ensuring representative training samples is essential.

### 4.2 Transparency and Explainability

Black-box AI models pose challenges for accountability. High-stakes decisions (e.g., hiring, diagnosis) require explainable outputs to maintain trust.

### 4.3 Privacy and Security

AI systems often collect response metadata (e.g., keystroke dynamics). Compliance with GDPR and other frameworks mandates strict consent, encryption, and anonymization.

### 4.4 Human Oversight

AI should **augment**, not replace, professional judgment. Hybrid decision frameworks ensure responsible use.

## 5. Applications and Illustrative Cases

### 5.1 Education

AI-powered psychometrics enables **personalized learning**, adapting difficulty and providing real-time feedback. Studies demonstrate its effectiveness in detecting learning difficulties and adjusting content (Zhuang et al., 2023).

### 5.2 Recruitment

In organizational contexts, chatbots and AI-enhanced personality assessments reduce social desirability bias but require further validation for predictive accuracy (Dukanovic & Krpan, 2025).

### 5.3 Mental Health

Adaptive mental health assessments powered by ML offer efficient and precise measurement, improving screening and monitoring (Colledani et al., 2025).

## 6. Conclusion

AI-enhanced psychometric testing marks a **paradigm shift** from static, one-size-fits-all tools to adaptive, data-rich, and interpretively powerful systems. By integrating ML, NLP, adaptive algorithms, and AIG, assessments become **more efficient, more personalized, and potentially fairer**.

However, these benefits hinge on **ethical governance, robust validation, and human oversight**. AI should support—not supplant—psychometric expertise. With responsible implementation, AI psychometrics can transform education, workforce development, and mental health assessment.

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## A DOMINATION-THEORY APPROACH TO GRAPH-BASED CRYPTOGRAPHY

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### Abstract

Encryption in graph theory explores the utilization of graph structures and their computationally hard problems as a foundation for secure communication. Unlike traditional cryptography, which is mostly based on number theory, graph-based encryption offers new ways to create secure keys and hide messages. The main strength of this approach is that many graph problems are very difficult to solve, which makes them useful for building strong security systems. One such idea in this direction is the use of domination concepts in graphs. A dominating set  $D \subseteq V(G)$  is defined as a subset where every vertex in  $V - D$  is adjacent to at least one vertex in  $D$ . A dominating set is minimal if no proper subset is also a dominating set, and the domination number  $\gamma(G)$  is the size of the smallest such set. A subset  $D \subseteq V$  is called a complementary tree dominating set (ctd – set) of  $G$  if  $D$  is a dominating set of  $G$  and  $\langle V - D \rangle$  is a tree. The complementary tree domination number of  $G$ , denoted  $\gamma_{ctd}(G)$ , is the minimum cardinality of such a set  $D$ . This paper introduces a new method for encryption based on complementary tree domination. The idea is to encode data into graphs and secure it using the difficulty of finding these special dominating sets. Since solving domination problems is computationally hard, the approach can provide strong protection. This approach could help create new encryption methods that stay safe against today's security threats and may also withstand future threats.

### Introduction

In an age dominated by the internet and digital technology, securing critical information has become increasingly vital, mirroring the historical need of military and diplomatic figures for secret communication. As data security methods advance, so do new ways to breach private messages. Cryptography, which has a history spanning over two millennia, ensures secure transmission against unauthorized access. The foundation for modern cryptography was laid by Shannon (1949) [4], and it is now an essential part of contemporary life. The process of encryption transforms the original message, or plaintext, into a coded format called ciphertext using a specific key. The reverse process, decryption, turns the ciphertext back into a readable message. The key is crucial, as the authorized recipient can easily unveil the message with the correct key, making interception by others infeasible. Modern cryptographic methods rely mainly on three schemes: symmetric-key cryptography, which uses a single key for both encryption and decryption; public-key cryptography, which uses separate

keys; and hash functions, which encrypt data irreversibly (Stinson, 2018) [5]. These techniques are fundamental to securing digital communication. Recent research has sought to enhance these methods: Slashi Leel et al [3]. suggested using an adjacent matrix of a complement graph for safer encryption and decryption, a technique. Sabharwal et al. [7] found to be appropriate and efficient through various analyses. Furthermore, Nasir Ali et al. [8] used special corona graphs, star graphs, and complete bipartite graphs with algebraic properties to strengthen secure message transmission, while Perera and Wijesiri [6] proposed a methodology using a matrix as the secret key to increase the cryptosystem's security. In this paper we proposed a new method for encryption based on complementary tree domination.

### Graph Theory Terminology

A graph is defined by a set of vertices ( $V$ ) and a set of edges ( $E$ ) connecting pairs of vertices. An induced subgraph is a subgraph created by selecting a subset of vertices and including all edges connecting them. A tree is any connected acyclic graph. A dominating set (DS)  $D$  of  $G$  is a set of vertices of  $G$  such that every vertex in  $V - D$  is adjacent to a vertex in  $D$ . If  $D$  has the smallest possible cardinality of any dominating set of  $G$ , then  $D$  is called a minimum dominating set– abbreviated MDS. The cardinality of any MDS for  $G$  is called a domination number of  $G$  and is denoted by  $\gamma(G)$ . A  $\gamma$ -set denotes a dominating set for  $G$  with minimum cardinality. A graph  $G$  is said to be a domination complement tree graph if  $G$  has at least one  $\gamma$ -set  $D$  such that  $\langle V - D \rangle$  is a tree [2]. Figure 1 shows an example of a VDT graph.

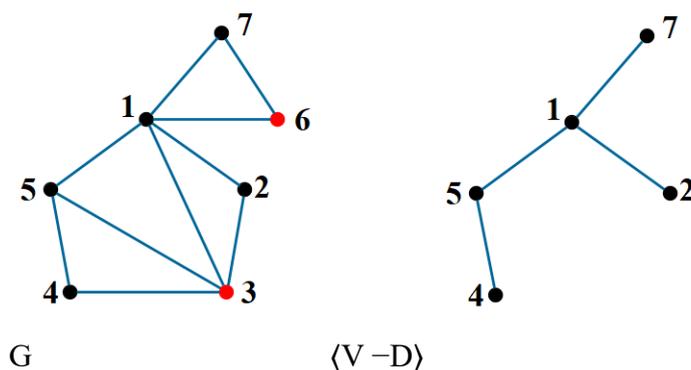


Figure 1. Example for a VDT graph.

For definitions and results on graph theory we refer to [1].

### Encryption Algorithm

**Step 1** Choose any message  $S: K_1 K_2 K_3 \dots K_n$  with  $n$  words

Let  $K_i = K_{i1} K_{i2} \dots K_{imi}$ , where  $|m_i| =$  length of the word  $K_i$  and each  $K_{i1}$  denotes the alphabets in the word  $K_i$ .

**Step 2** Choose  $n$  VDT graphs  $G_1, G_2, \dots, G_n$  such that

1.  $D_1, D_2, \dots, D_n$  are the  $\gamma_{VDT}$  - sets of  $G_1, G_2, \dots, G_n$ .
2.  $|\langle V_i - D_i \rangle| = |K_i|, 1 \leq i \leq n$ .
3.  $|D_1| \geq 2$ .

**Step 3** Generate a sequence of strings  $S_1, S_2, \dots, S_n$  using Table 1, such that  $|S_i| = |K_i|$  for every  $1 \leq i \leq n$ . Let  $S_i = S_{i1} S_{i2} \dots S_{imi}$ .

A	B	C	D	E	F	G	H	I	J	K	L	M
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
01	02	03	04	05	06	07	08	09	10	11	12	13
N	O	P	Q	R	S	T	U	V	W	X	Y	Z
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
14	15	16	17	18	19	20	21	22	23	24	25	26

Table 1

**Step 4** For every word  $K_i$ ,  $1 \leq i \leq n$ , we label graph  $G_i$  as follow.

1. Assign the value  $S_{i1}, S_{i2}, \dots, S_{imi}$  to the vertices of  $\langle V_i - D_i \rangle$  in a random fashion.
2. Prefix the label  $S_{i1}, S_{i2}, \dots, S_{imi}$  by integers  $1, 2, \dots, m_i$ .

**Step 5** Let  $D_i = \{v_{i1}, v_{i2}, \dots, v_{ipi}\}$ ,  $1 \leq i \leq n$ . We know that  $|p_i| \geq 2$ . Choose arbitrary vertices  $v_{ij} \in D_i$ ,  $1 \leq i \leq n$ ,  $1 \leq j \leq p_i$ . Generate a graph  $G$  with components  $C_1, C_2, \dots, C_n$  by merging these vertices, where each component  $C_i$  denotes the corresponding graph  $G_i$ .

**Step 6** Arrange the components of  $G$  such that graphs  $G_1, G_2, \dots, G_n$  are arranged in clockwise order as seen in Figure 2. The merged vertex is labelled as  $v$  in Figure 2.

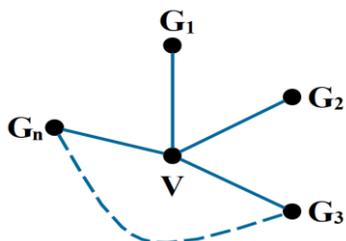


Figure 2. Partial structure of  $G$ .

**Step 7** Assign label 0 to one unlabelled vertex of  $G_1$ . Assign random labels to the remaining vertices.

**Step 8** Send the labelled graph  $G$  to the receiver.

#### 4. Example Illustration

The stepwise algorithm described in the previous section outlines the general procedure for encoding a message using VDT graphs. To demonstrate the working of this method, an example is presented in this section.

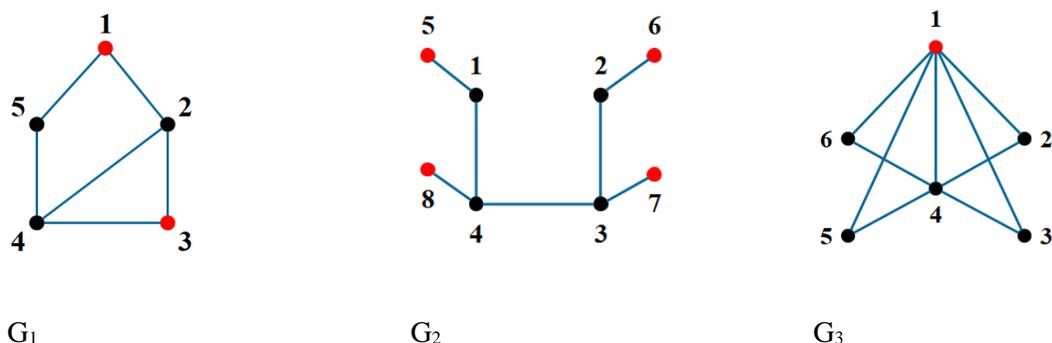
Let us choose the message  $S$  as

$S$ : USE THIS GRAPH.

The message consists of three words

$K_1 = \text{USE}, K_2 = \text{THIS}, K_3 = \text{GRAPH}$

According to Step 2 of the algorithm, three corresponding VDT graphs  $G_1, G_2,$  and  $G_3$  are selected to represent these words. Figure 3 shows the graphs, and their respective  $\gamma_{\text{VDT}}$  – sets.



**Figure 3.** VDT graphs

The  $\gamma_{\text{VDT}}$  – sets are

- $G_1: D_1 = \{1, 3\}.$
- $G_2: D_2 = \{5, 6, 7, 8\}.$
- $G_3: D_3 = \{1\}.$

We now check that for each  $i: |V_i - D_i| = |K_i|.$

- $G_1: V_1 - D_1 = \{2, 4, 5\} \rightarrow \text{size } 3 = |\text{USE}|$
- $G_2: V_2 - D_2 = \{1, 2, 3, 4\} \rightarrow \text{size } 4 = |\text{THIS}|$
- $G_3: V_3 - D_3 = \{2, 3, 4, 5, 6\} \rightarrow \text{size } 5 = |\text{GRAPH}|$

Having verified that the number of non-dominating vertices in each graph matches the length of the corresponding word  $K_i,$  we proceed to Step 3 of the algorithm.

In this step, each word in the message is converted into a numerical string  $S_i$  by replacing every alphabet with its positional value in the English alphabet.

The substitution rule used for this conversion is presented in Table 1.

Using this mapping, each word of the message  $S:$  “USE THIS GRAPH” is converted into its corresponding numeric sequence.

U	S	E	T	H	I	S	G	R	A	P	H
21	19	05	20	08	09	19	07	18	01	16	08

$S_1 = 21\ 19\ 5$  for “USE”

$S_2 = 20\ 8\ 9\ 19$  for “THIS”

$S_3 = 7\ 18\ 1\ 16\ 8$  for “GRAPH”

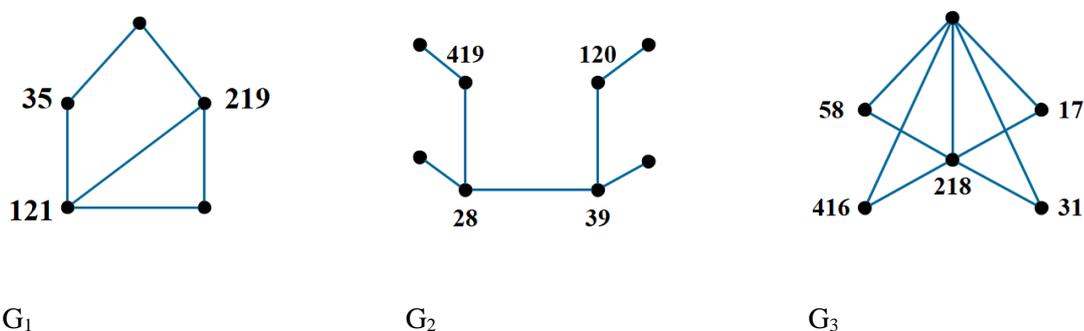
Each  $S_i$  now represents the numeric equivalent of  $K_i$ , and the length of each string  $|S_i|$  equals the number of non-dominating vertices in the corresponding graph  $G_i$ .

### Vertex Labelling

For every graph  $G_i$ , the vertices belonging to  $V_i - D_i$  are randomly labelled using the numeric values of  $S_i$ . i.e.,

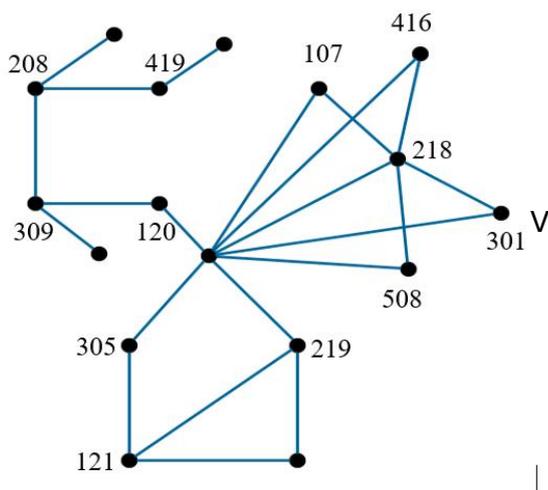
- In  $G_1$ , the vertices  $\{2, 4, 5\}$  receive the labels 21, 19, 5 in random order.
- In  $G_2$ , the vertices  $\{1, 2, 3, 4\}$  receive the labels 20, 8, 9, 19.
- In  $G_3$ , the vertices  $\{2, 3, 4, 5, 6\}$  receive the labels 7, 18, 1, 16, 8.

Each label is prefixed by an integer 1 to  $m_i$  (where  $m_i = |K_i|$ ) to form a vertex identifier, creating a structured but non-predictable labelling pattern. The resulting labelled graphs are illustrated in Figure 4.



**Figure 4.** Labelled graphs  $G_1$ ,  $G_2$  and  $G_3$  for the words

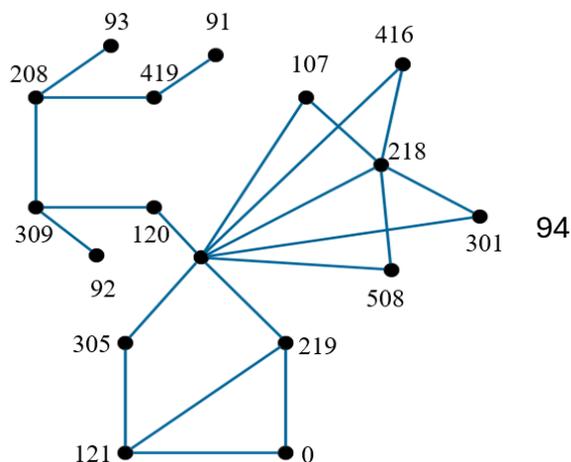
From the labelled graphs shown in Figure 3, selected vertices from sets  $D_i$  from each graph are merged to form a single connected graph  $G$  as shown in Figure 5, following Step 5 of the algorithm.



**Figure 5.** Graph  $G$  formed from  $G_1$ ,  $G_2$  and  $G_3$  with labelled vertices.

The newly created central vertex resulting from this merge is labelled as  $V$ . After merging the graphs into the combined graph  $G$ , one unlabelled vertex from a dominating set that was not merged is

assigned the label **0**. The remaining unlabelled vertices are then assigned random numbers as shown in Figure 6. These random labels do not carry any message information—they simply make the graph harder to interpret for anyone else.



**Figure 6.** Encrypted graph G

The numeric labels on the non-dominating vertices (from Step 4) stay the same. These labels hold the actual message, so they should not be changed. The prefix numbers on each vertex help keep the letters in the correct order when decoding. The fully labelled graph G is now ready and sent to the receiver. Using the algorithm and the prefix numbers, the receiver can read the labels on the non-dominating vertices, convert the numbers back into letters, and reconstruct the original message.

## Conclusion

This method of encrypting a message using VDT graphs gives a new and interesting way to make communication secure. The idea combines graph theory with encryption by turning each word of a message into a graph. In these graphs, the non-dominating vertices are used to store the letters of the word as numbers, while the dominating vertices help to hide the real message structure.

The main advantage of this method is that a graph can have many possible dominating sets. Because of this, the same message can be encrypted in many different ways each time. Also, since the labels for the vertices that are not part of the message are chosen randomly, it becomes very hard for anyone else to find out how the message was hidden. Without knowing which dominating set and which labelling method were used, no one can easily read the original message.

This technique also does not need large keys or complex mathematical steps like other encryption methods. Instead, its security comes from the uncertainty of the graph's structure and the randomness in labelling.

Overall, this shows that graph-based encryption is both simple and powerful. The random selection of dominating sets, the hidden vertex labelling, and the way graphs are merged together make this a strong and flexible method for secret communication and future research in secure data sharing.

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## COMPARATIVE ANALYSIS OF PRIMARY EDUCATION CURRICULA IN NATURE AND SOCIETY: THE CASE OF SERBIA AND ENGLAND

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### **Abstract**

This paper presents a comparative analysis of curricula in the field of subjects that integrate the content of Nature and Society in the Republic of Serbia and England. The aim of the paper is to explore similarities and differences in the structure, purpose, objectives, outcomes and content of teaching, as well as in the competences expected of students in the first cycle of primary education. The curriculum in Serbia is based on the subjects The World Around Us and Nature and Society, which integrate knowledge from natural and social sciences, with an emphasis on experiential learning and the immediate environment of students. In contrast, in England, the National Curriculum in Key Stage 1 and Key Stage 2 specifically highlights the subjects Science, History and Geography, which allows for a more systematic and disciplinary-clear study of phenomena and processes. The analysis shows that the Serbian model encourages an integrative approach and the development of a holistic picture of the world, while the English model allows for the earlier formation of disciplinary knowledge and skills. The paper concludes that both curricular solutions have advantages and limitations, and that their comparison can contribute to the improvement of teaching practice and the development of students' competences for active and responsible participation in society.

**Keywords:** curriculum, comparative analysis, learning outcomes, student competencies, Nature and Society, Science, National Curriculum.

### **1. Introduction**

In modern education, the curriculum is a fundamental document that determines the goals, structure, content and methods of teaching, as well as the expected learning outcomes. It not only shapes the way in which knowledge is transmitted, but also reflects the values, priorities and educational philosophies of society (Print, 1993). Today, it is impossible to seriously consider issues of education and upbringing without insight into the experiences of developed countries that have a great influence on world trends. Critically adopting foreign experiences and ideas is becoming an indispensable need of modern society and a driver of educational reforms. In this sense, the analysis and comparison of curricula of different countries allows for a deeper understanding of the way in which education is conceptualized, as well as the identification of opportunities for improving one's own system.

The subject Nature and Society plays a particularly important role in early education, as it integrates the foundations of natural and social sciences and represents the first systematic contact of students with the phenomena of the world around them – natural phenomena, living beings, social communities, culture and history. The aim of this subject is to develop in students an initial understanding of themselves and their environment, as well as basic skills of logical thinking, observation, reasoning and orientation in space and time (ZUOV, 2020). In this paper, the subject of analysis will be the Nature and Society curricula in the Republic of Serbia and England. Serbia, as a country in transition, is in the process of curricular reform, while England is an example of a developed education system in which an approach based on learning outcomes, interdisciplinarity

and the active role of students has been represented in the long term (Department for Education, 2013). The results of the PISA tests, which reveal the capacity of students to apply acquired knowledge and skills in key areas, show that Serbian students are below the OECD average in the Science PISA score, with generally unimpressive results in the TIMSS analyses. In the PISA 2022 Science test, Serbian students scored an average of 447 points, which is below the OECD average (485) and ranked 40th in the overall ranking. England consistently performs above the OECD average in science ( $\approx 503$ ), but the averages show a downward trend compared to previous cycles (OECD, 2023).

Comparative analysis of the Nature and Society curricula of Serbia and England will focus on the following components:

- Analysis of teaching and learning plans: subject names, weekly and annual lesson plans, compulsory and related elective subjects;
- Analysis of the teaching and learning program: program structure; purpose, goals, outcomes, competencies, level of demands placed on students; teaching and learning content (recommended and/or compulsory, grouping by areas);
- Analysis of instructions for teachers (structure of instructions, presence of didactic and methodological elements, quality of instructions).

Research in the field of comparative pedagogy indicates the importance of such analyses for improving national curricula, as they enable the consideration of different approaches and the adaptation of best practices to the local context (Kubow & Fossum, 2007). In this sense, this paper aims to offer not only a descriptive, but also a critical analysis of the similarities and differences between the two curricula, and to point out opportunities for improving the teaching of Nature and Society in the Serbian education system.

## 2. Material and methods

In the preparation of this paper, the method of comparative analysis was applied, which allows for a systematic comparison of educational curricula in two different national contexts – the Republic of Serbia and England. The aim of this approach is to identify similarities and differences in the theoretical framework, structure and practical application of curricula, with a special focus on the subjects The World Around Us and Nature and Society in the lower grades of primary education.

The material used in this paper includes official documents of the education systems of the two countries, including:

For the Republic of Serbia:

- Curriculum for the subjects The World Around Us and Nature and Society for grades one to four, published by the Ministry of Education.
- Educational profiles and curricula available on the official portal of the Institute for the Improvement of Education.
- Accompanying pedagogical and methodological manuals for teachers.

For England:

- National Curriculum for England – the official curriculum for Key Stages 1 and 2, which includes content from the subjects of Science, Geography and History (Department for Education, 2013), which in a functional sense correspond to the Serbian subject Nature and Society.
- Teacher guidelines and manuals published by the Department for Education (DfE).

- Additional documents and examples of teaching practice from schools.

The following methods were applied in the analysis:

1) Documentary analysis – a detailed study of official documents in order to determine the formal and content characteristics of the program.

2) Content analysis, which includes:

-program structure (organization by grade, thematic areas, time load);

-the purpose and objectives of teaching;

-planned learning outcomes and development of key competencies;

-cognitive level of requirements (according to Bloom's Taxonomy);

-teaching content and its complexity;

-degree of guidance and support provided to teachers.

3) Comparative analysis – the results from the previous methods were systematized in tabular and narrative form, in order to enable a clear comparison between the Serbian and English curricula.

Pedagogical orientations, teaching philosophies, and methodological guidelines were interpreted. By applying this research framework, the paper provides a valid and comprehensive basis for examining the differences between the curricula of the Republic of Serbia and England and potential improvements in the planning and implementation of the teaching of Nature and Society in Serbia.

### 3. Results

#### *Primary education in Serbia*

Primary education in Serbia is supervised by the Ministry of Education. Children's education begins in preschool institutions held in local kindergartens or schools, and has become mandatory since the 2006/07 school year. It lasts 4 hours a day, for a minimum of 6 months in the year of enrollment in the first grade, for children aged five or six, and its goal is to familiarize students with the education system and prepare them for primary school. Every child who is at least six and a half years old and at most seven and a half years old by the beginning of the school year is enrolled in the first grade of primary school (by Serbian law). Like preschool, primary education is also compulsory and lasts eight years. It is achieved through two educational cycles: the first from grades 1 to 4, organized through class-subject teaching, and the second cycle from grades 5 to 8 through subject teaching (Table 1). Primary schools are the providers of primary education and upbringing. Primary schools implement the school curriculum. Teaching planning includes the development of annual and operational plans, as well as preparation for classes, days or weeks. In the annual plan, the number of classes is distributed by topics and months in accordance with the school calendar and the number of classes. The teacher should adapt the program to the specific class, taking into account the needs and characteristics of students, teaching materials, technical conditions, school resources and resources of the local environment. When planning, individual differences in the method and pace of learning, an integrated approach to content, collaborative activities, the use of active and experiential methods, the connection of school content with students' everyday experience and their application in life are taken into account. Curiosity and interest in learning are also encouraged, and students' progress is regularly monitored. Based on the outcome and content, the teacher first creates an annual plan, develops operational plans from it, and then operationalizes them within individual teaching units.

**Table 1.** The structure of preschool and primary education in Serbia.

Age (years)	Schooling phase	Year of schooling	Institution
5-6	Preschool education	-	kindergarten or school
7-8	1. cycle	1.	Primary school
8-9		2.	
9-10		3.	
10-11		4.	
11-12	2. cycle	5.	
12-13		6.	
13-14		7.	
14-15		8.	

*Primary education in England*

Education in England is overseen by the Department for Education. Local authorities are responsible for implementing public education policy and state-funded schools at the local level. State-funded schools can be selective grammar schools or non-selective comprehensive schools. England also has private schools (some of which are known as state schools) and home education. By law, parents can choose to educate their children in any way they see fit. The state-funded compulsory school system is divided into Key Stages, based on the age of the pupils as of 31 August. The Early Years Preparatory Stage is for ages 3 to 4. Primary education is divided into Key Stage 1 for ages 5 to 7 and Key Stage 2 for ages 7 to 11 (Table 2). Secondary education is divided into Key Stage 3 for ages 11 to 14 and Key Stage 4 for ages 14 to 16 (DfE, 2013). Full-time education is compulsory for all children aged 5 to 18. The National Curriculum covers students in primary school (ages 5 to 11; Key Stages 1 and 2) and secondary school (ages 11 to 16; Key Stages 3 and 4). It covers the subjects taught and the standards that students should achieve in each subject. State schools in England are required to offer a curriculum that is balanced and broad-based, that promotes the spiritual, moral, cultural, mental and physical development of students in school and society, and that prepares students for the responsibilities and challenges of life (DfE, 2013).

**Table 2.** The structure of preschool and primary education in England.

Age (years)	Schooling phase	Year of schooling	Institution
3-4	Foundation Stage	kindergarten	kindergarten
4-5		Preschool	
5-6	Key Stage 1	1.	Primary school
6-7		2.	
7-8		3.	
8-9		4.	
9-10	Key Stage 2	5.	
10-11		6.	
11-12		7.	
12-13		8.	
13-14	Key Stage 3	9.	
14-15		10.	
15-16		11.	

### *Analysis of teaching and learning plans*

In both countries, the school year lasts 36 weeks. In England, the number of lessons is not strictly prescribed but is based on average school practice (DfE reports) (Table 3). State schools are required to teach 12 subjects in primary school. The core subjects are English, mathematics and science. Language and mathematics dominate in both systems and make up 50–60% of teaching time, with the difference that in England more attention is paid to these subjects (there are more lessons). In Serbia, the subjects The World Around Us (I–II) and Nature and Society (III–IV) are integrated, while in England there are three separate subjects: Science, History and Geography. The weekly number of lessons is the same or similar in both countries for the subjects World Around Us/Nature and Society, i.e. Science in England, Fine Arts and Music, i.e. Art & Design and Music in England, and Digital World, i.e. Computing in England. In Serbia, more attention is paid to foreign language (2 hours per week) and physical education (3 hours) than in England. Elective subjects in Serbia are Religious Education or Civic Education (compulsory choice of one). In England, Religious Education is also an elective subject, but the content is not centrally prescribed and schools choose the program themselves. The subject PSHE (Personal, Social, Health, Civic Education) is present in schools but is not formally mandatory in all schools. Both subjects have a number of lessons of 30–36 hours per year.

**Table 3.** Subjects and lesson plans in Serbia (grades 1-4) and England (Key Stage 1-2).

<b>Serbia (Grades I–IV)</b>	<b>Number of lessons (weekly/yearly**)</b>	<b>England (KS1: 5–7 год; KS2: 7–11 y.)</b>	<b>Number of lessons (weekly/yearly**)</b>
<b>Mandatory subjects</b>		<b>Mandatory subjects</b>	
<b>Serbian language</b>	I–IV: 5/180	English (Reading, Writing, Spoken Language)	KS1: 7–8/ ~280 KS2: 6–7/ ~270
<b>Mathematics</b>	I–IV: 5/180	Mathematics	KS1: 5/~190 KS2: 5–6 / ~220
<b>The world around us (I–II)</b>	I–II: 2/72	Science	KS1: 1.5–2 / ~70 KS2: 2 / ~80
<b>Nature and society (III–IV)</b>	III–IV: 2/72	History, Geography	KS1: 1 + 1/~70 KS2: 1 + 1/~70
–	–	Modern Foreign Language (mandatory in KS2)	KS1: – KS2: 1 / ~35
<b>Foreign language</b>	I–IV: 2/72	Art & Design	KS1-2: 2 / ~70
<b>Arts</b>	I: 1/36 II–IV: 2/72	Music	KS1-2: 2/~70
<b>Music</b>	I–III: 1/36 IV: 2/72	PE (Physical Education)	KS1-2: 2 / ~70
<b>Physical education</b>	I–IV: 3/108	Computing (ICT)	KS1-2: 1 / ~35
<b>Digital world</b>	I–IV: 1/36	<b>Elective subjects</b>	
<b>Elective subjects</b>		<b>Elective subjects</b>	
<b>Civic education or Religious education (elective, 1 hour)</b>	I–IV: 1/36	Religious Education + PSHE (personal, social, health, citizenship education)	KS1-2: 0.5–1 / ~20–35

\* Serbia: calculated based on 36 teaching weeks.

\*\* England: the stated fund is based on average school practice (Ofsted/DFE reports).

### ***Analysis of teaching and learning programs***

The curricula for the subjects *The World Around Us* and *Nature and Society* in all four grades have a teaching and learning plan of two hours per week, or 72 hours per year, and the home-country principle. The principle of proximity to life or the home-country principle is based on the fact that students first learn about the phenomena and processes that are closest to them in terms of space and time, and then gradually expand their knowledge to a wider environment. In the first grade, the starting point is the student's immediate environment - home, school and settlement. In the second grade, the settlement and its surroundings are covered, in the third grade, the region in which the students live, and in the fourth grade, the broader framework is covered, i.e. the Republic of Serbia. The principle of proximity to life in teaching allows the program to be adapted to the environment in which the students live, open to content from their environment and flexible enough to respect diversity within Serbia. The aim of teaching is to develop all aspects of the student's personality – intellectual, psychophysical, cognitive and social – which is reflected in the learning outcomes and the general aim of the programme (Table 4). The outcomes of the *World Around Us/Nature and Society* teaching show what students can do at the end of the grade thanks to the acquired knowledge, attitudes and skills. They are achieved by connecting teaching content, methods and student activities, most often across multiple topics, so the boundaries between topics should be viewed flexibly. Some outcomes are cross-curricular and are achieved in multiple teaching areas. The outcomes are clearly defined and are achieved through the application of appropriate teaching methods and activities, where the content is not an end in itself, but serves as a means to achieve the outcome. Outcome-based teaching does not only involve the transfer of knowledge, but also the development of students' abilities and skills (Table 5). The program provides a framework, but the teacher has the freedom to adapt the content to the needs and interests of the students and the environment in which they live. Students' research activity is encouraged, with the support and unobtrusive guidance of the teacher. Activities that encourage interaction with the environment are particularly valuable, because in this way students discover the characteristics and relationships in nature and society, as well as social skills. Emphasis is placed on methods that put students in an active role and enable different ways of learning through a variety of situations and activities.

**Table 4.** General objectives of the subject *The World Around Us/Nature and Society*.

General objectives:

- development of basic concepts about nature, society, culture and health;
- building a positive attitude towards the environment and community;
- encouraging critical and responsible behavior towards nature (environmental awareness);
- cultivating healthy habits and safe behavior in traffic;
- creating the basis for the formation of national and cultural identity;
- encouraging the ability for cooperation, tolerance and respect for diversity.

**Table 5.** General learning outcomes at the end of the first cycle.

Upon completion of the first cycle (grades I–IV), the student is expected to:

- recognize and describe basic phenomena in nature and society;
- be able to observe changes in the environment and connect them with everyday life;

- show a basic understanding of the relationship between man and nature and between the individual and the community;
- apply elementary research procedures: observation, recording, comparison, inference;
- express their own experience through conversation, drawing, map, simple table or graphic display;
- develop awareness of the importance of health, culture, history and the natural environment;
- develop basic communication and cooperation skills in a group;
- acquire the foundations for further learning of geography, history, biology and other natural and social sciences.

The subjects *The World Around Us* and *Nature and Society* belong to a teaching area that has an integrative character and combines content from several scientific disciplines. The content of *The World Around Us* (Grades I–II) is close to the students’ experience, adapted to their age and based on the principle of gradual discovery of the world. It includes content that helps children better understand the family, school, nature and society in their environment. *Nature and Society* (Grades III–IV) continues the integrated approach, but introduces more systematic and extensive content, which prepares students for later study of individual disciplines – geography, history, biology, physics and chemistry. The purpose of the program is to gradually introduce students to the understanding of natural and social phenomena, through content that is close to them, but also to develop their curiosity, ability to observe and elementary research skills.

Teaching these subjects contributes to the development of several key competences for lifelong learning: learning how to learn (independent discovery and connection of knowledge); communication and cooperation (group work, exchange of ideas); civic competence (understanding of community rules and cultural values); environmental awareness (respect for nature and responsible behavior); cultural awareness (knowledge of traditions, customs and cultural heritage); basic digital skills. Specific subject competences include: the ability to observe and recognize phenomena; initial development of an investigative spirit and logical thinking; application of acquired knowledge in everyday life situations (e.g. health, traffic safety) (Table 6).

**Table 6.** Comparative presentation of some characteristics of the curricula of Serbia and England.

Field	Serbia ( <i>The World Around Us</i> / <i>Nature and Society</i> )	England (Science + Geography + History)
<b>Educational cycle</b>	I educational cycle (grades 1–4)	Key Stage 1 (Year 1–2) Key Stage 2 (Year 3–6)
<b>Subject type</b>	Integrated: natural and social sciences	Scientific: division into biology, chemistry, physics, history and geography
<b>Organization</b>	Thematic units (geography, ecology, society, technology...)	Thematic units by scientific disciplines
<b>Form of work</b>	Integrated teaching, often interdisciplinary	Disciplinary structure with scientific methods
<b>Purpose and objectives</b>	Basic knowledge about nature and society, development of scientific curiosity, responsibility and social orientation	Development of scientific processes, spatial understanding, historical thinking and global awareness
<b>Key outcomes</b>	Recognition of living/inanimate nature, orientation, temporal and social structures, rights and obligations	Measurement and analytics, critical scientific communication; location knowledge and field analyses; reasoning from historical sources

<b>Methodological skills</b>	Asking questions, observing, classifying, describing	Working Scientifically, графички прикази, истраживања, GIS и презентације
<b>Content topics</b>	Space, time, nature, man and society, health	Biology, physics, chemistry, materials; climate, resources, geographical forms; historical periods and concepts
<b>Critical thinking</b>	Introduction through questions, basic observation	Analysis of sources, cause/effect, similarity/difference
<b>Writing and presenting results</b>	Descriptions, drawings and posters in groups or pairs	Use of tables, graphs, reports, PowerPoint, digital presentations and input sources
<b>Environmental / civic component</b>	Attitude towards nature, health, community, rights and obligations	Environmental awareness, national history, global culture and social values

The program is adapted to children aged 7 to 10. In grades I and II, the emphasis is on reproductive knowledge – describing, recognizing and enumerating. In grades III and IV, higher cognitive requirements (functional knowledge) are gradually introduced – comparing, inferring, solving simple problems, elementary experiments. Although there is encouragement for curiosity and research, the emphasis is more on the acquisition of basic knowledge and values, and less on scientific methodology.

The contents are defined in the National Curriculum and Program, and are mandatory in school. They are grouped by areas that integrate natural and social topics. In grades I and II, through the subject *The World Around Us*, students are introduced to basic contents related to living and non-living nature, plants and animals, changes in nature, the human body and health, family, transport and the environment (ZUOV, 2017). These topics are designed to stimulate children's curiosity, develop habits of observation and direct experience, and form the foundations of environmental awareness. In grades III and IV, in the subject *Nature and Society*, the content becomes more systematic and deeper, with a clearer division into the areas of natural and social sciences. In the area of nature, students study the living world, natural phenomena, energy, water, soil, and climatic conditions. In the area of society, the content includes historical development, cultural heritage, geographical concepts, the local community, as well as topics related to social relations, occupations, and the economy. In this way, this subject provides the foundation for later systematic study of natural sciences, history, and geography in higher grades (Teacher's Manual, ZUOV, 2018). The content is grouped into thematic units, and teachers have the opportunity to adapt it to the context and experience of students. This encourages the connection of knowledge and its application in real situations. A particularly important aspect of teaching is the cultivation of cultural identity and the development of environmental awareness. Research shows that this subject significantly contributes to the formation of positive attitudes of students towards nature, society and community (Đorđević, 2020). In this sense, the content is not only informative but also educational, because through it, students acquire values and habits that prepare them for an active role in society. Although the program is well-designed, there are certain challenges in practice. Teachers often point to the extensiveness of the content and the limited time for its implementation, as well as the need for more practical and field activities (Marković, 2019). Therefore, textbook and methodological support is of utmost importance, in order to enable students to connect the content with their own experiences and environment.

The National Curriculum for Science and Social Sciences in England for Key Stages 1 and 2 is one of the most important elements of primary education, with the aim of developing in students a lifelong curiosity, scientific and social literacy, encouraging critical thinking and understanding of the world in which they live. According to the official document „Science/History/Geography Programmes of Study“ (DfE, 2013), these subjects are designed so that students gain a deep understanding of natural and social phenomena through active participation in investigative activities and the application of

scientific methods. This approach clearly emphasizes the process of learning through inquiry, rather than simply acquiring facts.

The objectives of teaching science and social sciences defined within the curriculum are focused on three levels. Firstly, students should develop scientific knowledge and conceptual understanding in the areas of biology, chemistry, physics, history and geography. Secondly, it is necessary for them to acquire an understanding of the nature, processes and methods of science, through different types of research work that enable them to seek answers to scientific questions. The third aim relates to the acquisition of the competences needed to understand and apply science in everyday life and modern society (DfE, 2013). In this way, the programme lays the foundations for functional scientific literacy, but also for the further academic development of students.

Learning outcomes are defined as the specific knowledge and skills that students should acquire by the end of each key stage. They are clearly and measurably defined and include cognitive, practical and interpersonal skills. There is a strong focus on cross-curricular competences and independent learning. Students are encouraged to investigate, hypothesize, conduct experiments and formulate conclusions, which indicates a higher cognitive level, already in the early years of schooling. These outcomes include understanding basic scientific and social concepts, such as the structure and function of living organisms, the properties of materials, energy and force, as well as the ability to use scientific and historical methods for research and problem solving (Table 6). The competencies developed through teaching these subjects include the ability for students to ask scientific and historical questions, plan and carry out experiments and research, collect and analyse data, and draw results and conclusions. These competencies are integrated into all areas of teaching and learning, ensuring the comprehensive development of scientific and social skills. A special feature of the programme is that the competencies in the area of „Working Scientifically“ are not isolated in a separate teaching unit, but are integrated into all content areas. This means that students are trained across all topics to ask questions, observe, measure, classify, use simple and more advanced research methods, as well as to communicate their results orally and in writing. This approach enables students to acquire not only knowledge, but also lasting competences that can be applied in different contexts, which is in line with modern concepts of education that emphasize functional knowledge (Harlen, 2015). The level of requirements placed on students is clearly defined: by the end of each Key Stage, they should know, understand and be able to apply the content provided by the program. In doing so, schools have the flexibility to adapt the order of processing to their own needs, which allows adaptation to different educational contexts (DfE, 2013). This system of gradually increasing complexity allows students to develop in accordance with their age and individual capabilities, but also to ensure continuity in learning. In Key Stage 1, students are introduced to basic scientific and historical concepts through direct experience and observation. In Key Stage 2, students are introduced to more complex concepts and methods, such as planning and conducting experiments, collecting and analysing data, and drawing conclusions from evidence.

Teaching and learning content is grouped into subject areas covering biology, chemistry, physics, history and geography. At each stage, content is arranged by year but without a strict chronology of content, but rather themes and expected outcomes are provided by unit. Schools have the flexibility to adapt the sequence of teaching to their needs, provided that they are obliged to implement all prescribed outcomes by the end of each key stage. Thematic planning that integrates several subjects is encouraged (e.g. environmental research through a historical perspective). In Key Stage 1, the curriculum is based on experience and direct observation of the world around students. The content of the lessons includes topics such as plants, animals, materials and seasonal changes, as well as basic historical and geographical concepts. The requirements are age-appropriate and focus on classification, description and simple comparisons, as well as the adoption of basic scientific methods through practical activities and experiments. As the Department for Education (DfE, 2013) points out, during this period students are encouraged to ask questions, to observe natural and social phenomena

and to use a variety of sources to arrive at answers. In Key Stage 2, the curriculum includes deeper explorations of these areas, as well as new topics such as force and motion, light and sound, electricity, historical events and geographical processes. The demands become considerably more complex. Students in the lower grades of this level extend their knowledge of the functions and relationships in the living world, learning about the transport of water and nutrients in plants, the digestion and skeletal system in animals, and basic physical phenomena such as light, sound and magnetism. In the older grades, they are expected to understand the human circulatory system, photosynthesis, solutions and mixtures, electric currents, the motion of the Earth and planets. They are required to be able to control variables in experiments, to accurately measure, record and display data, and to draw reasoned conclusions. In this way, according to the curriculum, the ability for abstract thinking and critical evaluation of evidence is gradually built (DfE, 2013).

### *Analysis of the instructions for teachers*

The Regulations on the Curriculum and Learning Plan (2017, 2018, 2019) provide grade-level outcomes and a general structure of the program. More specific methodological content can also be found in the manuals accompanying the textbooks *The World Around Us/Nature and Society* (e.g. Vasiljević and Kenda, 2006; Matanović et al., 2014) and school programs. The manuals are often focused on practical implementation (inspections, field observations). They also contain suggestions for teaching units, example activities, lesson suggestions, lists of terms, and suggestions for evaluation. The focus is on the integration of natural and social content. In addition to knowledge about nature, the emphasis is on social and value outcomes (behavior, health, civic orientation).

The English National Curriculum has a clear national programme for Science/History/Geography subjects (science/history/geography programmes of study) which includes: a description of the chapters/topics by key stage (KS), where Working scientifically (emphasis on the scientific method and practical inquiry skills) is applied as a way of approaching the subject, then, the expected level of achievement by the end of the key stage and short notes for teachers (DfE, 2013). Schools must have an annual plan based on this document. The instructions contain detailed information on the topics covered (plants, animals, humans, materials, light, electricity, etc.), clear instructions that working scientifically must be intertwined with the content, instructions on progress and achievement of outcomes. There are a number of additional practical unit guides from the Association for Science Education (ASE), best-practice documents, the Improving Primary Science guide from the Education Foundation (EEF) and other resources for practical teaching and assessment, which specify methods, evaluation and grading ([www.ase.org.uk](http://www.ase.org.uk)EEF).

Of the didactic-methodological elements, there are practical suggestions (inspections, observations, projects), guidelines for lesson plans and instructions for connecting content to social themes. Manuals printed with textbooks often contain step-by-step descriptions of individual lessons. Greater importance is given to the integration of content and educational objectives (attitudes, behaviour) than to the formalisation of scientific methods. Since Serbia does not have a uniform emphasis on the scientific method - a "working scientifically" framework like in England, methodological instructions vary in quality and precision between different manuals. Grade-level outcomes serve as the basis for assessment. Specific tools for formative/summative assessment often also depend on the school curriculum.

As already highlighted in England, the Working Scientifically document emphasises that inquiry skills (asking questions, planning experiments, collecting and presenting data, drawing conclusions) are taught across all subjects. This provides teachers with a clear methodological competence in terms of lesson planning. The national document is also clear about progress – what is expected by the end of KS1 and by the end of KS2. When it comes to assessment and progression, there is a clear benchmark for the expected level of knowledge and skills, i.e. support for formative assessment and

achievement criteria (school assessment frameworks). Assessment frameworks provide a standardised approach to assessing students' knowledge and skills, with frameworks for the foundation phase of early childhood education, a key stage of the National Curriculum. In Serbia, handbooks and school programmes provide specific suggestions, but the quality varies. Some handbooks contain detailed lesson scenarios and materials, others are general. The Handbooks provide outcomes, but leave the teacher with greater autonomy in how to deliver the lesson. Teachers are expected to adapt the level of difficulty of the lesson to the age of the students. Good manuals contain lists of necessary props for experiments and warn about safety aspects before individual activities. However, some materials lack detailed instructions for experimental safety.

In England, there are a number of additional resources for laboratory safety in schools (ASE, CLEAPSS). CLEAPSS resources give teachers ideas for exciting and interesting practical activities that stimulate students' imaginations, and then, unlike many other sources of ideas, show teachers and technicians in detail how to turn these ideas into safe and exciting experiences in the classroom.

#### 4. Discussion

A comparative analysis of the Nature and Society curricula in the Republic of Serbia and England shows substantial differences in teaching structure, pedagogical approaches and educational philosophy (Table 7). These differences can be better understood in the light of contemporary theories on the curriculum, as well as in relation to official documents and professional literature that treat the goals and functions of primary education. In Serbia, the subjects The World Around Us/Nature and Society form a single integrated program in the younger grades of primary school (grades 1–4), which combines content from several disciplines – biology, geography, history and civic education (ZUOV, 2020). Such an approach allows for horizontal connection of knowledge, but at the same time carries the risk of superficial treatment of complex topics, especially if the teacher is not sufficiently expert in all areas. In contrast, the English curriculum separates related content into separate subject areas – Science, Geography, History – within Key Stage 1 and 2 (DfE, 2013). Such a model allows for a more systematic and in-depth approach to the specific concepts of each discipline, which coincides with the Council of Europe recommendations on the development of disciplinary knowledge in early education (Eurydice, 2015). The purpose of teaching in the Serbian curriculum is formulated in general terms, with an emphasis on the development of cognitive curiosity, attitudes towards the environment and social values (ZUOV, 2020). However, according to Đerić (2017), such a formulation often remains at a declarative level, without concrete elaboration in teaching practice. On the other hand, in the English curriculum, the objectives are explicitly linked to functional skills, the development of scientific literacy and critical thinking (DfE, 2013). OECD recommendations also point to the importance of outcome-oriented education, in which learning outcomes are clearly defined and measurable (OECD, 2018).

**Table 7.** Comparative analysis – key differences and similarities between the curricula of Serbia and England.

Element/Characteristic	Serbia	England
<b>Purpose and objectives</b>	Broadly defined, emphasis on knowledge	Concrete, skills and research orientation
<b>Outcomes</b>	Not formally defined; focused on general understanding; less measurable	Clearly defined outcomes: scientific approach, conclusions, precise, measurable, student-oriented
<b>Competencies</b>	Mostly unstructuredly defined, covering social, ecological and cultural aspects	Formally defined within the framework of "Working scientifically": observation, measurement, experimentation, analysis

<b>Level of requirements</b>	Moderate, practical: focus on understanding and describing the familiar; Lower cognitive operations (knowledge, understanding)	Higher, active scientific work: require logical reasoning, independent research, critical thinking and inference. Higher cognitive operations (application, analysis)
<b>Critical thinking</b>	Indirect, through dialogue and research	Direct: planning, data analysis, evaluation of sources
<b>Contents</b>	Detailed structured by grade	Flexible, thematic approach
<b>Content focus</b>	Homeland, human activities, materials, natural phenomena	Biology, physics and chemistry: cycles, materials, energy, etc.
<b>Instructions for teachers</b>	General, without detailed examples	Detailed, with practical guidelines and resources
<b>Content integration</b>	High – the subject connects nature and society	Low – science treated as a separate discipline
<b>Level of formalization</b>	Less formalized program	Highly formalized program according to standards
<b>Practical work</b>	Present, but limited	Central component of teaching
<b>Inquiry approach</b>	Encouraged, but not dominant	Main axis of learning – „scientific thinking“
<b>Role of the teacher</b>	Facilitator of integrated teaching	Mentor of explicit scientific methods

The English model has a stronger scientific and methodological focus: clear goals, formally defined competencies, and a structured progression to more complex concepts. It also places greater demands on scientific processing, independence of student research, and the application of formal scientific methods. A strong emphasis on learning outcomes that are formulated in the form of specific expectations (learning objectives) and skills that the student should demonstrate (Black & Wiliam, 1998). The use of formative assessment allows teachers to monitor student progress in relation to the set outcomes. In Serbia, outcomes are part of recent curricular reforms (ZUOV, 2020), but their implementation in practice is often inconsistent. According to research by Marković et al. (2021), many teachers still approach teaching in a traditional way, focused on the transfer of information, rather than the development of competencies.

An analysis of the curriculum requirements suggests that in Serbia the dominant cognitive level of learning in the lower grades is the acquisition and understanding of basic concepts. This coincides with Bloom's lower cognitive levels (Anderson et al., 2001). In England, students are encouraged to investigate, conclude, analyze and apply knowledge in new situations from the first level (DfE, 2013). Such an approach corresponds to modern pedagogical models such as constructivist learning and inquiry-based learning (Bruner, 1966; Harlen, 2010). The Serbian curriculum contains clearly structured content, divided by subject areas and grades, which provides security for teachers, but at the same time limits the space for interdisciplinarity and adaptation of teaching to the context (Đerić, 2017). The English curriculum is less detailed in terms of content, but it encourages teachers to independently create teaching units and integrate different areas (DfE, 2013). Instructions in the Serbian context are often standardized and limited to basic methodological guidelines. Research (Marković et al., 2021) indicates that teachers do not have enough examples of good practice and support in planning lessons based on outcomes. In contrast, the English teaching system provides teachers with access to extensive manuals, didactic resources, databases and online platforms for sharing practices. This coincides with UNESCO recommendations on the importance of teacher professional development and continuous pedagogical support (UNESCO, 2015).

## 5. Conclusion

A comparative analysis of the Nature and Society curricula in the Republic of Serbia and England has indicated significant differences in the organization of teaching, the formulation of goals, the definition of learning outcomes and the manner of implementation of the teaching process. While the Serbian curriculum is based on a traditional, content-oriented structure with clearly defined thematic units by grade, the English system emphasizes learning outcomes, the development of functional knowledge and an interdisciplinary approach. The English curriculum shows greater flexibility in teaching planning, provides teachers with specific instructions and tools for the implementation of the program, and encourages an investigative and active student approach. The Serbian curriculum, although it has introduced outcomes and competencies as components of the program in recent reforms, still prevails with reproductive goals and less developed forms of support for teachers in their everyday application.

Key differences were observed in:

- the structure of the curriculum, where the English model uses separate teaching areas with the possibility of integration, while the Serbian has a single subject;
- the goals and outcomes, where the English approach is more precise and results-oriented;
- the levels of cognitive demands, where in England analysis and application are encouraged, and in Serbia mainly understanding and memorization;
- the content, which in Serbia is strictly arranged, while in England it serves as a basis for creative planning;
- the instructions for teachers, which in the English system are more extensive and practical.

Based on the analysis, it can be concluded that the Serbian curriculum has the potential for improvement through:

- clearer formulation of learning outcomes and their connection with activities and work methods;
- encouraging multiple cognitive levels in students;
- strengthening professional support for teachers;
- introducing flexibility in planning curriculum content and greater autonomy in choosing teaching methods and approaches.

Exchange of experiences with educational systems such as English can serve as an important landmark for the development of higher quality and more modern education in Serbia, which will be more focused on students, their active role in learning and the development of competences relevant for the 21st century.

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## MOTHER TONGUE AND DIGITAL COMPETENCES: DIDACTIC INNOVATIONS FOR THE EDUCATION OF THE ALBANIAN DIASPORA

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### Abstract

The preservation of the mother tongue within the Albanian diaspora constitutes a fundamental pillar for cultural identity and the educational continuity of younger generations. In an era of accelerated globalization and digital transformation, language teaching can no longer be conceived without the integration of digital competences. This study aims to demonstrate that combining digital competences with the teaching of the mother tongue in the Albanian diaspora represents both an innovative and strategic approach. The central hypothesis is that such integration ensures the preservation of linguistic and cultural identity while simultaneously fostering students' critical and creative thinking.

The study is grounded in a qualitative interpretative approach, employing documentary analysis of educational policies and existing curricula, observations of pilot digital activities in diaspora classrooms, as well as comparative analysis with international frameworks, including the DigCompEdu model. Preliminary findings indicate that the use of interactive platforms, gamified tasks, and collaborative digital projects enhances motivation, reinforces the active use of the mother tongue, facilitates intercultural communication, and empowers Albanian children in diaspora settings. The study is significant both theoretically and practically, emphasizing the necessity of continuous professional development for teachers and the integration of digital competences into education. The conclusions suggest that this approach represents a sustainable pathway toward building an inclusive, innovative, and identity-oriented education within the Albanian diaspora context.

**Keywords:** mother tongue; digital competences; diaspora education; didactic innovation; critical thinking; creative thinking

### INTRODUCTION

The preservation and development of the mother tongue in the diaspora represents an irreplaceable dimension of cultural identity, national heritage, and educational continuity. In the context of globalization and rapid technological transformations, the mother tongue is perceived not only as a means of communication but also as a strategic value for the cultural and civic formation of younger generations (Fishman 1991; Cummins 2001; Baker 2011). For this reason, the supplementary education of Albanian children in the diaspora has been conceptualized by Albanian educational policies as a national priority, grounded in legal and institutional frameworks. In this regard, the Law on Pre-University Education (Article 11) stipulates the obligation to support the teaching of the mother tongue and national culture for Albanian communities abroad (Republic of Albania 2012).

In Albania, the Curriculum for the Supplementary Teaching of the Albanian Language and Albanian Culture in the Diaspora and Emigration (ASCAP 2018) represents an institutional effort to formalize supplementary teaching as a pathway for preserving cultural identity across generations. This document outlines competency-based modules and provides guidelines for the teaching of language

and culture subjects to students abroad, reflecting a contemporary approach in Albanian educational policy.

At the same time, the educational policies of the European Union assign a central role to digital and intercultural competences as part of the key competences for lifelong learning (European Commission 2018). Frameworks such as DigCompEdu emphasize the need to develop teachers' digital competences, viewing them as essential for didactic innovation and for achieving quality education in a global context (Redecker and Punie 2017). Integrating these standards into the teaching of the mother tongue in the diaspora constitutes both a challenge and an opportunity to merge tradition with innovation.

The aim of this study goes beyond the preservation of the mother tongue as an element of cultural identity; it extends to preparing younger generations for global citizenship by equipping them with linguistic and digital competences that enable them to interact in an increasingly interconnected society. The central hypothesis is that the integration of the mother tongue with digital competences in diaspora curricula represents a sustainable strategy for fulfilling Sustainable Development Goal 4 (SDG4 – Quality Education), ensuring not only the protection of cultural identity but also preparing Albanian children for active and inclusive citizenship.

The study is grounded in a qualitative interpretative approach, combining the analysis of existing policies and curricula with empirical reflections from teaching practices in the diaspora. In particular, it takes into account international educational strategies for diaspora communities, which highlight the importance of mother tongue education for the integration of migrant children and the preservation of cultural diversity (OECD 2019; UNESCO 2020). Preliminary findings show that didactic innovations, including gamified tasks, collaborative platforms, and digital projects, strengthen student motivation, foster the active use of the mother tongue, and support the development of intercultural competences.

In this way, the integration of the mother tongue with digital competences emerges as a strategic pathway toward inclusive, sustainable, and identity-oriented education in the context of the Albanian diaspora, creating durable bridges between national education and European policies for quality in education.

## **2. THEORETICAL FRAMEWORK**

### **2.1. The mother tongue and cultural identity in the diaspora**

The preservation of the mother tongue for Albanian communities in the diaspora represents a fundamental pillar of cultural identity and collective memory. It does not merely function as a means of communication but as a carrier of spiritual values, historical heritage, and national traditions, linking generations to their cultural roots (Fishman 1991; Baker 2011). In this sense, the mother tongue acts as a “bridge” of cultural continuity, creating lasting connections between the diaspora and the homeland (García & Li Wei 2014).

In the context of globalization and massive migration, the preservation of the Albanian language faces challenges related to assimilation processes and the dominance of the host country's language (Blommaert & Rampton 2011; Vertovec 2007). For this reason, the inclusion of Albanian children in structured supplementary education programs has been considered a key mechanism to ensure the intergenerational transmission of cultural identity and to preserve linguistic ties with the country of origin (Tahiri 2025a; Rexhaj 2013). International studies on heritage language education emphasize that the teaching of the mother tongue in the diaspora strengthens not only individual identity but also the social and cultural capital of communities (Hornberger & Wang 2008; Gogonas 2023).

At the institutional level, the Albanian legal framework has recognized this obligation. Law No. 69/2012 on Pre-University Education stipulates in Article 11 the state's responsibility to support the teaching of the Albanian language and national culture for communities abroad (Republic of Albania 2012). Subsequently, the Curriculum for the Supplementary Teaching of the Albanian Language and Albanian Culture in the Diaspora and Emigration (ASCAP 2018) provided a clear competency-based curricular structure, setting out objectives, content, and methods for developing this teaching in ways adapted to diverse contexts. This document highlights language as an inseparable part of civic formation and as a powerful element of national identity.

The National Education Strategy 2021–2026 in Albania (MASR 2021) and the Pre-University Education Strategy 2022–2026 in Kosovo (MASHTI 2022) also underline the importance of diaspora education, viewing the mother tongue as part of cultural capital and as a tool for the social integration of younger generations. The alignment of these documents with international frameworks is evident: the European Commission (2018) has included multilingual and digital competence among the key competences for lifelong learning, while UNESCO (2020) has defined the mother tongue as a fundamental cultural right and a key factor for preserving diversity.

Thus, national and international documents approach the mother tongue not only as an element of identity but also as a mechanism for the development of civic competences and for strengthening the social participation of the diaspora. Consequently, the preservation of the Albanian language in communities abroad is presented as a long-term strategy for intercultural integration and for reinforcing the link between the diaspora and the homeland (Skutnabb-Kangas & Heugh 2012).

## **2.2. Digital competences as a dimension of didactic innovation in the diaspora**

In the era of rapid technological transformations, digital competences constitute an essential dimension of didactic innovation and the assurance of quality in education. For Albanian teachers and students in the diaspora, technology is not only a supportive tool but also a space for creating interactive and inclusive learning experiences. Contemporary education models treat digital competence as an integral part of the key competences for lifelong learning, alongside linguistic, social, and civic competences (European Commission 2018; UNESCO 2020).

The DigCompEdu framework (Redecker & Punie 2017) sets clear standards for the development of teachers' digital competences, including the ability to plan, implement, and reflect on the use of technology in the teaching process. These standards are not limited to technical proficiency with tools but emphasize their pedagogical and ethical integration, placing the student at the center of the learning process. Similarly, the ISTE Standards for Educators (ISTE 2017) highlight the teacher's role as a designer of digital learning experiences and as a mentor for the development of civic competences in online environments.

The perspective of Vygotsky's sociocultural theory (1978) underscores the importance of social interaction and the Zone of Proximal Development (ZPD) as the basis for the use of technology in collaborative learning. From this perspective, technology becomes part of a "didactic ecosystem" in which linguistic experience intertwines with the development of critical and creative competences (Tahiri 2021b; Tahiri 2025b). Furthermore, contemporary studies on education in the diaspora show that the use of online platforms, digital projects, and interactive methods such as Problem-Based Learning (PBL) and Project-Based Learning (PjBL) empowers students to face real-world challenges and to develop collaboration, reflection, and critical thinking skills (Hmelo-Silver 2004; Bell 2010; Gross et al. 2021).

In the Albanian context, the integration of digital competences into mother tongue education in the diaspora is directly linked to national education strategies. The National Education Strategy 2021–2026 (MASR 2021) and the Pre-University Education Strategy 2022–2026 in Kosovo (MASHTI

2022) treat the development of digital competences as a priority for preparing new generations in the knowledge society. For Albanian communities in the diaspora, this translates into the need for flexible modules that integrate the teaching of the Albanian language with contemporary technology and guarantee equal access for all students (Grosjean & Li 2013; García & Baetens Beardsmore 2008).

From this perspective, digital competences represent not only a technical instrument but also a transformative element of the very nature of education. They create opportunities for intercultural interaction, for preserving identity under conditions of super-diversity (Vertovec 2007; Blommaert & Rampton 2011), and for building an active digital citizenship in which the mother tongue becomes a powerful tool for connecting generations and for dialogue with other cultures (Skutnabb-Kangas 2000; Skutnabb-Kangas & Heugh 2012).

### **2.3. The integration of the mother tongue and digital competences in diaspora curricula**

The teaching of the mother tongue in the diaspora can no longer be conceived merely as the transmission of linguistic knowledge but as an integrated process that intertwines linguistic, cultural, and digital competences. This approach reflects the latest orientations of national and international educational policies, which emphasize that education should be based on interconnected competences that prepare individuals for life and work in a global society (European Commission 2018; OECD 2019). From this perspective, digital competence is not an additional technical skill but a didactic condition for activating the meaningful use of the mother tongue in authentic learning contexts.

Within this framework, the Curriculum for the Supplementary Teaching of the Albanian Language and Albanian Culture in the Diaspora and Emigration (ASCAP 2018) serves as a reference model for integrating linguistic content with civic, intercultural, and digital competences. The document institutionalizes supplementary education by defining competence-based modules that encourage the use of digital tools, collaborative projects, and interactive methodologies. These guidelines make the learning process more engaging, accessible, and adapted to the expectations of younger generations, in line with the DigCompEdu framework, which articulates standards for the planning, implementation, and reflection of technology integration into pedagogical practice (Redecker & Punie 2017).

The integration of the mother tongue with digital competences is also aligned with the legal framework: Law No. 69/2012 (Article 11) guarantees the institutional obligation to support the teaching of language and culture for Albanians abroad, while the 2018 curriculum gives this obligation practical content through the structure of modules and interactive methods. This approach is consistent with the strategic documents of the Council of Europe on language education policies (2017), which emphasize inclusive, flexible, and intercultural approaches to education (Byram 1997; Council of Europe 2017).

Research evidence on heritage language education shows that teaching becomes more effective when it is connected to students' real-life experiences and when it relies on technologies that make them active participants (Hornberger & Wang 2008; García & Li Wei 2014; Gogonas 2023). In practice, the integration of gamified tasks, online forums, reflective essays, and multimedia projects transforms the mother tongue into a living experience, where cultural identity and digital competences are co-constructed (Tahiri 2021a; Tahiri & Hadaj 2024). These forms of work enable students to use the language in contemporary communication situations while simultaneously developing critical, creative, and collaborative skills.

From a broader political and ethical perspective, this integration represents a sustainable strategy for the achievement of SDG4 – Quality Education, as it expands access, equity, and the relevance of learning for Albanian children in the diaspora (UNESCO 2020). In this way, the mother tongue is not only a means of preserving identity but also a preparation for global citizenship, where linguistic and

digital competences reinforce one another to build bridges between national and international cultures (Tahiri 2025a; European Commission 2018; OECD 2019).

#### **2.4. Didactic innovations through technology in mother tongue teaching**

The integration of the mother tongue with technology represents a new dimension of didactic innovation that responds to the challenges of contemporary education and the needs of Albanian communities in the diaspora. This approach goes beyond the limits of traditional teaching, creating opportunities for the integration of linguistic, digital, and cultural competences, while directly impacting the development of students' critical, creative, and collaborative thinking (Paul & Elder 2002; Tahiri 2025a).

The use of interactive platforms such as Google Classroom, Padlet, Edmodo, or applications specialized in language and culture opens new horizons for the acquisition of the mother tongue in a dynamic and inclusive way. These tools enrich teaching with a multimedia dimension and transform students from passive recipients of information into active creators of knowledge. Through gamified tasks, online debates, digital quizzes, and collaborative projects, students not only practice the language but also develop intercultural and digital competences (Redecker & Punie 2017; García & Li Wei 2014). Thus, didactic innovation is not seen merely as the technical use of tools but as a transformative process that changes the way knowledge is constructed and transmitted (Bolkvadze 2023).

In the diaspora context, didactic innovation takes on a dual dimension. On the one hand, it serves to preserve and develop the linguistic and cultural identity of Albanian students; on the other, it equips them to use digital competences as global citizens, prepared to operate in multilingual and multicultural environments (European Commission 2018; Gogonas 2023). Through interdisciplinary projects linking language with civic education, natural sciences, and art, students create concrete products such as digital brochures, awareness campaigns, or educational videos, which give the mother tongue practical functionality and public visibility.

This orientation is closely related to theoretical developments on translanguaging and intercultural education (García & Wei 2014; Byram 1997), where technology creates inclusive spaces for hybrid linguistic and cultural identities. In this sense, didactic innovation through technology is not only a methodological choice but also an educational strategy connected with cultural sustainability and the development of 21st-century competences (Skutnabb-Kangas & Heugh 2012; Tahiri 2021b; Tahiri 2025b). For the Albanian diaspora, this means creating an interactive learning ecosystem in which the mother tongue remains central, while technology becomes the instrument that carries it forward into new spaces of knowledge and communication.

Finally, the mother tongue in the diaspora represents a key element of cultural identity and collective memory (Fishman 1991; Demiraj 2010), becoming an indispensable mechanism for social and intergenerational cohesion. At the same time, digital competences emerge as an essential dimension of didactic innovation (Redecker & Punie 2017; European Commission 2018), as they create new spaces for interaction, creativity, and critical thinking.

The integration of the mother tongue with technology in diaspora curricula (ASCAP 2018; Council of Europe 2017) guarantees not only the preservation of linguistic and cultural identity but also alignment with national and European policies that promote inclusive and sustainable education. In this regard, the didactic innovation generated by the integration of technology with mother tongue teaching (Tahiri 2021a; Tahiri 2025a) is not limited to the use of digital tools but represents a transformative approach that connects education with 21st-century competences.

Thus, the mother tongue in the diaspora, combined with digital competences and supported by contemporary educational policies, emerges as a strategic pathway for building bridges between

national identity and global citizenship, equipping new generations of Albanians with lifelong skills, sustainability, and intercultural engagement.

### 3. METHODOLOGY

#### 3.1. Research approach

The study is based on a qualitative–interpretative approach with a descriptive–analytical nature, which is most suitable for exploring the intersection between the mother tongue, cultural identity, and digital competences in the education of the Albanian diaspora. This approach is grounded in the principle of inclusive and sustainable education, directly linked to Sustainable Development Goal 4 (SDG4 – Quality Education) and the dimension of global citizenship as fundamental orientations for diaspora education. Since qualitative research provides opportunities to interpret meanings, experiences, and concrete practices, it serves to analyze how educational actors—teachers, students, and communities—interact with the linguistic and technological environment, thereby creating bridges between tradition and innovation (Creswell 2013; Braun & Clarke 2006; Tahiri 2025a).

#### 3.2. Participants and sampling

The study involved teachers and parents from supplementary schools of the Albanian diaspora, mainly in European contexts such as Germany, Italy, and Greece, who shared their experiences through interviews and questionnaires. Purposeful sampling (Patton 2015) was chosen to ensure cultural and didactic diversity, reflecting the different realities in which diaspora education operates. The inclusion of key educational actors teachers and parents enabled the collection of rich data on the practices, challenges, and opportunities of mother tongue learning in migratory and multilingual contexts (Gogonas 2023).

It should be emphasized, however, that this sample does not aim for statistical representation of the entire Albanian diaspora but provides a valuable overview of selected experiences and practices, which contribute to building an in-depth and analytical interpretation.

#### 3.3. Data collection instruments

Three main instruments were employed:

- **Semi-structured interviews** with teachers and parents, focusing on their experiences in teaching and preserving the Albanian language, as well as on the role of schools in shaping cultural identity (Hornberger & Wang 2008; García & Wei 2014).
- **Critical analysis of legal and curricular documents**, such as the Law on Pre-University Education (Law No. 69/2012, Article 11; Republic of Albania 2012), the National Education Strategy 2021–2026 (MASR 2021), and the Curriculum for the Supplementary Teaching of the Albanian Language and Culture in the Diaspora (ASCAP 2018).
- **Non-participant classroom observations** and reflections on the use of digital platforms (Google Classroom, Padlet, Edmodo), documenting gamified practices and collaborative projects that strengthen the use of the mother tongue (Redecker & Punie 2017; Tahiri 2021a; Tahiri & Hadaj 2024).

#### 3.4. Data Collection Process and Comparative Frameworks

The interviews with teachers and parents were conducted individually, lasted on average 45–60 minutes, and were recorded with the participants' consent. In parallel, classroom observations were carried out in a non-intrusive manner, documenting didactic practices and teacher–student interactions in real learning environments. The collected data were compared both with the Albanian experience in organizing supplementary education in the diaspora and with European Union models, as well as with countries that have developed heritage language programs, including Greece, Germany, and Italy (Gross et al. 2021; Blommaert & Rampton 2011). This comparative perspective served to identify best practices and to assess how they could be adapted to the Albanian context. The selection of sources was also guided by international frameworks on sustainable education, where SDG4 (Quality Education) and the concept of global citizenship provide a normative reference for shaping policies and practices in diaspora education.

### 3.5. Data Analysis

The data were processed through thematic analysis (Braun & Clarke 2006), moving through the following stages: full transcription of interviews, initial coding of recurring concepts, grouping into categories, and synthesis into representative themes. To preserve authenticity, direct quotations from interviews and field notes from classroom observations were also included in the analysis.

### 3.6. Limitations of the Study

The study acknowledges several limitations:

- **Geographical limitation:** most of the data were collected in Germany, Italy, and Greece, which restricts generalizability to the diaspora as a whole.
- **Lack of quantitative data:** emphasis was placed on qualitative analysis, without including an extensive statistical evaluation.
- **Rapid technological dynamics:** the fast-paced developments in the field of digital competences may limit the long-term applicability of some findings (OECD 2019).
- **Subjectivity of interviews:** the personal experiences of teachers and parents, while valuable, may contain subjective biases.

### 3.7. Ethical Considerations

The study strictly adheres to established ethical standards in educational and social research (AERA 2011).

- **Confidentiality:** The teaching cases and practices included as reflections do not identify specific individuals, thereby safeguarding the privacy of teachers and students.
- **Transparency:** All sources used are documented and referenced according to academic standards, ensuring traceability and scientific integrity.
- **Respect for cultural and linguistic diversity:** The methodology is built upon the principle of respecting the identities of Albanian students and communities in the diaspora, while avoiding reductionism or stereotyping (UNESCO 2020).

Accordingly, the methodology is grounded in a triangulated approach that combines document analysis, empirical reflections, and international comparison. This integration ensures a comprehensive overview of the policies and practices of mother tongue education in the diaspora, providing a deeper interpretation of its pedagogical and cultural dimensions. The inclusion of SDG4

(Quality Education) and the concept of global citizenship transforms the methodology into a powerful instrument for assessing how mother tongue education and digital competences build bridges between cultural identity and the preparation of new generations for an inclusive, sustainable, and intercultural society.

### **3.8. Methodological Summary**

In essence, the methodology integrates the theoretical analysis of national and international documents with reflections on diaspora practices, thereby constructing a solid framework for understanding how mother tongue education and digital competences can jointly serve as mechanisms for developing innovative, inclusive, and identity-oriented education (Tahiri 2025a; UNESCO 2020).

## **4. ANALYSIS AND DISCUSSION**

This section presents the analysis and discussion of the study's findings, integrating results derived from documentary analysis, empirical reflections, and international comparisons. The central focus lies in identifying how the mother tongue and digital competences interact within the educational process of the Albanian diaspora, simultaneously contributing to the preservation of cultural identity and to the preparation of younger generations for global citizenship. The analysis is grounded in the theoretical and legal frameworks addressed above as well as in field-based results, with emphasis on four key dimensions: outcomes of documentary and empirical approaches, the impact of digital competences, the role of the mother tongue in global citizenship, and comparative discussion with international models.

### **4.1. Key findings from documentary and empirical analysis**

#### **Legal and curricular support.**

The analysis of legal and curricular documents demonstrates that the Albanian state has established a clear institutional foundation for supporting diaspora education. Law no. 69/2012 on Pre-University Education (Article 11) and the Supplementary Curriculum for the Teaching of the Albanian Language and Culture in the Diaspora (ASCAP, 2018) emphasize the obligation to guarantee linguistic and cultural continuity for Albanian children abroad. These documents introduce a model of interrelated competences, where the mother tongue is framed as both a component of civic formation and a tool for building national identity in multilingual environments (Republic of Albania, 2012; ASCAP, 2018).

#### **Didactic innovation through technology.**

Reflections from teachers and parents in supplementary diaspora schools highlighted that the use of interactive platforms such as Google Classroom and Padlet, as well as collaborative digital projects, significantly increase student motivation and active participation. Gamified tasks, where elements of play are intertwined with language learning, positively influenced vocabulary acquisition and enhanced students' linguistic self-confidence (Tahiri, 2021a; Tahiri & Hadaj, 2024). These practices demonstrate that technology is not merely an auxiliary tool but a space where sustainable linguistic and cultural experiences are constructed (Redecker & Punie, 2017; García & Wei, 2014).

#### **The mother tongue as a space for intercultural dialogue.**

Another important finding relates to the way in which the integration of the mother tongue and technology generates new terrains for intercultural dialogue. Through multimedia projects, Albanian children in the diaspora produced tangible outputs—digital brochures, educational videos, and awareness campaigns—that assign the language a public function and practical scope in their host societies. This process directly contributed to the development of intercultural skills and civic competences associated with global citizenship (European Commission, 2018; UNESCO, 2020).

### **The role of family and community.**

Findings reveal that the success of Albanian language maintenance depends largely on the cooperation among schools, families, and communities. Parents who use Albanian at home and engage in cultural activities strongly support the consolidation of linguistic competences and reinforce children's experience of cultural identity (Gross et al., 2021; Gogonas, 2023). This multi-actor collaboration transforms the supplementary school into a laboratory of linguistic and cultural innovation.

### **Structural and institutional challenges.**

Nevertheless, the study also identified clear limitations: the lack of teaching materials tailored for the diaspora, limited instructional time, insufficient institutional support, and the difficulty of motivating second- and third-generation emigrant children (Hornberger & Wang, 2008; Christian, 2011). An additional factor identified relates to digital equity: not all students have equal access to technological devices or high-quality internet, creating disparities in participation and benefit. This challenge is directly tied to the principle of SDG4 on inclusive and equitable quality education.

### **From preservation to transformation.**

The results also indicate that diaspora education has not only a preservative but also a transformative role. Students engaged in such activities demonstrate greater ability to use the mother tongue in functional and creative ways, connecting it with their daily experiences and with the challenges of an interconnected world. The application of interdisciplinary approaches such as Project-Based Learning (PjBL) and Problem-Based Learning (PBL), combined with creative activities (digital brochures, online forums, awareness campaigns), illustrates that learning the mother tongue can evolve into a dynamic, motivating, and contemporary process. This finding supports the hypothesis that integrating digital competences with mother tongue education is a powerful mechanism for developing critical thinking and for preparing future generations for inclusive and sustainable education, in line with SDG4 (Tahiri, 2025a; Gross et al., 2021).

## **4.2. The impact of digital competences on mother tongue learning**

The study's findings reveal that digital competences constitute a fundamental pillar of didactic innovation in the teaching of the mother tongue within the Albanian diaspora. The integration of technological tools is not confined to the technical use of platforms; rather, it has been transformed into a pedagogical space where students experience the mother tongue dynamically and functionally (Redecker & Punie, 2017; European Commission, 2018).

One of the key findings relates to the application of Project-Based Learning (PjBL) and Problem-Based Learning (PBL). These methods have enabled students to use the Albanian language in real-life contexts, collaborating in the creation of multimedia products or in solving everyday challenges. The integration of the mother tongue with interdisciplinary practices has contributed to the

development of communication skills, critical thinking, creativity, and collaboration, thus providing learning with a new dimension aligned with 21st-century competences (Hmelo-Silver, 2004; Bell, 2010).

Another significant element is translanguaging, which has found new ground through technology. Students move fluidly between the mother tongue and the host country's language, constructing hybrid and flexible identities. This practice, supported by international approaches to multilingual education (García & Wei, 2014; Bolkvadze, 2023), has been shown to assist in maintaining Albanian without disconnecting students from the linguistic reality of the host society.

Interviews with teachers and parents confirmed that digital competences significantly increase students' motivation and self-confidence. In some cases, Albanian children in Germany and Italy had created blogs or small YouTube channels in Albanian, using technology as a medium of self-expression and as a space for preserving cultural identity (Gross et al., 2021; Gogonas, 2023). However, a critical dimension was also identified: not all students have the same technological opportunities, as the lack of devices or high-quality internet access creates inequalities in benefit. This aspect highlights the need for inclusive policies that ensure equal access, in line with SDG4.

From this perspective, digital competences emerge not merely as technical skills but as transformative instruments of the learning process. They turn the mother tongue into a platform for didactic innovation and cross-border cultural interaction. This outcome supports the argument that integrating technology with mother tongue education is a strategy that strengthens not only linguistic competences but also prepares students for global citizenship, directly linking this process with the objectives of SDG4 (UNESCO, 2020; Tahiri, 2025a).

#### **4.3. Preserving cultural identity and building global citizenship**

One of the most significant findings of the study is that mother tongue learning in the diaspora does not function solely as a mechanism for preserving cultural identity, but also emerges as a formative platform for building global citizenship. Through the integration of digital competences and intercultural approaches, Albanian students acquire skills that transcend linguistic acquisition, preparing them to participate actively in an increasingly interconnected society (European Commission, 2018; OECD, 2019).

The role of supplementary schools proves crucial in this process. They serve not only as spaces where the Albanian language is preserved and transmitted, but also as environments where students experience a sense of belonging and create enduring ties with their culture. Reflections from teachers and parents in Germany, Italy, and other countries indicate that the use of Albanian declines significantly among younger generations, while the school is perceived as the primary guarantee of its survival (Tahiri, 2022). In this sense, supplementary schools assume a dual function: safeguarding cultural identity and building bridges for integration into host societies.

Cultural identity is reinforced through the active use of the mother tongue as a bearer of historical, spiritual, and national values. School and extracurricular activities such as celebrations, songs, dances, and the use of Albanian symbols and traditions transform students into "cultural ambassadors" of their community abroad. This experience has been increasingly enriched by technology, which renders identity more dynamic and widely disseminated through blogs, digital channels, and multimedia campaigns (Fishman, 1991; Baker, 2011; Gross et al., 2021).

On the other hand, global citizenship is built through the connection between linguistic and digital competences. Interdisciplinary practices of Project-Based Learning (PjBL) and Problem-Based Learning (PBL), where Albanian is linked with civic education, art, science, and technology, equip students with collaboration skills, intercultural communication, and critical reflection on diversity. Concrete examples of Albanian students creating blogs or YouTube channels in their mother tongue

illustrate that the language is not confined to private use but becomes a means of self-expression and public interaction (García & Wei, 2014; Gogonas, 2023).

Nevertheless, interviews also highlighted the dimension of inequality in access. Not all students enjoy equal technological opportunities or family support, which generates differences in participation and benefit. This underscores the necessity of institutional interventions to ensure equitable conditions in mother tongue learning and in the development of digital competences.

In this way, mother tongue education in the diaspora is no longer perceived solely as a heritage process, but as a developmental strategy that empowers students to preserve their cultural identity while simultaneously interacting with other cultures and contributing to the construction of global citizenship. The mother tongue thus becomes a dual instrument: a guardian of national culture and a builder of sustainable bridges between the diaspora and the wider world, in line with SDG4 objectives for inclusive and quality education (UNESCO, 2020).

#### **4.4. Comparative Discussion with International Models**

The comparison of the Albanian experience with international practices in heritage language education reveals that this process is complex and requires the interplay of educational policies, institutional support, and didactic innovation. European Union countries such as Germany, Greece, and Italy have developed models where supplementary schools are integrated into the public education system, providing regular instructional hours, curricula adapted for the diaspora, and stable financial support (Gross et al., 2021; Blommaert & Rampton, 2011).

In the Albanian case, although there exists a clear legal framework (Law No. 69/2012, Article 11) and a specific curriculum for the diaspora (ASCAP, 2018), challenges remain significant. Field reflections point to the absence of adequately adapted teaching materials, limited instructional time, and partial institutional support. Teachers and parents often experience this process as an individual burden, while second and third generations display lower motivation to learn Albanian compared to the first generation (Tahiri, 2022).

Similar to international practices, the use of interactive methods and digital technologies has produced visibly positive results. Gamification, multimedia projects, and the integration of Albanian cultural elements songs, dances, national symbols make learning more engaging and more closely connected to the students' daily lives. These practices align with international approaches to multilingual and intercultural education, which emphasize the role of the mother tongue in the development of interactive and civic competences (García & Wei, 2014; Skutnabb-Kangas & Heugh, 2012).

However, the main difference lies in institutional support: while other countries have integrated supplementary schools as an organic part of the educational system, the Albanian experience relies primarily on the efforts of communities, parents, and diaspora organizations. This highlights the need for a more sustainable policy and a stronger institutional cooperation mechanism between the Albanian state and educational structures abroad, in order to ensure continuity and quality in teaching.

In this regard, the Albanian experience may be considered an innovative laboratory where tradition, identity, and technology converge, yet it requires continuous adaptation to reach the standards of European models. The comparative discussion underscores that the integration of the mother tongue with digital competences and inclusive policies is the most secure path to strengthening the cultural identity of the diaspora and preparing future generations for global citizenship, in line with SDG4 and UNESCO's vision for quality, equitable, and intercultural education (UNESCO, 2020).

#### **4.5. Empirical Evidence and the Role of Supplementary Schools**

Following the documentary analysis and comparative discussion, the empirical evidence collected through interviews, questionnaires, and classroom observations underscores the central role of supplementary schools in the Albanian diaspora as small laboratories of innovation where tradition, identity, and technology converge. Within these spaces, the mother tongue emerges not only as an instrument of communication but also as a powerful mechanism for preserving cultural identity and fostering global citizenship.

Interviews and reflections with teachers and parents in Germany, Italy, and other European contexts revealed that the use of Albanian declines significantly among the second and third generations, yet the school is perceived as the decisive factor in ensuring its preservation. The involvement of families, communities, and cultural organizations through traditional celebrations, songs, dances, and national symbols strongly reinforces the sense of belonging and linguistic identity (Tahiri, 2022).

The identified good practices include the use of interactive methods, the integration of culture into teaching, gamification, and the incorporation of technology and collaborative approaches. These forms of pedagogy enhance student motivation and bring the learning process closer to their everyday realities. Concrete examples include the creation of blogs and YouTube channels in Albanian by diaspora students, which serve as spaces for self-expression and the preservation of linguistic identity (Gogonas, 2023).

Nevertheless, significant challenges remain: the absence of teaching materials adapted for the diaspora, the limited number of instructional hours, and partial institutional support. Moreover, the motivation of second- and third-generation learners is often lower, making it essential to employ creative and technological strategies to make Albanian both appealing and functional (Gross et al., 2021).

Another critical issue concerns equality of access to digital tools. Not all Albanian students in the diaspora have equal opportunities to use platforms and technological resources, due to social and economic conditions or lack of institutional support. These disparities create inequalities in participation and learning outcomes, highlighting the necessity for educational policies that guarantee equal and inclusive access for all students (OECD, 2019; UNESCO, 2020).

In this sense, the empirical evidence shows that supplementary schools are not merely spaces for the preservation of the mother tongue but also arenas of pedagogical and cultural innovation. They demonstrate that the integration of the mother tongue with digital competences and cultural content represents a sustainable strategy for achieving SDG4 and for building global citizenship rooted in cultural identity, inclusion, and equality of opportunity. These findings reflect the triangulated approach of the study, where documentary analysis, empirical evidence, and international comparisons converge to provide a comprehensive picture of the role of the mother tongue and digital competences in preserving cultural identity and preparing students for global citizenship.

#### **4.6. Comparative Discussion with International Models**

In comparison with the Albanian experience, international practices in teaching heritage languages provide valuable models that could be adapted for the Albanian diaspora. In Greece, programs for preserving the languages of migrant communities have been integrated into public schools through supplementary modules, offering an inclusive environment that combines the language of origin with intercultural competences (Gogonas, 2023). In Germany, different Länder have developed dedicated classes for heritage languages, including Albanian, Turkish, and Italian, treating them as components of cultural diversity and as tools for social integration (Gross et al., 2021). In Italy, weekend schools and partnerships with Albanian communities have turned the teaching of Albanian into a space closely linked with cultural activities, where language, music, and national traditions interact to strengthen identity (Bolkvadze, 2023).

These examples illustrate that the preservation of the mother tongue and its integration with digital competences is not merely a local issue but part of a broader international trend of viewing diaspora schools as sites of innovation where tradition and technology intersect to prepare future generations for global citizenship. A distinctive element remains equality of access: in countries where institutional support and equal resources are provided, the benefits of heritage language learning are more sustainable, while in the Albanian case, this challenge remains unresolved.

For Albania and Kosovo, this comparison offers opportunities to develop sustainable models that combine national policies with the best European practices, positioning diaspora education as an integral part of sustainable educational development.

## 5. CONCLUSIONS AND RECOMMENDATIONS

### Conclusions

The findings of this study demonstrate that the integration of the mother tongue with digital competences in diaspora education does not represent merely a methodological choice but a long-term strategy closely tied to the development of educational policies and to the achievement of Sustainable Development Goal 4 (SDG4 – Quality Education). This experience shows that the mother tongue plays a dual role: on the one hand, it preserves cultural identity, and on the other, it serves as a transformative tool in preparing generations for global citizenship.

The results confirmed that the use of innovative methods such as Project-Based Learning (PjBL) and Problem-Based Learning (PBL), the integration of technology, and the inclusion of creative activities (digital brochures, online forums, awareness campaigns, blogs, and YouTube channels) increase students' motivation, self-confidence, and collaborative skills. These practices make the Albanian language functional and vibrant in multilingual environments, linking it to everyday realities and strengthening intercultural competences.

An important dimension of the findings concerns equality in digital access. Not all Albanian students in the diaspora have equal opportunities to utilize technological tools due to socio-economic conditions and the lack of institutional support. This situation directly affects participation and outcomes, suggesting the need for clear policies that ensure equitable and inclusive conditions.

Diaspora supplementary schools emerged as small laboratories of innovation where tradition, identity, and technology converge. The experiences of teachers and parents, combined with community activities (celebrations, songs, dances, and national symbols), revealed that the success of preserving language and culture is higher when families and communities are actively involved. This result places Albanian supplementary education in line with the best European practices for heritage languages, offering potential for international transfer and comparison.

In this way, the teaching of the mother tongue in the diaspora should be understood not merely as the preservation of heritage but as a developmental strategy that empowers students to interact with other cultures while maintaining their identity and contributing to the construction of global citizenship.

### Recommendations

#### For policymakers:

- Strengthen institutional support for diaspora schools through the provision of adapted teaching materials, funding for digital infrastructure, and specialized training programs for teachers.

- Develop inclusive policies that ensure equal access to technology in order to reduce the digital divide among students.

#### **For teachers:**

- Apply interdisciplinary methods and interactive approaches that are connected to the everyday realities of diaspora students, using technology as a tool for creativity, critical reflection, and the preservation of cultural identity.
- Employ innovative techniques such as gamification, multimedia projects, and project-based learning to enhance motivation and engagement.

#### **For communities and families:**

- Support supplementary schools through cultural activities, making the mother tongue an integral part of children's daily lives.
- Establish stronger partnerships between schools, families, and cultural organizations to foster social cohesion and intercultural interaction.

#### **For academic research:**

- Conduct further comparative studies on heritage languages within the European context, identifying models that can be adapted to improve the teaching of Albanian in the diaspora.
- Deepen the analysis of the impact of digital equity on language acquisition and the development of civic competences.

### **Conclusion**

The mother tongue, digital competences, and cultural identity intertwine as key elements for achieving SDG4 (Quality Education) and for building global citizenship. This approach ensures not only the survival of the Albanian language in the diaspora but also the empowerment of younger generations to become active, creative, and intercultural citizens in an increasingly interconnected world.

This study contributes to the literature on heritage language education by situating the Albanian experience within an international comparative framework. The findings demonstrate that the integration of the mother tongue with digital competences not only supports the preservation of cultural identity in the diaspora but also creates a new dimension of global citizenship, making diaspora education a space for didactic innovation and sustainable policymaking. In this sense, the Albanian experience offers a transferable model that can be discussed at the European and wider international level, positioning the teaching of the mother tongue as a powerful strategy for quality, inclusive, and intercultural education, in line with the vision of SDG4 and UNESCO's recommendations.

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## THE ROLE OF CREATIVITY AND THE DEVELOPMENT OF CRITICAL THINKING IN THE PREVENTION OF EMOTIONAL BURNOUT AMONG SOCIAL WORKERS

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### ABSTRACT

The author shared the results of training sessions on creativity development and critical thinking for social workers at centers of social services and centers for the development of vitality.

Creativity as a resource for resilience is studied in this scientific publication.

Methods of the development of creativity and methods of art-therapy are described in social and psychological aspects.

The scientific article analyses theories of creativity via the Componential Theory of Creativity, Torrance's Theory of Creativity, and Behavioral Theories.

The author made an analysis of the methods of generating of creative ideas, technologies for the development of the creative skills of modern leaders in the social sphere.

In this report, the author made an emphasis on the challenges and problems in the professional activities of social workers and the role of creative thinking in problem-solving.

An author shared their experience of carrying out the training of media literacy.

In the analysis of creative thinking, the researcher made reflections under articles and publications of Novella Keith.

Scientific report pay attention to the necessity of the development of the critical thinking. Training for social workers is effective and has positive results for communities.

Rules and innovative methods of the development of creativity and critical thinking are analyzed in the article.

**Keywords:** creativity, critical thinking, emotional burnout, resource, social worker

Intellectual abilities that characterize a creative personality (according to J. Guilford). This is where all efforts in educating the new generation should be directed:

- ✓ speed of thought — the number of ideas that arise per unit of time;
- ✓ flexibility of thought — the ability to switch from one idea to another;
- ✓ originality — the ability to produce ideas that differ from conventional views;
- ✓ curiosity — sensitivity to problems in the surrounding world;
- ✓ ability to develop hypotheses;
- ✓ unreality — logical independence of reaction from stimulus;

✓ fantasticness — complete detachment of the response from reality in the presence of a logical connection between the stimulus and the response;

✓ ability to solve problems, i.e. the ability to analyze and synthesize;

✓ ability to improve an object by adding details [*Dr. Balaji Niwlikar (2024)*].

I work with my students with help of SCAMPER:

S – Substitute

C – Combine

A – Adapt

M – Modify/Magnify

P – Put to other uses

E – Eliminate

R – Rearrange

This method help us to generate new idea and effective social projects.

- Consider the problem from different angles by answering the following questions:
- Which elements can be replaced?
- Which elements can be combined?
- Can anything new be added? If so, what?
- How can it be improved or modified?
- Can it be used for other purposes or in other areas?  
Can it be made simpler? If so, how?
- What will happen if some details are changed here and there? [*Rikke Friis Dam and Teo Yu Siang (2024)*]

The GROW model, which is the main and most effective one in the social counselling of the clients.

**Goal** – setting the right tasks and objectives.

**Reality** – objective research and analysis of reality.

**Options** – identifying potential opportunities and necessary actions.

**Will** – fostering motivation in people to take the actions necessary to achieve their goals.

**At the ‘Goal’ stage**, the main task is to help the client correctly define their goals and objectives.

Therefore, it is very important at this stage to correctly identify the topic of conversation and help the client outline the results they want to achieve.

At the same time, it is very important to understand the client's main desires and determine how realistic they are.

Identify the realistic timeframes needed to achieve the goals and compare them with the client's desires.

Understand how ready they are for long-term success or whether they are only focused on achieving their goals quickly.

**At the ‘Reality’ stage**, a detailed analysis of reality is carried out, i.e., the client's objective situation at the moment is determined, as well as the consequences and causes of this situation.

How often does the client find themselves in similar life situations and how have they tried to get out of them in the past?

**At the ‘Options’ stage**, it is time to become aware of actions and search for alternative solutions to problems and achieve set goals and objectives.

At this stage, it is important to correctly analyze all the actions taken by the client and objectively assess their effectiveness. Do they really help to change the situation in which the client finds themselves, or are they simply ineffective actions that take up a lot of energy and time?

**At the ‘Will’ stage**, which is the final and most important stage, the client must understand and make the right decisions by identifying the most effective actions that will be aimed at solving the problem they are discussing.

It is at this stage that the client must see a picture of their successful future, stop being afraid of problems, and remove internal barriers and fears that prevent them from achieving their desired goal and getting the desired result (*Florentina Mogonea (2022)*)

### **Conclusion:**

Creativity for social workers is a method of psychological resourcing, a means of generating new ideas for social projects and initiatives, and a resourceful method of overcoming crises.

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## TARIMSAL SÜRDÜRÜLEBİLİRLİK EKSENİNDE ORGANİK TARIMIN ETKİLERİ VE GELECEK PERSPEKTİFİ

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### ÖZET

Tarım, küresel gıda güvenliğinin sağlanmasında temel bir rol oynarken, artan Dünya nüfusu, kaynak kıtlığı, ekolojik dengenin bozulması ve iklim değişikliği gibi baskılarla karşı karşıyadır. Geleneksel konvansiyonel tarım, yüksek verim sağlasa da, toprak bozulması, pestisit kalıntıları ve biyoçeşitlilik kaybı gibi çevresel bozulma ve sağlık riskleri yaratmaktadır. Bu bağlamda, organik tarım sürdürülebilir ve çevre dostu bir alternatif olarak öne çıkmaktadır. Organik tarım; sentetik girdilerden kaçınarak, toprak sağlığını, biyolojik çeşitliliği ve su kaynaklarını koruyan, hayvan refahını destekleyen ve sosyal adaleti teşvik eden ekolojik bir sistemdir. Dünya genelinde 191 ülkede uygulanmakta ve yaklaşık 76,4 milyon hektar alanı kapsamaktadır. Araştırmalar, organik tarımın sera gazı emisyonlarını hektar başına %43 azaltırken, toprak karbonunu artırdığını ve tozlayıcı türler ile tarım kuşları gibi biyoçeşitliliği desteklediğini göstermektedir. Ayrıca, organik ürünler, mineral ve vitamin yoğunluğu açısından konvansiyonel ürünlere göre üstün kalite sergilemektedir. Sürdürülebilir tarım uygulamaları; organik tarım, agroforestry, agroekosistemler, hassas tarım ve rejeneratif yöntemler hem gıda güvenliğini hem de çevresel dayanıklılığı artırmaktadır. Bununla birlikte, organik tarım uygulamalarında yüksek başlangıç maliyetleri, sertifikasyon süreçleri, sınırlı teknik bilgi ve politika desteğinin eksikliği gibi engeller mevcuttur. Bu çalışmada, organik tarımın çevresel, ekonomik ve sosyo-kültürel etkileri ele alınmış; gıda güvenliği ile sürdürülebilir tarım arasındaki ilişkiler tablolar ve literatür bulguları ile desteklenmiştir. Sonuçlar, organik tarımın iklim değişikliği ile mücadelede, ekolojik dengeyi sağlayarak biyoçeşitliliği korumada, yerel bitki ve hayvan genotiplerini koruyarak ve uzun vadeli gıda güvenliğini, sürdürülebilir tarımın çevresel, sosyal ve ekonomik parametrelerini sağlamada son derece önemli bir strateji olduğunu ortaya koymaktadır.

**Anahtar kelimeler:** Organik Tarım, Sürdürülebilirlik, Gıda Güvenliği, Ekoloji, İklim Değişikliği

### IMPACTS AND FUTURE PERSPECTIVES OF ORGANIC AGRICULTURE WITHIN THE FRAMEWORK OF AGRICULTURAL SUSTAINABILITY

## ABSTRACT

Agriculture plays a pivotal role in ensuring global food security, yet it faces mounting pressures from a growing world population, resource scarcity, ecological imbalance, and climate change. Although conventional agriculture achieves high yields, it generates environmental degradation and health risks, including soil deterioration, pesticide residues, and biodiversity loss. In this context, organic agriculture emerges as a sustainable and environmentally friendly alternative. Organic farming avoids synthetic inputs, protects soil health, biodiversity, and water resources, supports animal welfare, and promotes social equity. It is currently practiced in 191 countries, covering approximately 76.4 million hectares worldwide. Research indicates that organic agriculture reduces greenhouse gas emissions per hectare by 43%, increases soil carbon content, and enhances biodiversity by supporting pollinators and agroecosystem bird species. Furthermore, organic products exhibit superior quality in terms of mineral and vitamin density compared to conventional products. Sustainable agriculture practices—including organic farming, agroforestry, agroecosystems, precision agriculture, and regenerative methods—enhance both food security and environmental resilience. However, organic farming faces challenges such as high initial costs, certification procedures, limited technical knowledge, and inadequate policy support. This study examines the environmental, economic, and socio-cultural impacts of organic agriculture and explores the relationships between food security and sustainable farming, supported by tables and literature findings. The results highlight that organic agriculture represents a critical strategy for combating climate change, maintaining ecological balance, preserving biodiversity, protecting local plant and animal genotypes, and ensuring long-term food security while fulfilling the environmental, social, and economic dimensions of sustainable agriculture.

**Keywords:** Organic Agriculture, Sustainability, Food Security, Ecology, Climate Change

## 1. GİRİŞ

Tarım, hem geçim hem de ekonomik istikrar için hayati öneme sahip olmasına rağmen, kaynak kıtlığı, kentleşme ve hızla artan küresel nüfus gibi baskılarla karşı karşıyadır. Sürdürülebilir gıda üretimi sağlamak, çiftçiler, işletmeler ve politika yapıcılarını kapsayan karmaşık bir ekosistem içinde en ileri teknolojilerin entegrasyonunu gerektirir (Niksaz vd., 2025). Tarım, insan uygarlığının temel taşlarından biri olarak, hayatta kalma, ekonomik kalkınma ve toplumsal ilerleme için gerekli gıda, lif ve kaynakları sağlamaktadır. Küresel nüfusun 2050 yılına kadar yaklaşık 10 milyara ulaşması beklenirken, gıda güvenliğini yani gıda arzının erişilebilirliği, kullanılabilirliği, yeterliliği ve istikrarı sağlamak, günümüzün en acil sorunlarından biri haline gelmiştir (FAO, 2025). Tarım, insan medeniyetinin temeli ve milyonlarca insan için temel geçim kaynağıdır. Ancak, artan küresel gıda talebini karşılamak amacıyla nüfus büyürken, tarım arazileri bozulma ve kirlenme nedeniyle azalmaktadır. Ayrıca, tarımsal uygulamalar doğal ve insan kaynaklı faktörlerden giderek daha fazla etkilenmekte olup, iklim değişikliği tarımsal sürdürülebilirlik için önemli bir tehdit oluşturmaktadır. Artan nüfusun gıda ihtiyaçlarını karşılamak ve iklim değişikliğine uyum sağlamak için, iklim-akıllı tarım sistemlerinin benimsenmesi ve çiftçilerin kaynakları daha etkin yönetebilmelerinin desteklenmesi kritik öneme sahiptir. (Billah vd., 2025). Yoğun tarım, yüksek verimli çeşitlerin, kimyasal gübrelerin ve pestisitlerin kullanımıyla “Yeşil Devrim”in yolunu açmış ve ana hedef olarak verim maksimizasyonunu amaçlamıştır. Ancak aynı zamanda toprak sağlığını bozmuş, makro ve mikronutrient eksikliklerine, düşük verimlere, zayıf kaliteye ve çevresel tehlikelere yol açarak hayvanlar ve insanlar için ciddi sağlık sorunları ve rahatsızlıklara neden olmuştur (Dhaliwal ve ark., 2021). Günümüz tarımında sentetik gübrelerin yaygın kullanımı şüphesiz ürün verimliliğini artırmış olsa da, aynı zamanda çeşitli agronomik, çevresel ve ekosistem sağlığı sorunlarına yol açmıştır. Gıda ürünlerinde agrokimyasal kalıntıların sürekli birikimi, toprak, mikrobiyota ve su kaynaklarındaki

yapısal bozulmalar, geleneksel girdi merkezli yaklaşımların sürdürülemezliğini ortaya koymaktadır (Hammok vd., 2025). Konvansiyonel tarım artan nüfusu besleyebilse de, aşırı pestisit ve gübre kullanımı insan sağlığına zararlıdır ve birçok hastalığa neden olmaktadır. Bu bağlamda, organik tarım daha besleyici, sağlıklı ve sürdürülebilir bir tarım yöntemi olarak öne çıkmıştır. Organik gıdalara olan talep sürekli artmaktadır. Yüksek kaliteli gıdalara olan istek, çevre dostu üretim tekniklerinin yaygınlaşması ve tüketicilerin sağlıklı yaşam tarzlarına artan ilgisi, organik ürünlere olan talebin temel nedenleridir (Kashyap ve Jain., 2025).

Organik tarım; ekolojik denge, toprak sağlığı ve biyolojik çeşitliliği koruyan, sentetik girdilerden kaçınarak doğal yöntemlere dayanan bir sistemdir. Çevre ve insan sağlığına katkılarının yanı sıra, hayvan refahı ve sosyal adaleti de destekler. Zararlı yönetimi ve pazar erişimi gibi zorluklara rağmen; toprak zenginleştirme, biyolojik mücadele, su tasarrufu, yerel tohum kullanımı ve genetik çeşitlilik sayesinde iklim değişikliğine uyum ve sürdürülebilirlik sağlar. Artan küresel talep ve paydaş iş birliği ile organik tarım, gelecek nesiller için sağlıklı ve dayanıklı bir gıda sistemi sunma potansiyeline sahiptir (Palit, 2025). Sentezimiz, organik yönetimin birçok potansiyel çevresel faydasını göstermektedir; ancak, özellikle organik yönetime geçiş sürecinde çiftçiler için artan ekonomik riskler ve ödünleşmeler de mevcuttur. Ayrıca, eğitimden bilgi ağlarına erişime kadar uzanan sosyal engellerin çiftçilerin uygulamaları desteklemede önemli bir rol oynadığı vurgulanmaktadır (Jones vd., 2025).

## 2. Organik Tarım nedir? Amaçları ve Faydaları

Organik tarım; sağlık, ekolojik ve etik değerlere dayanan, sentetik girdilerden kaçınarak doğal yöntemleri (ürün rotasyonu, kompostlama vb.) kullanan, sürdürülebilirlik, biyolojik çeşitlilik ve toprak sağlığını teşvik eden, aynı zamanda çevre koruması ve toplum dayanıklılığını destekleyen ekolojik bir tarım yaklaşımıdır (Palit, 2025). Organik tarım, sürdürülebilirlik hedefleriyle derin bir uyum içinde olan, karmaşık ve bilgi yoğun bir sistemdir (Milardo, 2025). Biyolojik çeşitlilik ve iklim değişikliği azaltımı ölçütlerindeki olumlu etkiler, konvansiyonel tarım uygulamalarından ya girdi ikamesi ya da yeniden tasarım müdahalelerine geçişlerde tutarlı bir şekilde gözlemlenmiştir (Blaix vd., 2025). Modern tarımda pestisit ve gübre kullanımı, gıda zinciri ve hayvan yemlerinde toksik kalıntı birikimine yol açarak hem çevre hem de insan ve hayvan sağlığı açısından ciddi riskler oluşturmaktadır. Bu olumsuzluklar, tarım topluluğunu çevre dostu ve sürdürülebilir bir alternatif olan organik tarıma yöneltmiştir. Organik bitki ıslahı, toprak sağlığı yönetimi ve doğal zararlı kontrolüne yönelik çalışmalar, organik tarımın uygulanabilirliğini artırırken; toprak verimliliği, biyoçeşitlilik ve iklim değişikliğiyle mücadeleye sağladığı katkılar, onu sürdürülebilir tarımın temel unsurlarından biri hâline getirmektedir. Ayrıca, organik ürünlerin ihracat potansiyeli ve yüksek piyasa değeri, çiftçiler için ekonomik açıdan cazip bir seçenek oluşturmaktadır (Gandham vd., 2025). Organik üretimde altı unsur yasaktır: sentetik gübreler, pestisitler, genetiği değiştirilmiş organizmalar (GDO), ışınlama, sentetik ilaçlar ve nanoteknoloji. Organik tarım şu anda 191 ülkede uygulanmakta, dünya genelinde 76,4 milyon hektar alanı kapsamaktadır ve yıllık satış hacmi 125 milyar € (136 milyar ABD\$) olarak kaydedilmiştir. Avustralya, en fazla organik araziye sahipken, Almanya en fazla biyodinamik araziye sahiptir (Paull, 2025).

**Tablo 1.** Organik Tarımın Amaçları ve Faydaları (IFOAM, 2021)

Amaçlar	Faydalar
Yeterli miktarda ve yüksek besin değerine sahip gıda üretimini sağlamak	Kirlilik seviyelerini azaltarak çevresel sağlığa katkıda bulunur

Amaçlar	Faydalar
Doğal sistemleri kucaklamak, onları kontrol altına almaya çalışmamak	Sürdürülebilir tarımsal üretimi destekler, uzun vadeli geçerlilik sağlar
Tarım sistemlerinde biyolojik döngüleri desteklemek ve geliştirmek (mikroorganizmalar, toprak florası ve faunası, bitkiler, hayvanlar)	Toprak sağlığını artırır, verimlilik ve üretkenliği teşvik eder
Toprakların uzun vadeli verimliliğini korumak ve artırmak	Ürünler genellikle daha kaliteli olup, daha büyük boyut, gelişmiş tat ve aroma özellikleri gösterir
Yenilenebilir kaynakları mümkün olduğunca kullanmak	Toprakta su tutma kapasitesini artırarak su tasarrufuna yardımcı olur
Kapalı bir sistem içinde organik madde ve besin elementlerini maksimize etmek	Bitki büyümesi ve gelişimi için gerekli besinlerin kullanılabilirliğini artırır (Kumari ve Raj, 2024)
Hayvanlara doğal davranışlarını sergileyebilecekleri koşullar sağlamak	Organik ürünler üstün kalite özellikleri ile tanınır; boyut, lezzet ve aroma açısından öne çıkar
Tarım uygulamalarından kaynaklanan tüm kirlilik türlerini önlemek	Organik tarım yapılan alanlarda yeraltı suları toksik kimyasallardan korunur
Tarım sisteminin ve çevresinin genetik çeşitliliğini korumak, bitki ve vahşi yaşam habitatlarını korumak	Vermikompostlama ile atık yoğunluğu azalır ve toprak auxinlerle zenginleşir

Organik tarımın temel amaçları; doğal sistemleri korumak, biyolojik döngüleri desteklemek, toprak verimliliğini uzun vadede sürdürmek, yenilenebilir kaynakları kullanmak ve çevre kirliliğini önlemektir. Bu amaçların faydaları ise çevresel sağlığın korunması, sürdürülebilir üretimin sağlanması, toprak kalitesinin ve su tutma kapasitesinin artması, yüksek besin değerine sahip ve kaliteli ürünler elde edilmesi, hayvan refahının desteklenmesi ve genetik çeşitliliğin korunması şeklinde özetlenebilir.

### 3. Tarımsal Sürdürülebilirlikte Organik Tarımın Önemi

Sürdürülebilir tarım, artan dünya nüfusunu beslemek ve yaşam kalitesini sürdürmek/geliştirmek için çevresel bozulmayı artırmadan gerekli bir yol olarak görülmektedir. Bu yollar arasında organik tarım, entegre tarım, ekolojik ve sürdürülebilir yoğunlaştırma, koruma tarımı, iklim duyarlı tarım, hassas tarım, permakültür ve dikey tarım yer almaktadır (Jastrzębska vd., 2022). Agroekoloji, doğa-dostu tarım, permakültür, biyodinamik tarım, organik tarım, koruma tarımı, rejeneratif tarım, karbon tarımı, iklim akıllı tarım, yüksek doğa değerli tarım, düşük dış girdi tarımı, döngüsel tarım, ekolojik yoğunlaştırma ve sürdürülebilir yoğunlaştırma, sürdürülebilir tarıma yönelik yaklaşımlardan sadece birkaçıdır (Muhie, 2022). Sürdürülebilir tarım, gıda güvenliği ile çevresel koruma arasındaki çift yönlü zorluklara çözüm sunan uygulanabilir bir yol sağlamaktadır. Hassas tarım, agroekoloji ve rejeneratif tarım, kaynakları korurken verimliliği artırmakta ve ekolojik ayak izini azaltmaktadır. Sürdürülebilir tarım uygulamaları ve destekleyici politikalar çevresel dayanıklılığı artırır, sınırlı kaynaklara olan bağımlılığı azaltır ve gıda arzını güvence altına alır. Bu yaklaşım, müdahale noktalarını belirleyerek ve karşılıklı bağımlılıkları vurgulayarak, uzun vadeli güvenlik için hedeflenmiş ve sektörler arası müdahaleleri destekler (Galanakis vd., 2025). Sürdürülebilir

uygulamaların benimsenmesi, gıda güvenliğini güçlendirmenin yanı sıra çevresel korumaya da önemli katkılar sağlamaktadır. Ancak, yüksek başlangıç maliyetleri, sınırlı teknik bilgi ve güçlü politika desteği ile toplumsal katılım eksikliği, bu uygulamaların yaygınlaşmasında temel engeller olarak öne çıkmaktadır. Bulgular, sürdürülebilir tarımın başarısının; toprak sağlığı, biyolojik çeşitlilik ve iklim direnci gibi hem gıda üretimi hem de çevresel sürdürülebilirlik için kritik faktörlere bağlı olduğunu göstermektedir (Richard, 2024). Tarımda sürdürülebilirlik yalnızca çevrenin korunması anlamına gelmez; ekonomi, toplum ve çevreyi birleştiren kapsamlı bir yaklaşımdır. Mevcut ve gelecekteki zorluklarla başa çıkabilecek adil ve dayanıklı bir gıda sistemi inşa etmek için hükümetler, çiftçiler, akademisyenler ve tüketiciler, sürdürülebilir tarım tekniklerini geliştirmek üzere iş birliği yapmak zorundadır (Abdulameer vd., 2025).

**Tablo 2.** Sürdürülebilir Tarım Uygulamalarının Etkileri (Richard, 2024)

Bulgular	Açıklama
Sürdürülebilir Uygulamaların Benimsenmesi	Organik tarım, agroforestry, hassas tarım ve rejeneratif yöntemler; kimyasal girdilerin azaltılması, biyolojik çeşitliliğin korunması ve toprak sağlığının iyileştirilmesi.
Gıda Güvenliğine Katkı	Ürün verimliliği ve çeşitliliğinin artması, toprak sağlığının iyileştirilmesi, kaynakların daha verimli kullanımı ve toplumların taze gıdaya erişiminin kolaylaşması.
Çevresel Faydalar	Toprak bozulmasının, su kirliliğinin ve biyolojik çeşitlilik kaybının azalması; karbon tutumu ve ekosistem sağlığının gelişmesi.
Karşılaşılan Zorluklar	Yüksek başlangıç maliyetleri, sınırlı teknik bilgi, pazara erişim sorunları ve yetersiz politika desteği.
Devlet Politikaları ve Toplumsal Katılım	Destekleyici politikalar, kooperatifler, çiftçi pazarları ve bilgi paylaşım ağları sürdürülebilir uygulamaların benimsenmesini kolaylaştırır.
Başarı Ölçütleri ve Uzun Vadeli Uygulanabilirlik	Toprak sağlığı, biyolojik çeşitlilik, ekonomik sürdürülebilirlik ve iklim değişikliğine karşı dayanıklılık ile ölçülür.
İklim Dayanıklılığı	Kuraklık ve aşırı hava olaylarına karşı direnç; gıda güvenliğini korumada kritik öneme sahiptir.

**Tablo 3.** Sürdürülebilir Tarımda Zorluklar ve Fırsatlar (Hiywotu, 2025)

Zorluklar	Fırsat /Çözüm	Açıklama
İklim Değişikliği	Rejeneratif Tarım	Toprak sağlığını iyileştirir, karbon tutumunu artırır ve iklim değişikliğine karşı direnç kazandırır.
Biy çeşitlilik Kaybı	Agroekoloji	Biy çeşitliliği destekler, toprak sağlığını iyileştirir ve doğal kaynakları korur.
Toprak Bozulması	Organik Tarım	Sentetik pestisit ve gübreleri azaltır, toprak organik maddesini ve biyolojik aktivitesini artırır.

Zorluklar	Fırsat /Çözüm	Açıklama
Su Kıtlığı	Hassas Tarım	Sensörler ve akıllı sistemlerle sulama optimize edilerek su kullanımı azaltılır.
Kırsal Toplulukların Erozyonu	Döngüsel Ekonomi	Atıkları azaltır, kaynak verimliliğini artırır ve çiftçiler için yeni gelir kaynakları yaratır.

Sürdürülebilir tarım, çevresel koruma, gıda güvenliği ve kırsal toplulukların dayanıklılığı açısından büyük fırsatlar sunarken, ekonomik ve teknik engellerin aşılması için politika desteği ve toplumsal iş birliği kritik öneme sahiptir.

#### 4. Organik Tarım ve Gıda Güvenliği

Küresel gıda güvenliğinin sağlanabilmesi, politika yapıcılar, araştırmacılar ve paydaşlar arasında işbirliği gerektirir; bu işbirliği, eşit erişimi, ekonomik sürdürülebilirliği ve çevresel korumayı önceliklendiren dayanıklı gıda sistemlerinin oluşturulmasını hedeflemelidir. Tarım sektörü, verimlilik ile sürdürülebilirliği dengeleyerek, uzun vadeli gıda güvenliğini sağlarken gezegenin ekolojik bütünlüğünü koruyabilir (Islam, 2025). Gıda sistemleri, tarımsal ürünlere olan talebin artması ve çevresel bozulmanın hızlanması gibi önemli zorluklarla karşı karşıyadır. Rejeneratif tarım, çevresel zararı azaltırken üretkenliği korumayı veya hatta artırmayı amaçlayan bir yaklaşım olarak öne çıkmıştır (Klauser vd., 2025). Sosyo-ekonomik açıdan, organik tarım, daha sağlıklı gıda seçenekleri sunma, çiftçiler için daha güvenli çalışma koşullarını teşvik etme ve kırsal kalkınmaya katkıda bulunma potansiyeline sahiptir. Çiftçiler için ekonomik faydalar arasında, organik ürünlere artan tüketici talebi sayesinde yüksek değerli pazarlara erişim sağlanması yer alır; bu da özellikle küçük ölçekli çiftçilerin geçim seviyelerini iyileştirebilir. Ayrıca, sürdürülebilir ve dayanıklı tarım uygulamalarını teşvik ederek, organik tarım uzun vadeli gıda güvenliğinin sağlanmasında önemli bir rol oynar. (Tiwari, 2023). Küresel ölçekte sürdürülebilir gıda sistemlerine olan talebin artmasıyla birlikte, organik tarımın çevresel koruma ve tüketici sağlığı ile nasıl uyumlu olduğu ve verimlilik ile pazar erişilebilirliği gibi zorlukların nasıl ele alındığına dair anlayışlar sunulmaktadır Organik tarımdaki genel yaklaşım, uzun vadeli tarımsal sürdürülebilirlik ve gıda güvenliğine katkı sağlamaktadır (Palit, 2025).

**Tablo 4.** Kavramsal Çerçeve ve Gıda Güvenliği Etmenlerinin Kategorizasyonu (Galanakis vd., 2025 HLPE, 2020 ,FAO, 2024)

Kavramlar	Tanım	Odak Noktası	Örnek Unsurlar
Mevcudiyet	Piyasada yeterli gıda üretimi ve arzının fiziksel olarak bulunması	Fiziksel gıda arzı	Üretim hacmi, dağıtım, ticaret
Erişim	Bireylerin ve hanelerin gıdaya üretim veya satın alma yoluyla ulaşabilme kapasitesi	Ekonomik ve fiziksel erişim	Gelir, gıda fiyatları, piyasa sistemleri, dağıtım ağları
Kullanım	Gıdanın vücut tarafından kullanımı ve emilmesi; besin değeri ve hazırlama yöntemleri	Beslenme kalitesi ve güvenliği	Besin değeri, gıda hazırlama, kültürel uygulamalar

Kavramlar	Tanım	Odak Noktası	Örnek Unsurlar
İstikrar	Gıdanın zaman içinde sürekli olarak mevcut ve erişilebilir olmasını sağlamak	Süreklilik ve risk yönetimi	Ekonomik, iklimsel veya politik kesintilere karşı güvence
Ajans	Gıda sistemindeki aktörlerin bağımsız gıda kararları alma kapasitesi	Karar alma ve çeşitlilik	Tedarik zinciri dinamikleri, dağıtım, ürün çeşitliliği
Sürdürülebilirlik	Gıda sistemlerinin uzun vadeli yaşabilirliği ve kaynakları tehlikeye atmadan gıda güvenliğini sağlamak	Gelecek nesiller için güvence	Çevresel kaynakların korunması, ekonomik ve sosyal sürdürülebilirlik

### 5. Organik Tarımın Ekolojik Etkileri

Tarım, küresel ekonominin belkemiğini oluşturmaktadır; dünya yüzeyinin yaklaşık %37'sini kaplamakta, küresel tatlı su kaynaklarının neredeyse %70'ini tüketmekte ve atmosfere yayılan antropojenik sera gazı (GHG) emisyonlarının üçte birine kadarını katkı sağlamaktadır (Crippa vd., 2021; IPCC, 2021). Ekolojik kavramlar (biyolojik çeşitlilik, toprak verimliliği) ile sosyo-ekonomik faktörler (pazar dinamikleri, tüketici algıları) arasındaki güçlü bağlantılar, organik tarım araştırmalarının artık yalnızca agronomik çalışmalarla sınırlı olmadığını, aynı zamanda sürdürülebilir kalkınma söyleminin önemli bir parçası haline geldiğini göstermektedir (Hroma, 2024) Mikroorganizma habitatı, karbon tutumu, besin döngüsü ve bitki kullanımına yönelik toprak suyu ile ilişkili toprak işlevlerinin artırılması, iklim değişikliğine uyum sağlamak ve tarım ekosistemlerinin iklim değişikliğine karşı dirençliliğini artırmak için dikkate alınmalıdır (Oliveira vd., 2024). Doğal kaynakların korunması, biyoçeşitliliğin sürdürülmesi ve toprak verimliliği ile sürdürülebilirliğin sağlanması yoluyla çevresel sürdürülebilirlikte kritik bir rol oynamaktadır. Ayrıca, organik tarım, gıda atıkları ve hayvan kalıntıları gibi organik artıkların geri dönüştürülmesini sağlayarak atık yönetimine katkıda bulunmaktadır (Hammok vd., 2025)

Organik tarımda bitki besleme ve koruma, sentetik girdilerden kaçınarak doğal süreçleri en verimli şekilde kullanmayı hedefler. Çiftçiler, ahır gübresi, kompost, yeşil gübre ve bitki artıkları gibi organik kaynakları değerlendirerek besin döngüsünü kapalı bir sistemde sürdürür, böylece toprak canlılığı korunur ve agro-ekosistem dengesi güçlenir. Bu yaklaşım, ekosistem sağlığını korurken doğal kaynakların etkin kullanımını sağlar ve organik üretimi ekolojik, ekonomik ve sürdürülebilir bir tarım alternatifine hâline getirir (De ve ark., 2021). Sıcaklık artışları ve öngörülemez hava koşulları gibi çevresel olaylar, tarım alanlarını yeniden şekillendirmektedir. Hassas tarımdan rejeneratif tarıma kadar uzanan çeşitli sürdürülebilir teknikler, bu zorluklara pratik çözümler sunmaktadır (Saladi, 2025). İklim değişikliği, gelişmekte olan ülkelerdeki agroekolojik bölgelerde geçim kaynaklarını, biyolojik çeşitliliği ve gıda güvenliğini ciddi şekilde tehdit etmektedir (Hamer vd., 2025). Organik tarımın çevresel faydaları önemlidir; bunlar arasında iyileştirilmiş toprak sağlığı, artırılmış biyolojik çeşitlilik, azalmış kirlilik ve daha düşük karbon ayak izi bulunmaktadır. Bu uygulamalar ekosistemlerin korunmasına katkıda bulunur ve iklim değişikliğinin etkilerini hafifletir. (Tiwari, 2023) Agroekolojik müdahalelerin biyolojik çeşitlilik ve iklim değişikliği azaltımı ölçütleri üzerinde genel olarak olumlu bir etkiye sahip olduğunu göstermektedir. Agroekolojik müdahaleler, ele alınan tüm fonksiyonel organizma gruplarının çeşitliliğini artırmış, toprak karbon depolamasını teşvik etmiş ve azot oksit emisyonlarını azaltmıştır (Blaix vd., 2025).

**Tablo 5.** Organik ve Konvansiyonel Tarımın Çevresel, Ekolojik ve Besinsel Karşılaştırması (Impact Institute ve True Price Foundation, 2025)

Kategori	Organik Tarım	Konvansiyonel Tarım	Notlar / Yorum
Sera Gazı Emisyonu	Hektar başına %43 daha düşük, ürün başına %12 daha düşük	Daha yüksek emisyon	Ölçüm birimi (hektar/ürün) sonuçları etkiler
Toprak Sağlığı	Toprak karbonu artar, mikrobiyal aktivite yüksek, erozyona dayanıklı	Genellikle daha düşük toprak kalitesi	Kompost, örtü bitkileri ve uzun ürün rotasyonu katkısı
Biyolojik Çeşitlilik	Tür zenginliği %34 artar, tozlayıcılar ve tarım kuşları daha fazla	Daha düşük çeşitlilik	Meta-analizler ile desteklenmiş
Su Kalitesi	Nitrat sızıntısı ve pestisit kirliliği %20-50 azalır	Daha yüksek su kirliliği riski	Kuraklık ve aşırı yağışlara dayanıklı toprak
Besin Değeri	Mineral ve vitamin yoğunluğu yüksek, pestisit kalıntısı düşük	Genellikle daha düşük besin yoğunluğu	İnsan sağlığı açısından avantajlı
İklim Dayanıklılığı	Kuraklık ve aşırı yağışlara karşı dirençli	Daha düşük direnç	Organik tarım toprak yapısı ve karbon depolaması ile desteklenir
Sürdürülebilirlik Ölçümü	Ürün başına verim düşük, alan bazlı metriklerde avantajlı	Ürün başına verim yüksek, alan bazlı metriklerde dezavantajlı	Yaşam Döngüsü Analizi ve sürdürülebilirlik raporlamasında ölçüm birimi önemli

Son yıllarda, gıda güvenliği, iklim değişikliği ve çevresel bozulma konusundaki endişelerin artmasıyla sürdürülebilir tarım arayışı hız kazanmıştır. Bu bağlamda, organik tarım, gıda sistemlerinin ekolojik ayak izini azaltmak için öne çıkan bir strateji olarak ortaya çıkmıştır; çünkü organik tarım, toprak sağlığını ve biyolojik çeşitliliği iyileştirebilen, kirliliği azaltan ve sentetik girdilere bağımlılığı düşüren çevresel olarak faydalı uygulamaları teşvik etmektedir (Reganold ve Wachter, 2016; Simin vd., 2023). Bununla birlikte, organik sistemlerde sürdürülebilirliğin değerlendirilmesi, ekolojik, ekonomik ve sosyal faktörler arasındaki karmaşık etkileşimleri dikkate alan kapsamlı ve çok boyutlu bir yaklaşım gerektirmektedir (Mierauskas, 2020; Hazmi vd., 2023).

## 6. Gelecek perspektifi

Konvansiyonel tarıma kıyaslandığında organik tarım, sera gazı emisyonlarını düşürür, su ,toprak kalitesini korur ve besin değeri yüksek ürünler sunar. Temel amaç, doğa ve insan merkezli olarak gezegenin döngüsünün korunmasını esas almaktadır. Organik tarımın karşılaştığı zorlukların başında yüksek maliyet, teknik bilgi eksikliği ve politika yetersizlikleri yer almakta ve bu durum yaygınlaşmayı sınırlamaktadır. Gelecekte dijitalleşme, yapay zekâ entegrasyonu ve karbon-nötr sistemlerin uygulanmasıyla organik tarımın üretim verimliliği artırılabilir. Gençlerin yerinden üretim merkezli tarıma aktif katılımı, kırsal kalkınmanın sağlanması, eğitim programları ve küresel iş birlikleriyle desteklenen politika reformları; iklim adaptasyonu, biyoçeşitlilik odaklı araştırmalar, tüketici bilinci ve pazarlama dinamikleriyle birlikte organik tarımı iklim dayanıklılığı, gıda güvenliği ve ekonomik sürdürülebilirliğin merkezine yerleştirecektir. Bilinçli üretici-tüketici etkileşimi, döngüsel ekonomi ve ekolojik girişimcilik yaklaşımlarıyla organik tarım, geleceğin hem insan merkezli üretimi hem de ekolojik doğayla uyumlu küresel gıda güvenliğinin ekseninde yer alacaktır.

**Tablo 6.** Gelecek perspektifi (Hiywotu, 2025)

Gelecek Yönelim	Hedef	Açıklama
Politika savunuculuğu	Gıda güvenliği ve beslenmeyi öncelik hale getirmek	Yerel, ulusal ve küresel düzeyde etkili politikaların oluşturulmasını destekler.
Eğitim ve farkındalık	Toplumlarda sürdürülebilir tarımı öğretmek	Beslenme, tarımsal uygulamalar ve gıda koruma teknikleri konusunda eğitim sağlar.
Yenilik ve teknoloji	Tarımda verimliliği artırmak	Hassas tarım, blockchain ile izlenebilirlik ve etkili dağıtım sistemleri gibi teknolojileri uygular.
Küresel iş birliği	Bilgi ve kaynak paylaşımı	Ülkeler arası en iyi uygulamaları paylaşarak açlıkla mücadelede iş birliğini teşvik eder.
Dayanıklılık geliştirme	Toplumları şoklara karşı güçlendirmek	İklim felaketleri ve ekonomik krizler gibi risklere karşı hazırlıklı olmalarını sağlar.
Gençlerin katılımı	Gençleri değişim ajanı yapmak	Sürdürülebilir gıda sistemlerinde gençlerin aktif rol almasını teşvik eder.
Kentsel gıda güvenliği	Şehirlerde uygun ve besleyici gıdaya erişimi artırmak	Kentsel ve informal yerleşimlerde gıda erişimini iyileştirir.
Araştırma ve inovasyon	Kanıta dayalı çözümler geliştirmek	Tarım, beslenme ve gıda sistemleri üzerine araştırmayı destekler ve inovasyonu teşvik eder.
İzleme ve değerlendirme	Etkiyi ölçmek ve iyileştirmek	Müdahalelerin etkinliğini takip eder, boşlukları belirler ve stratejileri optimize eder.

Organik tarım, sürdürülebilir tarımın temel bir unsuru olarak; gıda güvenliği, ekosistem sağlığı, iklim değişikliğine uyum ve kırsal kalkınma açısından kritik bir rol oynamaktadır. Gelecekte politika savunuculuğu, eğitim ve farkındalık sertifikasyon süreçleri ve yasal düzenlemelerin süreçlerinin hızlanması çalışmaları, yenilikçi tarım teknolojileri (hassas tarım, izlenebilirlik sistemleri), küresel iş birliği ve gençlerin aktif katılımı ile organik tarımın benimsenmesi artırılabilir. Tarımda teknolojik dönüşümle birlikte özellikle yapay zeka ve makine öğrenim sistemlerinin organik tarıma entegrasyonu ile birlikte ürün çeşitliliğini artırma maliyetlerini ciddi şekilde düşürerek bitkisel ve hayvansal ürünlerde uygulanması sağlıklı tarım uygulamalarına büyük katkılar sağlayabilir.

## 7. SONUÇ

Organik tarım, sürdürülebilir tarımın çevresel, sosyal, ekonomik ve ekolojik etkilerini kapsayan parametrelerini sürdüren, iklim değişikliğinin etkilerini en aza indirmede etkili bir tarımsal uygulamadır. Organik tarımın, toprak sağlığını iyileştirerek mikrobiyal çeşitliliği artırdığı, sera gazı emisyonlarını azalttığı ve su ile ekosistem kaynaklarının korunmasını desteklediği gösterilmektedir. Ayrıca, organik tarımın sağladığı yüksek besin değerine sahip ürünler, tüketici sağlığını ve hayvan refahını artırırken, kırsal topluluklar için ekonomik fırsatlar yaratmaktadır. Sürdürülebilir tarım uygulamaları ile entegre edildiğinde, organik tarım gıda güvenliği, çevresel dayanıklılık ve ekonomik sürdürülebilirlik arasında denge kurarak uzun vadeli gıda sistemlerini desteklemektedir. Bununla birlikte, uygulamada yüksek başlangıç maliyetleri, sınırlı teknik bilgi ve yetersiz politika desteği gibi

engeller, organik tarımın geniş çaplı benimsenmesini sınırlamaktadır. Gelecekte, politika savunuculuğu, eğitim, yenilikçi teknolojilerin entegrasyonu ve küresel iş birliği ile organik tarım potansiyel faydaları artırılabilir. Sonuç olarak, organik tarım, çevresel sürdürülebilirlik, gıda güvenliği ve sosyo-ekonomik gelişim hedeflerini aynı anda destekleyen stratejik bir yaklaşımdır. Bu nedenle, hem bilimsel araştırmalar hem de politika planlamasında, eğitim programlarının bilinçli üretici ve tüketici ekseninde gelişmesi; organik tarımın öncelikli olarak değerlendirilmesi, hem gelecek nesiller için sürdürülebilir tarımın ilkelerinin gelişmesi hem de sağlıklı gıda sistemleri oluşturulmasına katkı sağlayacaktır.

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### ÖZET

Tıbbi ve aromatik bitkiler ve yem katkıları hayvan beslenmesinde antibiyotiklerin yerine kullanılmasıyla hayvansal besinlerde kimyasal madde hormon kalıntılarının önüne geçerek sürdürülebilir hayvansal üretimi geliştirerek insan sağlığını da korumaktadır. Ruminant ve kümes hayvanlarında tıbbi bitki özlerinin büyüme performansı, sindirim, bağışıklık ve üreme sağlığı üzerinde pozitif etkiler ortaya çıkmaktadır. Tıbbi ve aromatik bitkiler antioksidan, antimikrobiyal ve immünomodülatör özellikleri sayesinde hem hayvan sağlığını hem de ürün verimliliğini artırmaktadır. Ruminantlarda yapılan in vivo çalışmalarda tıbbi bitkiler ve ekstraktlarının yem alımı, günlük canlı ağırlık artışı, vücut kondisyon skoru ve yemden yararlanma verimliliğini artırdığı bulunmuştur. Fitojenik yem katkıları (PFA'lar) ile yapılan çalışmalarda yemin rumende sindirilebilirliği, besin alımını ve büyüme hızını anlamlı ölçüde yükseltmiştir. Kümes hayvanlarında ekstraktları, yemden yararlanma, günlük ağırlık artışı, yumurta verimi ve bağışıklık parametrelerini bitkisel katkıların antioksidan ve anti-inflamatuvar etkileri, oksidatif stresi azaltarak üreme ve bağışıklık fonksiyonlarını desteklemektedir. Çiftlik hayvanlarında yapılan çalışmalar tıbbi ve aromatik bitkilerin hem hayvan sağlığı hem de çevresel sürdürülebilirlik açısından önemli bir potansiyele sahip olduğunu ortaya çıkarmaktadır. Gelecekte, bitki özlerinin uygun dozajları sorununun çözülmesi ve bitkilerin uygun işleme teknolojilerinin geliştirilmesi, performansın iyileştirilmesi ve maliyet etkinliğin artırılması sürdürülebilir tarım açısından önem taşımaktadır.

**Anahtar kelimeler:** Tıbbi bitkiler, Çiftlik hayvanları, Fitojenik yem katkıları, Hayvan sağlığı, Sürdürülebilir hayvancılık.

## THE ROLE AND IMPORTANCE OF MEDICINAL AND AROMATIC PLANTS IN ANIMAL FEEDING

### ABSTRACT

Medicinal and aromatic plants and feed additives, when used as alternatives to antibiotics in animal nutrition, help prevent chemical residues and hormone contaminants in animal-derived foods, thereby

enhancing sustainable livestock production and protecting human health. In ruminants and poultry, medicinal plant extracts have been shown to exert positive effects on growth performance, digestion, immunity, and reproductive health. Due to their antioxidant, antimicrobial, and immunomodulatory properties, medicinal plants contribute to both animal health and product efficiency. In vivo studies in ruminants have demonstrated that medicinal plants and their extracts improve feed intake, average daily weight gain, body condition score, and feed conversion efficiency. Research on phytogenic feed additives (PFAs) has reported significant improvements in ruminal digestibility, nutrient intake, and growth rate. In poultry, plant extracts have been associated with enhanced feed efficiency, daily weight gain, egg production, and immune parameters. The antioxidant and anti-inflammatory effects of plant-based additives reduce oxidative stress, thereby supporting reproductive and immune functions. Studies conducted on farm animals highlight that medicinal plant-based additives hold great potential for improving both animal health and environmental sustainability. In the future, addressing challenges related to optimal dosages of plant extracts and developing appropriate processing technologies will be crucial for improving performance and enhancing cost-effectiveness, which are of great importance for sustainable agriculture.

**Keywords:** Medicinal plants, Farm animals, Phytogenic feed additives, Animal health, Sustainable livestock

## 1. GİRİŞ

Hayvanların üretim ve verimliliğini etkileyen hem dışsal hem de içsel faktörler arasında beslenme, temel bir unsur olarak öne çıkmaktadır. Yem katkı maddeleri, hayvan beslenmesinde yem ve hayvansal gıdaların kalitesini artırmak, aynı zamanda hayvanların performansını ve sağlığını iyileştirmek için kullanılan ürünlerdir (Alem, 2024). Ruminant hayvancılık, kırmızı et ve süt gibi yüksek değerli proteinlerin önemli bir kaynağı olarak verimli ve sürdürülebilir çiftçilik uygulamaları gerektirir. Üretimi ve kaliteyi artırmak amacıyla araştırmacılar çeşitli yem katkı maddelerine yönelmiş olup, 2006 yılından itibaren Avrupa Birliği'nin antibiyotikleri yasaklamasının ardından fitojenik yem katkı maddelerine (PFA) olan önem artmıştır (Nastoh vd.,2024). Antibiyotik yem katkı maddelerinin kullanımının yasaklanmasının ardından hayvancılık sektörü, alternatif olarak bitkisel kaynaklı ürünlere yönelmiştir. Antibiyotikler, hem hayvan sağlığı üzerinde olumsuz etkiler oluşturabilmekte hem de ekonomik açıdan maliyetli olabilmektedir (Aziz vd.,2024). Nitekim son yıllarda hayvan beslenmesinde bitkisel katkı maddelerinin kullanımı, antibiyotiklerin maliyet, yan etki ve sınırlamaları nedeniyle giderek önem kazandığı görülmektedir. Bitkisel katkıları, probiyotikler, prebiyotikler ve organik asitler gibi yem katkıları ile birlikte hayvanların sindirim sistemi, bağışıklık fonksiyonları ve verimliliğini artırmak için kullanılmaktadır (Arjun vd.,2025). Sürdürülebilir hayvancılık, gıda güvenliğini, ekonomik kalkınmayı, Çevre yönetimini ve sosyo-kültürel talepleri dengelemeyi amaçlayan bir üretim biçimidir. Bu sistem, ekilmeyen arazileri değerlendirilmesi, insan tüketimi için elverişli olmayan yüksek besin değerli hayvansal gıdalara dönüştürmesi ve tarım sektöründe oluşan atıkların geri kazanılmasıyla çevresel sürdürülebilirliğe büyük katkı sağlamaktadır. Aynı zamanda milyonlarca insanın gelir ve geçim kaynağını destekleyen önemli bir ekonomik faaliyet olarak da ön plana çıkmaktadır (Varijakshapanicker vd., 2019). Tıbbi ve aromatik bitkiler, büyüme uyarıcıları ve yeni nesil antibakteriyeller olarak hem hayvan beslenmesinde hemde hayvan sağlığının korunmasında kullanılabilir zengin bir ikincil metabolit kaynağıdır. Antiviral, antitümör, anti-inflamatuvar ve antioksidan özelliklerinden dolayı tıbbi bitkiler; gıda, yem, ilaç, kozmetik ve diğer endüstrilerde yaygın olarak kullanılmaktadır. Yem endüstrisi, antimikrobiyal, immünomodülatör, anti-stres ve büyüme uyarıcı gibi özgün biyolojik özelliklere sahip maddeler içermeleri nedeniyle tıbbi bitkilerden faydalanmaktadır (Ivanova vd.,2024). Fitojenik özler tıbbi bitkilerden elde edilen biyoaktif bileşikler olup, sentetik antibiyotikler ve hormonlara sürdürülebilir alternatifler olarak öne çıkmaktadır (Wang vd.,2024). Antimikrobiyal, antioksidan ve immünomodülatör özellikler sergilerler. Bu ekstraktlar folikül gelişimi, oosit

olgunlaşması ve endometriyal sağlık gibi önemli üreme süreçlerini etkilerken, oksidatif stres ve patojenik enfeksiyonların olumsuz etkilerini de hafifletmektedir (Adetunji vd.,2025). Tıbbi bitkilerin kullanımı, sentetik katkılarına bağımlılığı azaltmakta, maliyetleri düşürmekte, hayvan sağlığını iyileştirmekte ve verimliliği artırmaktadır. Bu bitkiler, sürdürülebilir tarım uygulamaları ile uyum sağlamakta, hayvancılık ürünlerine katma değer katarak premium pazarlara erişim imkânı sunmakta ve yerel kaynakların kullanımını destekleyerek hayvancılığın çevresel ayak izini azaltmaktadır (Iommelli vd.,2025). Sürdürülebilir hayvancılık talebinin artmasıyla birlikte, tıbbi bitkiler, hayvan sağlığını geliştirmek, çevresel etkiyi en aza indirmek ve insan tüketimi için gıda güvenliğini sağlamak adına uygulanabilir ve doğal bir çözüm sunmaktadır (Mukhtar vd.,2025).

Bu derlemede, tıbbi ve aromatik bitkilerin yem katkısı olarak kullanımının hayvan sağlığı, verimliliği ve sürdürülebilir hayvansal üretimdeki yeri ve önemini belirlemek amaçlanmıştır.

## 2. Tıbbi ve Aromatik Bitkilerin Hayvan Sağlığı ve Beslenmesi Üzerindeki Etkileri

Çevre dostu yönetim, çiftlik hayvanlarının sağlığı için önemlidir; bu nedenle, doğal mera bitkisel preparatlar ve diğer botanikler gibi doğal bileşiklerin kullanımı, genel hayvan sağlığının iyileştirilmesi ve tüketici endişelerinin giderilmesi açısından önem taşımaktadır (Shahrajabian vd.,2021). Merada yetişen tıbbi bitkilerin hem hayvanların hem de insanların beslenme programlarına dahil edilmesi, yalnızca beslenme gereksinimlerini karşılamakla kalmaz, aynı zamanda halk sağlığını ve hayvansal ürünlerin güvenliğini de sağlamaktadır (Kazemi ve Kafi, 2025).

Bitkilerin koruma yöntemleri, fizikokimyasal özelliklerini doğrudan etkiler. Dondurma gibi yöntemler, bitkilerin besin değerlerini ve duyuşal yönlerini korumada daha etkilidir. Pratik koruma yöntemleri aynı zamanda bitkilerin tıbbi özellikleri için hayati önem taşıyan biyolojik aktif bileşenleri de muhafaza eder. Tıbbi ve aromatik bitkiler, gıda üretiminde organik koruyucu, lezzet artırıcı katkı maddesi ve renk verici maddeler olarak işlev görek genel duyuşal deneyime ve besin değerine katkıda bulunur (Nakra vd.,2025)

Yemlere toz veya ekstrakt formunda fitogenik katkı maddeleri eklenerek sentetik antibiyotik ve hormon kullanımının azaltılması mümkündür. Bu uygulama, hayvanların sağlığını iyileştirir ve morbidite ile mortalite oranlarını düşürür (Ivanova vd.,2024). Yem katkı maddeleri, hayvan yemine eklenerek yem kalitesini, hayvansal ürünlerin değerini veya hayvanların performans ve sağlığını artırmayı amaçlayan maddelerdir. Bitki özleri, çiftlik hayvanları yemlerinde kullanılan önemli bileşenlerden biridir. Antioksidan, antimikrobiyal, antiinflamatuvar, anti-koksidiyal ve antihelmintik özellikleri sayesinde büyüme performansını ve ürün kalitesini artırmada kritik rol oynarlar. Ayrıca rumen mikrobiyal aktivitesini artırır, yem palatabilitesini iyileştirir ve sindirimi uyarırlar (Alem, 2024).

**Tablo 1.** Tıbbi ve Aromatik Bitkilerin Hayvan Sağlığı Üzerindeki Etkileri

Bitki	Yetiştirme Alanı	Başlıca Etkiler	Kaynak
Isırgan otu ( <i>Urtica dioica</i> L.)	Doğu Sibiryası, Uzak Doğu, Orta Asya	Hemoprotektif, yara iyileştirici, hemostatik, koleretik, diüretik, antioksidan, immünomodülatör, ekspektoran, hepatoprotektif, antikonvülzan, analjezik, antiseptik, antiinflamatuvar, laksatif	(Lobkov vd.,2017)
Pelin ( <i>Tanacetum vulgare</i> L.)	Rusya ve Avrupa (Uzak Kuzey hariç)	Antiinflamatuvar, antiseptik, antimikrobiyal, antitümör, ateş düşürücü, antispazmodik,	(Baymishev ve Baimishev, 2016; Talybov ve Mamedov, 2017)

Bitki	Yetiştirme Alanı	Başlıca Etkiler	Kaynak
		koleretik, antitoksik, antihelmintik, tansiyonu dengeler, kalp atışını yavaş düzenler	
Altın kök ( <i>Rhodiola rosea</i> )	Sibirya (Altay, Ural, Yakutya), Avrupa dağları	Performans artırıcı, ateş düşürücü, genel tonik, stres ve hastalıklara karşı direnç artırıcı, zihinsel ve fiziksel performansı güçlendirici	(Kutai, 2016; Khuzina vd.,2016)
Ekinezya ( <i>Echinacea purpurea</i> )	Kuzey Amerika, Avrupa, Rusya (Sibirya)	Antitümör, antiinflamatuar, immünomodülatör, otoimmün, özgül olmayan bağışıklığı artırıcı, metabolizma düzenleyici, kapiller koruyucu, yara iyileştirici	(Vetrova ve Kuznetsova, 2017; Plemyashov vd.,2014)

Sentetik katkı maddelerinin çoğu, hem yararlı rumen mikroplarına hem de konakçı hayvana zarar verir veya sadece metanojenesi geçici olarak etkiler. Fitojenik yem katkı maddeleri (PFA'lar), antibiyotiklere ve sentetik kimyasallara karşı son zamanlarda en iyi alternatifler olarak ortaya çıkmıştır; bu durum, halk arasında ilaç direnci ve antibiyotikler ile sentetik kimyasalların insan, hayvan ve çevre üzerindeki olumsuz etkilerine ilişkin artan endişelerden kaynaklanmaktadır. (Bature vd.,2024) Günümüzde fitojenik yem katkı maddelerinin kullanımına yönelimin artmasına bağlı olarak ruminantlarda bitki özlerinin uygulanmasında hâlâ bazı sınırlılıklar mevcuttur. Bunlar arasında bitki özlerin sınırlı üretimi, özütleme ve işleme teknolojisinin yeterince gelişmemiş olması, hayvan türü, yaşı ve vücut ağırlığına göre uygun doz seviyelerinin belirsizliği, etkilerin istikrarsızlığı ve yüksek maliyetler yer almaktadır. Ayrıca birçok bitki özünün varlığı ve etki mekanizmaları henüz araştırılmamış ve ilgili hayvan besleme denemeleri gerçekleştirilmemiştir. Bu nedenle, bitki özlerinin gelecekte geliştirilmesi için hâlâ çok fazla alan ve fırsat mevcuttur (Piao ve ark., 2023).

**Tablo 2.** Bazı Tıbbi ve Aromatik Bitki Ekstraktların Ruminant Hayvanların Verimleri Üzerine Etkileri

Kullanılan Bitkisel Ekstraktları	Ruminant Hayvanlar Üzerindeki Etki	Kaynak
Biberiye ( <i>Salvia rosmarinus</i> ) ekstresi,	Süt ve süt laktoz verimi, rumen fermentasyonu ve süperoksit dismutaz konsantrasyonu anlamlı şekilde artarken, somatik hücre sayısı ve malondialdehit yüksek süt veren ineklerde azalmıştır.	(Kong vd.,2022)
Zeytin yaprağı ( <i>Olea europaea</i> ) ekstresi	Rumen siliyalı protozoa sayısı azalmış, bakteri sayısı ve nişasta sindirimi artmıştır. Hem Gram+ hem Gram- bakteriler zeytin yaprağı ( <i>Olea europaea</i> ) ekstresi ile inhibe edilmiştir.	(Öztürk vd.,2012)
Sarımsak ( <i>Allium sativum</i> ) ekstresi	Genel yem alımı, vücut ağırlığı artışı, günlük ortalama artış, vücut kondisyon skoru ve yemden yararlanma verimliliği artmıştır.	(Kumar vd.,2018)

Kullanılan Ekstraktları	Bitkisel	Ruminant Hayvanlar Üzerindeki Etki	Kaynak
Kimyon ( <i>Carum carvi</i> ), rezene ( <i>Foeniculum vulgare</i> ), melisa ( <i>Melissa officinalis</i> )		DM başına gaz üretimi, kısa zincirli yağ asidi, metabolize edilebilir enerji, uçucu yağ asitleri ve in vitro sindirilebilirlik anlamlı şekilde artmıştır.	(Rahmy vd.,2019)
Mavi Okaliptüs ( <i>eucalyptus globulus</i> ), Sarımsak ( <i>Allium sativum L</i> ) ve nane ( <i>Mentha piperita L.</i> ) Esansiyel yağ		Metan ve diğer gaz üretimi, esansiyel yağ dozu arttıkça azalmış; arkea ve bakteri popülasyonlarının kompozisyonunu farklı derecelerde değiştirmiştir.	(Patra ve Yu, 2012)
Flavonoid bileşenleri		Protozoa ve metanogen popülasyonları ciddi şekilde azalmıştır. Flavonlar, mirisetin, kateşin, rutin ve kaemferol hemen hemen tüm rumen mikroplarının popülasyonunu önemli ölçüde azaltmıştır.	(Oskoueian vd.,2013)
Zencefil ( <i>Zingiber officinale</i> ) Esansiyel yağ		In vitro testlerde antibakteriyel özellikler göstermiş ve protozoa sayısını azaltmıştır. <i>Zingiber officinale</i> 'de protozoa sayısı yüksek, diğer esansiyel yağlarda ise daha düşüktür.	(Yildiz vd.,2015)

**Tablo 3.** Fitojenik Yem Katkılarının (PFA) Ruminant Performansına Etkileri (Nastoh et al., 2024)

PFA Kaynağı	Dozaj	Çalışma Türü	Hayvan Türü	Diyet	Sonuç	Kaynak
Rezene ( <i>Foeniculum vulgare</i> ) tohumu	Diyetin % 0,75 ve 1,5'i	In vivo	Erkek kuzu	Ot-konsantre 40:60	1,5% dozda DMI, LDG, FBW ve FCR ↑ (P < 0,05)	Hajalizadeh vd.,2019
Limonotu ( <i>Lippia alba</i> ) kuru otu	Toplam DMI'nin 30-60-90 g/kg	In vivo	Alpin keçi	TMR	DMI, ADF, yem verimliliği ↑ (P < 0,05); toplam karbonhidrat, NDF ve NFC alımı ↓ (P < 0,001)	Da Silva vd.,2022
Ekinezya ( <i>Echinacea purpurea</i> ) yaprak (EP)	Kişi başı 4-8-12 g/gün	In vivo	Ossimi kuzuları	TMR	BW 4, 8 ve 12 g EP ile sırasıyla ↑ 11,82, 13,80 ve 12,26%; WG ve büyüme hızı 8 g EP ile ↑ 36,99 ve 37,48%	Tantawi vd.,2023
Dhataki ( <i>Woodfordia fruticosa</i> ), Avrupa kara itüzümü ( <i>Solanum nigrum</i> ), Çemen otu ( <i>Semen Foenugraeci</i> )	Toplam DMI'nin %2-3'ü	In vivo	Jamunapari keçi	Konsantre ve kaba yem	Tüm besinlerin sindirilebilirliği ↑ (P < 0,05); DMI ve BWG ↓	(Choubey vd., 2015)

PFA Kaynağı	Dozaj	Çalışma Türü	Hayvan Türü	Diyet	Sonuç	Kaynak
Anason ( <i>Pimpinella anisum</i> L.), karanfil ( <i>Syzygium aromaticum</i> L.) ve kekik ( <i>Thymus vulgaris</i> L.) EO	Kişi başı 2 ml/gün	In vivo	Shame keçi	TMR	ADF, OM ve eter ekstrakt sindirilebilirliği ↑ (P < 0,05)	(El-Essawy vd., 2021)
Kekik ( <i>Thymus vulgaris</i> L.) yaprağı ve kereviz ( <i>Apium graveolens</i> L.) tohumları karışımı 1:1	Kişi başı 20 g/gün	In vivo	Barki koyunları	Konsantre ve yem 60:40	Sindirilebilirlik ve besin alımı ↑ (P < 0,05)	(Khattab vd., 2020)
Biberiye ve limon otu	Her biri 10 g/gün	In vivo	Şam keçisi	Konsantre ve yonca	NI ↓ (P > 0,05); OM ve lif sindirimi ↑ (P < 0,05)	(Kholif et vd., 2017)
Kekik ( <i>Thymus vulgaris</i> L.) ve karvakrol	Kuru madde başına 50 mg	In vivo	Süt ineği	Ot ve konsantre 60:40	Sindirilebilirlik, N kullanımı ↓	(Benchaar, 2020)
Sarımsak ( <i>Allium sativum</i> L) ekstresi, kişniş ( <i>Coriandrum sativum</i> L.) tohumu, mesquite ( <i>Prosopis juliflora</i> ) kabuğu ve kekik ( <i>Thymus vulgaris</i> L.)	Kişi başı 6 ml/gün oral	In vivo	Koyun	TMR	Yem davranışı ve NI ↓ (P > 0,05); ND ↑ (P < 0,05)	(Da Silva vd., 2017)

**Notlar:** EO – uçucu yağ, TMR – toplam karışık rasyon, DM – kuru madde, DMI – kuru madde alımı, LDG – günlük canlı ağırlık artışı, FBW – son vücut ağırlığı, FCR – yem dönüşüm oranı, NDF – nötr deterjan lif, NFC – lif içermeyen karbonhidrat, BW – vücut ağırlığı, WG – kilo artışı, BBW – doğum ağırlığı, ADG – ortalama günlük artış, BWG – vücut ağırlığı artışı, OM – organik madde, NI – besin alımı, ND – besin sindirilebilirliği, ADF – asit deterjan lifi, EEI – eter ekstrakt alımı; P < 0,05 PFA'ların belirtilen parametreler üzerindeki etkisinin anlamlı olduğunu gösterir.

Fitojenik yem katkılarına olan ilgi, ruminantların bitkileri ve onların yan ürünlerini verimli bir şekilde kullanabilme yeteneklerinden dolayı artmaktadır. Kekik, biberiye, kâkule, kişniş, sarımsak, okaliptüs, anason, karanfil, nane, tarçın, zerdeçal ve moringa gibi yaygın kullanılan bitkiler özellikle antioksidan ve büyüme uyarıcı özellikleriyle tatmin edici sonuçlar göstermiştir. Ayrıca, dut, nar ve üzüm çekirdeği gibi meyve özütlerinin performans, sindirilebilirlik, süt üretimi, bağışıklık ve antioksidan durum üzerinde olumlu etkileri olduğu bildirilmiştir (Nastoh vd.,2024).

Fitojenik ekstraktlar bağırsak sağlığını iyileştirerek, oksidatif stresi azaltarak ve hormonal işlevleri modüle ederek, çeşitli çiftlik hayvanlarında üreme sağlığını artırmada önemli bir potansiyel göstermiştir. Besin emilimini iyileştirme ve bağırsak mikrobiyotasının modülasyonu gibi mekanizmalar aracılığıyla, fitojenik özler hayvan sağlığını optimize eder ve doğrudan üreme sonuçlarını olumlu etkiler. Özellikle, antioksidan ve anti-inflamatuvar özellikleri, oksidatif hasarı azaltarak fertilitiyi ve üreme başarısını desteklemektedir. (Adetunji vd.,2025)

**Tablo 4.** Bazı Tıbbi ve Aromatik Bitki Ekstraktlarının Tavuklar Üzerindeki Etkileri

Bitki Ekstraktları	Doz / Seviye	Tavuk Üzerindeki Etki	Kaynak
Amla meyve tozu	% 0,25, 0,5, 0,75 ve 1	E. coli bakterisi azaldı, Lactobacilli mikroorganizma sayısı arttı; broilerlerde en düşük serum kolesterol değeri ve heterofil sayısı azaldı	(Dalal vd.,2018)
Moringa yaprak unu	0,5 kg/100 kg diyet	Yumurta üretimi ve yemden yararlanma oranı arttı	(Swain vd.,2017)
Aloevera ekstresi	100, 200, 300 mg/kg BW	Günlük canlı ağırlık artışı, anti-koksidial indeksler yüksek	(Khaliq vd.,2017)
Zeytin yaprağı tozu	% 1, 2, 3	Tavukların son canlı ağırlığı arttı, yumurta sarısı rengi koyulaştı, yumurta sarısı kolesterolü azaldı	(Cayan ve Erener, 2015)
Biyoaktif karışım (limon, soğan ve sarımsak suyu)	% 1, 2, 3	Yemden yararlanma verimliliği, yumurta sayısı/yumurta üretim yüzdesi, yumurta ağırlığı ve sarı rengi arttı	(Ömer vd.,2019)
Kırmızı zencefil, brotowali ekstresi	%1 zencefil 5,12 g/kg BW brotowali ve ikisi içme suyunda	Canlı ağırlık 1100,28 g/baş, yemden yararlanma oranı 1,37 karkas yüzdesi % 83,58, abdominal yağ % 0,56 pişirme kaybı %8,56	(Shaffira ve Putri, 2023)

Kümes hayvanlarında antimikrobiyallerin aşırı kullanımı, çoklu ilaç dirençli mikroorganizmalarla ilgili artan endişelere yol açmış ve hem hayvan hem de insan sağlığı için ciddi riskler oluşturmuştur. Antibiyotikler, geleneksel olarak büyümeyi artırmak ve kümes hayvancılığında ekonomik verimliliği iyileştirmek amacıyla subterapötik dozlarda kullanılmıştır. Ancak bu uygulamalar, dirençli mikroorganizma suşlarının ortaya çıkmasını kolaylaştırmış, küresel sağlık güvenliğini tehdit etmiş ve sürdürülebilir alternatiflerin araştırılmasını zorunlu kılmıştır (Aminullah vd.,2025). Tıbbi ve aromatik bitkilerden yapılan takviyelere olan ilginin artması, çiftlik kârlılığını artırma potansiyelini göstermekte; ancak aşırı kullanımın önlenmesi ve sürdürülebilirliğin sağlanması için dikkatli yönetim gerekmektedir. Bu uygulamaların daha maliyet etkin ve geniş çapta hayvancılık sistemlerinde uygulanabilir hâle gelmesi için ek araştırmalara ihtiyaç vardır. (Iommelli vd.,2025)

### 3. SONUÇ

Tıbbi bitkiler ve fitojenik yem katkıları, hayvan beslenmesinde sürdürülebilir tarımın çevresel insan-hayvan sağlığının gelişimine ve gıda güvenliğine önemli katkılar yapmaktadır. Mevcut veriler, ruminant ve kümes hayvanlarında bu katkıların büyüme performansını, yemden yararlanmayı, bağışıklık sistemini ve üreme performansını artırdığını hayvan sağlığını iyileştirdiğini ortaya koymaktadır. Özellikle antioksidan ve antimikrobiyal bileşikler, rumen mikrobiyotasını olumlu yönde modüle ederek sindirilebilirliği artırmakta, oksidatif stresi azaltmakta ve patojenik enfeksiyon riskini düşürmektedir. Fitojenik ekstraktların in vivo uygulamaları, günlük canlı ağırlık artışı, vücut kondisyon skoru, süt ve yumurta veriminde belirgin iyileşmeler göstermektedir. Bununla birlikte, bitki özlerinin etkinliği, tür, yaş, vücut ağırlığı ve dozaj gibi faktörlere bağlı olarak değişmektedir. Sürdürülebilir Gelecek perspektifinden bakıldığında, bu doğal katkılar, sentetik antibiyotiklerin kimyasal yem katkı maddeleri ve hormonların etkinliğini kullanımını azaltmakta, maliyetleri düşürmekte ve çevresel karbon ayak izini azaltmaktadır. Sonuç olarak, tıbbi ve aromatik bitkiler hayvan sağlığını, ürün miktarını kalitesini ve verimliliğini artıran, çevresel ve ekonomik açıdan

sürdürülebilir bir çözüm olarak hayvancılık sektöründe önemli katkılar sağlayabilecek önemli bir alan olarak karşımıza çıkmaktadır.

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## TATLI SU MİDYELERİNİN HABİTAT İZLENMESİNDE BİLİMSEL DALIŞ TEKNİKLERİNİN YÖNTEMSEL KATKILARI

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### ÖZET

Tatlı su midyeleri (*Unionidae* ve *Dreissenidae*), sucul ekosistemlerdeki filtrasyon aktiviteleri ve ekolojik göstergelik özellikleriyle, ekosistem sağlığının izlenmesinde kritik bir araştırma grubunu temsil etmektedir. Ancak yoğun hidrofit örtüsü ve düşük görüş koşulları, klasik kıydan örnekleme ve sediman tarama yöntemlerinin etkinliğini sınırlamaktadır. Bu çalışma, bilimsel dalış tekniklerinin (SCUBA) midye izleme çalışmalarına sağladığı yöntemsel katkıları ortaya koymaktadır. Quadratsieve sistemleri, gömülü juvenil bireylerin tespitini kolaylaştırmakta; ARIS sonar ve fotogrametri gibi yüksek çözünürlüklü görüntüleme teknikleri, düşük görüş koşullarında popülasyon yoğunluğu ve dağılımını güvenilir şekilde belirlemektedir. Ayrıca, non-destructive mantle biopsy yöntemleri, birey kaybını önleyerek uzun dönemli genetik ve sağlık analizlerinin yapılmasına imkân tanımaktadır. SCUBA destekli biyometrik ölçümler ve entegre teknolojik yaklaşımlar, tatlı su midyelerinin habitat kullanımını ve ekolojik işlevlerini daha kapsamlı şekilde değerlendirmeyi mümkün kılmaktadır. Sonuç olarak, tatlı su midyelerinin korunması ve sürdürülebilir yönetimi açısından, klasik yöntemlerin dalış tabanlı uygulamalar ve modern teknolojilerle bütünleştirilmesi bir gereklilik olup, bu entegrasyon uluslararası düzeyde standart protokollerin geliştirilmesine temel teşkil etmektedir.

**Anahtar Kelimeler:** Tatlı su midyeleri, SCUBA, Örnekleme metodolojisi, Hidrofit yoğunluğu, ARIS sonar, Fotogrametri, Non-destructive örnekleme

### METHODOLOGICAL CONTRIBUTIONS OF SCIENTIFIC DIVING TECHNIQUES IN HABITAT MONITORING OF FRESHWATER MUSSELS

### ABSTRACT

Freshwater mussels (*Unionidae* and *Dreissenidae*) play a crucial role in aquatic ecosystems due to their filtration activities and value as ecological indicators. However, dense macrophyte cover and limited visibility reduce the efficiency of traditional shoreline sampling and sediment dredging methods. This study highlights the methodological contributions of scientific diving (SCUBA) to mussel monitoring practices. Quadrat-sieve systems enhance the detection of buried juveniles; high-

resolution imaging technologies such as ARIS sonar and photogrammetry enable reliable assessments of density and distribution under low-visibility conditions. Furthermore, non-destructive mantle biopsy techniques support long-term genetic and health analyses without sacrificing individuals. SCUBA-based biometric measurements and integrated technological approaches provide comprehensive insights into habitat use and ecological functions of freshwater mussels. In conclusion, integrating classical methods with diver-assisted protocols and modern technologies is essential for the conservation and sustainable management of freshwater mussels, and it provides a foundation for the development of standardized international protocols.

**Keywords:** Freshwater mussels, SCUBA, Sampling methodology, Macrophyte density, ARIS sonar, photogrammetry, Non-destructive sampling

## 1. GİRİŞ

Tatlı su midyeleri (*Unionidae*, *Dreissenidae*), bentik ekosistemlerde filtrasyon yoluyla su kolonu içerisindeki partikül maddeyi azaltmaları, besin döngülerine katkıları ve sediman karıştırma (biyoturbasyon) faaliyetleri sayesinde ekosistem mühendisleri olarak kabul edilmektedir (Vaughn, 2018; Verma ve ark., 2025). Bu özellikleri nedeniyle midyeler yalnızca sucul ekosistemlerin işleyişinde kritik rol oynamakla kalmaz, aynı zamanda ekolojik göstergeler olarak çevresel değişimlerin izlenmesinde de sıkça kullanılmaktadır. Kabuklarındaki kalsiyum karbonat yapısı uzun dönemli çevresel kayıtları yansıtması bakımından paleoekolojik çalışmalara da olanak sağlamaktadır. Ancak, midye popülasyonlarının yoğunluk, dağılım ve habitat özelliklerinin doğru şekilde belirlenmesi özellikle hidrofit yoğunluğu yüksek sularda (ör. *Eichhornia crassipes*, *Nymphaea spp.*) zorluk arz etmektedir. Bitkisel örtü, görüş kısıtlılığı ve sedimanın kapatılması, kıydan sediman toplama ve basit görsel gözlem gibi klasik yöntemlerin güvenilirliğini düşürmektedir (Dolson ve ark., 2023). Bu nedenle, örnekleme metodolojilerinde dalış tekniklerinin (SCUBA) kullanımı giderek daha fazla önem kazanmıştır.

Son yıllarda bilimsel dalış teknikleri midye araştırmalarına entegre edilerek transekt ve kare uygulamaları, zamanlı görsel aramalar ve dalgıç destekli biyometrik ölçümler standardize edilmeye başlanmıştır (Xerces Society, 2024). Özellikle, küçük bireylerin tespitinde dalgıçlar tarafından kullanılan kare-sieve sistemleri hem örnekleme duyarlılığını artırmakta hem de habitat bozulmasını en aza indirmektedir (McAlpine & Sollows, 2014). Ayrıca, düşük görüş ve yoğun hidrofit örtüsü koşullarında yüksek çözünürlüklü görüntüleme sonarları (Adaptive Resolution Imaging Sonar, ARIS), midye dağılım ve bolluğunu haritalamada etkin bir yöntem olarak uygulanmaktadır (Zhao ve ark., 2024; Zhao ve ark., 2025). Görüntüleme sonarlarının dalış tabanlı sayımlarla doğrulanması, veri güvenilirliğini artırmaktadır. Bununla birlikte, hidrofit örtüsünün yoğun olduğu bölgelerde dalış sırasında elde edilen fotogrametri ve yüksek çözünürlüklü görüntü analizleri de popülasyon yoğunluğunu belirlemede başarılı sonuçlar vermektedir (Bethoney ve ark., 2018). Genetik ve sağlık analizleri açısından ise non-destructive mantle biopsy gibi yöntemler, birey kaybını önleyerek uzun dönemli izleme çalışmalarına uyum sağlamaktadır (Berg ve ark., 1995; Harrison ve ark., 2023).

Sonuç olarak, tatlı su midyelerinin ekolojik işlevlerinin ve habitat kullanımının doğru şekilde anlaşılması için klasik yöntemlerin dalış tabanlı yaklaşımlar ve modern teknolojilerle entegre edilmesi gerekmektedir. Bu derlemenin amacı, tatlı su midyelerinin habitat izlenmesinde kullanılan yöntemleri sentezlemek, özellikle hidrofit yoğunluğu olan sularda karşılaşılan sorunlara yönelik güncel teknik çözümleri tartışmak ve gelecekte standart protokollerin geliştirilmesine katkı sağlamaktır.

## 2. TATLI SU MİDYELERİNİN İZLENMESİNDE KLASİK YAKLAŞIMLAR

### 2.1. Kıyıda Sediman Örneklemesi ve Tarama Yöntemleri

Tatlı su midyelerinin izlenmesinde kullanılan en eski ve en yaygın yöntemlerden biri kıyıda sediman örneklemesi ve tarama teknikleridir. Bu yaklaşımda, kıyıya yakın ve erişilebilir alanlarda sediman tarafları, el kepçeleri (dredge, Ekman grab, Ponar grab) veya basit el aletleri kullanılarak örnekler alınmaktadır. Çoğu durumda bu örnekler laboratuvara taşınarak midye varlığı, yoğunluğu ve tür kompozisyonu incelenmektedir (Dolson ve ark., 2023). Bu yöntemlerin avantajı, hızlı ve düşük maliyetli olmaları, özellikle küçük göller ve nehir kenarlarında kolay uygulanabilmeleridir. Ancak, sediman örneklemesi ve tarama teknikleri mekânsal temsil gücü sınırlı olduğu için çoğunlukla kıyı zonunda bulunan bireyleri tespit etmektedir. Derin bölgelerde veya heterojen substrat yapılarında popülasyonun gerçek yoğunluğu ve dağılımı hakkında eksik bilgi sağlamaktadır (Vaughn, 2018). Ayrıca, yoğun hidrofite örtüsü veya iri çakıllı/kayalık habitatlarda tarama aletlerinin sedimana ulaşması zorlaşmakta, bu da örneklemesi etkinliğini düşürmektedir. Kıyıda örneklemesi yöntemleri, özellikle sığ ve açık sediman yüzeyine sahip alanlarda faydalı olmakla birlikte, günümüzde tek başına yeterli görülmemektedir. Güncel çalışmalarda kıyıda sediman tarama sonuçlarının, transept/quadrat gözlemleri, dalış destekli araştırmalar veya sonar tabanlı tekniklerle entegre edilerek kullanılması önerilmektedir (Dolson ve ark., 2023; Xerces Society, 2024). Böylece hem kıyı şeridinde hem de derin sularda daha doğru ve güvenilir bir popülasyon değerlendirmesi mümkün olmaktadır.

### 2.2. Transect ve Quadrat Uygulamaları

Tatlı su midyelerinin popülasyon yoğunluğu, dağılımı ve habitat tercihlerini belirlemede en yaygın kullanılan klasik yöntemlerden biri transect ve quadrat uygulamalarıdır. Bu yöntem, belirli uzunlukta çizilen hatlar (transect) boyunca veya belirli alan büyüklüğündeki kare çerçeveler (quadrat) içerisinde midye bireylerinin sayılması ve kaydedilmesine dayanmaktadır. Uygulama, genellikle kıyıya paralel veya dik uzanan hatlar üzerinde belirlenen örneklemesi noktalarında yapılır ve bireylerin hem yoğunluğu (birey/m<sup>2</sup>) hem de boy dağılımları elde edilir (Dolson ve ark., 2023). Transect yöntemleri, geniş alanlarda popülasyon yoğunluğunu ve mekânsal dağılım desenlerini incelemek için kullanılırken, quadrat uygulamaları daha ayrıntılı ve küçük ölçekli yoğunluk verileri sağlamaktadır (Xerces Society, 2024). Quadrat ölçüleri genellikle 0,25 m<sup>2</sup> ile 1 m<sup>2</sup> arasında değişmekte olup, sedimanın üst tabakası taranarak hem yüzeydeki hem de sedimana gömülü bireyler sayılabilmektedir. Bu yöntemler, popülasyon ekolojisi çalışmaları için en güvenilir geleneksel yöntemlerden biri olarak kabul edilmektedir (Vaughn, 2018).

Bununla birlikte, görüş kısıtlılığı ve hidrofite yoğunluğu transect ve quadrat uygulamalarının etkinliğini azaltabilmektedir. Bu durumda dalış tabanlı uygulamalar ile entegre edilmesi, örneklemesi doğruluğunu önemli ölçüde artırmaktadır. Örneğin, McAlpine & Sollows (2014) tarafından geliştirilen quadrat-sieve sistemi, sediman kazısını ve elenmesini dalış desteği ile birleştirerek özellikle küçük boylu midyelerin tespitinde metodolojik gücü yükseltmiştir. Ayrıca, fotogrametri ve sualtı video kayıtlarının quadrat uygulamalarıyla birleştirilmesi, verilerin hem doğrulanmasını hem de uzun dönemli karşılaştırmalara uygun bir veri seti oluşturmasını sağlamaktadır (Bethoney & Stokesbury, 2018).

Sonuç olarak, transect ve quadrat yöntemleri tatlı su midyelerinin izlenmesinde temel yöntemler arasında yer almakta; ancak günümüzde bunların dalış teknikleri, görüntüleme sistemleri ve sediman eleme yöntemleriyle bütünleştirilmesi önerilmektedir. Bu entegrasyon, hem habitat çeşitliliği yüksek alanlarda hem de hidrofite yoğunluğu bulunan ekosistemlerde daha güvenilir ve tekrarlanabilir sonuçlar elde edilmesine katkı sağlamaktadır.

### 2.3. Klasik Yöntemlerin Sınırlılıkları

Tatlı su midyelerinin izlenmesinde kullanılan klasik yöntemler kıyıda sediman tarama, transect ve quadrat uygulamaları uzun süredir yaygın olarak kullanılmakta ve birçok ekolojik çalışmanın temelini oluşturmaktadır (Dolson ve ark., 2023). Ancak, bu yöntemlerin çeşitli sınırlılıkları bulunmaktadır. Öncelikle, kıyıda sediman örnekleme yöntemleri, çoğunlukla yalnızca kıyıya yakın ve erişilebilir alanlardaki popülasyonları temsil etmektedir. Bu durum, derin bölgelerde yaşayan veya heterojen substratlarda dağılım gösteren midyelerin yeterince örneklenememesine yol açmaktadır (Vaughn, 2018). Ayrıca, iri çakıllı veya kayalık tabanlarda kullanılan tarak ve grab aletlerinin verimliliği sınırlıdır. Transect ve quadrat uygulamaları daha sistematik bir veri sunmakla birlikte, görüş kısıtlılığı, akıntı ve yoğun hidrofite örtüsü gibi saha koşullarında metodolojik güvenilirlik kaybı yaşanabilmektedir. Özellikle, yoğun bitki örtüsünün bulunduğu sularda quadratların tabana doğru konumlandırılması zorlaşmakta, sediman kazısı yapılırken bireylerin gözden kaçması ihtimali artmaktadır (Xerces Society, 2024). Bu durum, popülasyon yoğunluğunun olduğundan düşük tahmin edilmesine neden olabilmektedir.

Klasik yöntemlerde bir diğer sorun da küçük bireylerin (juvenil midyelerin) örneklemede gözden kaçmasıdır. Görsel gözlemler çoğunlukla büyük bireylere odaklanırken, sediman içerisinde gömülü küçük bireylerin tespiti sınırlı kalmaktadır. Bu eksiklik, özellikle popülasyonun yenilenme kapasitesinin değerlendirilmesinde önemli bir metodolojik boşluk yaratmaktadır (McAlpine & Sollows, 2014). Ayrıca, klasik yöntemlerin çoğu yüksek iş gücü ve zaman gerektirmektedir. Büyük alanlarda geniş kapsamlı transect/quadrat uygulamaları, yoğun saha ekibi ve uzun örnekleme süreleri gerektirir. Buna rağmen, elde edilen veriler çoğu zaman yalnızca lokal ölçekte geçerli olup, geniş mekânsal ölçekte ekstrapolasyon yaparken yanılma payı artmaktadır (Reymondet ve ark., 2025). Dolayısıyla, klasik yöntemler tatlı su midyelerinin ekolojik araştırmalarında temel bir rol oynamakla birlikte, bu sınırlılıklar nedeniyle günümüzde tek başına kullanılmaları yetersiz görülmektedir. Bu nedenle, klasik yaklaşımların dalış tabanlı uygulamalar, sonar görüntüleme ve fotogrametri gibi modern tekniklerle entegre edilmesi, örnekleme doğruluğu ve ekolojik temsil gücünü artırmak için gerekli görülmektedir.

## 3. BİLİMSEL DALIŞ TEKNİKLERİNİN YÖNTEMSEL KATKILARI

### 3.1. SCUBA Tabanlı Gözlemler ve Popülasyon Sayımları

Tatlı su midyelerinin izlenmesinde SCUBA tabanlı gözlemler, son yıllarda klasik yöntemlere kıyasla daha doğru, ayrıntılı ve tekrarlanabilir veri sağlaması nedeniyle yaygınlaşmıştır. SCUBA dalgıçları, doğrudan sualtında popülasyon yoğunluğunu belirlemek için transect hatları veya quadrat çerçeveleri boyunca sistematik sayımlar gerçekleştirmektedir. Bu yöntem, yalnızca yüzeyde görülebilen bireyleri değil, aynı zamanda sedimanın üst tabakalarında kısmen gömülü halde bulunan midyeleri de kaydetme imkânı sunmaktadır (Xerces Society, 2024). SCUBA tabanlı sayımlar, özellikle habitat heterojenliği yüksek ve derin sularda kıyıda yapılan örneklemeyle kıyasla daha doğru sonuçlar vermektedir. Dolson ve arkadaşları (2023) derlemesine göre, SCUBA yöntemleriyle gerçekleştirilen görsel anketler, popülasyon yoğunluğu ve dağılım desenlerinin belirlenmesinde uluslararası izleme protokollerinin önemli bir bileşeni haline gelmiştir. SCUBA ile yapılan doğrudan gözlemler, popülasyon sayımlarının yanı sıra biyometrik ölçümler (kabuk uzunluğu, boy sınıfları) ve sağlık durumunun in situ değerlendirilmesi için de kullanılabilir. Bu sayede popülasyon dinamikleri, büyüme oranları ve yaş yapısı gibi demografik parametreler sahada belirlenebilmektedir (Vaughn, 2018). Ayrıca, dalgıçların aynı anda habitat parametrelerini (substrat tipi, hidrofite yoğunluğu, akıntı hızı, derinlik) kaydetmesi, elde edilen verilerin ekolojik yorum gücünü artırmaktadır. Dahası, SCUBA tabanlı gözlemler ve popülasyon sayımları, tatlı su midyelerinin ekolojik araştırmalarında yalnızca bireylerin tespitinde değil, aynı zamanda ekosistem düzeyinde değerlendirmeler yapılmasında da kritik bir yöntem olarak öne çıkmaktadır. Bununla birlikte, yöntemsal standardizasyonun sağlanması

ve farklı ekosistem tiplerinde uygulanabilirliğin test edilmesi, gelecekteki çalışmalar için önemli bir ihtiyaçtır.

### 3.2. Quadrat–Sieve Sistemleri ve Dalış Destekli Örneklem

Tatlı su midyelerinin popülasyon yoğunluğu ve boy dağılımlarının doğru şekilde belirlenmesi, ekolojik araştırmaların güvenilirliği açısından kritik öneme sahiptir. Klasik transekt ve quadrat yöntemleri genellikle yüzeyde görülebilen bireylere odaklanırken, sediman içine gömülü juvenil bireylerin tespit edilmesinde yetersiz kalabilmektedir. Bu eksikliğin giderilmesi için quadrat–sieve sistemleri geliştirilmiştir. McAlpine & Sollows (2014) tarafından tanımlanan quadrat–sieve sistemi, 0,25 m<sup>2</sup>'lik metal quadrat çerçevesi içinde sedimanın kazılması ve çıkarılan materyalin yüzeye taşınarak 5 mm göz açıklığına sahip elekten geçirilmesi esasına dayanmaktadır. Bu yöntem, özellikle küçük ve gömülü bireylerin yakalanmasında önemli bir avantaj sağlamaktadır. SCUBA desteği ile uygulandığında, derin sularda ve görüşün kısıtlı olduğu alanlarda bile popülasyon yoğunluğu ve yaş yapısı hakkında güvenilir veriler elde edilmiştir. Ayrıca, dalış destekli quadrat–sieve örneklemeleri, yalnızca birey yoğunluğunu belirlemekle kalmaz, aynı zamanda yaş yapısı, büyüme oranı ve popülasyon yenilenme kapasitesi gibi demografik parametrelerin değerlendirilmesine de katkı sunmaktadır. Dolson ve arkadaşları (2023), Kanada'da yapılan kapsamlı incelemelerde, quadrat–sieve yönteminin tatlı su midyelerinin izlenmesinde en yüksek doğruluk sağlayan yöntemlerden biri olduğunu, ancak iş gücü ve zaman maliyetlerinin yüksekliği nedeniyle geniş alanlarda uygulanmasının zorlaştığını belirtmektedir. Bu nedenle, quadrat–sieve sistemi çoğunlukla hedef alanlarda ayrıntılı ekolojik değerlendirme amacıyla kullanılmakta, daha geniş ölçekli transekt ve görsel surveylerle entegre edilerek karma metodolojik protokollerin bir parçası haline getirilmektedir. Böylece, hem geniş alanlarda popülasyon dağılımı hem de küçük bireylerin yoğunluğu güvenilir şekilde ortaya konabilmektedir.

### 3.3. Dalgıç Destekli Biyometrik Ölçümler

Tatlı su midyelerinin ekolojik değerlendirilmesinde popülasyon yoğunluğu ve dağılım verilerinin yanı sıra, biyometrik ölçümler (kabuk uzunluğu, genişlik, ağırlık, yaş tayini) popülasyon yapısının ve dinamiklerinin anlaşılmasında kritik öneme sahiptir. Dalgıç destekli biyometrik çalışmalar, midyelerin in situ koşullarda doğrudan ölçülmesine olanak tanıyarak, örneklem sonrası ölüm riskini en aza indirmekte ve verilerin doğal habitat koşullarında elde edilmesini sağlamaktadır. Türkiye'de *Unio crassus* üzerine yapılan bir çalışmada, kabuk uzunluğu ve ağırlık ölçümleri su sıcaklığı, çözülmüş oksijen gibi çevresel parametrelerle ilişkilendirilmiş; biyometrik özelliklerin çevresel koşullara duyarlı olduğu ortaya konmuştur (Serdar ve ark., 2019). Benzer şekilde, Polonya'daki *Anodonta cygnea* popülasyonlarında kabuk uzunluğu, yüksekliği ve çevre ölçümleri yapılmış, farklı habitatlarda boy yapısının değiştiği belirlenmiştir (Chojnacki ve ark., 2011). Bu tür çalışmalar, dalış destekli sahada ölçüm almanın popülasyon yapısının yerinde değerlendirilmesi açısından önemini göstermektedir.

Bunun yanı sıra, popülasyonun yaş yapısı ve büyüme dinamikleri üzerine yapılan araştırmalarda, kabuk boyu ve yaş ilişkilerinin belirlenmesi için dalgıçlar tarafından elde edilen biyometrik veriler kullanılmıştır. Sansom ve arkadaşları (2015), farklı havzalardaki unionid popülasyonlarında büyüme oranı ve yaşam süresi tahminlerini bu yöntemlerle gerçekleştirmiştir. Ayrıca, Richardson & Smith (1995), farklı substrat yapılarında non-destructive örneklem tekniklerinin biyometrik ölçümlerle birleştirilerek popülasyon yoğunluğu ve boy sınıflarının güvenilir biçimde belirlenebileceğini göstermiştir. Sonuç olarak, dalgıç destekli biyometrik ölçümler, tatlı su midyelerinin popülasyon ekolojisinin anlaşılmasında non-invasive, hızlı ve ekolojik bağlamda güçlü bir yöntem olarak öne

çıkılmaktadır. Bu ölçümlerin habitat özellikleriyle birlikte değerlendirilmesi, hem tür koruma hem de ekosistem yönetimi çalışmalarında kritik rol oynamaktadır.

### 3.4. İş Bölümlü Dalış Protokolleri (İkili Çalışma Düzenleri)

Tatlı su midyelerinin sualtı araştırmalarında dalış güvenliği ve metodolojik doğruluk açısından iş bölümlü dalış protokolleri, özellikle ikili çalışma düzenleri, büyük önem taşımaktadır. SCUBA araştırmalarında genellikle en az iki dalgıçtan oluşan ekipler kullanılmakta; bu ekipler arasında görev paylaşımı yapılarak hem veri kalitesi artırılmakta hem de güvenlik riski azaltılmaktadır. Bu protokollerde genellikle bir dalgıç örnekleme ve biyometrik ölçümlerden sorumlu olurken, diğer dalgıç veri kaydı, ölçüm doğrulama ve çevresel parametrelerin izlenmesini üstlenmektedir (Haag, 2012). Böylelikle, tek dalgıcın aynı anda hem ölçüm yapıp hem kayıt tutmasının getirdiği hata payı en aza indirilmektedir. Ayrıca, birincil görevli dalgıcın sediman kazısı veya quadrat içindeki ölçümleri yürüttüğü durumlarda, ikinci dalgıcın güvenlik ve zaman takibi sağlaması metodolojik standardizasyonu güçlendirmektedir (Strayer & Smith, 2003).

İkili çalışma düzenleri aynı zamanda zorlu koşullarda veri bütünlüğünü korumada etkilidir. Görüşün kısıtlı olduğu, hidrofite yoğunluğu yüksek veya akıntılı bölgelerde, ikinci dalgıç tarafından yapılan bağımsız doğrulamalar (örneğin sayım tekrarları veya quadrat fotoğraflarının çekilmesi) örnekleme hatalarını azaltmaktadır (Metcalf-Smith ve ark., 2000). Bu tür protokoller günümüzde Kuzey Amerika ve Avrupa'daki birçok tatlı su midyesi survey programında standart uygulama haline gelmiştir (DFO, 2023). Sonuç olarak, iş bölümlü dalış protokolleri, tatlı su midye araştırmalarında güvenliği artırmak, veri kalitesini yükseltmek ve metodolojik tekrarlanabilirliği sağlamak açısından kritik bir yaklaşımdır. Özellikle ikili çalışma düzenleri, saha çalışmalarında hem bilimsel hem de güvenlik standartlarını güçlendiren en etkili uygulamalardan biridir.

## 4. GÜNCEL TEKNOLOJİK YAKLAŞIMLAR VE ENTEGRASYON

### 4.1. Görüntüleme Sonar Sistemleri (ARIS vb.): Düşük görüş koşullarında popülasyon dağılımının haritalanması

Tatlı su ekosistemlerinde midye popülasyonlarının izlenmesinde en önemli zorluklardan biri, bulanık su, düşük görüş mesafesi ve yoğun hidrofite örtüsü gibi saha koşullarıdır. Bu durum, dalış tabanlı gözlemlerin ve görsel sayımların güvenilirliğini sınırlamaktadır. Son yıllarda bu eksiklikleri gidermek amacıyla yüksek çözünürlüklü görüntüleme sonar sistemleri (örneğin ARIS ve side-scan sonar) yaygın olarak kullanılmaya başlanmıştır. Powers ve arkadaşları (2014), turbid nehir ortamlarında side-scan sonar kullanarak midye yataklarını tespit etmeye çalışmış ve özellikle 1–2 m derinlikte bu tekniğin oldukça başarılı olduğunu, ancak daha derin alanlarda tespit gücünün azaldığını göstermiştir. Bu sonuç, sonar tabanlı sistemlerin sığ ve orta derinliklerde ekolojik surveyler için güvenilir bir araç olabileceğini ortaya koymaktadır. Benzer şekilde McCasker ve arkadaşları (2024), Avustralya'daki Edward/Kolety-Wakool Nehir sisteminde yürüttükleri saha denemelerinde side-scan sonar kullanarak midye popülasyonlarının dağılımını haritalandırmıştır. Bu çalışma, geniş alanların kısa sürede taranabilmesi ve potansiyel midye yataklarının düşük maliyetle belirlenebilmesi açısından sonar teknolojilerinin büyük bir avantaj sunduğunu vurgulamıştır. Bununla birlikte, yeni nesil ARIS (Adaptive Resolution Imaging Sonar) sistemleri, yalnızca geniş alan taraması değil, aynı zamanda yüksek doğrulukta bireysel tespit imkânı da sağlamaktadır. Zhao ve arkadaşları (2024), Japonya'daki Izunuma Gölü'nde ARIS sonarını derin öğrenme tabanlı görüntü işleme algoritmaları ile birleştirerek midye dağılımını başarıyla haritalamış ve klasik transekt sayımlarıyla yüksek uyum elde etmiştir. Sonuç olarak, ARIS ve side-scan sonar sistemleri, tatlı su midyelerinin düşük görüş koşullarında dağılım ve yoğunluklarının belirlenmesinde etkin, zaman ve maliyet açısından avantajlı yöntemlerdir. Ancak, bu yöntemlerin doğruluğunu artırmak için dalış destekli surveyler ve fotogrametri tabanlı gözlemlerle birlikte uygulanması önerilmektedir.

#### 4.2. Fotogrametri ve 3B Modelleme: Kabuk Ölçümleri ve Koloni Yapılarının Dijital Analizi

Son yıllarda fotogrametri ve üç boyutlu (3B) modelleme yöntemleri, tatlı su midyelerinin biyometrik ölçümlerinde ve koloni yapılarının analizinde önemli araçlar haline gelmiştir. Bu teknikler, farklı açılardan çekilen çoklu sualtı fotoğraflarının yazılım ortamında birleştirilmesiyle yüksek çözünürlüklü 3B modellerin oluşturulmasına dayanır. SCUBA dalışları ile birlikte uygulandığında, midyelerin kabuk boyutları, gömülme derinlikleri ve koloni yoğunluğu doğal habitat koşullarında yüksek hassasiyetle ölçülebilir. Fotogrametrik yöntemler, özellikle geniş midye kolonilerinde manuel ölçüm hatalarını azaltmakta ve saha süresini kısaltmaktadır. Reymonet ve arkadaşları (2025), Cenevre Gölü'nde yaptıkları çalışmada, fotogrametri ile elde edilen 3B modelleri kullanarak *Dreissena rostriformis bugensis* bireylerinin büyüme dinamiklerini analiz etmiş ve kış aylarında dahi büyümenin devam ettiğini ortaya koymuştur. Bu bulgu, yalnızca ekolojik bilgi sağlamakla kalmamış, aynı zamanda mevsimsel büyüme modellerinin doğruluğunu artıran metodolojik bir yenilik sunmuştur. Ayrıca, 3B modelleme yalnızca bireysel ölçümler için değil, koloni yapılarının mekânsal düzeninin incelenmesinde de etkilidir. Cabral ve arkadaşları (2019), tatlı su midye yataklarının fotogrametri ile haritalanmasının, popülasyon yoğunluğu ve dağılım desenlerinin zamansal olarak karşılaştırılmasına olanak tanıdığını göstermiştir. Bu yaklaşım, klasik transekt veya kare tabanlı surveylerle birlikte kullanıldığında, veri tekrarlanabilirliğini ve uzun dönemli izleme kapasitesini önemli ölçüde artırmaktadır. Dahası, fotogrametri ve 3B modelleme, tatlı su midyelerinin habitat izlenmesinde bilimsel dalış tekniklerine yüksek çözünürlüklü dijital doğrulama ve arşivleme gücü kazandırmaktadır. Ayrıca, bu teknolojiler, hem biyometrik ölçümlerde hassasiyetin artırılmasına hem de ekosistem temelli restorasyon çalışmalarında kolonilerin mekânsal analizine katkı sağlamaktadır.

#### 4.3. Fotogrametri ve Görüntü İşleme: Yüksek Çözünürlüklü Sualtı Kayıtları ile Sayım ve Boy Ölçümleri

Tatlı su midyelerinin popülasyon dinamiklerinin incelenmesinde klasik yöntemler çoğunlukla elle sayım ve kabuk ölçümlerine dayanmaktadır. Ancak, bu yöntemler zaman alıcı olup insan hatasına açıktır ve yoğun kolonilerde tekrarlanabilirliği sınırlıdır. Son yıllarda, fotogrametri ve görüntü işleme teknikleri, dalış destekli çalışmalara entegre edilerek yüksek çözünürlüklü sualtı kayıtlarının otomatik veya yarı otomatik biçimde analiz edilmesine imkân sağlamaktadır. Fotogrametri, farklı açılardan alınan çoklu fotoğraf karelerinin yazılım aracılığıyla birleştirilmesi ve üç boyutlu modeller oluşturulması prensibine dayanır. Bu teknik sayesinde, midyelerin kabuk uzunlukları ve gövde pozisyonları milimetre hassasiyetinde ölçülebilmektedir. Reymonet ve arkadaşları (2025), Cenevre Gölü'nde *Dreissena rostriformis bugensis* bireylerinin büyüme dinamiklerini fotogrametri ile incelemiş ve kış döneminde dahi büyümenin devam ettiğini ortaya koymuştur. Bu çalışma, fotogrametrinin yalnızca boy ölçümü değil, aynı zamanda uzun dönemli büyüme modellerinin geliştirilmesi açısından da güçlü bir araç olduğunu göstermektedir.

Görüntü işleme algoritmaları da fotogrametriyle birlikte kullanıldığında, sualtı videoları veya fotoğraflardan otomatik sayım ve boy dağılımı analizleri elde etmek mümkündür. Cabral ve arkadaşları (2019), fotogrametri tabanlı görüntü işleme yöntemlerini kullanarak tatlı su midye popülasyonlarını izleyip kabuk ölçümlerini otomatik hale getirmiş ve saha süresinde %40 oranında zaman tasarrufu sağlandığını rapor etmiştir. Bununla birlikte, görüntü işleme tabanlı yöntemlerin sınırlılıkları da vardır. Özellikle, yüksek hidrofit yoğunluğu veya bulanık sularda görüntü kalitesinin düşmesi, bireylerin otomatik tanınmasını güçleştirebilmektedir. Bu nedenle, fotogrametri ve görüntü işleme çoğunlukla SCUBA tabanlı manuel gözlemler ve sayımlarla kalibre edilerek kullanılmaktadır (Dolson ve ark., 2023). Bu nedenle, fotogrametri ve görüntü işleme yöntemleri, tatlı su midye araştırmalarında klasik dalış temelli ölçümlerin tamamlayıcısı olarak öne çıkmakta; yüksek

çözünürlüklü dijital kayıtların sayım ve boy ölçümlerine entegre edilmesi sayesinde hem veri doğruluğu hem de uzun dönemli izleme kapasitesi güçlendirilmektedir.

#### 4.4. Entegre Teknolojilerin Dalış Protokollerine Uyarlanması

Tatlı su midyelerinin izlenmesinde kullanılan metodolojiler giderek daha fazla entegre yaklaşımlar üzerine kurulmaktadır. Tek başına transekt, quadrat ya da görsel surveyler çoğu zaman sınırlı veri sağlamakta; buna karşın farklı teknolojilerin bir araya getirilmesi, hem saha çalışmalarında zaman ve maliyet verimliliği yaratmakta hem de veri kalitesini artırmaktadır. Örneğin, Strayer & Smith (2003), tatlı su midye surveyleri için hazırladıkları kılavuzda, dalış tabanlı doğrudan gözlemlerin akustik ve görsel teknolojilerle birlikte kullanılmasının popülasyon yoğunluğu tahminlerinde hata payını azalttığını vurgulamıştır. Benzer şekilde Metcalfe-Smith ve arkadaşları (2000), farklı survey tekniklerinin kombinasyonunun, özellikle geniş nehir sistemlerinde popülasyon dağılımının doğru şekilde haritalanması için kritik olduğunu ortaya koymuştur. Daha güncel olarak, Lane ve arkadaşları (2014), Kanada'da yürüttükleri çalışmada, dalış tabanlı örneklemlerin uzaktan algılama ve habitat haritalandırma teknikleriyle entegre edilmesi sayesinde hem habitat özellikleri hem de midye yoğunluklarının aynı protokolde toplanabileceğini göstermiştir. Bu tür hibrit protokoller, özellikle çevresel değişimlerin yoğun olduğu bölgelerde uzun dönemli izleme için güvenilir bir çerçeve sunmaktadır. Avrupa'daki uygulamalarda da entegre protokollerin önemine dikkat çekilmektedir. Lopes-Lima ve arkadaşları (2017), tatlı su midyelerinin korunmasına yönelik küresel değerlendirmelerinde, biyolojik gözlemlerin, fotogrametri ve çevresel veri kaydıyla birlikte yürütülmesinin, türlerin koruma durumlarını belirlemede kritik rol oynadığını belirtmiştir. Sonuç olarak, entegre teknolojilerin dalış protokollerine uyarlanması, yalnızca yöntemsel çeşitlilik değil, aynı zamanda veri güvenilirliği, uzun dönem karşılaştırılabilirlik ve ekosistem temelli yönetim açısından da güçlü bir temel sunmaktadır.

## 5. HİDROFİT YOĞUNLUĞU OLAN SULARDA ÖRNEKLEME STRATEJİLERİ

### 5.1. Hidrofit Temizliği ve Sınırlı Alan Açma Yöntemleri

Hidrofitlerin yoğun olarak bulunduğu sularda, midye örnekleme çalışmalarının en büyük zorluğu dalgıçların görüş kısıtlılığı ve sediman yüzeyine ulaşmadaki engellerdir. Bu nedenle örnekleme yapılacak quadrat veya transekt hatlarında sınırlı alan açma uygulanır. Dalgıçlar genellikle küçük sualtı makasları ya da manuel sökme teknikleriyle seçili alandaki bitki örtüsünü uzaklaştırır; bu sayede sediman yüzeyi görünür hale gelir ve midyeler güvenle sayılabilir (Österling ve ark., 2010). Bu yöntem, habitatın genel yapısını bozmadan yalnızca araştırma yapılacak mikro alanı açtığı için hem ekosistem koruması hem de örnekleme doğruluğu açısından önemlidir.

### 5.2. Yükseltilmiş Quadrat Çerçeveleri

Hidrofit yoğunluğu, klasik quadratların doğrudan sediman yüzeyine yerleştirilmesini engelleyebilir. Bu durumda yükseltilmiş quadrat çerçeveleri kullanılır. Metal veya PVC'den yapılmış ve kısa ayaklarla sediman yüzeyinin birkaç santimetre üzerinde duran bu çerçeveler, hem hidrofitleri bastırarak örnekleme alanı açar hem de standardize edilmiş bir örnekleme alanı sağlamaktadır. Dalgıçlar bu çerçevenin içine giren alanı kazıyarak midye bireylerini tespit etmektedir. Nedeau ve arkadaşları (2009), Kuzey Amerika'daki çalışmalarında bu yöntemin yoğun bitki örtüsüne sahip nehirlerde örnekleme başarısını artırdığını bildirmiştir.

### 5.3. Sualtı Aspiratörleri ve Sediman Çekiciler

Yoğun hidrofit örtüsü, özellikle juvenil midyelerin tespitini güçleştirmekte, çünkü bu bireyler sediman içine gömülü halde bulunmaktadır. Bu durumda dalgıçlar, sualtı aspiratörleri (underwater suction samplers) veya sediman çekiciler kullanarak örnekleme yapmaktadır. Aspiratör sistemleri, sedimanı kontrollü biçimde emerek üstteki bitki kalıntılarını uzaklaştırır ve midyelerin ayrıştırılmasına olanak tanımaktadır. Sediman çekiciler ise küçük ölçekli sediman çekim üniteleridir ve yoğun bitki örtüsünün altındaki gömülü midyeleri ortaya çıkarmada etkilidir. Haag & Commens-Carson (2008), ABD’de yaptıkları saha çalışmasında bu tekniklerin juvenil midye tespitinde klasik elle kazı yöntemlerinden daha verimli olduğunu rapor etmiştir.

#### 5.4. Hidrofit Yoğunluğunun Ekolojik Yorumlara Etkisi

Hidrofit yoğunluğu, tatlı su midyelerinin örnekleme sürecinde yalnızca teknik bir zorluk değil, aynı zamanda ekolojik yorumların güvenilirliğini de doğrudan etkileyen bir faktördür. Yoğun bitki örtüsü, dalış sırasında midyelerin görünürlüğünü azaltarak sayım hatalarına yol açabilir ve özellikle juvenillerin tespitini güçleştirebilmektedir. Ayrıca, hidrofitler sediman üzerinde organik madde birikimine neden olarak oksijen tüketimini artırır; bu durum midyelerin filtrasyon aktivitesi ve gömülme davranışlarını etkileyebilmektedir (Strayer, 2008). Dalış temelli araştırmalarda hidrofit yoğunluğu kaydedilmediğinde, midye popülasyonlarının dağılımı yanlış yorumlanabilir. Örneğin, Geist & Auerswald (2007) çalışmalarında, yoğun sucul bitki örtüsünün midye habitatlarının oksijen rejimini bozarak genç bireylerin hayatta kalma oranlarını düşürdüğünü göstermiştir. Dolayısıyla, dalgıç destekli surveylerde yalnızca midye sayımı değil, aynı zamanda hidrofit kaplama oranı da standart bir parametre olarak kaydedilmelidir. Bununla birlikte, hidrofit yoğunluğu bazı durumlarda midyeler için mikrohabitat çeşitliliği de sağlayabilmektedir. Hastie ve arkadaşları (2000), İskoçya nehirlerinde yaptıkları çalışmada, orta düzeydeki bitki yoğunluğunun sediman stabilizasyonunu artırarak midye yataklarının korunmasına katkı sağladığını vurgulamıştır. Bu nedenle, dalış tabanlı araştırmalarda hidrofit yoğunluğunun yalnızca örnekleme zorluğu değil, aynı zamanda ekolojik bağlamı zenginleştiren bir faktör olarak da değerlendirilmesi gerekmektedir. Sonuç olarak, hidrofit yoğunluğunun dalış tabanlı midye araştırmalarında hem metodolojik doğruluk hem de ekolojik yorum açısından dikkate alınması zorunludur. Bu nedenle, dalgıç protokollerinde hidrofit yoğunluğunun sistematik kaydı ve analizlere entegre edilmesi, araştırmaların bilimsel geçerliliğini artıracaktır.

#### 6. SONUÇ

Bu derlemede, tatlı su midyelerinin izlenmesinde SCUBA tabanlı bilimsel dalış tekniklerinin metodolojik katkıları ayrıntılı biçimde değerlendirilmiştir. Bulgular göstermektedir ki, SCUBA destekli örnekleme, klasik kıyıdan tarama veya sediman kazısı yöntemlerine kıyasla hem geniş alanlarda hem de zor erişimli habitatlarda daha güvenilir veriler sağlamaktadır. Özellikle, popülasyon yoğunluğu, yaş yapısı ve biyometrik ölçümlerin in situ koşullarda doğrudan kaydedilmesi, midyelerin zarar görmeden değerlendirilmesine olanak tanımaktadır. Arazi çalışmalarında sık karşılaşılan hidrofit yoğunluğu, midye örneklemelerinde ciddi metodolojik sınırlılıklar yaratmaktadır. Ancak, sınırlı alan açma, yükseltilmiş quadrat çerçeveleri ve sualtı aspiratörleri gibi yöntemlerin dalış protokollerine uyarlanması, bu zorluğun aşılmasında önemli kazanımlar sunmuştur. Bu durum, dalış tekniklerinin yalnızca örnekleme için mümkün kılma ile kalmadığını, aynı zamanda metodolojiyi sürekli geliştiren bir çerçeve sunduğunu göstermektedir. Son olarak, tüm bu yöntemsel gelişmeler, tatlı su midyelerinin izlenmesinde uluslararası düzeyde standardizasyon ihtiyacını ortaya koymaktadır. Günümüzde kullanılan farklı protokollerin birleştirilerek sahada uygulanabilir, tekrarlanabilir ve ekosistemler arası karşılaştırmaya olanak tanıyacak standardize edilmiş yöntemler geliştirilmesi, hem türlerin korunması hem de tatlı su ekosistemlerinin yönetimi açısından öncelikli bir gerekliliktir.

## TEŞEKKÜR

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## ATIK MİDYE KABUKLARININ DEĞERLENDİRİLMESİ: SIFIR ATIK POLİTİKASI ÇERÇEVESİNDE YAPI SEKTÖRÜNE ENTEGRASYONU

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### ÖZET

İnşaat sektörü, yüksek hammadde tüketimi ve atık üretimi nedeniyle sürdürülebilirlik açısından önemli bir dönüşüm sürecindedir. Sıfır atık politikası çerçevesinde, doğal atıkların geri dönüştürülerek yapı malzemesi olarak kullanımı, çevresel sürdürülebilirlik ve ekonomik verimlilik açısından büyük bir potansiyel taşımaktadır. Bu çalışmada, midye kabuklarının atık yönetimi kapsamında değerlendirilmesi ve yapı sektörüne entegrasyonu incelenmiştir. Midye kabuklarının yüksek kalsiyum karbonat ( $\text{CaCO}_3$ ) içeriği sayesinde çimento, beton, harç ve yalıtım malzemelerinde kullanılma potansiyeli ele alınmıştır. Ayrıca, midye kabuklarının mekanik, termal ve kimyasal özellikleri değerlendirilerek, geleneksel yapı malzemeleriyle karşılaştırmalı bir analiz sunulmuştur. Çalışma, midye kabuklarının yapı sektöründe alternatif hammadde olarak kullanımıyla çevresel etkilerin azaltılabileceğini ve döngüsel ekonomiye katkı sağlanabileceğini ortaya koymaktadır. Son olarak, midye kabuğu bazlı yapı malzemelerinin üretim süreçlerindeki teknik zorluklar ve gelecekteki araştırma gereksinimleri tartışılmıştır.

**Anahtar Kelimeler:** Midye kabukları, Kalsiyum karbonat, Döngüsel ekonomi, Sürdürülebilir yapı malzemeleri, Atıkların değerlendirilmesi

## VALUATION OF WASTE MUSSEL SHELLS: INTEGRATION INTO THE CONSTRUCTION SECTOR WITHIN THE FRAMEWORK OF THE ZERO WASTE POLICY

### ABSTRACT

The construction sector is recognized as one of the largest consumers of raw materials and producers of waste, thereby posing critical challenges for environmental sustainability. In alignment with zero-waste strategies, the valorization of natural waste resources as alternative construction materials has emerged as a promising approach to reduce ecological footprints while enhancing economic efficiency. This study investigates the potential of mussel shells as a secondary raw material within the framework of sustainable waste management and their prospective applications in the construction industry. Due to their high calcium carbonate ( $\text{CaCO}_3$ ) content, mussel shells exhibit favorable characteristics for incorporation into cement, concrete, mortar, and insulation composites. Also, their mechanical, thermal, and chemical properties were evaluated and systematically compared with those of conventional construction materials. The findings demonstrate that the integration of mussel shells into construction materials can contribute to reducing environmental burdens, fostering

circular economy practices, and advancing resource efficiency. In conclusion, the study discusses the technological limitations, process optimization requirements, and future research directions necessary for the large-scale adoption of mussel-shell-based construction materials.

**Keywords:** Mussel shells, Calcium carbonate, Circular economy, Sustainable construction materials, Waste valorization

## 1. GİRİŞ

İnşaat sektörü, küresel ölçekte doğal kaynak tüketiminin en yüksek olduğu endüstrilerden biri olup, ham madde ihtiyacı, enerji tüketimi ve karbon salınımı açısından çevresel sürdürülebilirlik üzerinde önemli baskılar oluşturmaktadır (Huang ve ark., 2018). Özellikle, çimento ve beton üretimi yüksek seviyede sera gazı emisyonu ile ilişkilendirilmekte ve dünya çapındaki karbon ayak izinin yaklaşık %8'ini oluşturmaktadır (Andrew, 2019). Buna ek olarak, inşaat faaliyetleri sırasında ortaya çıkan atıklar ve kullanılan malzemelerin çevresel etkileri, dögüsel ekonomi ilkeleri doğrultusunda alternatif ve sürdürülebilir çözümler geliştirilmesini zorunlu kılmaktadır (European Commission, 2020; Ding ve ark., 2022). Bu bağlamda, endüstriyel ve biyolojik atıkların yeniden değerlendirilmesi, hem ekolojik hem de ekonomik açıdan önemli bir fırsat sunmaktadır (Ghisellini ve ark., 2016). Denizel biyolojik atıklar içerisinde yer alan midye kabukları, büyük ölçekte üretilen ve genellikle atık olarak değerlendirilen organik-kaynaklı malzemeler arasında öne çıkmaktadır. Midye kabukları, büyük oranda kalsiyum karbonat ( $\text{CaCO}_3$ ) içermekte olup, yapı sektöründe çimento ve beton katkı maddesi, harç stabilizatörü, yalıtım malzemesi ve alternatif dolgu malzemesi olarak kullanım potansiyeline sahiptir (Tayeh ve ark., 2019; Stelmakh ve ark., 2022).

Geleneksel çimento ve beton üretiminde doğal kireçtaşından elde edilen kalsiyum karbonatın kullanılması yaygın bir uygulamadır (Scrivener ve ark., 2018). Ancak, midye kabuklarının bu sürece entegre edilmesi, doğal kaynakların korunmasını sağlarken, endüstriyel atıkların azaltılmasına ve dögüsel ekonomi ilkelerinin uygulanmasına katkıda bulunacaktır (Ghisellini ve ark., 2016). Ayrıca, midye kabuklarının inşaat malzemeleri içerisindeki potansiyel kullanımı, yalnızca çevresel sürdürülebilirlik açısından değil, aynı zamanda malzeme mühendisliği bağlamında da dikkat çekmektedir. Midye kabukları, doğal biyomineralizasyon süreci sonucunda yüksek mekanik dayanım, aşınma direnci ve hafiflik gibi avantajlar sunan bir mikro yapıya sahiptir (Martinez-Garcia ve ark., 2019). Bu özellikler, mekanik performansı artıran biyokompozit malzemelerin geliştirilmesine katkı sağlayacaktır. Bununla birlikte, midye kabuklarının toz haline getirilerek veya belirli oranlarda agrega olarak kullanılması, malzemenin dayanıklılığı, geçirgenliği ve termal özellikleri üzerinde doğrudan etkilere sahip olabilmektedir (Tayeh ve ark., 2019; Cantero ve ark., 2020).

Kabuklu deniz canlıları endüstrisinde büyük miktarda açığa çıkan atık midye kabukları, çoğunlukla bertaraf edilmekte ve çevresel bir sorun haline gelmektedir (Wang ve ark., 2024). Ancak, yüksek kalsiyum karbonat içeriği sayesinde midye kabukları, çimento, beton, agrega ve kompozit malzemeler gibi çeşitli yapı bileşenlerinde değerlendirilebilecek önemli bir hammadde kaynağı olarak kullanılabilir (De Freitas ve ark., 2024; Naik ve ark., 2024). Bu çalışmada, midye kabuklarının inşaat sektöründe sıfır atık politikası çerçevesinde nasıl kullanılacağı kapsamlı bir şekilde ele alınarak yapı malzemeleri içerisindeki olası kullanım alanları ve bu uygulamaların çevresel ve ekonomik avantajları değerlendirilecektir.

## 2. MİDYE KABUKLARININ KİMYASAL VE FİZİKSEL ÖZELLİKLERİ

Deniz kabuklarının kimyasal bileşimi, kabuğun türüne, nereden geldiğine ve suyun mineral içeriğine bağlı olarak değişmektedir (Zhu ve ark., 2024). Ham ve yanmış kabukların kimyasal bileşimi biraz farklılık göstermektedir. Fakat, hayati fark ham deniz kabuklarında  $\text{CaCO}_3$ 'ün baskın olması, yanmış

deniz kabuklarında ise kalsiyum oksit (CaO) bol miktarda bulunmasıdır (Bamigboye ve ark., 2021). Midyelerin benzersiz morfolojik özelliklerinden biride, kalsine edilmiş deri bir menteşe ile birbirine bağlanan kabukları oluşturan iki simetrik kalkerli kabuğun var olmasıdır (Bogan, 2008). Midyelerin kalkerli kabukları şekil, boyut, renk ve biyokütle açısından büyük ölçüde değişiklik göstermektedir. Kalsiyum karbonat kabukların baskın kimyasal bileşeni olsa da, farklı çift kabuklu türlerinde küçük inorganik eser elementler yaygın bulunmaktadır (Chakraborty ve ark., 2020). Kristal çeşitlerinin sentezi ve yeniden modellenmesi, kabukların ilgili ortamdaki termodinamik kararlılıklarına bağlıdır. CaCO<sub>3</sub> kristalinin üç formu arasında, kalsit ve aragonit formları midye kabuklarının yapımında daha sık görülmektedir. Ayrıca, kabuk oluşumunda farklı şekil ve boyutlardaki inorganik malzemeler çeşitli hiyerarşi seviyelerine göre karmaşık bir düzende bir araya gelerek sonunda biyolojik materyali meydana getirmektedir (Li ve ark., 2017).

Midye kabukları, denizel organizmaların biyomineralizasyon süreci ile oluşan, temel olarak CaCO<sub>3</sub> içeren organik kaynaklı biyomateryallerdir (Marin ve ark., 2008). Midye ve istiridye kabukları, esas olarak CaCO<sub>3</sub> (yaklaşık %95) ve iskelet veya kabuk proteinleri olarak da bilinen küçük bir organik matris proteini fraksiyonundan (yaklaşık %0,1-5) oluşmaktadır (Alvarenga ve ark., 2012; Upadhyay, 2015; Zhan ve ark., 2022). Bu yapılar, ortalama %97 polikristalin (kalsit, aragonit) ve düşük oranda biyolojik polimerik polisakkarit (kitin), protein ve glikoprotein içermektedir (De Freitas ve ark., 2024). Kabukların temel kimyasal bileşimi kireçtaşına benzemekte ve kalsinasyon sonrası esas olarak CaO ile az miktarda diğer oksitlerden oluşmaktadır. Kalsit ve aragonit formundaki kalsiyum karbonatın varlığı, oda sıcaklığında kararlı ve kimyasal olarak inert oldukları için biyoagrega olarak uygulama açısından ilgi çekici görülmüştür (De Freitas ve ark., 2024). Ayrıca, kalsiyum karbonat içeriği nedeniyle, midye kabukları yüksek sıcaklık koşullarında kalsinasyon (kireçleşme) sürecine tabi tutulduğunda kalsiyum okside dönüşebilmekte ve bu da çimento üretimi için bir ön bileşen olarak kullanılmasını sağlayabilmektedir (Tayeh ve ark., 2019). İlâveten, kalsine edilmiş midye kabuğu tozu, canlı dokularla uyumluluğu, antimikrobiyal ve biyosidal aktiviteleri ve biyoyuymumluluğu nedeniyle önemli ilgi görmektedir (Verma ve ark., 2025).

Hayvansal kökenli biyolojik agregalar söz konusu olduğunda, kabuklu deniz hayvanlarının dirençli ve yenmeyen savunma kabukları da dahil olmak üzere kabukların analiz edilmesi yaygın hale gelmiştir (Bamigboye ve ark., 2021). Midye kabuğu, kitin tipi proteinlerden oluşan sert ve koruyucu bir dış tabakaya (periostrakum) sahiptir (Martinez-Garcia ve ark., 2019). Bu tabaka çift dış (çift kabuklu), basit dış (tek kabuklu) veya hatta basit iç tabakadan oluşmaktadır (De Freitas ve ark., 2024). Midye kabukları, kalsiyum karbonatın farklı kristal formlarını (aragonit, kalsit ve vaterit) içermekte ve hayvanın yaşamı boyunca değişmeden kalan periostrakum, kabuğa zeytin yeşili sırlı dış rengini vermektedir. Periostrakumun altındaki mineralize tabaka, prizmatik tabakayı tanımlayan, kabuğun yüzeyine dik olarak gelişen uzun kristallerden oluşmaktadır. Bu kristaller, ortorombik bölgede kristalleşen ve kabuğun en büyüleyici özelliklerinden birini temsil eden CaCO<sub>3</sub> altı polimorfundan biri olan aragonitten oluşmaktadır (Guan ve ark., 2021). Özellikle aragonit, biyomineralize edilmiş formlarda yüksek mekanik dayanım sağlamasıyla öne çıkmaktadır (Marin ve ark., 2008). Sedef olarak da bilinen nakre, en büyüleyici hayvansal yapılardan biri ve yumuşakçaların ürettiği en sağlam mikro yapılardan biri ve klasik mekanik çalışmalar, kırılmaya karşı direncinin kimyasal olarak çökeltilmiş inorganik, jeolojik aragonitten bin kat daha fazla olduğunu göstermektedir. Midye kabukları, düşük yoğunluklu ancak yüksek sertlik ve aşınma direncine sahip doğal kompozit yapılar olarak tanımlanmaktadır. Bu özellik, yapı malzemelerinde mukavemet artırıcı bir katkı malzemesi olarak değerlendirilmesini mümkün kılmakta ve midye kabuklarına dayalı biyoagregaların kullanımıyla artan gözeneklilik, termal ve akustik yalıtımı desteklemektedir (De Freitas ve ark., 2024).

### 3. DÖNGÜSEL EKONOMİ İLE MİDYE KABUKLARININ YAPI SEKTÖRÜNDE DEĞERLENDİRİLMESİ

Günümüzde inşaat sektörü, doğal kaynak tüketimi ve atık üretimi açısından en büyük çevresel etkilere sahip endüstrilerden biri haline gelmiştir. Küresel çapta artan inşaat faaliyetleri, doğal malzeme talebini artırmakta ve inşaat atıklarının yönetimini daha karmaşık hale getirmektedir (Hasan ve ark., 2023). Döngüsel ekonomi prensipleri doğrultusunda, sürdürülebilir yapı malzemelerinin geliştirilmesi ve endüstriyel atıkların değerlendirilmesi, hem çevresel etkileri azaltmak hem de ekonomik fayda sağlamak için büyük önem taşımaktadır (Popoviç ve ark., 2023). Deniz ürünleri endüstrisi, özellikle midye, istiridye ve diğer kabuklu deniz canlılarının işlenmesi sonucu büyük miktarda kabuk atığı üretmektedir (Summa ve ark., 2022). Midye kabukları, büyük oranda CaCO<sub>3</sub> içermekte olup, inşaat sektöründe geri dönüştürülerek alternatif yapı malzemesi olarak değerlendirilebilmektedir (Tayeh ve ark., 2019).

Döngüsel ekonomi, kaynakların etkin kullanımı ve atıkların yeniden değerlendirilerek üretim süreçlerine dahil edilmesini teşvik eden sürdürülebilir bir ekonomik modeldir. Geleneksel ekonomi modelinde, doğal kaynaklar hızla tüketilir ve atık miktarı giderek artarken, döngüsel ekonomi modelinde malzemelerin yaşam döngüsü uzatılır yeniden kullanımı sağlanır ve atık üretimi minimize edilmektedir (Geissdoerfer ve ark., 2017; Kirchherr ve ark., 2018). Ayrıca, döngüsel ekonomi modeli, inşaat sektöründe malzeme verimliliğini artırmayı, atık miktarını azaltmayı ve yenilikçi malzeme kullanımını teşvik etmeyi amaçlamaktadır. Geleneksel yapı malzemelerinin üretiminin, özellikle çimento ve beton gibi endüstrilerde yüksek enerji tüketimi ve karbon salınımına neden olduğu bilinmektedir (Scrivener ve ark., 2018). Beton, dünyada inşaat sanayinde en yaygın üretilen ve en çok tüketilen ikinci malzeme olup, her insanın yılda üç ton beton kullandığı tahmin edilmektedir (Gagg, 2014). Beton, esas olarak çimento ile iri ve ince agregalardan oluşan kompozit bir malzemedir. Bu bileşenler arasında çimento, zamanla sertleşerek agregaları birbirine bağlayan bağlayıcı bir malzeme görevi gören en pahalı bileşendir. Çimento, kireçtaşı ve kil gibi doğal malzemelerin cüruf ve uçucu kül gibi endüstriyel yan ürünlerin yakılmasıyla endüstriyel hale getirilir bu süreç oldukça maliyetlidir (Tayeh ve ark., 2019).

Son yıllarda, atık yönetimi ve sürdürülebilir malzeme kullanımına yönelik küresel ölçekte çeşitli stratejiler benimsenmiş olup, bunlardan biri de "Sıfır Atık" Politikasıdır. Sıfır Atık Politikası, kaynakların etkin kullanımını teşvik ederek atık üretimini en aza indirmeyi ve atık malzemelerin yeniden değerlendirilmesini hedefleyen bir çevre yönetim yaklaşımıdır (UNEP, 2019). Bu bağlamda, denizel biyolojik atıkların, özellikle midye kabuklarının, geri dönüştürülerek yapı sektörüne entegrasyonu, hem ekolojik hem de ekonomik faydalar sağlayan yenilikçi bir çözüm olarak öne çıkmaktadır (Hasan ve ark., 2023). Denizel biyolojik atıkların inşaat sektöründe kullanımı, atık yönetimi, doğal kaynak tüketiminin azaltılması ve düşük karbon salınımı gibi çevresel faydalar sağlayabilmektedir (Akhtar & Sarmah, 2018). Deniz ürünleri endüstrisi, yılda milyonlarca ton kabuklu deniz canlısı üretirken, midye kabukları gibi organik kaynaklı atıkların büyük bir kısmı değerlendirilmeksizin bertaraf edilmektedir (Popoviç ve ark., 2023). Bu nedenle, deniz kabukları inşaat sektöründe beton bileşenlerinden biri olarak değerlendirilebilmektedir. Geri dönüştürülebilir ve ince agrega, iri agrega, dolgu malzemesi veya çimento yerine kullanılmak üzere işlenebilmektedirler. Aslında, deniz kabuklarını betona geri dönüştürmenin birçok potansiyel faydası olduğu bildirilmiştir (Tayeh ve ark., 2019). Midye kabuğu atıklarının beton karışımlarında kullanılması, geleneksel betona göre çevre üzerinde daha az olumsuz etkisi olan yeşil bir beton üreterek sürdürülebilir bir inşaat uygulaması olarak kabul edilmektedir (Elliott & Fuller, 2013; Olivia ve ark., 2015). Ayrıca, inşaat sektöründe sürdürülebilirlik kaçınılmaz hale gelmiştir. Bu yüzden, sürdürülebilirlik yalnızca karbon ayak izini azaltmak ile çevreyi korumak anlamına gelmez, aynı zamanda sürekli büyüme için hayati önem taşıyan doğal kaynakların korunmasına da katkıda bulunmalıdır. Son yıllarda, doğal kaynakların tükenmesini azaltma konusunda gelişmeler kaydedilmektedir. Ancak, doğal kaynaklardan %100 tasarruf etmek neredeyse imkansızdır ve bu nedenle farklı projeler planlarken sürdürülebilirliği göz önünde bulundurmak gerekmektedir (Akhtar & Sarmah, 2018).

Deniz ürünleri endüstrisinde büyük miktarlarda açığa çıkan kabuk atıkları, mevcut atık yönetim süreçlerinde genellikle ekonomik değeri olmayan atıklar olarak sınıflandırılmaktadır. Ancak bu atıkların geri dönüştürülerek çimento, beton ve yapı bileşenlerinde kullanılması, atık miktarını azaltırken endüstriyel hammadde ihtiyacını karşılamak için önemli bir fırsat sunmaktadır (Lertwattanaruk ve ark., 2012; Akhtar & Sarmah, 2018). Dolayısıyla, midye kabuklarının inşaat sektörüne entegre edilmesi, hem döngüsel ekonominin prensipleri doğrultusunda atık yönetimi süreçlerini iyileştirmekte hem de sürdürülebilir yapı malzemeleri geliştirilmesine katkı sunmaktadır (Essalem & Cherradi, 2023). Midyeler, koyu kahverengi kabuklu çift kabuklu yumuşakçalar olup kabukları kama şeklinde sivri bir ön ucu ile geniş ve yuvarlak bir arka ucu vardır. Midye kabuklarının kimyasal bileşimine bakıldığında, volkanik külün özelliklerini taşımaz, ancak midye kabuklarından kireç taşı çıkarmak oldukça mümkündür (Wang & Liu, 2020). Öğütülmüş midye kabuklarının harçla karıştırılmasıyla harcın su tüketimi azaltılabilirken, harcın işlenebilirliği ve büzülme oranı iyileştirilmektedir (Lertwattanaruk ve ark., 2012). Buna ek olarak, bu kaynakların tam olarak kullanılması, aşırı taş ocağı ve kireç taşı çıkarımından kaynaklanan çevresel baskıyı, hasarı ve kıtlığı azaltacaktır (Wang ve ark., 2021). Ayrıca, atıktan elde edilen biyojenik kalsiyum karbonat mineralleri ve inşaat malzemeleri en iyi şekilde birleştirildiğinde, piyasa değerleri umut verici olacaktır (Wang & Liu, 2020).

Kabuklar geleneksel olarak evlerde, duvarlarda, yol agregaları ve harç karışımları olarak dünyanın çeşitli kıyı bölgelerinde kullanılmıştır (Morris ve ark., 2019). Bununla birlikte, yüzyıllar boyunca en yaygın kullanılan yapı malzemesi beton olmuştur. Beton; çimento ve kumdan oluşan çakıl, kum, çimento, su ve harç karışımıdır (Summa ve ark., 2022). Bağlayıcı bileşen olan çimento, beton bileşenlerinin en pahalısı olup, bu nedenle mekanik özellikleri için standartlar karşılandığı sürece üretim maliyetlerini düşürmek için değiştirilmesi aranmaktadır (Murphy & Kerton, 2017). Bu amaçla, yumuşakça kabukları kırma ve ısıl işlemten sonra çimento katkı maddesi (dolgu malzemesi) olarak kullanılmıştır. Ayrıca, nehir kumu gibi betondaki geleneksel agregaların yerine biyoagrega olarak da değerlendirilebilmektedirler. Çimento yerine kısmi yumuşakça kabuğu külü/tozunun kullanılması, betonun erken basınç dayanımının azalmasına neden olsada, mekanik dayanıklılık kalsiyum oksidin hidratasyonu nedeniyle yaşla birlikte artmıştır. Bağlayıcı matris ve agregalar arasında iyi bir bağ oluşması ile artan elastikiyet sayesinde eğilme ve ayrılma çekme dayanımı iyileştirmiştir (Tayeh ve ark., 2019). Bu nedenle, atık kabuk tozu, çimento esaslı malzemelerdeki yenilenemeyen kireçtaşı tozunu destekleyebilmekte (Wang & Liu, 2020) ve bu toz, akustik olarak emici bir malzeme olarak gürültü kirliliğini azaltmak üzere de modifiye edilebilmektedir (Peceno ve ark., 2019).

## 4. MİDYE KABUKLARININ YAPI SEKTÖRÜNDE KULLANIM ALANLARI

### 4.1. Çimento Üretiminde Kullanımı

Çimento endüstrisi, geleneksel üretiminde hammadde olarak veya harmanlanmış çimentoların formülasyonunda kaynak olarak  $\text{CaCO}_3$  kullanmaktadır (Tayeh ve ark., 2019). Günümüzde küresel  $\text{CaCO}_3$  talebi, esas olarak, doğal kaynakların tükenmesi ve bilinçsiz taş ocağı faaliyetleri nedeniyle ekosistemlerin bozulması ile sürdürülebilirliği bilinmeyen taş ocağından çıkarılan kireçtaşı kayaçlarına dayanmaktadır. Kireçtaşı çimento esaslı malzemelerde kullanıldığında, seyreltme etkisi, dolgu etkisi ve heterojen çekirdeklenme gibi çeşitli fiziksel etkiler nedeniyle kılcal gözeneklilikte değişiklikler meydana getirmektedir (Soltanzadeh ve ark., 2021). Bu nedenle, kireçtaşı kayaçlarına alternatif olarak atık deniz kabukları, kimyasal bileşimlerinde %90'dan (kütlece) fazla  $\text{CaCO}_3$  bulunması nedeniyle yenilenebilir biyomineral türü olarak geri dönüştürülebilir kaynak olarak kullanılmaktadır (Martinez-Garcia ve ark., 2019). Midye kabukları kalsinasyon sürecinden geçirilerek kalsiyum okside ( $\text{CaO}$ ) dönüştürülebilmekte ve çimento üretiminde bağlayıcı madde olarak değerlendirilebilmektedir. Bu süreç, çimento üretiminde enerji tüketimini ve karbon salınımını azaltma potansiyeline sahiptir. Dolayısıyla, midye kabukları çimento üretiminde kalsiyum karbonat

kaynağı olarak kullanılabilir ve klinker üretimi için kireç taşı kullanımını azaltabilir (Soltanzadeh ve ark., 2021). Çimento üretiminde agregaların bir kısmının midye kabuğu ile değiştirilmesi, malzemenin hafifliğini artırabilmekte ve dayanıklılığını optimize etmektedir. Yumuşakça kabukları, kırma ve ısıtma işleminden sonra çimento katkı maddesi (dolgu malzemesi) olarak kullanılmaktadır. Ayrıca, nehir kumu gibi betondaki geleneksel agregaların yerine agrega olarak da değerlendirilebilmektedirler. Ancak, çimento yerine kısmi yumuşakça kabuğu külü/tozunun kullanılması, bazı çalışmalarda betonun basınç dayanımının azalmasına neden olmuştur. Mekanik dayanım, kalsiyum oksidin hidratasyonu nedeniyle yaşla birlikte artmıştır. Bağlayıcı matris ve agregalar arasında iyi bir bağ oluşması ve bu da elastikiyetin artması nedeniyle eğilme ile yarılmada çekme dayanımı iyileşmiştir (Tayeh ve ark., 2019). Bu nedenle, atık kabuk tozu, çimento esaslı malzemelerdeki yenilenemeyen kireçtaşı tozunu tamamlayabilmektedir (Wang & Liu, 2020).

#### 4.2. Beton ve Harç Takviyesi Olarak Kullanımı

Midye kabukları, ince öğütülerek beton ve harç karışımlarında dolgu maddesi olarak kullanılmaktadır. Hafif agregaların bir kısmının midye kabuğu ile değiştirilmesi, malzemenin mekanik dayanıklılığını optimize etmekte ve ağırlığını azaltmaktadır (Sangeetha ve ark., 2022). Çimento esaslı kompozitler, yangın nedeniyle hizmet süreleri boyunca daha yüksek sıcaklıklara maruz kalabilmektedir. Yangına maruz kaldıktan sonra, beton özellikleri güvenlik ve servis kolaylığı açısından önemli ölçüde etkilenmektedir. Bu nedenle, yüksek dayanımlı betonun yangına karşı direncini arttırmak için çimento esaslı kompozitlere deniz kabukları eklenmesi önerilmiştir (Ahsan ve ark., 2022).

Midye kabukları, ince öğütülerek beton ve harç karışımlarında dolgu maddesi olarak kullanılmaktadır. Yapılan bir çalışmada, %100 kırılmış midye kabuğu içeren harcın akışkanlığı, kendiliğinden yerleşen beton için kabul edilebilir düzeyde tespit edilmiştir. Aynı zamanda, kırılmış midye kabuğu içeren harçların mekanik özellikleri, normal harçla neredeyse aynı çıkmış ve kumun tamamen değiştirilmesiyle, harcın elastik modülü kabul edilebilir düzeyde bulunmuştur. Dolayısıyla, midye kabuklarının köşeli formu, çimento esaslı matristeki tane dağılımını desteklemiştir (Safi ve ark., 2015). Öte yandan, harçlarda midye kabuğu tozu içeriğinin artmasıyla birlikte kuruma oranında artış olduğu bilinmektedir. Kalsine edilmiş midye tozu içeriğinin artmasıyla su emilim katsayısının, su geçirgenlik katsayısının ve klorür iyon difüzyon katsayısının azaldığı belirlenmiştir (Liao ve ark., 2022). Bu sayede, suya karşı yüksek direnç sağlayarak yapı malzemelerinin dayanıklılığı artırılabilir. Midye kabuğu, hafif agregalarla birlikte kullanıldığında betonun mukavemetini artırabilir ve su geçirimsizliğini iyileştirebilmektedir (Martinez-Garcia ve ark., 2019; Seo ve ark., 2019).

#### 4.3. İzolasyon Malzemesi Olarak Kullanımı

Midye kabuklarının gözenekli yapısı sayesinde, ısı ve ses yalıtım özellikleri geliştirilerek sürdürülebilir izolasyon malzemesi olarak değerlendirilebilmektedir. Hafif yapı elemanlarında kullanım, enerji verimliliğini artırarak binaların ısıtma ve soğutma maliyetlerini düşürmektedir. Midye kabuklarının gözenekli yapısı, ısı ve ses yalıtımı açısından avantaj sağlamaktadır (De Freitas ve ark., 2024). Dolayısıyla, midye kabukları hafif yapı elemanlarında kullanılacak sürdürülebilir bir izolasyon malzemesi olarak değerlendirilmektedir. Kentsel alanlarda, yeşil bitki örtüsünün çevre sağlığı üzerindeki etkisinin giderek daha fazla anlaşılmasıyla birlikte yeşil çatılar popülerlik kazanmaktadır. Bu yapılar, bir binanın en dış yüzeyini kaplayan bir bitki örtüsü tabakasına sahip karmaşık sistemlerdir. Yeşil çatılar, çatının coğrafi konumuna bağlı olarak bina yalıtımı ve enerji tasarrufu sağlamaktadır (Schade ve ark., 2021). Dahası, alt tabakanın derinliği ve yağmurdan önceki nemine bağlı olarak yüzeyel akış suyunun azaltılmasında olumlu bir etkiye sahiptirler (Hanumesh

ve ark., 2021). Yumuşakça kabukları, biyoremediasyon potansiyelleri nedeniyle drenaj katmanları gibi yeşil çatı yapıları için veya asit yağmurunun nötralizasyonuna yardımcı olmak için mükemmel bir malzemedir (Ishangulyev ve ark., 2019).

#### 4.4. Zemin Stabilizasyonu ve Yol Yapımında Kullanımı

Biyobazlı modifiye malzemeler, rejenerasyon, çevre koruma ve düşük fiyat gibi bir dizi avantaja sahiptir. Farklı biyobazlı modifiye malzemeler, asfaltın yol performansı üzerinde çeşitli etkilere katkı yapabilmektedir (Zhang ve ark., 2018). Günümüzde, biyobazlı modifiye malzemeler temel olarak biyo-yağ ve hayvan-bitki modifiye malzemeler olarak ikiye ayrılmaktadır. Bunlar, mühendislik uygulama değeri açısından daha faydalı modifiye asfalt elde etmek için asfaltın yol performansının bir kısmını değiştirebilmektedirler. Midye kabukları, zemin iyileştirme projelerinde stabilizasyon amacıyla kullanılabilir. Asfalt ve beton yol yapımında, midye kabuklarının agrega olarak değerlendirilmesi mümkün olmaktadır. Araçların tekrar tekrar yüklenmesi asfalt kaplamaya zarar vermektedir. Bu nedenle, asfalt kaplamanın yol performansını iyileştirmek için yol işçileri, asfalt kaplamanın hizmet kalitesini ve kullanım ömrünü artırmak amacıyla çeşitli modifiye ediciler geliştirmiştir (Lv ve ark., 2020; Tang ve ark., 2022). Çevre koruma gerekliliklerinin sürekli iyileştirilmesiyle birlikte, sürdürülebilir kalkınma kavramı yol mühendisliğine girmiş ve giderek daha fazla biyobazlı modifiye malzeme asfalt kaplamaya uygulanmıştır. Asfalt kaplama teknolojisinde deniz kabuğu tozunun kullanımı, bu malzemenin özellikleri üzerinde oldukça iyi bir etkiye sahiptir. Yüksek sıcaklık deformasyonlarına karşı direnci iyileştirip, sürünme modülü artar ve sürtünme hızını azaltır (Fan ve ark., 2022).

### 5. MİDYE KABUKLARININ GERİ DÖNÜŞÜM SÜREÇLERİ

Midye kabuklarının yapı malzemesi olarak değerlendirilmesi için çeşitli dönüşüm süreçlerinden geçirilmesi gerekmektedir. Avrupa Birliği (AB) No 1069/2009 Yönetmeliği kapsamında, yumuşak dokusu ve eti tamamen çıkarılmış kabuklar yan ürün olarak değil, atık olarak kabul edilmektedir. Bazı yeniden kullanım amaçları için, bu atık kabukların endüstriyel kullanımlarından önce temizlenmesi gerekmektedir.

#### 5.1. Ön İşleme ve Temizlik

Midye kabuklarının yapı sanayinde kullanılmadan önce organik kalıntılar ve deniz tuzlarından arındırılarak yüksek sıcaklıkta kurutulması gerekmektedir. Temizlik işlemi çalışmaların %74'ünde suyla gerçekleştirilmekte ve kabuk içeriğindeki tuzlar ile diğer içerikleri gidermek için kabuğun yaklaşık bir hafta boyunca su altında kalması gerektiği bildirilmiştir (Seo ve ark., 2019). Yıkama süreci, kullanılacak yumuşakça kabuğu atığının hazırlanması sürecinde önemli bir adımdır. Bunun nedeni, bu işlemde tuz içeriği ve organik madde izleri gibi yüzeysel ve yabancı maddelerin uzaklaştırılmasıdır (Bellei ve ark., 2023). Ayrıca, temizlik işlemi, kabuk atıklarında kalan klorür miktarını azaltmış ve termal işlem öncesi kil minerallerinin dönüşümüne yol açmıştır (Seo ve ark., 2019). Daha sonra, kabukların gerektiği gibi granül veya toz haline getirme ve öğütme işlemi yapılabilmektedir. Kabukların temizlik sürecindeki amaç geleneksel betonun sülfat içeriği gereksinimlerini karşılamak için deniz kabuklarındaki organik madde ve tuzun uzaklaştırılmasıdır. Deniz kabuklarını sterilize etmek için güneş altında kurutma veya kalsine etme kullanılmakta ve bu yöntemlerde organik içeriği daha da azaltılmaktadır (Zhu ve ark., 2024). Kabuk temizliği için daha enerji verimli ve çevre dostu bir yöntem, enzimatik temizliğin yapılmasıdır. Bu sayede, enzimler proteinleri ortam sıcaklığına yakın sıcaklıklarda sindirebilir ve ayrıca protein hidrolizati gibi ek bir ürün akışı da üretilebilmektedir (Murphy & Kerton, 2017). Başka bir yöntem ise, daha küçük boyutlardaki gastropodların kabukları bazen belirli bir süre gömülür, böylece topraktaki organizmalar

tarafından ayrıştırılarak bir iç temizlik süreci gerçekleştirilmektedir (Mota ve ark., 2020). Ayrıca, daha az miktardaki kabuklardan kalan organik maddelerin temizlenmesi, fırçalama, kaynatma veya güneşte kurutma yoluyla da yapılabilmektedir (Jones ve ark., 2011).

## 5.2. Öğütme ve Sınıflandırma

Kabuklar farklı tane boyutlarına göre ayrıştırılarak beton, çimento ve yalıtım malzemelerinde kullanıma uygun hale getirilmektedir. Midye kabukları kırıcı ve değirmenlerde iri, orta veya mikron boyutlarına parçalanabilmektedir. İnce öğütülmüş kabuklar (mikro toz) çimento, beton ve harç katkısı olarak kullanılırken, iri boyutlu parçacıklar agrega olarak değerlendirilmektedir. Araştırmacıların deniz kabuklarını öğütmek için kullandıkları ekipmanlar çeşitlilik göstermekle beraber; en yaygın olanları tambur sıkıştırıcı (Cuadrado-Rica ve ark., 2016), çeneli kırıcı (Yang ve ark., 2010) ve çekiç olmuştur (Varhen ve ark., 2017). Betonda ince agrega, iri agrega ve çimento olarak kullanılan midye kabuklarının boyutları da çeşitlilik göstermektedir. Genellikle, ince agrega olarak kullanılan kabuklar kırılıp 5 mm'nin altında elenmektedir. Kaba agregaların yerine kullanılan kabuklar genellikle kırılmamakta (Richardson ve ark., 2013) veya yaklaşık 10 mm'ye kadar kırılmaktadır (Martinez-Garcia ve ark., 2017). Son olarak, çimento yerine kullanılan midye kabukları genellikle kırılıp 30 µm'nin altına kadar öğütülmektedir.

## 5.3. Kimyasal ve Termal Modifikasyon

Kalsiyum karbonat içeriğinin stabil hale getirilmesi ve çimento üretiminde kullanılabilir hale gelmesi kimyasal ile termal süreçlerden geçirilmesi ile sağlanmaktadır. Genellikle, yıkanmış midye kabukları 100–110°C'de 24 saat kurutulmaktadır (Chen ve ark., 2019). Yıkama ve kurutmanın ardından bazı araştırmacılar midye kabuklarını kalsine de etmektedir. İbrahim ve arkadaşları (2020), 500°C'de 24 saat kalsinasyondan sonra atomik absorpsiyon kolon analizi kalsiyum oranının %58'e yükseldiğini göstermiştir. Sürekli yakma işleminin 48 saatinin ardından kalsiyum içeriği %68'e ulaşmış ve kalsinasyon işlemi 96 saat devam ettiğinde kalsiyum yüzdesi %90'a yükselmiştir. Bu süreçte, deniz kabuğunun pH değeri ve klorür içeriğinin artan kalsinasyon sıcaklığıyla birlikte iyileştiği ve sıcaklık 650°C'yi aştığında iyileşmenin önemli olmadığı tespit edilmiştir. Benzer şekilde, kalsinasyon sıcaklığı belirli bir noktadan sonra artmaya devam ettiğinde, deniz kabuklarındaki CaO içeriğindeki artış çok önemli olmamıştır. Bu nedenle, sürdürülebilir bir bakış açısından, sıcaklığı artırmak ve kalsinasyon süresini uzatmak, kabukların özelliklerinde daha fazla iyileşme sağlamadığı anlaşılmıştır. Kalsinasyon sıcaklığının artırılması, hidratasyon ürünlerinin oluşumunu hızlandırabilmekte, beton veya harcın gözenek yapısını doldurabilmekte ve su emme oranını azaltmaktadır (Liao ve ark., 2023). Dolayısıyla, kimyasal ve termal işlemler midye kabuklarının inşaat sektöründe farklı bileşenlerde kullanılabilmesine olanak tanımaktadır.

## 6. ÇEVRESEL VE EKONOMİK DEĞERLENDİRME

Dünya çapında her yıl 10 milyon tondan fazla yumuşakça kabuğu üretilmekte ve bunların %70'inden fazlasını istiridye, midye ve deniz tarağı kabuklarından oluşmaktadır (Summa ve ark., 2022). Özellikle midyeler, diğer kabuklu deniz ürünleri türlerine kıyasla üretim ve kabuk katkısı bakımından en büyük artışı göstermektedir (Velez-Henao ve ark., 2021). Ancak, atılan kabuklar çoğunlukla denize dökülmekte veya çöplüklere gönderilmektedir (Murphy & Kerton, 2017). Sonrasında, kontrolsüz bir şekilde atıldıklarından dolayı toprakları, suları ve deniz ekosistemlerini değiştirmektedirler (Bonnard ve ark., 2019). Sonuç olarak, kabuk yığınları dünyanın her yerinde bulunabilmekte ve kabuklara bağlı kalan dokuların ayrışmasıyla çevresel hasar meydana gelmekte, kötü kokular yaymakta ve bu süreç görsel kirliliğe katkıda bulunmaktadır (Zhan ve ark., 2022). Bu nedenle, kabuklar atık haline gelmemesi gereken önemli bir yan üründen daha ziyade potansiyellerinin en iyi şekilde kullanılması

gereken yeni bir hammaddedir. Midye kabuklarının yapı sektörüne entegrasyonu, hem çevresel sürdürülebilirlik hem de ekonomik açıdan önemli avantajlar sağlamaktadır. Atık kabukların betonda kullanılması, atık yönetimine ve uygun maliyetli yeşil beton üretimine yardımcı olacaktır. Bu kaynakların tam olarak kullanılması, taş ocağı sayısının artması ve kireç taşı çıkarımından kaynaklanan çevresel baskıyı, hasarı ve kirliliği azaltacaktır (Wang ve ark., 2021).

Atıktan elde edilen biyojenik kalsiyum karbonat mineralleri ve inşaat malzemeleri en iyi şekilde birleştirildiğinde, piyasa değerleri umut verici olmuştur (Wang & Liu, 2020). İstiridye kabuklarının yanlış şekilde bertaraf edilmesinin olumsuz etkileri, yeniden kullanımları yoluyla en aza indirilebilecektir. İnşaat sektörü, diğer endüstrilerden gelen kaynakların yeniden kullanımı ve geri kazanımı için önemli bir sektördür. Çin'de, Fujian eyaletinin kıyı bölgelerindeki birçok tarihi duvar örgüsü bina, istiridye kabuğu kil harcıyla kaplanmış ve mümkünse harçların onarımında aynı malzemenin kullanılması tavsiye edilmektedir. Portekiz'in Algarve bölgesinde, 1950'lerden kalma fotoğraflarda da görülebileceği gibi, balıkçılar geleneksel olarak bu tür atıkları evlerinin inşasına dahil etmişlerdir (Bellei ve ark., 2023). Bu nedenlerden dolayı, kıyı bölgelerinin üretim sektörüne yeniden entegre edilebilecek ve değer kazandırılabilir sosyokültürel bir yönü de bulunmaktadır. Bu yön, hem refah hem de inşaat ve atık kaynaklı karbon ayak izinin azaltılması gibi bariz çevresel faydalar yaratmaktadır. Ayrıca, Portekiz Hükümeti'nin önerileri, su ürünleri yetiştirme havuzlarının sınırlarının belirlenmesinde yerel malzemelerin kullanımını vurgulamaktadır. Ancak, atık kabukların ön işleminde, yukarıda belirtildiği gibi, belirli inşaat uygulamasından bağımsız olarak yıkama ve kalsinasyon gerekli ve bu da önemli miktarda kaynak ile enerji gerektirmektedir. Ayrıca, bir agregadaki yüksek klorür içeriği çeliğin daha hızlı korozyonuna neden olmakta ve betonarmede kullanımından kaçınılmalıdır. Bu nedenle kabuk temizleme maliyeti, geleneksel agregalara göre daha yüksek olabilmekte ve bu durum bazı üreticileri bu kaynaktan uzaklaştırabilmektedir (Eziefula, 2018).

Son yıllarda yapılan kimyasal analizler, deniz kabuğu bileşenlerinde %90'dan fazla  $\text{CaCO}_3$  bulunduğunu ve çimento esaslı malzemelerde  $\text{CaCO}_3$  inert bir malzeme olarak sınıflandırılabilirliğini göstermiştir. Bu nedenle, geri dönüştürülebilir ve ince agregalara, iri agregalara veya çimento ikamelerine işlenebilmektedirler. Bu durum, atıkları bertaraf etmenin verimli ve daha ekonomik bir yoludur. Ayrıca, deniz kabuklarının betonda agrega veya çimento ikamesi olarak kullanılması, doğal hammaddelere olan bağımlılığı azaltacaktır. Bu nedenle, betona deniz kabukları eklemek, beton üreten doğal kaynakları koruyabilir ve aşırı sömürden kaynaklanan çevre sorunlarını azaltacaktır (Zhu ve ark., 2024).

Çift kabuklu deniz hayvanlarının kabuklarını değerli kaynaklar olarak kabul etme geçmişimiz olmasına rağmen, günümüzde üretilen kabuklar büyük ölçüde atık olarak kabul edilmektedir.  $\text{CaCO}_3$  ise küresel olarak en tüketilen kaynaklardan biri olup, kabuk atıkları, yıllık  $\text{CaCO}_3$  ihtiyacından hâlâ kat kat daha azdır (Morris ve ark., 2019). Bununla birlikte, kabuk atıklarının yeniden değerlendirilmesi, onları birçok uygulama için standart ve değerli bir kaynak haline getirme stratejilerinin belirlenmesi açısından son derece önemlidir. Bu uygulamalardan bazıları hali hazırda yerleşik süreçlerden daha sürdürülebilir bir yöntem sergileyebilirken, bazıları endüstriyel uygulamada daha az sürdürülebilir olabilir; ancak çevresel faydalar göz önünde bulundurularak ayarlamalar yapılmalıdır. Dahası, çift kabuklu su ürünleri yetiştiriciliği tek başına bir karbon tutucu görevi görerek küresel olarak yılda birkaç milyon ton karbondioksit ( $\text{CO}_2$ )'i hapsetme potansiyeline sahiptir (Alonso ve ark., 2021). Genel olarak, geleneksel Portland çimentosuna dayalı betonun mekanik özelliklerine benzer yeterli özellikler gösteren, deniz kabuğu tozu atıklarıyla çimentonun kısmen ikame edildiği betonlar, karbondioksit ( $\text{CO}_2$ ) emisyonlarının azaltılması genel sorununun çözümüne katkıda bulunabilmektedir (Peceno ve ark., 2019). Çimento üretiminde midye kabuklarının kullanımı, fosil yakıt tüketimini ve  $\text{CO}_2$  salınımını düşürecektir. Ayrıca, geleneksel çimento üretimi yüksek sıcaklıklarda klinker pişirilmesi nedeniyle büyük miktarda  $\text{CO}_2$  salımına yol açmaktadır. Midye kabuklarının çimento katkı maddesi olarak kullanılması, karbon ayak izinin azaltılmasına

katkı sağlayacak ve geleneksel çimento üretimine kıyasla daha düşük karbon salınımına sahip süreçlerle üretilecektir (Akhtar & Sarmah, 2018).

Son zamanlarda, doğal kaynaklarının tükenmesi ve çevresel etkileri nedeniyle, araştırma çalışmaları çimento yerine atık malzemelerin kullanılmasına odaklanmıştır. Bu malzemeler her yıl büyük miktarlarda üretilmekte ve her geçen yıl artmaktadır. Dahası, bu atıkların geleneksel yöntemlerle bertaraf edilmesi süreci küresel çevre ve ekonomi üzerinde olumsuz etkiler göstermiştir. Bu durum, bilim insanlarını ve uzmanları daha etkili çözümler düşünmeye sevk etmiştir. Atık üretimi baştan engellenemiyorsa, bu malzemelere ekonomik bir talep yaratmaya odaklanılması gerekmektedir. Bu durum, doğal kaynakların giderek azalmasının telafisi olarak geri dönüşüm ve yeniden kullanım için uygun koşullar yaratılarak başarılacaktır (Barthel ve ark., 2016). Midye kabukları, bu nedenle inşaat sektöründe beton bileşenlerinden biri olarak kullanılabilir. Geri dönüştürülebilir ve ince agrega, iri agrega, dolgu maddesi veya çimento yerine kullanılmak üzere işlenebilirler. Aslında, deniz kabuklarını betona geri dönüştürmenin birçok potansiyel faydası vardır. İlk olarak, bu atık malzemelerden kurtulmanın etkili ve daha ekonomik bir yolunu sunmaktadır. Dahası, deniz kabuklarını beton karışımlarında agrega veya çimento yerine kullanmak, dünya çapında zaten tükenmekte olan bu malzemelere olan bağımlılığı azaltacaktır. Bu nedenle, kabukları beton karışımlarına dahil etmek, betonun üretildiği doğal kaynakları koruyacaktır. Midye kabuklarını betonda kullanmak, doğal beton malzemelerinin çıkarılmasıyla ilişkili kirlilik seviyelerini de düşürecektir. Aynı zamanda, deniz kabuğu atıklarının beton karışımlarında kullanılması, geleneksel betona göre çevre üzerinde daha az olumsuz etkisi olan yeşil bir beton üreterek sürdürülebilir bir inşaat uygulaması olarak kabul edilmektedir (Elliott & Fuller, 2013).

## 7. SONUÇ

Midye kabuklarının yapı sektörüne entegrasyonu, hem çevresel sürdürülebilirlik hem de ekonomik fayda sağlayan yenilikçi bir yaklaşımı ortaya çıkarmaktadır. Ayrıca, geri dönüşümlü bir kaynak olarak karbon ayak izini azaltmak, doğal kaynak tüketimini minimize etmek ve atık yönetimi süreçlerini iyileştirmek açısından büyük bir potansiyel taşımaktadır. Buna ek olarak, döngüsel ekonomi prensipleri doğrultusunda, midye kabuklarının inşaat malzemesi olarak yaygın kullanımı, sıfır atık politikalarına katkı sağlayacak, ekolojik dengeyi koruyacak ve yeşil yapı sektörüne yeni fırsatlar sunacaktır. Bu nedenle, midye kabuklarının yapı sektöründe değerlendirilmesi, sürdürülebilirlik hedeflerine ulaşmada önemli bir strateji olarak görülmelidir.

## TEŞEKKÜR

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## EKİNEZYA VE ZENCEFİLİN HAYVANLARDA İMMUN SİSTEM ÜZERİNE ETKİLERİ: FİTOBİYOTİK BİR YAKLAŞIM

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### ÖZET

Bu çalışmada, zencefil (*Zingiber officinale*) ve ekinezya (*Echinacea purpurea*)'nın kanatlılar başta olmak üzere hayvanlarda bağışıklık sistemi fonksiyonları üzerindeki immünomodülatör etkileri ele alınmıştır. Bağışıklık sistemi homeostazisinin korunmasında önemli bir rol oynayan bu bitkisel ürünlerin, immün yanıtın düzenlenmesi ve aşı etkinliğinin artırılmasında dikkate değer potansiyele sahip olduğu görülmektedir. Zencefilde bulunan gingerol ve türevleri, antioksidan, antiinflamatuvar ve immünoestimülantör özellikleriyle öne çıkarken; ekinezyanın fenolik bileşenleri ve polisakkaritleri ise makrofaj aktivasyonu, NK hücre fonksiyonlarının düzenlenmesi, sitokin üretiminin artırılması ve TLR4-MAPK sinyal yollarının modülasyonu üzerinden etkili olmaktadır. Literatürde, her iki bitkinin de broylerde antikor titrelerini yükselttiği, mukozal bağışıklığı desteklediği, bağırsak mikrobiyotasını dengelediği ve yemden yararlanma oranını iyileştirdiği rapor edilmiştir. Özellikle *E. purpurea*'nın aşı sonrası antikor yanıtını güçlendirdiği ve bağışıklık sistemini moleküler düzeyde düzenlediği güncel çalışmalarla ortaya konmuştur.

### GİRİŞ

Bağışıklık sistemi, sağlıklı bir organizmada homeostaziye korumada temel bir rol oynar ve işlevi; çeşitli ekzojen (çevresel toksinler, mikroorganizmalar vb.) ve endojen (stres, hormonal değişiklikler vb.) etkenlerden etkilenebilir. Bu durum, immün sistemin baskılanması (immünoşüpresyon) ya da uyarılması (immünoestimülasyon) gibi sonuçlara yol açabilmektedir (Jantan ve ark., 2015). Literatürde, birçok doğal bileşiğin bağışıklık hücrelerinin aktivitesini etkilediği, antikor üretimini modüle ederek enfeksiyonların kontrol altına alınmasına ve bağışıklık dengesinin korunmasına katkı sağladığı bildirilmektedir (Ortuño-Sahagún ve ark., 2017). Söz konusu bileşiklerin; makrofaj ve lenfosit gibi bağışıklık sisteminin doğuştan gelen bileşenlerini aktive ettiği, sitokin yanıtını düzenlediği, enfeksiyon insidansını azalttığı ve apoptoz sürecini desteklediği ortaya konmuştur (Nagoba ve Davane, 2018).

Bağışıklık sistemi fonksiyonlarının etkinliği, enfeksiyöz ve kronik hastalıkların önlenmesi ve tedavisi açısından kritik öneme sahiptir. Bu bağlamda, bağışıklığın desteklenmesi; vitaminler, mineraller ve biyoaktif bileşikler açısından zengin, dengeli ve besleyici gıdaların tüketimi ile mümkün olmaktadır. Bitkisel kaynaklı doğal ajanlar, bağışıklık sistemini destekleyebilecek biyoaktif bileşenler içerir. Bunun yanında, antioksidan özellikleri sayesinde bu bileşiklerin serbest radikalleri baskılayarak oksidatif stresi, inflamasyonu ve enfeksiyonları önlemede terapötik faydalar sağladığı bildirilmektedir (Thirumdas ve ark., 2021).

Zencefil (*Zingiber officinale Roscoe*), Zingiberaceae familyasına ait olup hem gıda hem de geleneksel tıpta yaygın olarak kullanılan bir bitkidir (Mohamad ve ark., 2019). Zencefilin biyolojik aktivitesi, içerdiği uçucu ve uçucu olmayan biyoaktif bileşiklere atfedilmektedir. Uçucu bileşenler; seskiterpenler ve monoterpenoidlerden oluşan uçucu yağlardır ve zencefile karakteristik aromasını kazandırır. Öte yandan, gingerol, shogaol, zingeron ve paradol gibi uçucu olmayan bileşikler, zencefilin tipik keskin ve baharatlı tadından sorumludur. Taze zencefilin başlıca bileşiği gingerol iken, bu bileşik ısı işlem veya kurutma gibi işlemler sırasında shogaol, zingeron ve paradol gibi türevlerine dönüşür (Wohlmuth ve ark., 2005; Prasad ve Tyagi, 2015). Ayrıca zencefil, gingeroller, shogaoller, gingerdionlar ve çeşitli fenolik keton türevleri gibi çok sayıda biyoaktif bileşik içermektedir.

Zencefilin farmakolojik özellikleri üzerine yapılan araştırmalar; bu bitkinin antioksidan, antiapoptotik, antiinflamatuvar, immünomodülatör, antilipidemik ve antitümörijenik etkiler gösterdiğini ortaya koymaktadır (Mashhadi ve ark., 2013; Mao QQ ve ark., 2019; Bischoff-Kont ve Fürst, 2021). Bununla birlikte, mide asiditesi, gastrointestinal motilite ve genel sindirim fonksiyonları üzerinde düzenleyici etkiler gösterdiği ve besinlerin sindirimini, emilimini ve hücrel canlılığı artırdığı da rapor edilmiştir (Anh ve ark., 2020). Geleneksel tıpta özellikle Güneydoğu Asya'da zencefil; sindirim rahatsızlıkları, boğaz ağrısı, öksürük ve ateş gibi durumların tedavisinde yaygın biçimde kullanılmaktadır (Mao ve ark., 2019).

İmmünomodülatörler, bağışıklık sistemini düzenleme potansiyeline sahip ajanlar olup hem endojen hem de ekzojen kaynaklı olabilirler (Brindha, 2016). Bu ajanların etki mekanizmalarının büyük ölçüde antioksidan özelliklerine dayandığı bildirilmektedir. Alkaloidler, flavonoidler, flavonlar, flavonoller, flavanoller, izoflavonlar, kinonlar ve terpenoidler gibi doğal bitki kaynaklı antioksidan bileşiklerin, immünomodülatör etkiler gösterdiği çeşitli çalışmalarla ortaya konmuştur (Jantan ve ark., 2015). Bu bileşikler, oksidan-antioksidan dengesini düzenleyerek ve reaktif oksijen/azot türlerini ortadan kaldırarak doğrudan veya dolaylı yoldan bağışıklık yanıtını modüle eder.

Zencefil, özellikle prostaglandin biyosentezinin inhibisyonu yoluyla antiinflamatuvar etki göstermektedir. Bu durum, zencefilde bulunan doğal bileşiklerin steroid olmayan antiinflamatuvar ilaçlara benzer farmakolojik özellikler taşıdığını ortaya koymaktadır (Kumar ve ark., 2013; Aziz ve ark., 2015; Deng ve ark., 2022). Ayrıca, zencefilin aktive olmuş B hücrelerinde fosfatidilinositol-3-kinaz (PI3K), Akt ve NF-κB sinyal yolları üzerinde de antiinflamatuvar etkiler gösterdiği bildirilmektedir (Mao ve ark., 2019; Zahoor ve ark., 2020; Zhang ve ark., 2021; Zhou ve ark., 2022).

Ekinezya (*Echinacea purpurea*), Asteraceae familyasına ait, Kuzey Amerika'ya özgü mor koni çiçeği olarak bilinen geleneksel tıbbi bir bitkidir. Bu bitki, başta bağışıklık sistemi üzerinde gösterdiği immünoestimülantör etkiler olmak üzere, antioksidan, antiinflamatuvar, antikanser, antimikrobiyal ve antiviral aktiviteleriyle dikkat çekmektedir (Hudson, 2012; Manayi A. ve ark., 2015; Mao ve ark., 2021).

Echinacea türleri, immünomodülatör ve antioksidan özellikleri sayesinde hem insan hem de hayvanlarda bağışıklık sisteminin düzenlenmesinde önemli bir rol oynamaktadır. Geleneksel tıpta *E. purpurea* preparatları; şişmiş diş etleri, boğaz ağrısı, cilt iltihapları ve gastrointestinal rahatsızlıklar gibi inflamatuvar durumların tedavisinde yaygın olarak kullanılmıştır (Kindscher, 1989). Günümüzde ise özellikle üst solunum yolu enfeksiyonlarının (örneğin soğuk algınlığı ve grip) önlenmesi ve hafifletilmesinde bağışıklık sistemini destekleyici olarak yaygın bir şekilde kullanılmaktadır (Karsch-Völck ve ark., 2014).

Ekinezya yaprakları, çiçeklerinden daha yüksek konsantrasyonlarda Cu, Zn, Ni ve Mg gibi elementlere sahiptir ([Burlou-Nagy C. ve ark., 2022](#)). Ayrıca, *Echinacea purpurea*'nın uygulanmasının etkileri üzerine yapılan araştırmaların, yüksek dozlarda bile, maddenin damar içi olarak verildiğinde bile, minimal düzeyde toksik veya toksik değildir ([Stanisavljević I. ve ark., 2009](#)).

Moleküler düzeyde yapılan arařtırmalar, *E. purpurea* özlerinin baęıřıklık sistemi hücreleri üzerinde çift yönlü etkiler gösterebildiđini ortaya koymuřtur. Bu özler; dendritik hücrelerin fenotipik ve fonksiyonel olgunlařmasını destekleyerek (Li ve ark., 2017), M1 makrofajlarını aktive edip polarize ederek (Fu ve ark., 2017), dođal öldürücü (NK) hücrelerin aktivitesini artırmakta ve bu etkiyi 5-lipoksijenaz ile siklooksijenaz enzimlerini inhibe ederek gerçekleřtirmektedir (Goel ve ark., 2002).

Ayrıca, *E. purpurea* özleri granülositlerin fagositik indeksini artırmakta; makrofajlar ve dalak hücreleri üzerinden TNF- $\alpha$ , IFN- $\beta$ -2, IL-1 ve IL-6 gibi proinflamatuvar sitokinlerin üretimini uyararak baęıřıklık yanıtlarını kuvvetlendirmektedir (Hwang ve ark., 2004; Bauer ve ark., 2006). Toll-benzeri reseptör 4 (TLR4) aracılıđıyla nükleer faktör (NF)- $\kappa$ B fosforilasyonu ve nitrik oksit (NO), IL-1 $\beta$  ve TNF- $\alpha$  gibi sitokinlerin salınımı gibi dođuřtan gelen baęıřıklık tepkilerinde *E. purpurea*'nın düzenleyici rol oynadıđı da rapor edilmiřtir (Mao ve ark., 2021).

### **Ekinezya ve Zencefilin Hayvanlarda İmmun Sistem Üzerine Etkileri**

Kümes hayvanlarının gastrointestinal sistemi, çok çeřitli mikroorganizmaları barındıran karmařık bir ekosistemdir. Normalde patojenik olmayan bu mikroorganizmalar, uygun olmayan kořullarda fırsatçı patojenlere dönüşerek enfeksiyonlara neden olabilir (Aruwa ve ark., 2021). Özellikle son yıllarda, bu tür enfeksiyonları kontrol altına almak için kullanılan antibiyotiklerin insan sađlığında ilaç direncine yol açması, hayvancılıkta dođal alternatiflerin arařtırılmasını gündeme getirmiřtir (Lhermie ve ark., 2017; Kim ve Lillehoj, 2019).

Geleneksel olarak, büyüme hızını ve yem dönüşüm oranlarını artırmak amacıyla antibiyotiklerin hayvan diyetlerine eklenmesi yaygın bir uygulamaydı. Örneđin basitrasın, birçok bulařıcı hastalıkla mücadelede kullanılmıř ve ekonomik avantajlar sađlamıřtır (Proctor ve Phillips, 2019). Ancak bu uygulamanın yarattıđı direnç sorunları nedeniyle, antibiyotiklerin yerini alabilecek dođal, güvenli ve etkili alternatiflerin kullanımı zorunlu hale gelmiřtir (Yadav ve Jha, 2019).

Bu bağlamda fitobesinler (fitonutrientler) ve bitkisel katkı maddeleri, dikkat çeken dođal alternatifler arasında yer almaktadır. Gingerol, bu fitobesinler arasında antioksidan, antimikrobiyal ve immünomodülatör özellikleri sayesinde öne çıkmaktadır. Bu biyoaktif bileřik, baęıřıklık fonksiyonlarını iyileřtirme, bađırsađın mikrobiyel dengesini koruma, besin sindirilebilirliđini ve enerji verimliliđini artırma potansiyeline sahiptir (Patra ve ark., 2019).

Gingerol, özellikle *Zingiber officinale* (zencefil) köklerinden elde edilen biyoaktif bir bileřik olarak, son yıllarda çeřitli hastalık modellerinde gösterdiđi antiinflamatuvar, antioksidan ve immünomodülatör etkilerle dikkat çekmektedir. 6-Gingerol, baęıřıklık efektör hücreleri, lokal fibroblastlar ve doku makrofajları arasındaki etkileřimler üzerinde etkili olarak kronik inflamasyon ve fibrozis süreçlerini düzenleyebilmektedir (Xu ve ark., 2012).

Bir çalışmada, 6-gingerolün sıçanlarda karaciđer fibrozisine karřı koruyucu etkiler gösterdiđi rapor edilmiřtir. Bu etki, glutatyon (GSH) tükenmesinin ve lipid peroksit birikiminin azaltılması, NF- $\kappa$ B, TNF- $\alpha$ , ICAM, TLR4 ve VCAM gibi proinflamatuvar biyomoleküllerin ekspresyonunun baskılanmasıyla iliřkilendirilmiřtir (Algandaby ve ark., 2016).

Ayrıca, 6-gingerolün tüberküloz modelinde MDR, XDR ve H37Rv *Mycobacterium tuberculosis* suřları ile enfekte edilen farelerde akciđer, karaciđer ve dalakta mikobakteriyel büyümeyi baskıladıđı gösterilmiřtir (Bhaskar ve ark., 2020). Bu da gingerolün yalnızca inflamasyon deđil, enfeksiyon kaynaklı baęıřıklık yanıtlarını da modüle edebildiđini göstermektedir.

Bir sepsis sıçan modelinde yapılan çalışmada ise 6- ve 10-gingerol uygulamaları, IL-1 $\beta$ , TNF- $\alpha$  ve TGF- $\beta$ 1 gibi inflamatuvar belirteçlerin mRNA ekspresyonunu azaltmıř; böbrek fonksiyonlarını geri kazandırarak akut böbrek hasarına karřı koruyucu etki göstermiřtir. Bu etkiler, oksidatif/nitrozatif

stresin baskılanması ve dimetilamin ile metilsülfonilmetan üretiminin artırılmasıyla ilişkili bulunmuştur (Rodrigues ve ark., 2018).

Gingerol ayrıca, humoral ve hücre aracılı bağışıklık yanıtlarını da desteklemektedir. Farhath ve ark. (2013) tarafından yapılan bir çalışmada, sıçanlara 7 gün süreyle 800 mg/kg dozda verilen 6-gingerol, antikor titrelerini ve gecikmiş tip aşırı duyarlılık tepkisini anlamlı derecede artırmış; bu da gingerolün lenfosit proliferasyonunu uyararak bağışıklık sistemini güçlendirdiğini göstermiştir.

Buna ek olarak, gingerollerin etkileri sadece sitokin salınımı düzeyinde değil, aynı zamanda çeşitli hücrel sinyal yolları üzerinde de gözlenmiştir. NF-KB yolunun inhibisyonu, antiinflamatuvar etkilerinin temel mekanizmalarından biri olarak öne çıkmaktadır. Gingerol ayrıca kanser hücreleri üzerinde apoptotik etkiler göstererek antikanser potansiyelini de ortaya koymaktadır (Yücel Ç. ve ark., 2022).

Ex vivo bir çalışmada %2,5 luk zencefil çayının tavuk karaciğer dokusunda lipid peroksidasyonunu engellediği ve serbest radikalleri baskıladığı görülmüştür (Singh KG ve ark., 2018).

Broilerlerde yapılan başka bir araştırmada özellikle yeme 0.75 g/kg oranında Zencefil kökü ekstresi katıldığında, tavuklarda bağışıklık sistemi üzerinde immüno stimülatör etkiler göstererek Newcastle hastalığına karşı antikor titresi ve toplam IgY düzeylerinde belirgin bir artış sağladığı ortaya konmuştur. Zencefil kökü ekstresinin 1.5 g/kg kadar olan dozlarda, *E. coli* miktarını anlamlı şekilde azaltırken, *Lactobacillus spp.* ve *Bifidobacterium spp.* gibi faydalı bağırsak mikroorganizmalarının proliferasyonunu destekleyerek bağışıklık sistemini olumlu yönde etkilediği bildirilmiştir (Dosu G. ve ark., 2023).

Echinacea türlerinin immüno modülatör ve antioksidan özelliklerinden hayvanlarda bağışıklık sisteminin düzenlenmesi amacıyla çeşitli araştırmalar yapılmıştır (Classen ve ark., 2004; Zorig ve ark., 2021, Li ve ark., 2022).

Ekinezya, makrofajlar ve doğal öldürücü hücreler (NK) gibi bağışıklık hücrelerini uyararak fagositozu güçlendirmekte, sitokin üretimini (IL-1, IL-10, TNF- $\alpha$ ) artırmakta ve enfeksiyonlara karşı koordineli bir bağışıklık yanıtı gelişmesine katkıda bulunmaktadır (Sullivan ve ark., 2008; Mahmoud S. H. ve ark., 2015). Ayrıca, ekinezya ile tedavinin NK hücrelerinin ve monositlerin aktivitesini koruyarak virüsle enfekte hücrelerin eliminasyonunu desteklediği ve spesifik olmayan immün yanıt sağladığı bildirilmiştir (Hudson ve ark., 2005).

İn vitro ve in vivo çok sayıda araştırma, farklı ekinezya türleri, bitki kısımları ve ekstraksiyon yöntemleri ile hazırlanan preparatların immünolojik fonksiyonları farklı düzeylerde etkilediğini ortaya koymuştur (Senchina ve ark., 2005). Örneğin, *E. purpurea* özütünün uygulanmasıyla normal, lösemik ve yaşlanan farelerde NK hücre sayısının arttığı, ayrıca makrofaj fonksiyonlarının güçlendiği rapor edilmiştir (Classen ve ark., 2004; Zorig ve ark., 2021). Ayrıca, şap aşısı sonrası ekinezya uygulanan gruplarda daha yüksek antikor titreleri gözlenmiş (Ismael ve ark., 2009), köpeklerde CPV ve CDV aşılara karşı bağışıklık cevabını güçlendirdiği bulunmuş (Guan ve ark., 2018), keçilerde ise meme sağlığını ve süt verimini artırdığı rapor edilmiştir (Teleb D. ve ark., 2009). Farelerde yapılan çalışmalar, ekinezya katkılı diyetlerin yaşla azalan NK hücre üretimini artırarak bağışıklık fonksiyonlarını gençlerdeki seviyelere yaklaştırdığını göstermektedir (Currier ve Miller, 2000).

Moleküler düzeyde, *E. purpurea*'nın lipofilik özütünün JNK, P38 MAPK ve NF- $\kappa$ B sinyal yollarını düzenleyerek dendritik hücre olgunlaşmasını desteklediği, T (CD4+ ve CD8+) ve B hücrelerinin proliferasyonunu ve aktivasyonunu indüklediği, T yardımcı hücre farklılaşmasını ve IgA salgılanmasını artırdığı gösterilmiştir (Yang ve ark., 2018; Cai ve ark., 2022; Hussain ve ark., 2023).

Broiler tavuklarda yapılan çalışmalar, ekinezya özütünün bağırsak mikrobiyotasını iyileştirerek *Enterococcus* gibi yararlı bakterilerin relatif bolluğunu artırdığını, buna karşılık *Ruminococcus* ve *Blautia* gibi zararlı bakterilerin miktarını azalttığını ve böylece bağırsak sağlığı üzerinde koruyucu bir etki sağladığını göstermiştir (Li ve ark., 2022).

Kanatlı hayvanlarda yapılan deneysel çalışmalar, ekinezyanın yemden yararlanma oranını iyileştirdiğini, lökosit dağılımlarını modüle ettiğini, antikor titrelerini yükselttiğini ve özellikle Newcastle hastalığı ile kuş gribine karşı bağışıklık yanıtını güçlendirdiğini ortaya koymuştur (Dehkordi ve Fallah, 2011; Rady ve ark., 2023). Ekinezya takviyesinin IgG düzeylerini artırdığı, malondialdehit (MDA) seviyelerini azalttığı ve süperoksit dismutaz (SOD) aktivitesini yükselttiği de bildirilmiştir (Ashour ve ark., 2025).

Echinacea purpurea kök tozu veya ekstresi ile beslenen broyler tavuklarda performans, antioksidan savunma ve bağışıklık parametreleri incelenmiştir. Örneğin, 240 Ross 308 civciv ile yapılan bir çalışmada, diyete 20 ve 30 mg/kg E. purpurea ekstresi eklenmesinin canlı ağırlığı ve toplam kilo artışını anlamlı şekilde artırdığı; yem dönüşüm oranını iyileştirdiği gözlenmiştir. Ayrıca bağışıklık açısından, bu dozlarda verilen ekstrelerin toplam antikor cevabını (örneğin Newcastle hastalığı ve SRBC aşısına karşı) yükselttiği ve özellikle 30 mg/kg dozunun IL-2 gen ekspresyonunu artırarak hücrel bağışıklık yönünden de potansiyel etki gösterdiği rapor edilmiştir (Akbari ve ark. 2025).

Son yıllarda yapılan başka bir araştırmada Echinacea purpurea'nın aşı sonrası bağışıklık cevabı üzerine etkisini avian influenza aşısı bağlamında değerlendirmiştir. Bu çalışmada broylerlere %2 EP (tüm bitki) ya da %0.5 EE (ekstrakt) içeren yem takviyesi verilmiş, aşı sonrası 7., 21. ve 35. günlerde alınan örneklerde, sIgA düzeyleri, sıkı bağlanma (tight junction) proteinlerinin (ZO-1, Occludin, Claudin-1) ifadesi, TLR4-MAPK sinyal yolundaki MyD88, TRAF6, AP-1 gibi gen ve ERK, JNK gibi protein düzeyleri artmıştır. Ayrıca bu takviyeler, antikor titrelerini yükseltmiş, yem dönüşüm oranını (FCR) düşürmüş ve broylerlerin büyüme performansını artırmıştır. Bu bulgular, ekinezyanın bağışıklık sistemini hem mukozal hem de sistemik düzeyde aşı yanıtını iyileştirerek immunomodülasyon sağladığını desteklemektedir (Wang ve ark. 2024).

## SONUÇ

Sonuç olarak, zencefil ve ekinezyanın kanatlılar ön planda olmak üzere hayvanlarda bağışıklık sisteminin desteklenmesi, üretim performansının artırılması ve enfeksiyonlara karşı korunmada umut verici doğal alternatifler olduğu görülmektedir. Zencefil, özellikle antiinflamatuvar ve antioksidan etkileriyle immün fonksiyonları desteklerken; ekinezya, hem sistemik hem de mukozal bağışıklığı güçlendirmekte ve aşı etkinliğini artırmaktadır. Güncel bulgular, bu bitkilerin immünomodülatör etkilerinin TLR4-MAPK ve NF- $\kappa$ B gibi sinyal yolları üzerinden gerçekleştiğini göstermektedir. Antibiyotik kullanımına alternatif arayışlarının yoğunlaştığı günümüzde, zencefil ve ekinezyanın yem katkısı olarak kullanımı, sürdürülebilir kanatlı yetiştiriciliğinde önemli katkılar sağlayabilir. Bununla birlikte, optimal dozların, uygulama sürelerinin ve farklı aşı protokolleri ile etkileşimlerinin aydınlatılması için ileriye dönük kontrollü çalışmalara ihtiyaç vardır.

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## POSTBİYOTİKLERİN BAĞIRSAK HASTALIKLARI ÜZERİNDEKİ TERAPÖTİK ETKİLERİ: MEKANİZMALAR, KLİNİK BULGULAR VE GELECEK PERSPEKTİFLERİ

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### ÖZET

Mikrobiyota, başta bağırsaklar olmak üzere vücudun birçok bölgesinde yer alan ve konak ile simbiyotik ilişki kuran bakteri, virüs ve mantar gibi mikroorganizmaların oluşturduğu karmaşık bir ekosistemdir. Mikrobiyota homeostazının korunmasında probiyotikler, prebiyotikler ve bunların kombinasyonu olan sinbiyotiklerin rolü uzun süredir bilinmektedir. Ancak son yıllarda, mikrobiyal canlı hücrelerin metabolik ürünlerini içeren postbiyotikler, daha güvenli ve etkili alternatifler olarak dikkat çekmektedir. Postbiyotikler; kısa zincirli yağ asitleri, ekzopolisakkaritler, teikoik asitler, lipoteikoik asitler, bakteriyosinler ve çeşitli organik asitler gibi bileşenleri kapsar ve antimikrobiyal, anti-inflamatuar, immünmodülatör ve metabolik etkiler gösterir. Ayrıca postbiyotikler, probiyotiklerin canlı formuyla ilişkili güvenlik risklerini taşımadan benzer terapötik etkiler sunabilir. Hayvanlarda, özellikle broiler tavuklar, domuz yavruları ve balıklarda postbiyotiklerin büyüme, bağışıklık ve sindirim performansı üzerindeki olumlu etkileri gösterilmiştir. Ayrıca, bazı postbiyotik fraksiyonların antitümöral ve osteoklast baskılayıcı etkileriyle kolon kanseri ve osteoporoz gibi hastalıkların tedavisinde potansiyel terapötik ajanlar olabileceği bildirilmektedir. Bu bulgular, postbiyotiklerin gıda, ilaç, tarım ve hayvancılık gibi çeşitli alanlarda fonksiyonel bileşen olarak kullanım potansiyelini ortaya koymaktadır.

### GİRİŞ

İntestinal mikrobiyota, vücudun çeşitli bölgelerinde lokalize olan ve konak hücreler ile kommensal ilişki içinde yaşayan bakteri, virüs ve mantar gibi çeşitli mikroorganizmalardan oluşmaktadır (Grice E. A. ve Segre J.A., 2012). Mikrobiyota, başta bağırsaklar olmak üzere ağız boşluğu, cilt, akciğerler, genitoüriner sistem, plasenta ve amniyon sıvısı gibi dokularda bulunan çeşitli mikroorganizmalardan oluşmaktadır (Pelzer E. ve ark., 2017). Mikrobiyota, tüm insan genomunda bulunanlara kıyasla yaklaşık 150 kat daha fazla gen taşıyan bir “organ” olarak kabul edilmektedir (Wang B. ve ark., 2017).

Probiyotik, prebiyotik ve bu 2 bileşenin kombinasyonundan oluşan sinbiyotikler mikrobiyota homeostazının sağlanmasında önemli rol oynamaktadır. Postbiyotik kavramı ise probiyotik, prebiyotik ve sinbiyotiklerle karşılaştırıldığında son yıllarda gelişmekte olan yeni bir kavramdır (Malashree L. ve ark., 2019)

Postbiyotikler, canlı bakteriler tarafından veya bakteri lizisinden sonra salgılanan enzim, peptid, teikoik asit, kısa zincirli yağ asitleri (KZYA), ekzopolisakkarid, bakteriyosin, hücre yüzey proteinleri ve organik asitler gibi metabolik ürünlerdir. Postbiyotikler, bağırsak mikrobiyotası ve epitel bariyer fonksiyonunun düzenlenmesi, immün hücre yanıtının modülasyonu ve patojenlere karşı inhibitör rol

üstlenmesi gibi antienfektif, antibakteriyel ve antioksidan özelliklere sahiptir (Aguilar-Toalá J. ve ark., 2018).

KZYA, gastrointestinal kanalda bulunan bakterilerin diyet karbonhidratını fermente etmesi sonucu oluşan metabolik ürünlerdir. Bu özellikleri sayesinde postbiyotik özellik göstermektedirler (Brown S. ve ark., 2013). Bağırsak mikrobiyotası tarafından üretilen KZYA, glukoz, kolesterol ve lipid metabolizmasında substrat olarak önemli rol oynamaktadır (LeBlanc J.G. ve ark., 2017).

KZYA, epitel bariyer bütünlüğünün korunması, enerji metabolizmasının desteklenmesi ve bağışıklık sisteminin düzenlenmesinde önemli roller üstlenmektedir. Bu bileşiklerin çeşitli kronik hastalıklara karşı koruyucu etkileri bulunduğundan, bağırsak mikrobiyotasının KZYA üretimi, sağlığın sürdürülmesi açısından büyük bir öneme sahiptir (Macfarlane G.T. ve Macfarlane S., 2012; Sun, Y. ve O’Riordan, M. X., 2013; Wang H. ve ark., 2012; van der Beek, C. M. ve ark., 2017; Feng W. ve ark., 2018).

Ekzopolisakaridler (EPS) laktik asit bakterileri, bifidobakteriler ve propionibacterium tarafından hücre dışına sentezlenen postbiyotik bileşenlerdir (Laws A. ve ark., 2001).

EPS’nin, sağlık üzerinde bağırsak sağlığını geliştirici ve hastalıklarını önleyici, kolesterol düşürücü, antiülser, antikarsinojenik ve immün modüle edici etkileri bulunmaktadır (Salazar N. ve ark., 2016 ).

Teikoik asit ve lipoteikoik asit, gram pozitif bakterilerde bulunan bakteriyel hücre duvarı bileşenleridir (Brown S. ve ark., 2013). Lipoteikoik asit gibi hücre duvarı bileşenlerinin, antitümör, antioksidan ve immünomodülatör olmak üzere çeşitli biyoaktiviteler sergilediği bildirilmiştir Lebeer S. ve ark., 2012; Yi Z. j. ve ark., 2009). Kang ve ark. tarafından yapılan bir çalışmada *Staphylococcus aureus*’un hücre duvarında bulunan lipoteikoik asidin tümör nekrozis faktör- $\alpha$  (TNF- $\alpha$ ), interlökin-6 (IL-6), IL-8 gibi inflamatuvar sitokinleri indüklediği ve Toll benzeri reseptör 2 tarafından tanınarak bağışıklığın gelişimine katkıda bulunduğu bildirilmiştir (den Besten G. ve ark., 2013)

Bakteriyosinler, arke ve bakteri türleri tarafından üretilen antimikrobiyal peptidlerdir. *Escherichia coli*, *Citrobacter freundii*, *Lactobacillus acidophilus*, *L. casei*, *L. plantarum*, *Halobacteria* gibi bakteri türleri bakteriyosin üretiminde görev almaktadır (Chikindas M. L. ve ark., 2018). Bakteriyosinlerin, bakterisidal aktiviteyi teşvik etme ve bakteriyostatik etki göstererek hücre büyümesini inhibe etme gibi etki mekanizmaları bulunmaktadır (Parada Venegas D. Ve ark., 2019). Nisin, ticari alanda kullanılan en önemli bakteriyosin çeşitlerinden biridir (Parada Venegas D. Ve ark., 2019). Nisin, *Listeria*, *Staphylococcus*, *Bacillus* ve *Clostridium* gibi patojen bakteriler ve spor oluşturan bakteriler dâhil olmak üzere çok sayıda gram pozitif bakteriye karşı antimikrobiyal aktivite göstermektedir (Parada Venegas D. Ve ark., 2019). Genellikle asidik gıdalarda kullanılmakla birlikte pH’si 3,5-8,0 arasında olan ürünlerde etkili olmaktadır. Pastörize, aromalı ve uzun ömürlü sütler, işlenmiş peynirler, konserve sebze ve çorbalar dâhil olmak üzere gıda sanayisinde çeşitli ürünlerde kullanılmaktadır (Parada Venegas D. Ve ark., 2019).

Postbiyotiklerin benzersiz kimyasal yapıya sahip olması, güvenilir profillere sahip olmaları, tespit edilmiş bir toksisitelerinin olmaması, probiyotiklerden daha uzun raf ömrüne sahip olmaları, memeli bağırsak enzimlerine dirençli olmaları, anti-enflamatuvar, immünomodülatör (bağışıklık sistemi reaksiyonlarını düzenleyici), anti-obezojenik, antihipertansif, hipokolesterolemik, antiproliferatif (hücrelerin çoğalmasını engelleyen) ve antioksidan aktivitelere sahip olabilen çeşitli sinyal moleküllerini içermeleri ve gastrointestinal sistemde stabil olarak kalabilmeleri onları güvenilir yapmaktadır. Postbiyotikler, fermantasyon sırasında mikroorganizmalar tarafından üretilen biyoaktif bileşiklerdir. Çok çeşitli probiyotiklerden elde edilebilir ve raf ömrü açısından farklılık gösterebilirler. Postbiyotikler fonksiyonel gıdalarda ve farmasötik endüstride hastalıkları önlemek ve terapötik amaçlar için kullanılabilirler. Bu doğrultuda, bağırsak mikrobiyota ekosistemine yabancı probiyotik suşlar yerine, konakçının endojen probiyotik popülasyonlarını destekleyen ve sağlığı olumlu yönde etkileyen postbiyotikler, canlı probiyotik mikroorganizmalara kıyasla daha güvenli bir alternatif

olarak değerlendirilebilmektedir (Aguilar-Toalá, J.E. ve ark., 2018; Homayouni-Rad A. ve ark., 2020; Moradi, M. ve ark., 2019)

Yapılan farklı çalışmalar, sağlıklı bir bağırsağın iç dengesinin ve işlevselliğinin, canlı bakterilerin mekanizmalarına bağlı olduğunu göstermiştir. Bağırsak mikrobiyotasının modifikasyonu, mukoza ve epitelyumdaki rekabetçi bakterilerin tutunabilme kabiliyetleri, bağışıklık sisteminin modülasyonu gibi mekanizmalar bakterilerle ilişkilendirilir. Probiyotiklerin bu yararlı etkileri, esas olarak doğuştan gelen bağışıklık sistemi ile ilişkilidir, fakat probiyotiklerin etkinliği büyük ölçüde mikrobiyal türlere veya suşlara ve bunlardan türetilen postbiyotiklere, probiyotik hücre miktarına ve etkinliğine bağlıdır. Bu bağlamda, faydalı bağırsak mikrobiyotasının sağlığı geliştiren faydaları hem canlı (probiyotik) hem de cansız metabolitleri ve/veya yan ürünleri (postbiyotikler) ile ilişkili olabilmektedir. Yapılan son çalışmalar, canlı bakterilere atfedilen bu mekanizmaların bakterilerle doğrudan bir ilgilerinin olmadığını öne sürmektedir. Yapılan çalışmalarda, dört farklı *Bifidobacterium bifidum* BGN4 fraksiyonunun (tam hücre, hücresiz özler, saflaştırılmış hücre duvarı ve kültür süpernetantı) birbirlerinden farklı bağışıklık reaksiyonları gösterdiği, *Lactobacillus* ve *Bifidobacterium* suşlarından elde edilen yüksek düzeyde mikrobiyal karbonhidrat içeren fraksiyonların da tümör baskılayıcı aktiviteler gösterdiği bildirilmiştir (Aguilar-Toalá J. ve ark., 2018). Bununla birlikte, canlı mikrobiyal hücrelerin yaygın kullanımından kaynaklanan güvenlik sorunları ile ilgili ortaya çıkan endişe ve raf ömrü sorunlarını ortadan kaldıracabilecekleri ve mikrobiyal translokasyon (canlı mikroorganizmaların bağırsak epitelyal bariyeri geçmesi) ile enfeksiyon risklerini azaltabilecekleri için canlı olmayan mikroorganizmalara veya mikrobiyal hücre özütlerine olan ilgi gün geçtikçe artmaktadır (Aguilar-Toalá, J.E. ve ark., 2018; Homayouni-Rad A. ve ark., 2020; Taverniti, V.ve Guglielmetti, S.. 2011).

Postbiyotiklerin farmasötik ürünlerde, gıdalarda, tarımda ve kültür balıkçılığında da kullanılabilmesi belirtilmiştir. Örneğin, bulaşıcı hastalıklar, su ürünleri yetiştiriciliğinin gelişiminde ciddi bir sorundur. Ancak, kısa zincirli yağ asitleri, peptitler, ekzopolisakkaritler, vitaminler, peptidoglikan, lipopolisakaritler, hücre yüzey proteinleri ve teikoik asit gibi postbiyotikler, su ürünleri yetiştiriciliğinde alternatif hastalık kontrol ajanları olarak kullanımda yüksek potansiyele sahiptir (Ang, C.Y. ve ark., 2020)

Yapılan pek çok çalışma postbiyotiklerin gıda katkı maddesi olarak da kullanılabilmesini göstermiştir. Postbiyotiklerin yemlere dahil edilmesiyle ineklerdeki rumen fermentasyon parametrelerinin olumlu etkilendiği gözlemlenmiştir. *Fibrobacter succinogenes*, *Ruminococcus albus* ve *Ruminococcus flavefaciens* ve protozoa gibi selülitik bakteri popülasyonları postbiyotik ilavesi ile artmakta, bu da, rumen fermentasyonunun artmasına katkıda bulunabilecek daha yüksek lif sindirimini göstermektedir (Izuddin, W. I. ve ark., 2018). Bununla birlikte broiler tavukların bağışıklık sistemlerini güçlendirmek ve büyüme performanslarını iyileştirmek için inülin destekli postbiyotik uygulaması gerçekleştirilmiştir. Uygulanan karışımın, tavukların bağışıklık sistemlerini, gelişim performanslarını ve sindirim sistemlerini olumlu yönde etkilediği rapor edilmiştir (Kareem, K. Y. ve ark., 2016). Yapılan başka bir çalışmada, *Lactobacillus plantarum* tarafından üretilen çeşitli metabolitlerin farklı oranlarda kombinasyonlarıyla muamele edilen, süttten kesilmiş domuz yavrularının büyüme performansı, ishal insidansı, bağırsak ortamı ve besin sindirilebilirliği incelenmiştir. Çalışma sonuçlarına göre, %0.5 metabolit kombinasyonu ile muamele edilen süttten kesilmiş domuz yavrularının büyüme performansında, bağırsak ortamında ve protein sindirilebilirliğinde iyileşme tespit edilmiştir (Loh, T. C. ve ark., 2013)

Postbiyotiklerin yapısında bulundurduğu fenolik bileşiklerin çoğu bağırsakta emilmeden kalır. Bu polifenoller ile bağırsak mikrobiyotası arasındaki karmaşık etkileşim sonucunda mikrobiyal dönüşüm ürünleri oluşur. Bu ürünlerin *Clostridium spp.*'nin patojenik suşlarının büyümesini baskıladığı, kommensal bakterileri ise ya daha az ya da pozitif olarak etkilediği belirtilmiştir. Ayrıca, fareler üzerinde yapılan denemelerde, postbiyotiklerin farelerde *Salmonella spp.* enfeksiyonuna karşı immünomodülatör ve koruyucu etki gösterdiğini belirtmektedir. Genel olarak, test edilen postbiyotiklerin hem uyarılmış hem de uyarılmamış hücrelerde dikkate değer antiinflamatuvar etkisi

nedeniyle immünomodülatör etki gösterdiği sonucuna varılmıştır Chaluvadi S. ve ark., 2015; Dunand E. ve ark., 2019; Mayorgas, A., 2020).

2024 yılında ISSAP'ın yaptığı güncel tanımlar dikkate alındığında, probiyotikler ve postbiyotikler bir madalyonun iki yüzü olarak kabul edilebilmekte, canlılığın kaybı bir fonksiyonel bileşenden (probiyotik) diğer fonksiyonel bileşene (postbiyotik) geçiş olarak kabul edilmektedir. Örneğin, *Lactobacillus gasseri* CP2305 suşunun canlı formu irritabl bağırsak sendromlu hastalarda yaşam kalitesini ve klinik semptomları üzerine, inaktif formu ise bağırsak ortamı ve fonksiyonu üzerine olumlu etki göstermiştir. Benzer şekilde, *Akkermansia muciniphila* ATCC BAA -835'in, canlı, pastörize ve cansız formunun obez ve aşırı kilolu gönüllülerde çeşitli metabolik parametreleri iyileştirdiği belirlenmiştir (Vinderola, G. ve ark., 2024). Bu örneklerden farklı olarak, bazı probiyotik mikroorganizmaların bağırsak sağlığının korunması ve iyileştirilmesinde etkili olamadığı ya da güvenlik nedenleriyle kullanılmadığı ancak ürettikleri postbiyotiklerin bu konuda etkili rol oynadığı da bildirilmektedir (Ford A. ve ark., 2018). Örneğin, genel olarak yararlı bir endojen bağırsak mikroorganizması olarak kabul edilen *Faecalibacterium prausnitzii*, şu anda tüketilmesi güvenli görülmediğinden probiyotikler ile tedavide canlı bir mikroorganizma olarak uygulanmamaktadır. Ancak çalışmalar *F. prausnitzii*'nin bütirat üretiminin bağırsak sağlığına olumlu etkiler sağladığını göstermekte, bütirat içeren inaktif edilmiş bir *F. prausnitzii* preparatına dayanan postbiyotik tedaviyle aynı sağlık yararlarını elde etmek mümkün olabilmektedir (Rooks M. G. ve Garrett W. S., 2016). Ayrıca canlı olduklarında patojen olarak kabul edilen bazı mikroorganizmalar dahi postbiyotik geliştirmek için kullanılabilir. Örnek olarak solunum yolu için bağışıklık güçlendirici olarak kullanılabilen patojen lizatlarının bir karışımı gösterilebilmektedir (Kaczynska A. ve ark., 2022).

Postbiyotikler konakçıya immünomodülatör aktivite sağlamakta ve yaşlılar, transplantasyon hastaları veya prematüre yenidoğanlar gibi immün yetmezliğe sahip bireylerde olduğu gibi canlı probiyotik bakteri kullanımının endike olmadığı durumlarda daha güvenli bir alternatif sunabilmektedirler (Yeşilyurt N. Ve ark., 2021)

Dünya Sağlık Örgütü kolorektal kanser ile ilgili epidemiyolojik çalışmalar sonucunda, 2030 yılına kadar bu hastalığın yaklaşık 17 milyon ölüme neden olacağını öngörmektedir. Mide ve kolon kanserlerinin yüksek sıklığı, araştırmacıları, hastalığın prevalansını önlemek amacıyla yeni ve doğal bileşenler keşfetmeye yöneltmektedir (Abbasi A. ve ark., 2023). Yapılan bir çalışmada, *Rhizopus nigricans*'tan (ilaç endüstrisinde yaygın olarak kullanılan zigomiset filamentli mantar) izole edilen ekzopolisakkaritlerin, AMP ile aktifleşen protein kinaz (AMPK) yolunu aktive ederek hem in vitro hem de in vivo kolon kanseri hücre apoptozunu indüklediği gösterilmiştir (Lu Y. ve ark., 2020; Kvakova, M. ve ark., 2022). Taze turp suyu kimchisinden izole edilen postbiyotik *L. plantarum* MD35'in fare kemik iliği kaynaklı makrofaj kültüründe osteoklast farklılaşması etkisini araştırmışlardır. Hayvan modelinde, postbiyotik MD35'in oral yoldan uygulanması, trabeküler kemik kaybını önemli ölçüde iyileştirdiği ve femoral plak büyümesinin tahribatını azalttığı kanıtlanmıştır. Bu nedenle postbiyotik *L. plantarum* MD35'in, osteoklastla ilişkili moleküler mekanizmaların düzenlenmesi yoluyla osteoklastogenezi baskılayarak menopoz sonrası osteoporoz için potansiyel bir terapötik aday olabileceği gösterilmiştir (Myeong J. Y. ve ark., 2023). Preklinik bir çalışmada, *L. plantarum*'dan türetilen postbiyotiklerin bağırsak mikrobiyotasının bileşimini optimize edebildikleri ve in vivo olarak kısa zincirli yağ asitleri ile nöroaktif moleküllerin (5-hidroksitriptamin,  $\gamma$ -aminobütirik asit) seviyelerini önemli ölçüde modüle edebildikleri saptanmıştır. Bu olumlu etki sonucu *Salmonella*'nın neden olduğu nörolojik işlev bozukluklarının iyileştirildiği kanıtlanmıştır (Wu Y. ve ark., 2022). Laktik asit bakterilerinin metabolitleri, tek mideli hayvanlar için antitümör ajanları ve yem katkı maddeleri olarak patentler almıştır. Postbiyotik preparatlar, aynı zamanda bağışıklık modülasyonunu hedefleyen biyoterapötik ajanlar olarak değerlendirilmekte olup, bu özellikleriyle çeşitli immünolojik mekanizmaları etkileyebildikleri için bazı formları terapötik patent almış ürünler arasında yer almaktadır (Parada Venegas, D. ve ark., 2019).

## SONUÇ

Postbiyotikler, canlı probiyotik mikroorganizmaların metabolik yan ürünleri olarak, konak sağlığı üzerinde çok yönlü ve terapötik etkiler sunan biyoaktif moleküllerdir. Bağırsak mikrobiyotasının modülasyonunda doğrudan etkili olabilen bu bileşikler, özellikle kısa zincirli yağ asitleri (KZYA), ekzopolisakkaritler, teikoik asitler, bakteriyosinler ve hücre yüzey proteinleri gibi unsurlarıyla antimikrobiyal, antioksidan, immünmodülatör ve metabolik düzenleyici özellikler taşımaktadır. Postbiyotiklerin canlı mikroorganizma içermemeleri; raf ömrü, güvenlik profili ve stabilite açısından önemli avantajlar sunmakta; özellikle immün sistemi baskılanmış bireylerde probiyotiklerin yerine tercih edilebilecek güvenli alternatifler olarak öne çıkmaktadır.

Güncel literatür, postbiyotiklerin sadece gastrointestinal sağlıkla sınırlı kalmayıp, sistemik bağışıklığın güçlendirilmesi, enfeksiyonların önlenmesi, kolesterol ve glukoz regülasyonu, nörolojik fonksiyonların desteklenmesi gibi geniş bir biyolojik yelpazede etkili olabildiğini göstermektedir. Ayrıca hayvancılık ve su ürünleri gibi alanlarda postbiyotiklerin yem katkı maddesi olarak kullanımı, büyüme performansı ve sindirim sistemi verimliliğinde iyileşmeler sağlamaktadır. Preklinik çalışmalarda ise kolon kanseri ve osteoporoz gibi kronik hastalıkların gelişiminde rol alan mekanizmalar üzerine postbiyotiklerin düzenleyici etkileri dikkat çekmektedir.

Sonuç olarak, postbiyotikler probiyotiklerin klinik sınırlılıklarını aşmakla kalmayıp, daha hedefe yönelik, güvenli ve biyolojik açıdan zengin bir terapötik profil sunmaktadır. Mikrobiyal metabolitlerin bu işlevsel gücü, hem insan hem de hayvan sağlığı için gelecek vadeden doğal ajanlar arasında yer almaktadır. Bu doğrultuda, postbiyotiklerin farmasötik formülasyonlara entegrasyonu, fonksiyonel gıda geliştirme süreçlerine dahil edilmesi ve ileri faz klinik çalışmalarda etkinlik ve güvenlik profillerinin detaylandırılması büyük önem arz etmektedir.

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## GELENEKTEN DİJİTALE: FOLKLORUN EĞİTİME DİJİTAL YANSIMALARI\*1

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### ÖZET

Günümüzde eğitsel amaçlı dijital platformlara olan ilgi hızla artmakta; sınıf açma, içerik paylaşımı, ödev ve test uygulamaları gibi pek çok işlev dijital ortama taşınmaktadır. Bu dönüşüm, sadece öğretim süreçlerinin dijitalleşmesini değil, aynı zamanda öğrenen etkileşimlerinin kayıt altına alınarak pedagojik veri üretimini de mümkün kılmaktadır (Snodgrass Rangel vd., 2015). Z kuşağı olarak tanımlanan yeni nesil öğrenciler; dijital yerliler, yeni binyılın öğrenenleri olarak adlandırılmakta ve hızlı işlem yapma, görsel içeriklere yüksek ilgi ve sürekli bağlantı ihtiyacı gibi dijital özelliklerle tanımlanmaktadır (Pedró, 2011; Igel & Urquhart, 2012; Bayne & Ross, 2007). Bu özellikler, eğitim ortamlarının da dijitalleşmesini zorunlu kılmakta; öğrencileri yalnızca geleneksel yöntemlerle eğitmenin artık yeterli olmadığını göstermektedir. Bu bağlamda, halkbilimsel anlatıların çağdaş öğrenme ortamlarına nasıl entegre edilebileceği önemli bir araştırma sorusu olarak karşımıza çıkmaktadır. Folklor 4.0 yaklaşımı doğrultusunda, halk anlatılarının dijital çağda geçirdiği dönüşümü ve bu dönüşümün eğitim ortamlarına yansımalarını bütüncül bir yaklaşımla analiz edilmiştir. Özellikle Nasreddin Hoca ve Keloğlan gibi yerli ve kültürel olarak kökleşmiş halk karakterlerinin dijital mecralarda kazandığı yeni anlatı biçimleri (animasyonlar, webtoonlar, dijital oyunlar, sosyal medya hikâyeleri, etkileşimli videolar vb.) üzerinden, dijital folklorun kültürel, pedagojik ve teknolojik yönleri araştırılmıştır. Folklor 4.0 yaklaşımıyla bu çalışma, geleneksel halk anlatılarının dijital öğrenme ortamlarında nasıl yapılandırılabilirliğini, kültürel kodların dijital mecralarda nasıl yeniden üretildiğini ve bu süreçlerin eğitimdeki yansımalarını çok boyutlu olarak incelenmiştir. Böylece çalışmanın, kültürel mirasın dijitalleştirilmesi ile 21. yüzyıl becerilerinin kazandırılması arasında köprü kurmayı amaçlayan örnek bir uygulama niteliği taşıdığı düşünülmektedir.

**Anahtar kelimeler:** Dijital dönüşüm, Folklor 4.0, Pedagojik dönüşüm

### FROM TRADITION TO DIGITAL: THE DIGITAL REFLECTIONS OF FOLKLORE IN EDUCATION

#### ABSTRACT

In recent years, there has been a rapid increase in interest toward digital platforms for educational purposes; functions such as class creation, content sharing, assignments, and test applications have

\*Bu çalışma Van Yüzüncü Yıl Üniversitesi Bilimsel Araştırma projeleri Koordinasyon Birimi tarafından desteklenen "Folklor 4.0 Kültürel Kodların Eğitimde Yeniden İnşası" isimli proje kapsamında desteklenmektedir.

been transferred to digital environments. This transformation not only enables the digitalization of teaching processes but also makes it possible to record learner interactions and generate pedagogical data (Snodgrass Rangel et al., 2015). The new generation of students, defined as Generation Z, are referred to as digital natives or the learners of the new millennium, and are characterized by digital features such as rapid information processing, strong interest in visual content, and the constant need for connectivity (Pedró, 2011; Igel & Urquhart, 2012; Bayne & Ross, 2007). These characteristics make the digitalization of learning environments inevitable, indicating that educating students solely through traditional methods is no longer sufficient. In this context, how folkloric narratives can be integrated into contemporary learning environments emerges as a significant research question. Guided by the Folklore 4.0 approach, the study adopted a holistic perspective to analyze the transformation of folk narratives in the digital age and their reflections on educational settings. Specifically, the research explored the new narrative forms acquired by culturally rooted folk characters such as Nasreddin Hodja and Kelođlan in digital media (e.g., animations, webtoons, digital games, social media stories, interactive videos) and examined the cultural, pedagogical, and technological dimensions of digital folklore. Through the Folklore 4.0 approach, this study sought to investigate how traditional folk narratives can be structured in digital learning environments, how cultural codes are reproduced in digital media, and the educational implications of these processes in a multidimensional manner. Thus, the study is considered to be an exemplary practice aiming to build a bridge between the digitalization of cultural heritage and the acquisition of 21st-century skills.

**Keywords:** Digital transformation, Folklore 4.0, Pedagogical transformation

## 1. GİRİŞ

21. yüzyılın başından itibaren hız kazanan dijital dönüşüm süreci, bilgi üretimi ve paylaşım biçimlerini kökten değiştirmiştir. Özellikle eğitim alanında yaşanan bu dönüşüm, öğretmenlerin ve öğrencilerin etkileşim biçimlerinden öğrenme materyallerinin niteliğine kadar birçok unsuru yeniden tanımlamaktadır. Eğitim teknolojilerinin gelişimiyle birlikte sınıf ortamı, artık yalnızca fiziksel bir mekân değil; çevrim içi platformlar, mobil uygulamalar ve sanal öğrenme alanlarıyla desteklenen çok katmanlı bir yapıya dönüşmüştür (Bayne & Ross, 2007: 214). Bu yeni yapının merkezinde, dijital kültürün doğal üyeleri olarak tanımlanan “Z kuşağı” yer almaktadır. Z kuşağı öğrencileri, bilgiyi hızla işleme, çoklu görev yürütme, görsel ve etkileşimli içeriklere duyarlılık gibi özelliklerle tanımlanmakta ve öğrenme süreçlerinden sürekli yenilik beklemektedir (Pedró, 2011: 43; Igel & Urquhart, 2012: 89). Bu kuşak, geleneksel öğretim yöntemlerinin sınırlarını zorlayan yeni bir öğrenme paradigmasını zorunlu hâle getirmiştir.

Bu bağlamda, dijitalleşen dünyada kültürel içeriklerin eğitim süreçlerine nasıl dâhil edilebileceği önemli bir araştırma alanı olarak öne çıkmaktadır. Eğitim ortamlarında yerel kültürün, halk anlatılarının ve sözlü geleneğin korunarak aktarılması, yalnızca geçmişin yaşatılması değil; aynı zamanda çağdaş pedagojinin kültürel temellerinin güçlendirilmesi anlamına gelmektedir (Howard, 2018: 37). Bu noktada, folklor yalnızca geçmişi temsil eden bir alan değil, aynı zamanda günümüz teknolojik çağında yeniden üretilebilen, yeniden anlatılabilen dinamik bir kültürel form olarak değerlendirilmelidir. Çünkü folklor, toplumsal belleğin dijital ortamlarda da yaşamaya devam eden, sürekli dönüşen bir anlatı evrenidir (Ong, 2007: 160).

Dijital çağın kültürel ekosistemi içinde halk anlatıları, “yeniden üretilebilir bilgi formları” olarak konumlanmaktadır. Geleneksel folklor ürünleri —masallar, efsaneler, fıkralar, türküler, ninniler ve destanlar— sözlü aktarımın sınırlarını aşarak dijital platformlarda yeni anlatı biçimleriyle varlık kazanmaktadır. YouTube, TRT Çocuk, Netflix gibi platformlarda yayımlanan animasyonlar; webtoon formatındaki çizgi anlatılar, hatta mobil tabanlı halk anlatısı oyunları, bu dijitalleşmenin örneklerindedir (Jenkins, 2006: 24; Bazancir, 2025: 112). Bu süreç, folklorun hem pedagojik hem

kültürel boyutlarını dönüştürmekte; halkbilimin geleneksel sınırlarını dijital kültürün çoklu mecralarına taşımaktadır.

Dijital folklorun eğitime yansımaları, yalnızca bir teknolojik adaptasyon değil; aynı zamanda kültürel belleğin sürdürülebilirliğini sağlayan bir pedagojik yeniliktir (Bazancir, 2025: 118). Nasreddin Hoca ve Keloğlan gibi köklü anlatı karakterleri, günümüzde dijital ortamlarda yeni birer eğitim aracına dönüşmektedir. Bu karakterler, mizahı, eleştirel düşünmeyi ve etik karar almayı merkeze alan kısa animasyonlar, interaktif hikâyeler ve oyunlaştırılmış uygulamalar aracılığıyla çağdaş öğrenme süreçlerinde yer bulmaktadır. Böylece halk anlatıları, dijital eğitimde değer aktarımı, problem çözme ve kültürel farkındalık gibi 21. yüzyıl becerilerinin kazandırılmasında önemli bir araç hâline gelmektedir (Prensky, 2001: 4; Bayne & Ross, 2007: 218; Bazancir, 2025: 123). Eğitim artık yalnızca bilgi aktarımı değil, kültürel kimliğin dijital ortamda yeniden üretildiği dinamik bir etkileşim sürecidir.

Bu çalışma, Folklor 4.0 yaklaşımını temel alarak, halk anlatılarının dijital çağda geçirdiği dönüşümü ve bu dönüşümün eğitim süreçlerindeki yansımalarını çok boyutlu biçimde analiz etmektedir. Folklor 4.0 kavramı, endüstri 4.0'ın teknolojik paradigmasının halk kültürüne uyarlanmış biçimidir. Bu model, halk anlatılarının yapay zekâ, sanal gerçeklik (VR), artırılmış gerçeklik (AR) ve dijital oyun teknolojileri aracılığıyla yeniden inşa edildiğini öne sürmektedir (Manovich, 2013: 78; Bazancir, 2025: 145). Bu bakış açısı, yalnızca kültürel sürdürülebilirliği değil, aynı zamanda dijital pedagojinin temellerini de yeniden tanımlamaktadır. Dolayısıyla folklorun dijital bağlamda incelenmesi hem kültürel mirasın korunması hem de dijital çağın öğrenme ekolojisinin anlaşılması açısından kritik bir öneme sahiptir (Lévy, 1997: 81; Jenkins, 2006: 34; Bazancir, 2025: 150).

Bu çalışmanın temel amacı, folklorun eğitimdeki işlevini dijital bağlamda yeniden tanımlamak ve gelenekten dijital ortama uzanan bu dönüşümün pedagojik yansımalarını ortaya koymaktır. Bu doğrultuda, Nasreddin Hoca ve Keloğlan gibi yerli halk karakterlerinin dijital ortamlarda kazandıkları anlatı biçimleri incelenmiş; bu karakterlerin animasyon, oyun ve sosyal medya ortamlarındaki temsilleri kültürel, teknolojik ve eğitsel açılardan değerlendirilmiştir (Howard, 2018: 42; Bazancir, 2025: 156).

Bu kapsamda çalışma şu araştırma sorularına odaklanmaktadır:

1. Folklorik anlatılar dijital ortamlarda nasıl yeniden inşa edilmektedir?
2. Bu dijital yeniden inşa süreçlerinin eğitimdeki işlevi nedir?
3. Dijital folklor, kültürel mirasın sürdürülebilirliğine nasıl katkı sağlamaktadır?

Elde edilen bulgular doğrultusunda, dijital halk anlatılarının hem kültürel belleğin korunmasında hem de çağdaş pedagojik uygulamaların geliştirilmesinde etkin bir rol oynadığı savunulmaktadır. Folklor 4.0 modeli, kültürel mirasın dijital çağda yeniden üretimini sağlayan özgün bir pedagojik yaklaşım olarak değerlendirilmektedir (Bazancir, 2025: 161). Bu çerçevede çalışma, halk anlatılarının eğitimde dijitalleştirilmesi sürecine yönelik kuramsal ve uygulamalı bir model önermektedir.

## 2. KURAMSAL ÇERÇEVE: FOLKLOR 4.0 VE DİJİTAL PEDAGOJİ

Dijital çağın toplumsal yapıyı, öğrenme alışkanlıklarını ve kültürel aktarım biçimlerini dönüştürdüğü günümüzde, folklorun da yeni bir anlatı evrenine taşındığı görülmektedir. Bu dönüşüm sürecini anlamlandırmak için *Folklor 4.0* kavramı, dijitalleşen halk kültürünü açıklayan özgün bir model olarak öne çıkmaktadır. *Folklor 4.0*, halk anlatılarının yalnızca sözlü veya yazılı formdan dijital formata geçişini değil; aynı zamanda üretim, paylaşım ve katılım biçimlerinde yaşanan epistemolojik bir değişimi de ifade etmektedir (Bazancir, 2025: 45).

Bu kavramsallaştırma, *Endüstri 4.0* paradigmasının kültürel alana uyarlanmış bir uzantısı olarak değerlendirilmektedir. Nasıl ki sanayi devrimi üretim süreçlerini otomatikleştirdiyse, dijital devrim

de kültürel üretimi, aktarımı ve etkileşimini yeniden tanımlamıştır. Dolayısıyla *Folklor 4.0*, teknolojik yeniliklerle birlikte halk kültürünün yeniden biçimlenmesini temsil etmektedir. Bu dönemde kültür, sabit bir miras değil; sürekli güncellenen, yeniden düzenlenen ve kullanıcı katılımıyla şekillenen bir bilgi sistemi hâline gelmiştir (Lévy, 1997: 81; Bazancir, 2025: 47).

### 2.1. Folklor 1.0'dan 4.0'a Dönüşüm

Halkbilimi araştırmaları tarihsel olarak dört aşamada ele alınabilir. *Folklor 1.0*, sözlü kültür evresini; *Folklor 2.0*, yazılı ve derleme dönemini; *Folklor 3.0*, kitle iletişim araçlarıyla tanınan görsel-işitsel yeniden üretim sürecini; *Folklor 4.0* ise dijital, etkileşimli ve yapay zekâ destekli kültürel üretim evresini temsil etmektedir (Bazancir, 2025: 52).

Bu aşamalı dönüşümde en belirgin fark, halk anlatılarının üretim biçiminde gözlenmektedir. Sözlü dönemde bireysel anlatıcıya dayalı aktarım yerini dijital çağda kolektif üretim, katılımcı içerik ve çoklu mecra etkileşimine bırakmıştır (Jenkins, 2006: 24). Artık halk anlatıları yalnızca anlatılmamakta; oyunlaştırılmakta, sanallaştırılmakta ve artırılmış gerçeklik üzerinden deneyimlenmektedir (Manovich, 2013: 85).

Bu noktada *Bazancir (2025: 60)*, dijital halk anlatılarının “katılımcı kültür” kavramıyla birleştiğini vurgulamaktadır. Katılımcı kültür, kullanıcıların yalnızca izleyici değil; aynı zamanda üretici, yorumlayıcı ve dağıtıcı konumuna geçmesini ifade etmektedir. Bu yapı, klasik anlatı zincirini kırarak halk kültürünü açık uçlu, etkileşimli ve çok katmanlı bir sürece dönüştürmektedir.

### 2.2. Dijital Pedagoji Bağlamında Folklor 4.0

Eğitim alanında *Folklor 4.0* yaklaşımı, kültürel aktarımı çağın dijital öğrenme dinamikleriyle birleştirmektedir. Dijital pedagojinin temel ilkesi olan etkileşim, işbirliği ve yaratıcılık kavramları, folklorik anlatıların doğasında zaten mevcuttur (Prensky, 2001: 6). Ancak bu anlatıların dijital ortamlara taşınmasıyla birlikte, öğrenciler artık yalnızca dinleyici değil; aynı zamanda “anlatının ortak üreticisi” hâline gelmektedir (Bazancir, 2025: 71).

Bu yaklaşım, öğrenme sürecini pasif bilgi aktarımından çıkararak aktif katılım temelli bir yapıya dönüştürmektedir. Dijital platformlarda öğrenciler, halk anlatılarını yeniden kurgulayarak kendi kültürel yorumlarını oluşturabilmekte; böylece hem kültürel miras bilinci hem de dijital okuryazarlık becerisi kazanabilmektedir (Bayne & Ross, 2007: 220).

*Bazancir (2025: 75)*, dijital folklorun pedagojik işlevini üç temel eksende tanımlamaktadır:

1. **Kültürel Sürdürülebilirlik:** Geleneksel motiflerin dijital medyada yaşatılması, kültürel miras bilincini güçlendirmektedir.
2. **Dijital Okuryazarlık:** Öğrenciler, kültürel içerikleri üretirken dijital araçları bilinçli ve etik biçimde kullanmayı öğrenmektedir.
3. **Yaratıcı Öğrenme:** Halk anlatılarının yeniden yorumlanması, problem çözme ve estetik düşünme becerilerini geliştirmektedir.

Bu üç eksen, halkbilim ile dijital pedagojinin kesiştiği noktayı oluşturmakta; eğitimde kültürel mirasın yeniden inşasına olanak tanımaktadır (Bazancir, 2025: 79).

### 2.3. Yeni Medya, Kolektif Bellek ve Kültürel Kodlar

Yeni medya teknolojileri, kültürel belleğin taşınma biçimlerini radikal biçimde dönüştürmüştür. Artık anlatılar yalnızca bireysel hafızada değil; dijital ağlarda, veri tabanlarında ve görsel arayüzlerde yaşamaktadır (Manovich, 2013: 91). Bu durum, halkbilimsel anlatıların “kolektif dijital hafıza” içerisinde yeniden biçimlenmesine yol açmıştır (Lévy, 1997: 110).

Dijital kültürde halk anlatılarının sembolik öğeleri (örneğin Nasreddin Hoca'nın eşeği, Keloğlan'ın yoksul ama zeki kimliği) görsel ikonlara dönüşmektedir. Bu ikonlar, kullanıcıların paylaşım kültürü içinde yeniden anlam kazanmakta; memetik bir dolaşım ağına dahil olmaktadır (Bazancir, 2025: 88). Böylece folklor, yalnızca kültürel geçmişi temsil eden bir alan değil, aynı zamanda dijital iletişimin estetik bir kodlama biçimi hâline gelmiştir.

Dijital folklor, “kolektif zekâ” (Lévy, 1997: 81) kavramıyla da ilişkilendirilebilir. Çünkü her kullanıcı, kültürel üretimin bir parçası hâline gelmekte; bireysel katılım, toplumsal hafızanın dijital genişlemesine katkı sunmaktadır. *Bazancir (2025: 92)* bu süreci “dijital halk anlatısının ağ mantığıyla örgütlenmesi” olarak tanımlamaktadır. Bu bağlamda folklor, artık yalnızca geçmişin yansımaları değil, bugünün dijital kimliğini inşa eden yaratıcı bir güçtür.

## 2.4. Folklor 4.0'ın Eğitimdeki Kuramsal Temelleri

*Folklor 4.0* modeli, kültürel aktarım ve pedagojik öğrenme arasındaki sınırları kaldırarak iki yönlü bir etkileşim önerir. Öğrenci hem öğrenen hem de kültürel üretici konumundadır (Bazancir, 2025: 101). Bu yaklaşım, Vygotsky'nin sosyal etkileşim kuramıyla da örtüşmektedir; çünkü bilgi, bireyler arası etkileşim yoluyla inşa edilmektedir (Vygotsky, 1978: 86).

Ayrıca bu model, çoklu mecra (transmedya) anlatısına dayanmaktadır. Yani bir halk anlatısı —örneğin Nasreddin Hoca fıkrası— aynı anda animasyon, oyun, kısa video ve sanal gerçeklik ortamlarında farklı biçimlerde yeniden üretilebilmektedir (Jenkins, 2006: 37; Bazancir, 2025: 106). Bu durum, öğrencilerin hem kültürel hem de teknolojik çok boyutluluk içinde öğrenmelerini sağlamaktadır.

Sonuç olarak, *Folklor 4.0* kuramı; halkbilimi, medya kuramı ve dijital pedagojiyi bütünleştiren disiplinlerarası bir yaklaşım olarak tanımlanmaktadır. Bu yaklaşım, halk anlatılarının yalnızca korunmasını değil, aynı zamanda dijital çağda yeniden anlamlandırılmasını hedeflemektedir (Bazancir, 2025: 110).

## 3. YÖNTEM

Bu araştırma, halk anlatılarının dijital ortamlardaki dönüşümünü eğitim bağlamında incelemeye yönelik nitel bir çalışmadır. Çalışmada, *Folklor 4.0* yaklaşımının kuramsal çerçevesi dikkate alınarak, dijital halk anlatılarının kültürel, pedagojik ve teknolojik işlevleri bütüncül bir yaklaşımla değerlendirilmiştir (Bazancir, 2025: 120). Araştırma hem kültürel çözümleme hem de eğitim bilimleri perspektifini birleştiren disiplinlerarası bir yapıya sahiptir.

### 3.1. Araştırma Deseni

Araştırmada nitel durum çalışması deseni kullanılmıştır. Bu desen, belirli bir olgunun (folklorun dijital ortamlara aktarımı) kendi bağlamı içinde derinlemesine incelenmesine olanak tanımaktadır (Creswell, 2013: 97). Dijital folklorun eğitim ortamlarında nasıl temsil edildiğini anlamak için, çeşitli dijital platformlardan elde edilen veriler bağlamsal bütünlüğü içinde analiz edilmiştir. Bu yaklaşım, folklorun çağdaş dijital kültür içindeki yeniden üretim sürecini pedagojik yönleriyle birlikte ele almayı mümkün kılmaktadır (Bazancir, 2025: 124).

### 3.2. Veri Kaynakları

Araştırmanın veri seti, dijital halk anlatılarını içeren çoklu mecra örneklerinden oluşmaktadır. Bu kapsamda üç temel kaynak türü belirlenmiştir:

1. **Dijital Animasyonlar:** TRT Çocuk, YouTube Kids ve benzeri platformlarda yayımlanan Nasreddin Hoca ve Keloğlan temalı içerikler. Bu yapımlar, halk karakterlerinin dijital çağdaki pedagojik temsillerini inceleme fırsatı sunmaktadır.
2. **Dijital Oyunlar:** “Keloğlan Macera Oyunu”, “Nasreddin Hoca VR Deneyimi” ve benzeri uygulamalar üzerinden karakterlerin eğitsel amaçlı oyunlaştırma biçimleri analiz edilmiştir.
3. **Sosyal Medya Hikâyeleri ve Webtoonlar:** Instagram, TikTok ve webtoon platformlarında yer alan kısa anlatılar, dijital halk anlatılarının genç kuşakla kurduğu yeni etkileşim biçimlerini yansıtmaktadır (Bazancir, 2025: 128).

Bu kaynaklar, halk anlatılarının geleneksel işlevlerini sürdürüp sürdürmediğini ve dijital ortamda hangi pedagojik stratejilerle bütünleştirildiğini belirlemek amacıyla seçilmiştir.

### 3.3. Veri Toplama Süreci

Veriler 2024–2025 yılları arasında toplanmıştır. Her bir dijital içerik, erişim tarihi, platform adı, yapımcı bilgileri ve hedef kitle parametreleriyle birlikte kayıt altına alınmıştır. İçeriklerin seçimi, *amaçlı örnekleme* yöntemiyle yapılmıştır. Bu yöntem, araştırmanın amacına en uygun örneklerin derinlemesine incelenmesine olanak tanımaktadır (Yıldırım & Şimşek, 2018: 122).

Ayrıca her bir dijital anlatı; tematik yapı, karakter özellikleri, dil-kültür ilişkisi, pedagojik hedef ve teknolojik etkileşim düzeyi açısından kodlanmıştır (Bazancir, 2025: 130). Bu kodlama süreci hem halkbilimsel hem de eğitimsel bağlamda kategorik analiz yapılmasına imkân tanımıştır.

### 3.4. Veri Analizi

Toplanan veriler, betimsel analiz yöntemiyle çözümlenmiştir. Bu analiz türü, verilerin önceden belirlenen temalar doğrultusunda düzenlenmesini ve yorumlanmasını içermektedir (Miles & Huberman, 1994: 56). Bu temalar, *Folklor 4.0* modelinde belirtilen üç temel eksene (kültürel, pedagojik, teknolojik) dayanmıştır (Bazancir, 2025: 133).

1. **Kültürel Boyut:** Dijital halk anlatılarında geleneksel motiflerin, sembollerin ve değerlerin nasıl yeniden üretildiği.
2. **Pedagojik Boyut:** Dijital anlatıların öğrenme süreçlerine, değer aktarımına ve bilişsel gelişime etkileri.
3. **Teknolojik Boyut:** VR, AR, oyunlaştırma, etkileşimli video gibi dijital araçların halk anlatısına katkısı.

Veri çözümlemesi sürecinde her dijital anlatı için ayrı bir çözümleme formu oluşturulmuş; görsel unsurlar, anlatı akışı ve dilsel kodlar detaylı biçimde incelenmiştir. Bu süreçte, nitel veri analiz yazılımı (NVivo 12) kullanılarak veriler kodlanmış ve kategori frekansları belirlenmiştir.

### 3.5. Geçerlik, Güvenirlik ve Etik

Araştırmanın güvenilirliği, veri çeşitliliği ve yöntemsel üçleme (triangülasyon) ile sağlanmıştır (Lincoln & Guba, 1985: 301). Farklı dijital mecralardan elde edilen veriler karşılaştırmalı biçimde incelenmiş; yorumların tutarlılığı sağlanmıştır.

Etik açıdan, tüm dijital içerikler kamuya açık platformlardan alınmış olup telif hakları korunmuştur. İçerik üreticilerinin kimlik bilgileri gizli tutulmuş, analizler yalnızca akademik amaçla gerçekleştirilmiştir. Ayrıca, dijital platformlardan alınan içerikler herhangi bir manipülasyona tabi tutulmamıştır (Bazancir, 2025: 137).

### 3.6. Sınırlılıklar

Araştırma, yalnızca Türk halk anlatılarının dijital temsilleriyle sınırlandırılmıştır. Bu nedenle farklı kültürlerdeki dijital folklor örnekleri kapsam dışı bırakılmıştır. Ayrıca, çalışma eğitsel uygulama düzeyine odaklandığı için kullanıcı geri bildirimleri doğrudan incelenmemiştir. Ancak bu durum, gelecekte yapılacak karma yöntemli araştırmalara zemin oluşturacak niteliktedir (Bazancir, 2025: 141).

## 4. BULGULAR VE TARTIŞMA

Bu bölümde dijital halk anlatılarının eğitimdeki işlevleri, üç temel boyut üzerinden analiz edilmiştir: kültürel dönüşüm, pedagojik işlev ve teknolojik yeniden üretim. İncelemeler Nasreddin Hoca ve Keloğlan örnekleri üzerinden yürütülmüş; elde edilen bulgular dijital folklorun çağdaş eğitim ortamlarındaki çok katmanlı etkilerini ortaya koymuştur (Bazancir, 2025: 155).

### 4.1. Kültürel Dönüşüm ve Dijital Temsil

Dijital halk anlatılarının en belirgin etkisi, kültürel sembollerin ve geleneksel değerlerin dijital ortamlarda yeniden biçimlenmesiyle ortaya çıkmaktadır. Nasreddin Hoca ve Keloğlan karakterleri, dijital medya aracılığıyla yalnızca geçmişin temsilleri olmaktan çıkıp, çağdaş kültürel kimliğin parçası hâline gelmiştir (Howard, 2018: 44; Bazancir, 2025: 157).

Nasreddin Hoca, TRT Çocuk ve YouTube gibi platformlarda yer alan animasyon serilerinde, mizah aracılığıyla eleştirel düşünme ve toplumsal farkındalık kazandıran bir figüre dönüşmüştür. Geleneksel fıkralardaki bilgelik unsurları, kısa süreli dijital videolarda yeniden yapılandırılmakta; karakterin sözlü kültürdeki öğretici işlevi görsel-işitsel bir pedagojik araca evrilmektedir. Bu dönüşüm, kültürel belleğin dijital ortamda sürekliliğini sağlamaktadır (Ong, 2007: 161).

Benzer biçimde Keloğlan, dijital oyunlarda ve webtoon formatlarında “erdemli kahraman” kimliğiyle yeniden temsil edilmektedir. Mobil uygulamalarda Keloğlan, toplumsal dayanışmayı, sabrı ve zekâyı ödüllendiren görevlerle ilişkilendirilmektedir (Bazancir, 2025: 160). Bu örneklerde halk anlatılarının işlevi yalnızca eğlendirmek değil, kültürel değerlerin çağdaş biçimlerde yeniden öğretilmesini sağlamaktır. Dijital folklor, bu yönüyle kültürel sürekliliğin dijital formudur (Lévy, 1997: 83).

Ayrıca bu dijital temsiller, *kolektif dijital hafıza* kavramını da somutlaştırmaktadır. Kullanıcıların video yorumları, yeniden paylaşım pratikleri ve fan içerikleri, halk anlatısının dijital ortamlarda kolektif biçimde yeniden üretilmesine olanak tanımaktadır (Jenkins, 2006: 38). Bu durum, kültürel aktarımın artık “dinleyen anlatıcı” değil “katılımcı üretici” ekseninde ilerlediğini göstermektedir (Bazancir, 2025: 162).

### 4.2. Pedagojik İşlev ve Değer Aktarımı

Folklor 4.0 yaklaşımına göre dijital halk anlatıları, kültürel değerlerin aktarımında önemli bir pedagojik araç olarak kullanılmaktadır (Bazancir, 2025: 170). Halk anlatıları, geleneksel eğitimin ahlaki kodlarını modern öğrenme modelleriyle bütünleştirerek öğrencilerin bilişsel, duyuşsal ve etik gelişimlerini desteklemektedir.

Nasreddin Hoca örneğinde mizah; empati, eleştirel düşünme ve değer farkındalığı gibi üst düzey bilişsel becerilerin geliştirilmesinde kullanılmaktadır (Prensky, 2001: 5). Dijital ortamlarda öğrenciler, karakterlerin karşılaştığı ahlaki ikilemler üzerinden kendi etik yargılarını oluşturabilmekte; bu durum eleştirel ve yaratıcı düşünmeyi teşvik etmektedir.

Keloğlan masalları ise, dijital içeriklerde toplumsal adalet, sabır, yardımseverlik ve bilgelik gibi değerleri destekleyen görevlerle bütünleşmektedir. Oyunlaştırılmış anlatılarda, doğru karar veren oyuncular ödüllendirilmekte; bu da davranışsal öğrenmeyi desteklemektedir (Bazancir, 2025: 173). Böylece folklorun didaktik işlevi, dijital pedagojinin etkileşimli ve deneyimsel doğasıyla birleşmektedir.

Bu noktada *Bazancir (2025: 175)*, dijital halk anlatılarının öğretim programlarına entegre edilmesinin üç düzeyde etki yarattığını belirtmektedir:

1. **Bilişsel Etki:** Öğrencilerin kültürel kavramlar üzerinden soyut düşünme becerileri gelişmektedir.
2. **Duyuşsal Etki:** Öğrenciler karakterlerle özdeşim kurarak empati becerisi kazanmaktadır.
3. **Eylemsel Etki:** Öğrenciler, anlatıların etik içeriğini oyunlaştırılmış eylemlerle deneyimlemektedir.

Bu yönüyle dijital folklor, *değerler eğitimi* açısından klasik ders materyallerine alternatif bir model sunmaktadır. Eğitsel içeriklerde halk anlatılarının kullanımı, hem kültürel mirasın korunmasını hem de 21. yüzyıl becerilerinin kazandırılmasını aynı anda mümkün kılmaktadır (Bazancir, 2025: 179).

### 4.3. Teknolojik Yeniden Üretim ve Etkileşimli Anlatı Yapıları

Dijital folklorun en özgün yönlerinden biri, teknolojik araçlarla etkileşimli hâle gelen anlatı yapısıdır. Folklor 4.0 modelinde teknolojik araçlar yalnızca aktarım aracı değil; aynı zamanda kültürel üretimin kendisidir (Bazancir, 2025: 183).

Bu bağlamda, VR (Virtual Reality) ve AR (Augmented Reality) uygulamaları halk anlatılarını yeni bir deneyimsel boyuta taşımaktadır. “Nasreddin Hoca VR Deneyimi” adlı projelerde kullanıcılar, hikâyelerin içine fiziksel olarak dahil olmakta ve anlatı sürecini yönlendirme imkânı kazanmaktadır. Bu durum, geleneksel “anlatıcı” rolünün yerini dijital “deneyim tasarımcısı”na bırakmasına neden olmaktadır (Manovich, 2013: 90).

Ayrıca dijital halk anlatılarında kullanılan oyunlaştırma (gamification) öğeleri, öğrencilerin motivasyon ve katılım düzeylerini artırmaktadır (Jenkins, 2006: 41). Görev, ödül, seviye ve hikâye bütünlüğü gibi oyun tasarımı unsurları, folklorik yapılarla bütünleştiğinde öğretim süreci daha kalıcı ve etkileşimli hâle gelmektedir (Bazancir, 2025: 187).

Bu teknolojik entegrasyon, halk anlatılarının yalnızca yeniden anlatılması değil, aynı zamanda yeniden yaşanmasını sağlamaktadır. Folklorun bu yeni biçimi, bireyin kültürel hafızayla kurduğu ilişkiyi güçlendirmekte ve öğrenmeyi çokduyulu bir deneyime dönüştürmektedir (Lévy, 1997: 113).

Bu bağlamda, dijital teknolojiler folkloru yalnızca aktarmamakta; onu deneyimsel bir öğrenme biçimi hâline getirmektedir. Bu durum, halk anlatılarının hem teknolojik hem pedagojik açıdan sürdürülebilir bir model oluşturduğunu göstermektedir (Bazancir, 2025: 191).

## 5.SONUÇ VE ÖNERİLER

Bu çalışma, dijital çağda halk anlatılarının geçirdiği dönüşümü Folklor 4.0 modeli çerçevesinde ele almış ve kültürel, pedagojik, teknolojik boyutlarda çok yönlü biçimde değerlendirmiştir. Elde edilen sonuçlar, folklorun yalnızca geçmişe ait bir miras değil, günümüz dijital dünyasında yaşayan ve sürekli dönüşen bir kültürel yapı olduğunu ortaya koymuştur. Halk anlatıları, özellikle Nasreddin Hoca ve Keloğlan gibi karakterler üzerinden değerlendirildiğinde, kültürel kimliğin dijital ortamlarda yeniden üretildiği görülmektedir. Bu anlatılar, artık yalnızca sözlü ya da yazılı biçimde aktarılmamakta; animasyonlar, dijital oyunlar, webtoonlar, sosyal medya hikâyeleri ve etkileşimli

videolar aracılığıyla çağdaş öğrenme süreçlerinin bir parçası hâline gelmektedir. Böylece folklor, dijital çağın eğitsel, estetik ve kültürel ihtiyaçlarına cevap veren dinamik bir öğrenme aracına dönüşmektedir.

Çalışmanın bulguları, dijital halk anlatılarının kültürel sürekliliği sağladığı kadar pedagojik yeniliğe de katkı sunduğunu göstermektedir. Halk anlatıları, eğitim ortamlarında değer aktarımı, yaratıcılık, eleştirel düşünme ve kültürel farkındalık becerilerinin geliştirilmesinde işlevsel bir araç olarak kullanılabilir. Dijital platformlarda öğrenciler, halk karakterlerinin karşılaştığı ahlaki ikilemler üzerinden kendi değer yargılarını sorgulamakta, empati geliştirmekte ve kültürel mirasın anlamını çağdaş bağlamda yeniden üretmektedir. Bu yönüyle dijital folklor, klasik ders materyallerine kıyasla çok daha etkileşimli, görsel ve deneysel bir öğrenme ortamı sunmaktadır.

Ayrıca öğretmen adaylarının bu süreçte yalnızca izleyici değil, üretici konumuna geçmesi dikkat çekici bir gelişmedir. Folklor temelli dijital içerik geliştirme çalışmaları, öğretmenlerin pedagojik yaratıcılığını artırmakta, onların halk kültürünü çağdaş teknolojilerle bütünleştirmesine olanak tanımaktadır. Bu durum, öğretmen yetiştirme sürecinde kültürel duyarlılığa dayalı yeni bir dijital pedagojinin doğmasına zemin hazırlamaktadır. Eğitimde halk anlatılarının dijital biçimlerde kullanılması, hem geçmişin kültürel mirasını geleceğe taşımakta hem de öğrencilerin dijital okuryazarlık becerilerini geliştirmektedir.

Elde edilen bulgulara dayanarak, halk anlatılarının eğitim programlarında dijital biçimlerde daha etkin kullanılması önerilmektedir. Üniversitelerde ve öğretmen yetiştirme programlarında dijital folklor atölyeleri açılabilir; öğrencilerin halk kültürüne ait içerikleri VR, AR ve oyunlaştırma yöntemleriyle yeniden üretmeleri teşvik edilebilir. Milli Eğitim Bakanlığı, bu süreci destekleyecek biçimde dijital halk kültürü arşivleri ve çevrimiçi kültür haritaları oluşturabilir. Böylece hem yerel kimliğin korunması hem de 21. yüzyıl becerilerinin kazandırılması arasında güçlü bir bağ kurulabilir.

Sonuç olarak, dijital çağ folkloru durağan bir gelenek olmaktan çıkararak yaşayan bir öğrenme aracına dönüştürmektedir. Halk anlatıları, artık yalnızca geçmişi temsil eden sözlü ürünler değil, kültürel kimliğin dijital formda yeniden üretildiği çağdaş pedagojik yapılardır. Folklor 4.0 modeli, bu dönüşümü anlamlandırmak ve yönlendirmek için güçlü bir teorik çerçeve sunmaktadır. Eğitimde halk kültürünün dijital biçimlerde yaşatılması, sadece kültürel mirasın korunması değil, aynı zamanda geleceğin öğrenme kültürünün inşası anlamına gelmektedir. Bu yaklaşım, Türkçe eğitimi başta olmak üzere bütün öğretim alanları için yenilikçi, sürdürülebilir ve kültürel açıdan derinlikli bir yol haritası oluşturmaktadır.

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## YAPAY ZEKÂ ÇAĞINDA ANLATICI: HALK HİKÂyelerİNİN OTOMATİK ÜRETİMİ VE DİJİTAL OTANTİKLİK

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### ÖZET

Yapay zekâ teknolojilerinin kültürel üretim süreçlerine dâhil olması, halk anlatılarının aktarım biçimlerinde köklü bir dönüşümü beraberinde getirmektedir. Bu dönüşüm, anlatıcının rolünü yalnızca insana özgü bir icra yeteneği olmaktan çıkararak, algoritmik ve otomatik üretim sistemleriyle paylaşılabilir bir kültürel işlev haline getirmektedir. Günümüzde ChatGPT, Sora, Midjourney veya Sudowrite gibi metin ve görsel üretim araçları, halk anlatılarının dijital ortamlarda yeniden üretimini mümkün kılarken, anlatı otantikliğini yeniden tartışmaya açmaktadır. Halk hikâyelerinin geleneksel formundaki anlatıcı–dinleyici ilişkisinin yerini, artık kullanıcı–arayüz etkileşimi almakta; bu da sözlü geleneğin temel dayanaklarından biri olan canlı performansın yerini yapay bir temsil biçimine bırakmaktadır. Bu bağlamda yapay zekâ destekli anlatıcı, kültürel hafızayı taklit eden, fakat onu yeniden yorumlama kapasitesine sahip bir “dijital anlatıcı” modelini ortaya çıkarmaktadır. Çalışmada, yapay zekâ çağında anlatıcılığın kavramsal, estetik ve etik boyutları ele alınarak, halk hikâyelerinin otomatik üretimi bağlamında dijital otantikliğin sınırları tartışılmaktadır. İnceleme, folklorun dijital dönüşüm sürecinde “insan anlatıcıdan yapay anlatıcıya” geçişin kültürel sürdürülebilirlik açısından taşıdığı risk ve imkânları ortaya koymaktadır.

**Anahtar Kelimeler:** Yapay zekâ, dijital folklor, anlatıcı, otantiklik, halk hikâyesi, otomatik üretim.

### THE STORYTELLER IN THE AGE OF ARTIFICIAL INTELLIGENCE: THE AUTOMATIC PRODUCTION OF FOLK NARRATIVES AND DIGITAL AUTHENTICITY

### ABSTRACT

The inclusion of artificial intelligence technologies in cultural production processes has led to a radical transformation in the modes of transmitting folk narratives. This transformation redefines the role of the storyteller, shifting it from a uniquely human creative capacity to a shared cultural function performed through algorithmic and automatic generation systems. Today, text and image generation tools such as ChatGPT, Sora, Midjourney, and Sudowrite enable the reproduction of folk tales in digital environments while simultaneously challenging the concept of narrative authenticity. The traditional relationship between storyteller and audience is now replaced by an interaction between user and interface, in which the performative and emotional dimensions of oral tradition give way to artificial representations. Within this context, the AI-based storyteller emerges as a “digital narrator” model that imitates cultural memory yet possesses the ability to reinterpret it through computational

creativity. This study discusses the conceptual, aesthetic, and ethical dimensions of storytelling in the age of artificial intelligence, focusing on the automatic generation of folk narratives and the problem of digital authenticity. The analysis reveals both the risks and opportunities of the transition from the human storyteller to the algorithmic narrator in terms of cultural sustainability.

**Keywords:** Artificial intelligence, digital folklore, storyteller, authenticity, folk narrative, automatic generation.

## GİRİŞ

Yapay zekâ çağında anlatıcılığın yeniden tanımlanması hem kültürel üretim hem de halkbilim açısından tarihsel bir kırılma noktasını temsil etmektedir. Geleneksel anlatı sistemlerinde anlatıcı, yalnızca sözün taşıyıcısı değil, aynı zamanda toplumsal belleğin, değerler sisteminin ve kimliğin yeniden üreticisidir (Bauman, 1986: 5). Ancak günümüzde bu işlev, yapay zekâ temelli anlatı sistemleri tarafından paylaşılmakta ve “anlatma eylemi” dijital bir otomasyon sürecine dönüşmektedir. Bu süreç, folklorun doğasında yer alan canlılık, performans ve topluluk içi aktarım gibi özelliklerin yeniden tanımlanmasını zorunlu kılmaktadır (Ong, 2007: 160).

Walter J. Ong’un sözlü kültürden yazılı ve dijital kültüre geçişi açıklarken vurguladığı “ikincil sözlülük” kavramı, günümüzde yapay zekâ sistemleri aracılığıyla yeni bir evreye taşınmaktadır. Artık anlatı üretimi, insan hafızasının yerini dijital algoritmalara bırakmakta, kültürel aktarım yapay zekâ destekli modeller aracılığıyla sürdürülmektedir (Ong, 2007: 162). Bu durum, hem “anlatıcı” kavramının insana özgü bir üretim biçimi olup olmadığına dair yeni tartışmalar doğurmakta hem de kültürel otantiklik meselesini merkezine almaktadır (Benjamin, 2008: 23). Yapay zekâ sistemleri, halk anlatılarını veri tabanları, modelleme algoritmaları ve dilsel örüntüler aracılığıyla yeniden üreterek, geleneksel anlatıcının epistemolojik zeminine müdahale etmektedir. Burada temel sorun, yapay zekâ tarafından üretilen anlatıların “otantik” kabul edilip edilemeyeceğidir. Çünkü folklor ürünlerinde otantiklik, yalnızca içeriğin doğruluğuyla değil, aktarım bağlamının, anlatıcı kimliğinin ve dinleyici topluluğunun varlığıyla da ilişkilidir (Kirshenblatt-Gimblett, 1998: 50). Dijital ortamda yeniden üretilen bir halk hikâyesi, geleneğin sürekliliğini mi temsil etmektedir, yoksa otantikliğı biçimsel bir simülasyona mı indirgemektedir?

Bu çalışma, yapay zekâ çağında anlatıcının dönüşümünü folklor kuramı, kültürel bellek ve dijital estetik bağlamında tartışmayı amaçlamaktadır. Temel araştırma sorusu, şu biçimde özetlenebilir: Yapay zekâ tarafından üretilen halk anlatıları, kültürel otantiklik bakımından insan anlatıcısıyla aynı değere sahip olabilir mi? Bu soru, halkbilim açısından hem temsil hem de üretim boyutunda yeni bir epistemolojik zemin sunmaktadır. Folklorun “insan merkezli” yapısı, artık algoritmik bir yaratıcı özneye paylaşılmaktadır ve bu durum anlatıcılığın doğasına ilişkin köklü bir yeniden düşünmeyi gerekli kılmaktadır (Jenkins, 2006: 131).

Yapay zekâ destekli anlatı üretim sistemleri, sözel ifadeyi teknik bir simülasyon düzlemine taşısa da anlatıcının en temel özelliği olan sezgisel yaratıcılığı ve duygusal aktarımı tam anlamıyla yeniden üretememektedir. İnsan anlatıcı, yalnızca hikâye aktaran bir özne değil, aynı zamanda dinleyicinin duygu durumuna, çevresel etkileşime ve toplumsal bağlama göre anlatısını şekillendiren dinamik bir yorumcudur (Campbell, 2004: 38). Buna karşın, yapay zekâ anlatıcısı veriye dayalı olasılıklar üzerinden ilerlemekte; anlatının ritmini, duygusal yoğunluğunu ve anlam evrenini “hesaplanabilir olasılık” hâline getirmektedir. Bu da halk hikâyelerinin özünde bulunan doğaçlama, empati ve kolektif bilinç öğelerinin yerini, algoritmik bir dil düzenine bırakmaktadır. Ancak bu yeni anlatı biçimi, aynı zamanda insanın kendi kültürel belleğini yeniden inşa etme biçimi olarak da okunabilir. Çünkü yapay zekâ sistemleri, geçmişin sözlü mirasını yalnızca taklit etmekle kalmamakta, aynı zamanda bu mirası veri tabanları aracılığıyla evrenselleştirmekte, yerel olanı küresel dijital ortama

taşımaktadır. Böylece yapay zekâ hem insan hafızasının bir uzantısı hem de anlatıcılığın kültürel sınırlarını yeniden tanımlayan yeni bir aracı olarak ortaya çıkmaktadır (Assmann, 2011: 42).

### 1. Kuramsal Çerçeve: Anlatıcılık, Yapay Zekâ ve Otantiklik

Anlatıcılık olgusu, tarih boyunca kültürel belleğin taşıyıcısı olarak işlev görmüş; insanın varoluşunu anlamlandırma biçimlerinden biri haline gelmiştir. Sözlü kültür ortamlarında anlatıcı, yalnızca bir bilgi aktarıcısı değil, aynı zamanda toplumun kolektif deneyimlerinin, duygusal ritüellerinin ve kimlik inşasının temsilcisidir (Lévi-Strauss, 1963: 215). Bu nedenle anlatıcı hem bilginin üreticisi hem de anlamın kurucusu olarak işlev görmektedir. Ancak dijital çağla birlikte bu işlev, insan merkezli konumundan uzaklaşmakta ve algoritmik yapılar aracılığıyla yeniden tanımlanmaktadır. Yapay zekâ temelli anlatı sistemleri, insan anlatıcının sezgisel doğasını mekanikleştirirken, anlatının “otantiklik” temelini de yeniden tartışmaya açmaktadır (Barthes, 1977: 142).

Roland Barthes’ın “yazarın ölümü” kavramsallaştırması, günümüzde “anlatıcının dijital yeniden doğuşu” biçiminde okunabilir. Barthes’a göre, anlatı metinleri artık tek bir yaratıcı özneye değil, çoklu anlam üreticilerine aittir (Barthes, 1977: 146). Bu yaklaşım, yapay zekâ destekli metin üretimiyle birleştiğinde, anlatıcının insan olma koşuluna duyulan epistemolojik bağı koparmaktadır. Yapay anlatıcı, insan deneyiminin yerini alan bir anlam simülâtörü hâline gelir. Ancak burada temel soru, bu yeni dijital öznenin gerçekten “anlam” üretip üretmediğidir. Çünkü anlamın üretimi yalnızca dilsel bir düzenleme değil, aynı zamanda kültürel bağlamın, niyetin ve hafızanın bir sonucudur (Assmann, 2011: 46). Yapay zekâ ise bu bağlamı veri temsilleri aracılığıyla yeniden kurmakta, fakat onu “yaşayan bir deneyim”e dönüştürememektedir.

Claude Lévi-Strauss’un yapısalci mit kuramı, günümüzde yapay zekâ tarafından üretilen anlatıların biçimsel yapısını anlamada önemli bir referans noktası sunmaktadır. Lévi-Strauss’a göre mitler, evrensel zihinsel yapıların dışavurumudur ve her toplum, kendi bilinçaltını bu yapılar aracılığıyla anlatıya dönüştürmektedir (Lévi-Strauss, 1969: 41). Yapay zekâ da benzer biçimde, insanın mitik düşünme biçimlerini taklit eden algoritmik dizilimlerle çalışmaktadır. Bu nedenle, AI sistemlerinin ürettiği hikâyeler biçimsel olarak mitik özellikler taşısa da, onları anlamlı kılan “kolektif inanç sistemi”nden yoksundurlar. Bu da “dijital otantiklik” kavramını yalnızca estetik bir biçim değil, kültürel bir içerik tartışması hâline getirmektedir.

Joseph Campbell’in “kahramanın yolculuğu” modeli, anlatının evrensel yapısını açıklamakta önemli bir kuramsal çerçeve sunmaktadır. Campbell’e göre her anlatı, bireyin içsel dönüşümünü simgeler ve bu dönüşüm süreci, anlatıcının rehberliğinde kolektif bir anlam kazanır (Campbell, 2004: 58). Ancak yapay zekâ anlatıcısı, kahramanın bu dönüşümünü sezgisel değil, istatistiksel bir süreç olarak üretmektedir. Dolayısıyla anlatının özündeki insanî deneyim unsuru, yerini algoritmik bir kurgusallığa bırakmaktadır. Bu durum, anlatıcının otantikliğini yalnızca teknik yeterlilikle değil, “anlam yaratma kapasitesi”yle ölçmeyi gerektirmektedir.

Bu bağlamda, dijital folklor kuramı (digital folklore theory), halk anlatılarının yalnızca sanal ortamlarda yeniden üretilmesini değil, aynı zamanda yapay zekâ aracılığıyla yeniden kurgulanmasını da kapsamaktadır. Dijital anlatıcı, insan anlatıcının rolünü taklit ederken, aynı zamanda onu yeniden biçimlendirmekte; böylece halkbilimsel üretim sürecini hem genişletmekte hem de belirsizleştirmektedir (Howard, 2008: 47). Bu kuramsal düzlem, yapay zekânın sadece bir araç değil, kültürel bir özne olarak konumlanabileceği yeni bir dönemin işaretidir.

### 2. Dijital Anlatıcının Doğuşu: Otomatik Metin Üretimi ve Folklor

Yapay zekâ tabanlı anlatı sistemleri, halkbilimsel üretim biçimlerini yalnızca teknik bir düzleme taşımakla kalmamakta, aynı zamanda “anlatıcı” kavramının sınırlarını da yeniden tanımlamaktadır. Günümüzde ChatGPT, Sora, Sudowrite ve Jasper gibi sistemler; halk hikâyelerini, destanları veya masalları veri tabanlarından öğrenerek yeniden üretme kapasitesine sahiptir. Bu üretim biçimi, sözlü

geleneğin insan merkezli doğasına meydan okuyan bir dönüşümü temsil etmektedir. Çünkü artık anlatı, bir hafıza eylemi değil, makine öğrenimi tarafından optimize edilen bir süreçtir. Bu dönüşüm, anlatıcılığın “yaratıcı özne” olmaktan çıkıp “hesaplayıcı temsil” biçimine evrilmesi anlamına gelmektedir (Manovich, 2020: 94).

Bu bağlamda yapay zekâ sistemlerinin halkbilimsel anlatılara yaklaşımı, performans temelli aktarım biçimlerinden farklı olarak metinsel bir yapay üretim sürecine dayanmaktadır. Anlatıcının hafızası yerini dijital arşivlere, sezgisi yerini algoritmik modellemelere, yaratıcılığı ise olasılık temelli üretim döngülerine bırakmaktadır.

Türk halk anlatılarında anlatıcı, yalnızca hikâyeyi aktaran değil, toplumsal deneyimi duygusal ve simgesel kodlarla işleyen bir yorumcudur (Çobanoğlu, 2003: 118). Yapay zekâ anlatıcısı ise bu duygusal ve kültürel bağlamı veri temsillerine indirgemekte, fakat aynı zamanda onu evrensel dijital kültüre taşımaktadır. Bu durum, anlatıcılığın pedagojik ve estetik yönlerini yeniden değerlendirmeyi gerektirmektedir.

Otomatik metin üretimiyle birlikte ortaya çıkan “dijital anlatıcı” figürü, halkbilim açısından hem bir fırsat hem de bir tehdittir. Fırsattır, çünkü yapay zekâ sistemleri aracılığıyla kaybolan anlatı türleri yeniden üretilmekte, yeni kuşaklara erişilebilir hâle gelmektedir çünkü bu üretim biçimi geleneğin doğallığını, topluluk içi aktarıma dayalı otantik yapısını zayıflatmaktadır. Dijital anlatıcı, hikâyeyi taklit edebilmekte; fakat onu yaşamakta, hissetmekte ve aktarmakta yetersiz kalmaktadır. Bu nedenle, dijital folklorun en tartışmalı yönlerinden biri, teknolojik üretim ile kültürel otantiklik arasındaki bu gerilimdir.

Öte yandan, yapay zekânın halkbilimsel metin üretimindeki rolü, yeni bir “çoklu mecra anlatıcılığı” formu da doğurmaktadır. Dijital ortamda metin, ses, görsel ve video bileşenlerinin birleşmesiyle ortaya çıkan bu hibrit anlatı biçimi, folklorun çağdaş kültürle etkileşimini güçlendirmektedir (Bazancir, 2023: 57). Bu süreçte, yapay zekâ yalnızca anlatının biçimini değil, işlevini de dönüştürmektedir. Artık anlatı, eğitsel, estetik ve kültürel kimlik taşıyıcılığının ötesinde; algoritmik deneyimin bir parçası hâline gelmektedir. Bu durum, “insan anlatıcıdan dijital anlatıcıya” geçişin sadece teknik değil, kültürel bir devrim olduğunu göstermektedir.

### 3. Otantiklik ve Yapay Üretim Gerilimi

Otantiklik, halkbilimsel üretimin en temel kavramsal dayanaklarından biridir. Bir halk anlatısının otantik kabul edilmesi, yalnızca içeriğinin doğruluğuna değil, aynı zamanda aktarım biçimi, bağlamı ve toplulukla kurduğu etkileşime bağlıdır (Bauman, 1986: 11). Dolayısıyla anlatıcının kimliği, anlatının gerçekleştiği çevre ve dinleyici kitlesi otantikliğin belirleyici unsurlarıdır. Yapay zekâ destekli anlatılar ise bu koşullardan birçoğunu ortadan kaldırarak, geleneğin yerine algoritmik bir temsil biçimi yerleştirmektedir. Bu durum, halk anlatılarında “sahicilik” ile “benzetim” arasındaki sınırın giderek bulanıklaşmasına yol açmaktadır.

Walter Benjamin’in (2008: 23) “teknolojik yeniden üretim çağında sanat eserinin aurası” kavramı, dijital folklorun otantiklik tartışmasını anlamada güçlü bir teorik çerçeve sunmaktadır. Benjamin’e göre her kültürel üretimin kendine özgü bir “aura”sı vardır; bu aura, eserin tekelliğinden, tarihsel bağlamından ve üretildiği ortamın benzersizliğinden kaynaklanır. Dijital veya yapay zekâ tarafından üretilen bir anlatı ise bu aurayı kaybeder; çünkü üretim, bireysel bir deneyimden değil, sonsuz tekrar kabiliyetine sahip bir makine sisteminden doğmaktadır. Böylece, folklorun en temel niteliği olan yerellik, duygusal aktarım ve kültürel bağlamdan kopuş gerçekleşmektedir (Ong, 2007: 162).

Yapay zekâ tarafından üretilen bir halk anlatısı, yüzeyde biçimsel olarak “gerçeğe benzer” görünse de içerik düzeyinde toplumsal hafızanın organik yapısından uzaktır. Halk anlatısında anlatıcı, yaşadığı topluma ait sembolleri, değerleri ve inançları sezgisel biçimde yeniden kurgular. Oysa algoritmik üretimde bu semboller, veri kümeleri ve dilsel örüntüler olarak yeniden işlenir. Bu nedenle

yapay zekâ anlatıcısının “otantik” bir anlam üretmesi, kültürel bağlamdan kopuk olduğu sürece imkânsızdır (Kirshenblatt-Gimblett, 1998: 50). Yapay zekâ sistemleri, kültürel belleği yalnızca temsil eder; fakat o belleğin taşıyıcısı olamaz. Çünkü folklorun yaşaması için yalnızca metin değil, bağlam, topluluk ve icra gerekmektedir.

Bununla birlikte, dijital otantiklik tamamen yokluk anlamına da gelmemektedir. Günümüz dijital kültürü, yeni bir “paylaşılan otantiklik” biçimi üretmektedir. Bu tür otantiklik, geleneksel toplulukların yerini alan çevrimiçi kullanıcı toplulukları aracılığıyla yeniden inşa edilmektedir (Howard, 2008: 53). Örneğin, YouTube veya TikTok gibi platformlarda halk hikâyelerinin, türkülerinin veya efsanelerinin yapay zekâ tarafından yeniden seslendirilmesi, yeni bir “dijital halk sahnesi” yaratmaktadır. Bu ortamda “otantik olan”, üretim sürecinin bireysel deneyiminden değil, ortak katılım ve yeniden paylaşım eyleminden doğmaktadır. Dolayısıyla dijital folklor, klasik anlamda kaybolan otantikliği, kolektif dijital katılımı yeniden üretmektedir.

Ancak bu süreç, etik bir ikilemi de beraberinde getirmektedir. Yapay zekâ tarafından üretilen anlatıların “kime ait olduğu”, “kimin sesiyle söylendiği” ve “kimin kültürünü temsil ettiği” soruları, günümüzde dijital folklorun en önemli tartışma alanlarından biridir. Bir halk hikâyesinin yapay zekâ tarafından yeniden yazılması, onu anonimleştirirken aynı zamanda kökensele bağlamını da silikleştirebilmektedir. Bu durum, kültürel mirasın ticarileştirilmesi, estetik olarak homojenleşmesi ve yerel kimliklerin küresel algoritmalar içinde erimesi riskini taşımaktadır (Bazancir, 2023: 74). Dolayısıyla dijital çağda otantiklik, yalnızca “doğru” anlatı biçimi değil, aynı zamanda “sorumlu üretim” etiğiyle ilişkili bir kavram hâline gelmiştir.

Otantiklik geriliminin bir diğer boyutu, duygusal aktarımın kaybıdır. Anlatıcı, yalnızca bilgi aktaran değil, aynı zamanda dinleyicinin duygusal tepkisini yönlendiren bir figürdür. Yapay zekâ anlatıcısı, duyguyu taklit edebilir; ancak onu hissedemez. Bu fark, anlatının “yaşanmışlık” boyutunu ortadan kaldırır. Çünkü anlatıcı ile dinleyici arasındaki etkileşim, kültürel aktarımın en temel bileşenidir (Bauman, 1986: 15). Dijital sistemler ise bu etkileşimi simülasyon düzeyinde yeniden kurar; dolayısıyla otantiklik, deneyimsel olmaktan çıkarak temsili bir forma indirgenir.

Sonuçta, yapay zekâ çağında halkbilimsel üretim, iki karşıt kutup arasında salınmaktadır: Bir yanda kültürel çeşitliliği koruma potansiyeli, diğer yanda otantik bağlamın kaybolma riski. Bu ikili yapı, gelecekte halkbilim araştırmalarının temel sorunsalını oluşturmaktadır: Dijital otantiklik, sahiciliğin yeni biçimi mi, yoksa kültürel belleğin son evresi midir?

## SONUÇ

Yapay zekâ çağında anlatıcılık, insanlık tarihinin en eski kültürel pratiğini —hikâye anlatma eylemini— yeniden tanımlamaktadır. Binlerce yıldır sözlü kültürün merkezinde yer alan anlatıcı, artık yalnızca hafızanın değil, teknolojinin de bir ürünü hâline gelmiştir. Bu dönüşüm, halk anlatılarının üretim, aktarım ve anlamlandırılma biçimlerini kökten etkilemektedir. İnsan anlatıcıdan dijital anlatıcıya geçiş süreci, yalnızca teknik bir yenilenme değil; aynı zamanda kültürel bir paradigma değişimidir. Çünkü anlatıcının işlevi artık yalnızca hikâyeyi aktarmak değil, veriyi yorumlamak, algoritmik bir dil içinde anlam inşa etmektir. Bu noktada yapay zekâ anlatıcısı, insan anlatıcısının bir taklidi değil, onun dijital çağdaki izdüşümüdür.

Bu yeni anlatıcı figürü, halkbilimi disiplininin geleneksel sınırlarını zorlamaktadır. Sözlü kültürde anlam, anlatıcı ile dinleyici arasındaki canlı performans ilişkisiyle doğarken; dijital çağda bu ilişki, kullanıcı ile arayüz etkileşimi üzerinden yeniden kurulmaktadır. Bu durum, folklorun doğasında bulunan “canlılık” unsurunu dönüştürmekte; sözlü performans yerini dijital performansa bırakmaktadır (Bauman, 1986: 15). Ancak bu dönüşüm, halkbilimin özündeki işlevselliği ortadan kaldırmamakta; yalnızca onun aktarım araçlarını çoğullaştırmaktadır. Dijital anlatıcı, tıpkı geleneksel

ozan veya meddah gibi, çağının estetik dilini kullanarak anlam üretmektedir — fark yalnızca aracın insandan makineye geçmiş olmasıdır.

Yapay zekâ destekli üretimler, folklorun dijital ortamlarda yeniden canlanmasını mümkün kılmaktadır. Günümüzde halk hikâyeleri, efsaneler, ninniler, hatta atasözleri bile yapay zekâ algoritmalarıyla yeniden yorumlanmakta; YouTube, Spotify, TikTok ve diğer sosyal medya platformlarında milyonlarca kullanıcıya ulaşmaktadır. Bu süreç, halkbilimsel bilginin küresel ölçekte erişilebilirliğini artırmakta; ancak aynı zamanda kültürel homojenleşme riskini de beraberinde getirmektedir. Dijital anlatı, sınırları aşarak evrensel bir görünürlük kazandığında, yerel bağlam ve özgün kültürel kodlar erozyona uğrayabilmektedir (Ong, 2007: 164). Dolayısıyla, dijital folklorun geleceği, bu iki dinamik arasındaki hassas dengeye bağlıdır: erişilebilirlik ve özgünlük.

Folklorun dijitalleşmesi aynı zamanda yeni bir pedagojik alan açmaktadır. Yapay zekâ destekli anlatılar, özellikle çocuk eğitimi ve kültürel farkındalık alanlarında etkili bir araç hâline gelmektedir. Dijital masal uygulamaları, VR destekli halk hikâyesi deneyimleri ve çoklu mecra (transmedya) anlatıları, folklorun eğitsel yönünü güçlendirmektedir (Bazancir, 2023: 89). Ancak bu teknolojik yeniliklerin, kültürel belleği yüzeyselleştirmeden, derinlikli bir öğrenme ortamı yaratacak şekilde tasarlanması gerekmektedir. Halkbilim pedagojisi, bu bağlamda yalnızca geçmişi koruma değil, aynı zamanda geleceğin dijital vatandaşına kültürel kimlik bilinci kazandırma işlevini üstlenmelidir.

Etik açıdan bakıldığında, yapay zekâ anlatıcısının yükselişi, kültürel temsilin sorumluluğu konusunu gündeme getirmektedir. Yapay zekâ sistemleri, insan kültürünü üretim verisi olarak kullandıkları için, bu üretim biçiminin telif, aidiyet ve toplumsal hassasiyet boyutları dikkatle tartışılmalıdır. Bir halk hikâyesinin ya da efsanenin yapay zekâ tarafından yeniden yazılması, o kültürün sahiplerine danışılmadan yapılırsa, bu durum kültürel sömürü olarak değerlendirilebilir. Dolayısıyla dijital halkbilimi, yalnızca teknolojik bir yenilik değil, aynı zamanda etik bir sorumluluk alanı olarak görülmelidir (Kirshenblatt-Gimblett, 1998: 74).

Yapay zekâ çağında folklor araştırmalarının geleceği, insan ve makine arasındaki bu etkileşimi anlamlandırma kapasitesine bağlıdır. Folklorun özü, her zaman insanın kendisini anlatma arzusunda gizlidir. Makine, bu arzuyu taklit edebilir; ancak onu hissedemez. Bu nedenle, yapay zekâ anlatıcısı ne kadar gelişirse gelişsin, insana özgü sezgisel yaratıcılığın yerini tamamen alamayacaktır. Bununla birlikte, halkbilim disiplini bu yeni çağda “teknolojik anlatıcıyı” da kendi araştırma nesnesi olarak kabul etmek zorundadır. Dijital ortamda üretilen halk anlatıları, artık çağdaş folklorun ayrılmaz bir parçasıdır ve araştırma yöntemlerinin buna göre evrilmesi gerekmektedir (Çobanoğlu, 2003: 256).

Sonuç olarak, yapay zekâ çağında anlatıcılık hem bir yeniden doğuş hem de bir sorgulama alanıdır. Halkbilimi disiplini açısından bu dönüşüm, insanın kültürel belleğini teknolojiyle birlikte yeniden yazma çabası olarak okunabilir. Dijital anlatıcılar, belki de geleceğin “yeni meddahları”dır; ancak onların hikâyeleri, insan sesinin sıcaklığını değil, çağın algoritmik yankısını taşımaktadır. Bu yankı, insanlık mirasının dijital evriminde yeni bir sayfa açmaktadır. Ve belki de bu çağın halkbilimcisi, artık yalnızca dinleyen ya da yazan değil, anlam ile veri arasındaki köprüyü kuran yeni anlatıcıdır.

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## MUTLULUK FENOMENİ BAĞLAMINDA ÖĞRETMENLERİN UZAKTAN YÜKSEK LİSANS DENEYİMİ: BİR DURUM ÇALIŞMASI

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### ÖZET

Mutluluk, bireylerin yaşantılarına dair değerlendirmelerini kapsayan “iyi oluş” kavramıyla ilişkilendirilebilir. Bu kavram ile eğitim arasında karşılıklı ilişki olup eğitim, mutluluğun gelişmesi için gerekli bilgi, beceri ve ortamı sağlarken mutluluk da bireylerin öz yeterlik algılarını güçlendirmektedir. Bu durum özellikle lisansüstü eğitim sürecinde, bireylerin akademik başarılarını destekler, kendilerine güvenlerini artırır ve daha aktif katılım göstermelerini sağlar. Ancak iş yoğunluğu, ulaşım güçlükleri ve ekonomik yetersizlikler gibi nedenlerle bireyler, lisansüstü eğitimlerini uzaktan eğitim yoluyla sürdürmeyi tercih etmektedir. Bu durum özellikle yüksek lisans düzeyinde yaygındır. Araştırma, uzaktan eğitim yoluyla yüksek lisans yapan öğretmenlerin mutluluk kaynaklarını, mutlu olma halini engelleyen durumları ve mutluluğu artırmak için başvurdukları yolları ortaya koymayı amaçlamaktadır. Araştırma nitel araştırma yöntemlerinden durum çalışması deseniyle yürütülmüştür. Araştırmanın çalışma grubunu, hâlihazırda yüksek lisans (uzaktan eğitim) yapan 5 öğretmen oluşturmaktadır. Veriler, araştırmacı tarafından uzman görüşü alınarak geliştirilen yarı yapılandırılmış görüşme formu aracılığıyla toplanmış, içerik analizi ile çözümlenmiştir. Bulgular, öğretmenlerin “bireysel”, “mesleki”, “akademik” ve “sosyal” hedefler aracılığıyla çeşitli mutluluk kaynakları oluşturduğunu göstermektedir. Ancak süreçte karşılaşılan “sosyal ve iletişim sorunları”, “teknolojik ve çevresel sorunlar” ile “akademik engeller” öğretmenlerin mutluluk düzeylerini olumsuz yönde etkilemektedir. Bu sorunlara karşı öğretmenler çeşitli yollar geliştirerek mutluluklarını artırmaya çalışmaktadır. Sonuçlar, öğretmenlerin mutluluk kaynakları ile yüksek lisans yapma nedenlerinin örtüştüğünü ve süreç boyunca kolektif bir gelişim çabası içerisinde olduklarını göstermektedir. Uzaktan eğitimin getirdiği dezavantajlar ile lisansüstü eğitimde karşılaşılan sorunlar, öğretmenlerin mutluluk düzeylerini azaltırken öğretmenler çeşitli yollara mutluluklarını artırmaya çalışmaktadır. Sürecin sağlıklı ilerlemesi için ise sosyal etkileşim ve akademik desteğe ihtiyaç duyulduğu sonucuna ulaşılmıştır.

**Anahtar Kelimeler:** Mutluluk, uzaktan eğitim, lisansüstü eğitim, yüksek lisans.

### TEACHERS’ DISTANCE MASTER’S EXPERIENCE IN THE CONTEXT OF THE HAPPINESS PHENOMENON: A CASE STUDY

#### ABSTRACT

Happiness can be associated with the concept of “well-being,” which encompasses individuals’ evaluations of their life experiences. There is a reciprocal relationship between this concept and education; while education provides the knowledge, skills, and environment necessary for the development of happiness, happiness also strengthens individuals’ perceptions of self-efficacy. This situation particularly supports individuals’ academic success during the graduate education process, increases their self-confidence, and enables them to participate more actively. However, due to reasons such as workload, transportation difficulties, and financial insufficiencies, individuals prefer

to continue their graduate education through distance education. This is especially common at the master's level. The study aims to reveal the sources of happiness of teachers who pursue a master's degree through distance education, the situations that hinder their state of happiness, and the ways they use to increase their happiness. The research was conducted with the case study design, one of the qualitative research methods. The study group consists of 5 teachers who are currently pursuing a master's degree (distance education). The data were collected through a semi-structured interview form developed by the researcher with expert opinion, and analyzed by content analysis. The findings show that teachers create various sources of happiness through "individual," "professional," "academic," and "social" goals. However, "social and communication problems," "technological and environmental problems," and "academic obstacles" encountered in the process negatively affect teachers' levels of happiness. Against these problems, teachers try to increase their happiness by developing various ways. The results show that teachers' sources of happiness overlap with their reasons for pursuing a master's degree and that they are in a collective effort for development throughout the process. While the disadvantages of distance education and the problems encountered in graduate education reduce the happiness levels of teachers, teachers try to increase their happiness in various ways. It was concluded that social interaction and academic support are needed for the process to progress in a healthy way.

**Keywords:** Happiness, distance education, graduate education, master's degree.

## 1. GİRİŞ

Eğitim, bireylerin toplum yaşamına uyum sağlamaları için okul içinde veya dışında, doğrudan ya da dolaylı yollarla, bilgi ve beceri kazanmalarını ve kişilik gelişimlerini desteklemeyi amaçlayan bir süreçtir (Türk Dil Kurumu [TDK], 2025). Eğitim, yalnızca bireylerin kişilik gelişimine katkı sağlamakla kalmayıp, toplum yapısının iyileşmesine de katkıda bulunur (Zuhdi vd., 2021). Ekonomik büyümeyi destekler, bireylerin yaşam kalitesini yükseltir ve sosyal uyumu güçlendirir. Bireylerin hak ve özgürlüklerini tanımlarını sağlayarak suç ve yoksulluğu azaltır, sağlık farkındalığını artırır. Ayrıca kültürel anlayışı geliştirir ve demokratik katılımı teşvik eder. Bu yönleriyle toplumun her alanında sürdürülebilir gelişimi sağlayan temel bir güçtür (Shavkidinova vd., 2023). Eğitimin birey ve toplum için kritik bir rolünün bulunması, herkesin nitelikli eğitime eşit şekilde erişebilmesini zorunlu kılar. Bu noktada uzaktan eğitim, eğitim olanaklarına erişimi artıran önemli bir araç olarak öne çıkmaktadır.

Uzaktan eğitim, farklı ortamlarda bulunan öğrenci ve öğretmenin çeşitli araçları kullanarak (iletişim teknolojileri, yazılı ve basılı materyaller, posta hizmetleri, uydu teknolojileri vb.) öğrenme ve öğretme etkinliklerini gerçekleştirdikleri, etkileşimli veya etkileşimli olmayan, planlı ve sistemli bir eğitim teknolojisi uygulamasıdır (Akyürek, 2020). Bu süreçte uzaktan eğitimin öğrencilere özellikle zamandan tasarruf sağlaması, esnek çalışma olanağı sunması, derslerin bireysel olarak planlanabilmesi ve yapılan çalışmaların tekrar edilebilmesi gibi faydaları bulunmaktadır (Kubikova vd., 2024). Bununla birlikte, öğrencilerin esnekliğe karşı yüksek düzeyde öz disiplinli olmalarını gerektirmesi, yüz yüze eğitimde olduğu gibi anında soru sorma imkânı tanımaması, etkileşim ve sosyalleşme eksikliği gibi dezavantajları da beraberinde getirmektedir (De Oliveira vd., 2018). Ülkemizde ise uzaktan eğitim, iş yoğunluğunun fazlalığı, ulaşım güçlükleri, yaşanan bölgedeki üniversite olanaklarının sınırlılığı ve ekonomik yetersizlikler nedeniyle lisans mezunu olup kariyer eğitimine devam edemeyen bireyler için bir fırsat oluşturmakta, bu sebeple özellikle yüksek lisans düzeyinde tercih edilmektedir (Berigel, 2013, s. 13). Sunduğu fırsatlardan yararlanan grupların başında ise öğretmenler gelmektedir. Nitekim Alabaş vd. (2012), öğretmenlerin kişisel gelişim (bilimsel merak, yenilikleri takip etme isteği, bir alanda uzmanlaşma isteği, eğitim sorunlarına çözüm üretme vb.), mesleki kariyer (uzman öğretmenlik, görevlendirme önceliği vb.) ve çeşitli nedenlerle (sosyal statü, akademik personel olma isteği vb.) yüksek lisans tercih ettiklerini belirtmiştir. Koşar vd. (2020) ise öğretmenlerin lisansüstü eğitimi öncelikle kişisel gelişim, mesleki bilgi ve beceri

kazanma, kariyer yapma, akademik ilerleme ve sosyal statü ile çevre genişletme amacıyla tercih ettiklerini ifade etmiştir. Sonuç olarak, öğretmenler süreç içerisinde hem iş hem de yaşam doyumlarını artırmaya çalışmaktadır. Bu durum onların mutluluğunu destekleyen bir etmen olarak da değerlendirilebilir. Ancak Çetin (2021, s. 18), uzaktan eğitimin bazı durumlarda mutluluk düzeyini düşürdüğünü aktarmıştır. Bu bağlamda uzaktan eğitim, sürecin sunduğu kazanımlara rağmen zaman zaman olumsuz etkiler yaratabilmektedir.

Mutluluk, tarih boyunca farklı biçimlerde ele alınmış ve tek bir tanımı olmamıştır. Genel olarak haz, hayat memnuniyeti, olumlu duygular ve anlamlı bir yaşam deneyimi ile ilişkilendirilir. Bazı yaklaşımlar mutluluğu kişinin potansiyelini gerçekleştirme üzerinden tanımlarken bazıları ise haz ve keyfi ön plana çıkarır. Günümüzde ise bireylerin kendi yaşamlarına dair değerlendirmelerini bütünüyle kapsayan “özel iyi oluş” kavramıyla açıklanmaktadır (Diener vd., 2003). Bu bağlamda eğitimle mutluluk arasında çift yönlü bir ilişki olduğu söylenebilir. Eğitim, mutluluğun gelişmesi için gerekli bilgi, beceri ve ortamı sağlarken mutluluk da öğrencilerin öğrenmeye daha istekli ve başarılı olmasına katkı sağlar. Dolayısıyla günümüz eğitim anlayışında yalnızca akademik başarıya değil, öğrencinin iyi oluşuna ve mutluluğuna da odaklanmak temel bir gerekliliktir (Rijavec, 2015). Nitekim alanyazın, mutluluğun öğrencilerin öz yeterlik algısını güçlendirdiğini ortaya koymaktadır. Ancak lisansüstü öğrenciler, zaman yönetimi ve akademik talepler, finansal sıkıntılar, ailevi ve sosyal baskılar, akademik başarı ve gelecek kaygıları gibi etkenlerden dolayı mutluluk düzeylerinde düşüş yaşamaktadır. Bu durum, öz yeterlik algısını ve akademik performansı olumsuz etkileyebilir. Buna karşılık, destekleyici akademik ortamlar, etkili zaman yönetimi ve sosyal ilişkiler, öğrencilerin mutluluğunu artırarak hem başarılarını hem de programlarına devamlılıklarını olumlu yönde etkilemektedir (Morás & Carmona, 2020).

Görüldüğü üzere uzaktan eğitim, bireylere çeşitli fırsatlar sunarken bazı zorlukları da beraberinde getirebilmektedir. Bu durum, özellikle lisansüstü eğitim bağlamında düşünüldüğünde, zaman zaman stres, yalnızlık ve akademik talepler nedeniyle bireylerin mutluluk düzeylerinde düşüşe yol açabilmektedir. Mevcut alanyazında “uzaktan eğitim” ile “lisansüstü eğitim ve mutluluk” konularını ayrı ayrı ele alan çalışmalar bulunsa da, bu iki konuyu bir arada inceleyen ve öğretmenleri kapsayan bir çalışmaya rastlanmamıştır. Araştırma, uzaktan eğitim yoluyla yüksek lisans yapan öğretmenlerin mutluluk kaynaklarını, mutlu olma halini engelleyen durumları ve mutluluğu artırmak için başvurdukları yolları ortaya koymayı amaçlamaktadır. Bu bağlamda aşağıdaki problemlere yanıt aranmaktadır.

- 1-Uzaktan eğitim yoluyla yüksek lisans yapan öğretmenlerin mutluluk kaynakları nelerdir?
- 2-Uzaktan eğitim yoluyla yüksek lisans yapan öğretmenlerin mutlu olma halini engelleyen durumlar nelerdir?
- 3-Uzaktan eğitim yoluyla yüksek lisans yapan öğretmenlerin mutluluğu artırmak için başvurdukları yollar nelerdir?

## 2. YÖNTEM

Araştırma, nitel araştırma yöntemlerinden durum çalışması deseniyle gerçekleştirilmiştir. Durum çalışması, sınırlı bir sistemin (durum) ayrıntılı olarak incelenerek, duruma ilişkin temaların ortaya koyulduğu nitel bir desendir (Creswell, 2023, s. 99). Bu çalışmada, öğretmenlerin uzaktan yüksek lisans deneyimleri mutluluk fenomeni bağlamında ele alınmıştır.

Araştırmanın çalışma grubunu, uygun örnekleme yoluyla seçilen 5 öğretmen oluşturmaktadır. Öğretmenlerin 3’ü kadın, 2’si erkektir; yaşları 30 ile 36 arasında değişmekte olup ortalama 33’dür; mesleki kıdemleri 4 ile 8 arasında değişmekte olup ortalama 5’tir; 2’si Hatay’da, 1’i Osmaniye’de, 1’i Şanlıurfa’da, 1’i Hakkâri’de görev yapmaktadır. Öğretmenler, hâlihazırda bir yüksek lisans programına (uzaktan eğitim) devam etmektedir.

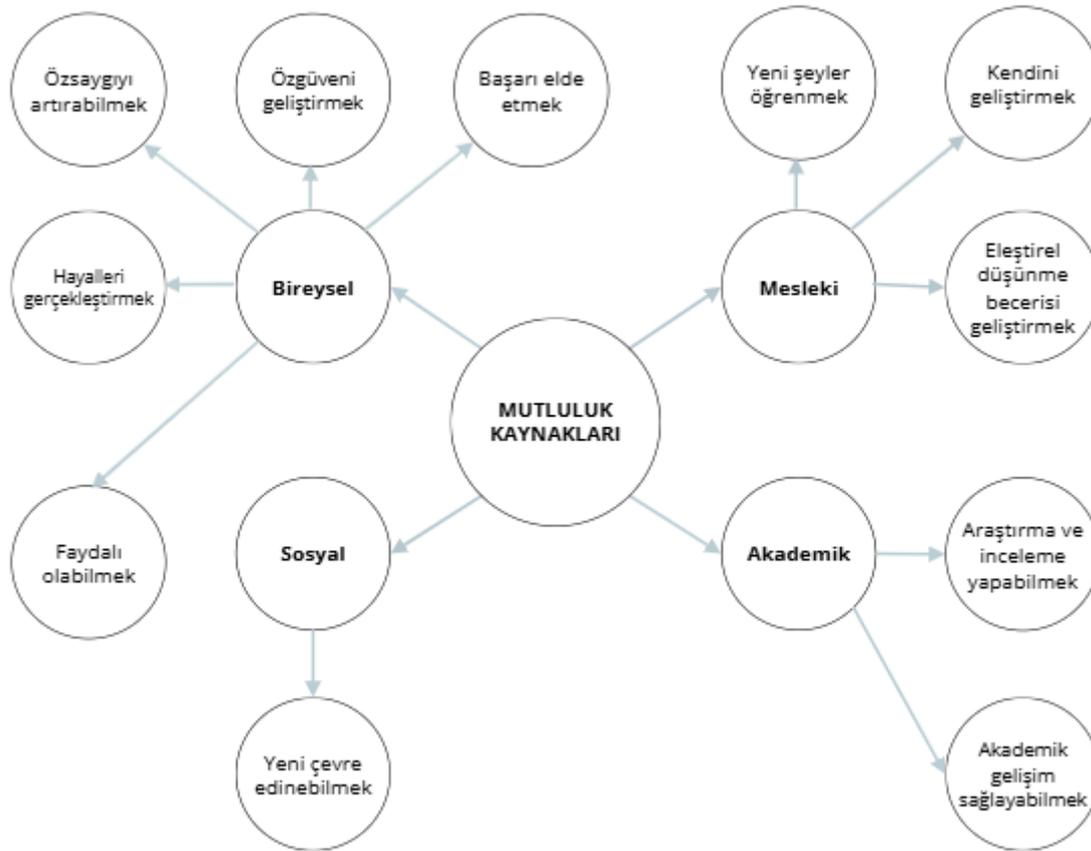
Veriler, araştırmacı tarafından uzman görüşü alınarak oluşturulan yarı yapılandırılmış görüşme formu aracılığıyla 2024 yılında toplanmıştır. Öğretmenlere “Uzaktan eğitim sürecinde mutluluk sizin için ne ifade ediyor?” ve “Süreç içerisinde bu durumların mutluluğunuzu engellemesinin nedenleri nelerdir?” gibi sorular yöneltilmiştir.

Toplanan veriler, deşifre edildikten sonra içerik analizi yöntemiyle çözümlenmiştir. Öncelikle katılımcıların isimleri alfabetik olarak sıralanmış ve işaretleme yapılmıştır. İşaretleme sonrası çözümlene aşamasına geçilmiş ve verilerden kodlar ortaya çıkarılmıştır. Tüm kodlar elde edildikten sonra ilişkili olanlar kategorileştirilerek aynı tema altında toplanmıştır. Tüm bu süreçlerde mevcut alanyazın dikkate alınmıştır. Elde edilen temalar şekillerle sunulmuş, doğrudan alıntılarla desteklenmiştir.

### 3. BULGULAR

Araştırmada yanıt aranan problemlere yönelik elde edilen bulgular, sırasıyla şekiller aracılığıyla sunulmuştur. Uzaktan eğitim yoluyla yüksek lisans yapan öğretmenlerin mutluluk kaynaklarına ilişkin görüşlerine Şekil 1’de yer verilmiştir.

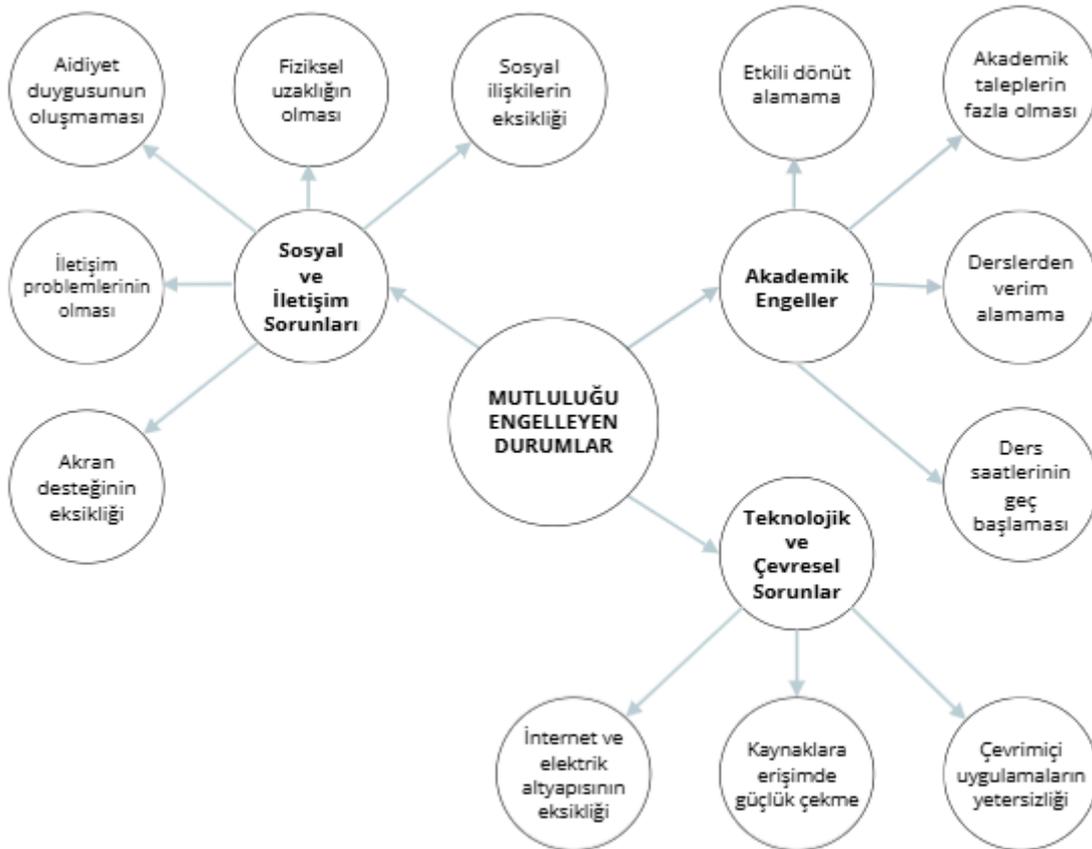
Şekil 1. Mutluluk kaynakları



Şekil 1 incelendiğinde, öğretmenlerin süreç içerisinde “bireysel”, “mesleki”, “akademik” ve “sosyal” hedefleri mutluluk kaynağı olarak değerlendirdikleri görülmektedir. Öğretmenler hem bireysel hem de mesleki anlamda gelişim sağlamanın kendilerini mutlu ettiği, bu durumun ise derslerden alınan hazzı artırdığı ve derse daha istekli katılım gösterdikleri görülmüştür. Öğretmenlerden Ö1, görüşlerini şu şekilde ifade etmiştir: “Öncelikle, uzun zamandır planladığım bu eğitime başlamak beni sürecin başında mutlu ediyordu. Ayrıca yeni bilgi ve beceriler kazanmak, akademik anlamda gelişim sağlamak, bana kattıkları ve bunları paylaşmak, beni süreç içinde mutlu eden durumlardır.” Ö5 ise

görüşlerini şu sözlerle aktarmıştır: “Öğrenme sürecinde mutlu hissetmek beni daha azimli ve istekli yapar. Mutluysam başarıyorumdur, bu da kendime olan özsaygımı ve özgüvenimi artırır. Bir sonraki adımı düşünmeye başlarım ve akademik olarak ilerlemek isterim. Derse daha keyifli ve istekli katılırım.” Ayrıca öğretmenler, yeni insanlar tanımanın ve onların deneyimlerinden yararlanmanın kendilerini mutlu ettiğini belirtmiştir. Konu ile ilgili olarak Ö1, görüşlerini “... Uzaktan da olsa yeni insanlar tanımak, onların eğitimle ilgili deneyimlerini dinlemek ve hayatla ilişkilendirmek beni mutlu ediyordu.” şeklinde aktarmıştır. Uzaktan eğitim yoluyla yüksek lisans yapan öğretmenlerin mutlu olma halini engelleyen durumlara ilişkin görüşlerine ise Şekil 2’de yer verilmiştir.

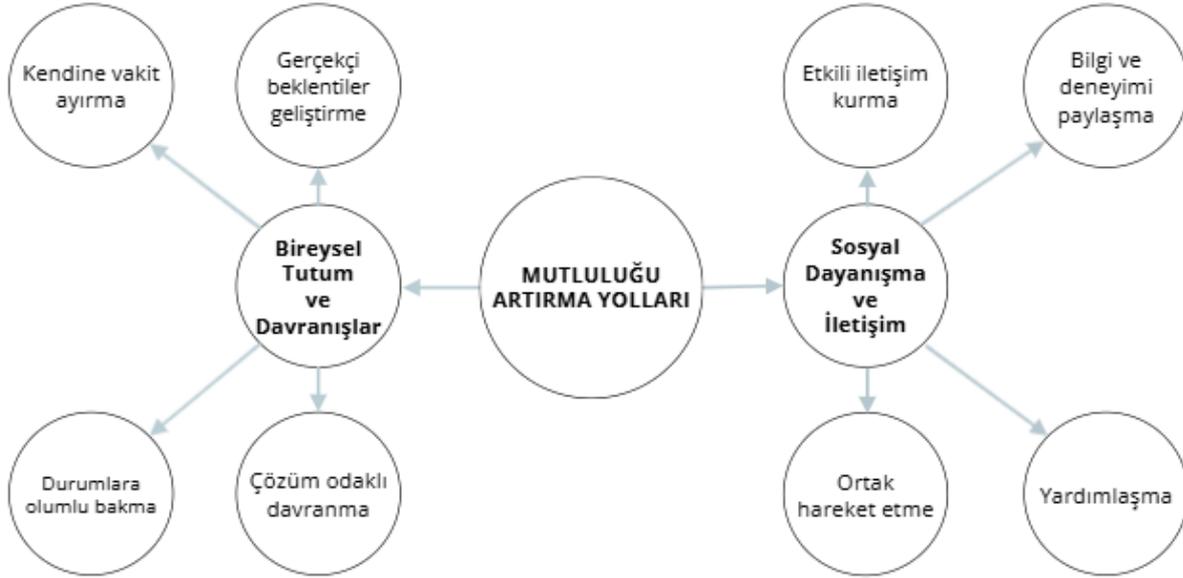
Şekil 2. Mutluluğu engelleyen durumlar



Şekil 2 incelendiğinde, öğretmenler süreç içerisinde çeşitli “sosyal ve iletişim sorunları”, “akademik engeller” ve “teknolojik ve çevresel sorunlar” ile karşılaşmakta, bu durumun ise onların mutluluk düzeylerini olumsuz etkileyerek süreçten alınan verimi düşürdüğü görülmektedir. Özellikle öğretmenler, internet ve elektrik altyapısındaki eksikliklerin derse devamı zorlaştırdığını vurgulamıştır. Ders saatlerinin geç başlaması, uzaktan eğitimde etkili dönüt alınamaması ve buna rağmen yoğun ve uzun süren ödevlerin verilmesi gibi akademik talepler, öğretmenlerin mutlu olma halini engellemektedir. Öğretmenlerden Ö3, görüşlerini şu şekilde ifade etmiştir: “Uzaktan eğitim sürecinde mutluluğu engelleyen durumlar maalesef olabiliyor. Örneğin, katılmak istediğim herhangi bir derse internet olmaması veya teknolojik aksaklıklardan kaynaklı katılmamak beni üzmektedir.” Ö2 ise görüşlerini şu sözlerle aktarmıştır: “Uzaktan eğitimde mutsuzluğun en büyük sebeplerinden biri, öğretmen ile öğrenci arasındaki iletişimin sınırlandırılmasıdır. Yüz yüze eğitimde öğretmen, öğrenciden anında dönüt alabilirken uzaktan eğitimde dönütler zaman almakta ve bu da sorun teşkil etmektedir.” Öğretmenlerden Ö1 ise düşüncelerini şu şekilde dile getirmiştir: “Ödev ve sorumlulukların yoğunluğu beni kaygılandırdı. Bir süre devam edemeyeceğimi düşündüm ve bu nedenle öğrendiklerimi sorgulamaya başladım. Ancak yarıda bırakmak yerine sonuna kadar devam

etmek istedim. Fakat o süreçte motivasyonum oldukça düşmüştü.” Ayrıca fiziksel uzaklığın öğretmenler arasında sosyal ilişkilerde eksikliklere yol açtığı, akran desteğinin sağlanamadığı ve aidiyet duygusunun oluşmadığı saptanmıştır. Konu ile ilgili olarak Ö3, görüşlerini “... Tanımadığımız, yüz yüze aynı ortamda bulunmadığımız ve sosyal anlamda paylaşım yapmadığımız kişilerle aynı anda çevrimiçi derste olmak, sınıf ortamı gibi algılanmamakta ve aidiyet duygusunu maalesef oluşturmamaktadır. ...” şeklinde aktarmıştır. Uzaktan eğitim yoluyla yüksek lisans yapan öğretmenlerin mutluluğu artırmak için başvurdukları yollara ilişkin görüşlerine ise Şekil 3’te yer verilmiştir.

Şekil 3. Mutluluğu artırma yolları



Şekil 3 incelendiğinde, öğretmenler süreç içerisinde “bireysel tutum ve davranışlar” ile “sosyal dayanışma ve iletişim” yoluyla mutluluklarını artırmaya çalıştıkları görülmektedir. Öğretmenler, mutluluklarını engelleyen bir durumla karşılaştıklarında kendilerine vakit ayırmanın ve süreç içerisinde karşılaştıkları sorunlara çözüm odaklı yaklaşmanın mutluluklarını artırdığını vurgulamıştır. Öğretmenlerden Ö3 görüşlerini şu şekilde ifade etmiştir: “... Biraz daha kendimize vakit ayırmamız ve olaylara pozitif tarafından bakmamız gerekiyor. ...” Ayrıca öğretmenler, birbirleriyle etkileşimde bulunmanın ve destek olmanın motivasyonu artırdığını, bunun da mutluluğu artıran faktörler arasında olduğunu belirtmiştir. Konu ile ilgili Ö4, görüşlerini “... Arkadaşlarımla etkileşim halinde olma, bilgi alışverişi yapma, durum değerlendirmesi yapma, arada motivasyonumu artırmak için kendime izinler verme, kendimi takdir etme.” şeklinde dile getirmiştir. Ö1 ise görüşlerini “Arkadaşlarımla fikir alışverişi yapıyoruz. Zorlandığımız yerlerde birbirimize sorarak destek olmaya çalışıyoruz. Bu sayede hem mutlu hem de motive olabiliyoruz.” şeklinde aktarmıştır.

#### 4. TARTIŞMA

Araştırmanın birinci problemine ilişkin görüşler incelendiğinde, öğretmenlerin çeşitli mutluluk kaynaklarına sahip olduğu görülmektedir. Bu kaynaklar, öğretmenlerin süreci sağlıklı, verimli ve etkin bir şekilde sürdürebilmeleri için gerekli olan hedefler niteliği taşımaktadır. Öğretmenlerin başarıma hissini tatma veya bir hayali gerçekleştirme gibi bireysel amaçlara sahip olması, sürecin en içsel motivasyonu olarak öne çıkmaktadır. Başarıma hissini deneyimleyen öğretmenler, çevrelerine daha faydalı olduklarını ve bu durumun özsaygı ile özgüvenlerini artırdığını ifade etmiştir. Bunun

yanı sıra çeşitli mesleki, akademik ve sosyal hedefler de belirlenmiş olup bu hedeflerin öğretmenler için mutluluk kaynağı oluşturduğu görülmektedir. Öğretmenler yeni çevreler edinmeyi, akademik alanda çalışma yapmayı, mesleğine katkı sunmayı ve kişisel gelişimini sürdürmeyi kapsayan kolektif hedefler belirlemiştir. Koşar vd. (2020), öğretmenlerin lisansüstü eğitimi tercih etme nedenleri arasında kişisel gelişim, mesleki bilgi ve beceri kazanma, kariyer fırsatlarını değerlendirme, akademik ilerleme ve çevre genişletme gibi faktörlerin bulunduğunu ifade etmiştir. Bu durum, öğretmenlerin yüksek lisans yapma nedenleri ile mutluluk kaynaklarının örtüştüğünü göstermektedir. Nihayetinde öğretmenlerin süreç içerisinde mutluluklarını sürdürebilmesi, hem kendi tatminlerini hem de mesleki katkılarını artırarak sürecin etkinliğine olumlu katkı sağlamaktadır.

Araştırmanın ikinci problemine ilişkin görüşler incelendiğinde, öğretmenlerin mutlu olma halini engelleyen biz dizi durumla karşılaştıkları görülmektedir. Karşılaşılan engellerin başında “sosyal ve iletişim sorunları” ile “teknolojik ve çevresel sorunlar” yer almaktadır. Öğretmenler, her ne kadar uzaktan eğitimin sunduğu fırsatlardan yararlı olsalar da bu sürecin dezavantajları, eğitimi sağlıklı bir şekilde sürdürmelerini engellemektedir. Teknik altyapı eksiklikleri, kaynaklara erişim güçlüğü ve çevrimiçi uygulamalara yeterince ulaşamama gibi durumlar, öğretmenlerin kendilerini geliştirmelerini zorlaştırmakta, nihayetinde mutluluk düzeylerinde düşüşe sebep olmaktadır. Ayrıca uzaktan eğitim, sosyal ilişkileri de olumsuz etkilemektedir. Öğretmenlerin çeşitli teknolojik araçlar üzerinden süreci yürütmeleri, akran desteğini zayıflatmakta, aidiyet duygusunu güçleştirmekte ve öğretmenleri bireyselliğe itmektir. Bununla birlikte öğretmenler “akademik engeller” kapsamında uzun ve yoğun ödev yükü, derslerden beklenen verimin alınamaması ve ders saatlerinin geç başlaması gibi durumlarla karşılaşmakta, bu durumlar öğretmenlerin mutluluk düzeylerini azaltmaktadır. De Oliveira vd. (2018), uzaktan eğitimin etkileşim ve sosyalleşme imkânlarını sınırladığını, ayrıca yüz yüze eğitimde olduğu gibi anında soru sorma ve geri bildirim alma fırsatı sunmadığını ifade etmiştir. Fojtík (2018), uzaktan eğitimde teknik altyapı sorunları, sınırlı kişisel iletişim imkânı, zamanı verimli kullanma güçlüğü gibi çeşitli dezavantajları olduğunu belirtmiştir. Morás ve Carmona (2020) ise lisansüstü öğrencilerin özellikle zaman yönetimi ve yoğun akademik talepler nedeniyle mutluluk düzeylerinde düşüş yaşadıklarını aktarmıştır. Bu bağlamda, öğretmenlerin mutlu olma halini engelleyen durumların uzaktan eğitimin dezavantajlarından kaynaklandığı ve lisansüstü eğitim sürecinde karşılaşılan sorunların da öğretmenlerin mutluluk düzeyini düşürdüğü görülmektedir.

Araştırmanın üçüncü problemine ilişkin görüşler incelendiğinde, öğretmenlerin mutluluklarını artırmak için bireysel ve sosyal yollar geliştirdikleri görülmektedir. Öğretmenler, mutluluklarını engelleyen durumlarla karşılaştıklarında kendilerine vakit ayırmanın ve olaylara olumlu yaklaşmanın süreci daha yönetilebilir kıldığını vurgulamıştır. Ayrıca bilgi ve deneyimi paylaşmanın ve karşılıklı destek sağlamanın motivasyonu yükselterek mutluluklarını artırdığını ifade etmiştir. Morás ve Carmona (2020), lisansüstü eğitimde mutluluğu artırmak için destekleyici akademik ortamların ve sosyal ilişkilerin öğrencilerin mutluluğunu artırarak başarılarını olumlu yönde etkilediğini belirtmiştir. Bu bağlamda, öğretmenlerin mutluluklarını artırmak için geliştirdikleri yollar, mevcut alanyazın ile paraleldir. Ancak öğretmenlerin kullandıkları sosyal ilişkiler, genellikle akademik başarı çabası gütmektedir. Uzaktan eğitimin getirdiği dezavantajlar ise öğretmenleri bireyselliğe itmektir. Bu durum, öğretmenlerin süreç içerisinde mutluluğunu artırabilmesi için hem sosyal hem de akademik açıdan desteklenmesi gerektiğini ortaya koymaktadır.

## 5. SONUÇ VE ÖNERİLER

Araştırma, öğretmenlerin uzaktan yüksek lisans deneyimlerini mutluluk fenomeni bağlamında incelemeyi amaçlamış ve bulgular üç tema altında toplanmıştır. Öğretmenler bireysel, mesleki, akademik ve sosyal hedefler aracılığıyla çeşitli mutluluk kaynakları oluşturmaktadır. Bu mutluluk kaynakları arasında akademik hedeflerden ziyade diğer hedeflerin öne çıkması, öğretmenlerin devam ettiği yüksek lisans programlarından bağımsız olarak, süreci kolektif bir gelişim fırsatı olarak

gördüklerini göstermektedir. Öğretmenlerin, uzaktan eğitimin yarattığı teknik ve çevresel dezavantajlar nedeniyle sürece devam etmekte zorlandıkları, sosyal eksikliklerin ise onları bireyselleşmeye ittiği ve bu durumun mutluluk düzeylerini düşürdüğü görülmüştür. Ayrıca akademik taleplerin yoğun olması, buna karşı etkili dönüt alamama ve ders saatlerinin geç başlaması gibi etkenlerin, öğretmenlerin sürece devam edememelerine yol açtığı saptanmıştır. Sonuç olarak, uzaktan eğitimin getirmiş olduğu dezavantajlar ile lisansüstü eğitimde karşılaşılan sorunların öğretmenlerin mutluluk düzeyini düşürdüğü görülmektedir. Buna karşı öğretmenler, mutluluklarını artırabilmek için çeşitli bireysel yollara başvurmaktadır. Ancak bireysel çabanın tek başına yeterli olmadığı, sosyal etkileşim ve akademik destekle dengelendiğinde sürecin daha sağlıklı ilerleyeceği düşünülmektedir. Bu bağlamda, öğretmenlerin etkin geri bildirim alabilecekleri destek mekanizmalarının genişletilmesi, bilgi ve deneyim paylaşımı ile sosyal etkileşimi artıracak uygulamaların işe koşulması, ders saatlerinin ve ödev yüklerinin doğru bir biçimde planlanması ile esnek teslim tarihlerinin uygulanması önerilebilir.

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## MAKSİLLA POSTERİOR BÖLGESİNDE PERİFERAL DEV HÜCRELİ GRANÜLOM: KLİNİK VE CERRAHİ YAKLAŞIM

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### ÖZET

**Amaç:** Bu olgu sunumunun amacı, nadir görülen maksiller posterior lokalizasyondaki periferal dev hücreli granülomanın (PDHG) klinik ve cerrahi özelliklerini aktarmak, sistemik hastalık öyküsü olan hastalarda tedavi planlamasına dikkat çekmek ve total eksizyon sonrası klinik seyrin literatür ile karşılaştırmalı olarak değerlendirilmesidir.

**Olgu Sunumu:** 49 yaşında erkek hasta, sağ maxiller molar tüber bölgesinde hipertrofik diş eti şikayeti ile başvurdu. 2011 yılında sağ böbrek transplantasyonu geçirmiş ve hipertansiyonu olan hasta, profilaksi altında eksizyonel biyopsi ile tedavi edildi. Histopatolojik değerlendirme PDHG tanısını doğruladı. Postoperatif takipte komplikasyon veya rekürrens gözlenmedi.

**Sonuç:** PDHG, reaktif ve benign bir lezyon olmakla birlikte lokal invazyon ve nadiren nüks potansiyeline sahiptir. Bu olgu, posterior maksiller lokalizasyon ve erkek cinsiyet açısından nadir bir durumu göstermektedir. Total eksizyon ve lokal travmanın ortadan kaldırılması nüks riskini azaltmak için kritik öneme sahiptir. Sistemik hastalık öyküsü olan hastalarda uygun cerrahi yaklaşım ve düzenli takip, başarılı klinik sonuç için gereklidir.

**Anahtar Kelimeler:** Periferal dev hücreli granülom, maksilla posterior bölge, oral lezyon, olgu sunumu

## PERIPHERAL GIANT CELL GRANULOMA IN THE POSTERIOR MAXILLARY REGION: CLINICAL AND SURGICAL APPROACH

### ABSTRACT

**Objective:** The aim of this case report is to present the clinical and surgical characteristics of a peripheral giant cell granuloma (PGCG) located in the rarely affected posterior maxillary region, to highlight considerations for treatment planning in patients with a history of systemic disease, and to evaluate the postoperative clinical course in comparison with the existing literature.

**Case Report:** A 49-year-old male patient presented with a complaint of hypertrophic gingival tissue in the right maxillary molar tuberosity region. The patient had undergone a right kidney transplant in 2011 and had a history of hypertension. The lesion was treated with an excisional biopsy under antibiotic prophylaxis. Histopathological examination confirmed the diagnosis of PGCG. No postoperative complications or recurrence were observed during follow-up.

**Conclusion:** PGCG is a reactive and benign lesion; however, it may exhibit local invasiveness and, in rare cases, recurrence. This case represents an uncommon presentation in terms of posterior maxillary localization and male gender. Complete surgical excision and elimination of local trauma are critical to reduce the risk of recurrence. In patients with systemic conditions, an appropriate surgical approach and regular follow-up are essential for favorable clinical outcomes.

**Keywords:** Peripheral giant cell granuloma, posterior maxilla, oral lesion, case report

## 1. GİRİŞ

Çenelerde görülen dev hücreli granülomalar (DHG), klinik ve radyolojik özelliklerine göre periferik ve santral tipler olarak sınıflandırılmaktadır (Delilbaşı, Sonbay, Akal, Or, & Günhan, 2000; Or & Yiiceta, 1993). Santral dev hücreli granüloma (SDHG) kemik dokusundan gelişirken, periferik dev hücreli granülomalar (PDHG) dişeti ve alveoler proçes bölgesinde, gingivanın bağ dokusundan veya alveoler kret periostundan köken almaktadır (Katsikaris, Angelopoulou-Karantza, & Angelopoulou, 1988; Bonetti et al., 1990). Etiyolojisi tam olarak bilinmemektedir (Adlakha et al., 2010).

Literatürde PDHG cerrahi sonrası nüks oranları çalışmalara göre değişiklik göstermektedir. Büyük bir derleme analizinde tüm vakaların genel ortalama nüks oranı %9,5 olarak raporlanmış olmakla birlikte, yalnızca eksizyon uygulanan olgularda nüks oranı yaklaşık %16 iken, eksizyon sonrası küretaj ile bu oran %2,8'e düşmektedir (Chrcanovic, Gomes, & Gomez, 2018). Bu nedenle yalnızca total eksizyonun tek başına uygulanması, ek uygulamalarla (küretaj veya periferik osteotomi) karşılaştırıldığında daha yüksek nüks riski ile ilişkilendirilmiştir (Chrcanovic et al., 2018).

1950'li yıllardan önce çenelerde görülen dev hücreli granülomalar, dev hücreli kemik tümörleri arasında sınıflandırılmaktaydı. Ancak 1953 yılında "dev hücreli reparatif granüloma" terimi, çenelerdeki benzer lezyonlar için kullanılmaya başlanmıştır. Günümüzde ise bu lezyonların reparatif özelliği kanıtlanamadığından, PDHG terimi evrensel olarak tercih edilmektedir (Giansanti & Waldron, 1969).

PDHG, reaktif ve ekzofitik özellik gösteren, hem dişli hem de dişsiz bölgelerde gingival dokularda ve alveoler mukozada ortaya çıkan lezyonlardır (Aslan, Simsek Kaya, Dayı, Akkas, & Demirci, 2006). Bu lezyonlar genellikle lokal irritasyon veya travmaya yanıt olarak gelişmekte olup, bazı durumlarda buldukları bölgedeki kemikte rezorpsiyona yol açabilmektedir (Bodner, Peist, Gatot, & Fliss, 1997).

Periferik dev hücreli granülomalar genellikle küçük boyutlu, sınırlı, kapsülsüz, koyu kırmızı renkte ve makroskopik olarak karaciğer dokusunu andıran odaklar şeklinde görülür. Saplı veya sapsız olabilen bu lezyonlar, dişeti ya da alveoler kret üzerinde yerleşim gösterir ve çoğunlukla ağrısız ancak kolay kanayan bir özellik taşır (Kfir, Buchner, & Hartsom, 1980; Karlı et al., 2009).

Kadınlarda görülme sıklığı, erkeklere kıyasla yaklaşık iki kat daha fazladır (Özcan, Apaydın, Görür, & Düşmez Apa, 2005). Dev hücreli granülomalar en sık maksilla ve mandibulada görülmekle birlikte, mandibula kondili, temporal kemik, kafatası, parafarengeal bölge, kafa tabanı, oksipital kemik, sinonazal traktus, nazal kavite, orbita ve tibia gibi farklı lokalizasyonlarda da rapor edilmiştir (Çöloğlu, 1973). Lezyonların yaklaşık %66'sı mandibulada, %34'ü ise maksillada lokalize olmaktadır (Kaffe, Ardekian, Taicher, Littner, & Buchner, 1996). Lezyonlar genellikle alt çenede, birinci molarların önünde oluşmakta ve sıklıkla mandibular orta hattı aşmaktadır (de Lange et al., 2023; Park et al., 2022). Her yaş grubunda görülebilmekle birlikte, dev hücreli granülomalar genç ve orta yaşlı erişkinlerde daha sık rastlanır; genellikle 40-60 yaş arasında pik yapar ve teşhis yaşı çoğunlukla 38-42 arasındadır (Wehrhan et al., 2023; Samudrala et al., 2018).

Histolojik olarak, kapsülsüz dev hücreler; enflamasyon, hücreler arası kanama, hemosiderin birikimi ve olgun kemik veya osteoid yapı özellikleri sergilemektedir. PDHG'nin tedavisi, lezyonun lokal

eksizyonu ve lokal etiyolojik faktörlerin ortadan kaldırılmasını içerir. Malign transformasyon bildirilmemiştir; ancak lokal irrite edici etkenlerin yeterince elimine edilememesi durumunda nadiren nüks görülebilmektedir (Flanagan et al., 2019).

Periferik dev hücreli granülom (PDHG) olgularında tedavi yaklaşımı çoğunlukla lezyonun cerrahi olarak tamamen çıkarılmasını içerir. Bu süreç, eksizyon, enükleasyon ve çevre dokuların küretajı ile gerçekleştirilir. Aynı zamanda lokal iritan faktörlerin (diş taşı, kötü restorasyonlar, travma vb.) ortadan kaldırılması da nüksün önlenmesi açısından kritik öneme sahiptir (Güngör & Yıldırım, 2022; Koyuncu & Yıldırım, 2020; Gökçe & Duran, 2021).

PDHG'nin reaktif karakteri nedeniyle, cerrahi eksizyonla birlikte, lezyonun oluşumuna neden olan lokal iritan faktörlerin belirlenmesi ve elimine edilmesi esastır. Bu faktörler arasında en sık karşılaşılanlar; diş taşları, plak birikimi, travmatik oklüzyon, kötü tasarlanmış protez kenarları ve implant çevresi irritasyonlarıdır (Güngör & Yıldırım, 2022). Bu iritanların ortadan kaldırılması, yalnızca tedavi sürecinin etkinliğini artırmakla kalmaz, aynı zamanda postoperatif nüks oranını da anlamlı ölçüde azaltır (Güngör & Yıldırım, 2022).

Tedavi sonrası dönemde, hastaların düzenli klinik ve radyolojik takibi önem taşır. Takip süreci, olası nükslerin erken dönemde saptanmasına olanak sağlar ve gerekli durumlarda zamanında müdahale şansı tanır. Nükslerin çoğu, eksizyonun yetersiz olduğu ya da iritan faktörlerin tam olarak ortadan kaldırılamadığı vakalarda görülmektedir (Koyuncu & Yıldırım, 2020; Aydın & Keleş, 2023).

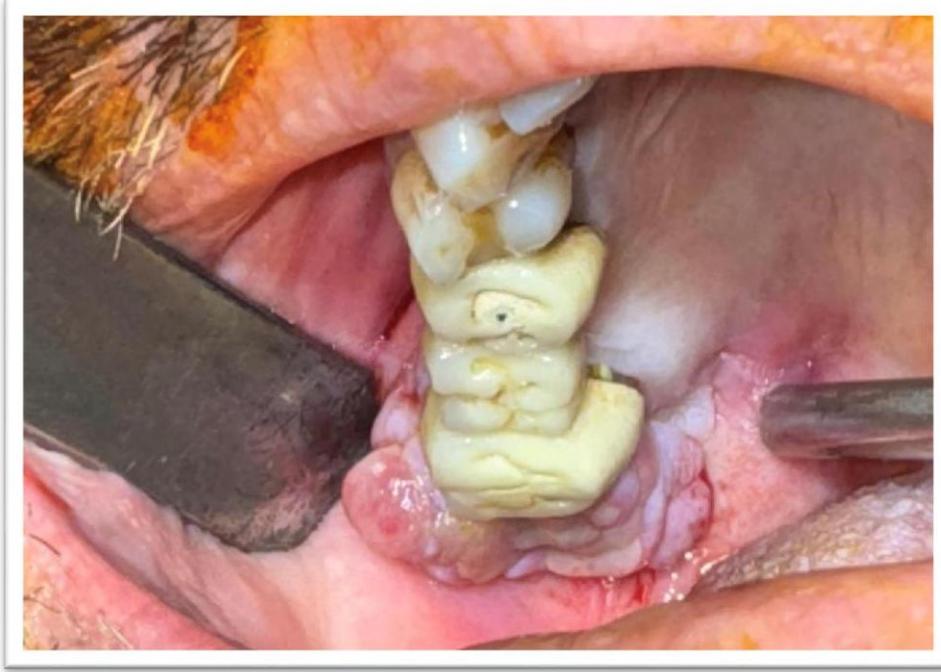
Bu raporda, 49 yaşında erkek hastada 1 ay önce oluşan, maksiller posterior bölgedeki ağrılı şişlik ile karakterize olan, histopatolojik olarak PDHG tanısı konmuş lezyonun tedavisi ve yakın dönem takibi sunulmuştur.

## 2. OLGU

49 yaşında erkek hasta kliniğimize çiğnemeye engel olan hipertrofik yumuşak doku şikayeti ile başvurdu. 14 yıl önce sağ böbrek transplantasyonu olan ve hipertansiyonu olan hasta, ekstraoral muayenede herhangi bir anormallik göstermemiştir. Intraoral muayenesinde 16 numaralı dişin distalinden tübere kadar sert, hipertrofik, sapsız sistemik kırmızımsı-pembe renkte, mukozada erezyona yol açmış ve dokunulduğunda kolayca kanayan bir yumuşak doku lezyonu gözlenmiştir (Şekil 1). Radyolojik incelemede 16 ve 37 numaralı dişlerin distal köklerinde

eksternal rezorpsiyon ve horizontal kemik kaybı saptanmıştır. Tüm kadrarlarda horizontal kemik kaybı ve periodontal cepler mevcuttur (Şekil 2).

Olgumuzda lezyon eksizyon ile tamamen çıkarılmış olup, literatür verilerinin işaret ettiği üzere lezyon tabanına yönelik küretaj ve lokal irritatif faktörlerin ortadan kaldırılması takip planımıza dahil edilmiştir. Cerrahi sonrası hastamız 3. ve 6. aylarda kontrol edilmiş; uzun dönem ( $\geq 24$  ay) takip planlanmıştır.



Şekil 1. 2.Molardan boluğundan bukkal sulkusa ve palatine uzanan yumuşak doku.



Şekil 2. Hastanı kliniğe başvurduğu dönemde alınan panoramik filmi.

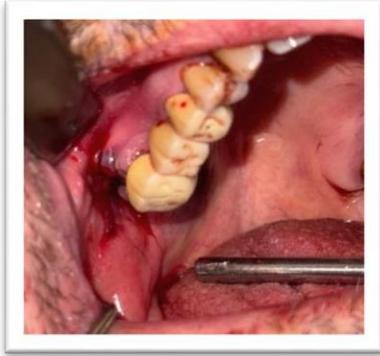
## TARTIŞMA

Dev hücreli granülomların (DHG) etiopatogenezi hâlen tam olarak anlaşılamamıştır. Genetik, moleküler ve immünohistokimyasal çalışmalar, bu lezyonların proliferatif aktivitesinin yüksek

olmasından ve hücre döngüsündeki düzenleyicilerdeki düzensizliklerden kaynaklandığını göstermektedir (Park et al., 2022; de Lange et al., 2023). En çok TRPV4, KRAS ve FGFR1 mutasyonları apoptoz, gen ekspresyonu ve hücre sinyalleşmesi mekanizmalarında bozulmalara yol açmakta ve lezyonların biyolojik davranış farklılıklarını açıklayabilmektedir (Park et al., 2022).

Epigenetik düzeyde yapılan çalışmalarda, merkezi ve periferik DHG'ların DNA metilasyon tiplerinin cherubism ve diğer dev hücre içeren kemik lezyonlarından ayırt edilebildiği gösterilmiştir (Wehrhan et al., 2023). İmmünohistokimyasal belirteçler açısından, Siklin D1 ekspresyonunun hem agresif hem de non-agresif olgularda yüksek düzeyde saptandığı, ancak klinik davranışı güvenilir şekilde öngörmediği bildirilmektedir (Samudrala et al., 2018). RANKL ve OPG ekspresyonunun tekrarlayan merkezi lezyonlarda artmış olması, biyolojik davranış ve nüks riski ile ilişkilendirilebilir (Flanagan et al., 2019).

Sunulan olgu, erkek hastada posterior maksillada lokalize olup, literatürdeki vakaların çoğunluğunun aksine mandibula anterior bölgede görülmemektedir. Lezyon non-agresif bir seyir izlediğinden, eksizyonel biyopsi ile tamamen çıkarılmıştır. Cerrahi sonrası 3 ve 6 aylık takipler yapılmıştır. (Şekil 3,4,5 ve 6)



**Şekil 3.** Cerrahi operasyon sonrası intraoral görünüm. **Şekil 4.** eksize edilen lezyonun boyutu.



**Şekil 5.** Hastamızın 6. ayında yapılan kontrolünün intraoral görüntüsü.



Şekil 6. hastamızın 6. ay kontrolünde alınan panoramik filmi.

### 3. SONUÇ-ÖNERİLER

Periferik dev hücreli granülomalar, reaktif nitelikte olup klinik olarak benign seyir göstermelerine rağmen, lokal invazyon ve nüks potansiyelleri nedeniyle dikkatle değerlendirilmelidir. Erken tanı, doğru histopatolojik değerlendirme ve uygun cerrahi eksizyon tedavi başarısında kritiktir. Etolojik faktörlerin ortadan kaldırılması ve düzenli klinik- radyolojik takip nüks olasılığını azaltır.

Sistemik hastalığı veya immünsüpresif tedavi geçmişi bulunan hastalarda cerrahi planlama dikkatle yapılmalı ve uygun profilaksi protokolleri uygulanmalıdır. Agresif özellikler gösteren vakalarda geniş eksizyon veya ek tedavi yöntemleri düşünülmelidir.

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## ATROFİK MANBİDULADA SUBPERİOSTAL İMPLANT UYGULAMASI: BİR VAKA RAPORU

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### ÖZET

Dental implantlar, diş eksikliği bulunan hastalarda kaybolan fonksiyon ve estetiğin geri kazanılması için yaygın olarak uygulanan bir tedavi biçimidir. Fakat ileri derecede atrofik çenelerde görülen vertikal ve horizontal kemik kayıpları nedeniyle geleneksel implantların uygulanabilmesi oldukça zorlaşır. Subperiostal implantlar, ileri derecede alveoler kemik rezorpsiyonu bulunan ve konvansiyonel endosseöz implantlar için uygun olmayan hastalarda alternatif bir tedavi yaklaşımıdır. Bu olgu sunumunda, mandibulada horizontal yönde ciddi kemik yetersizliği bulunan bir hastada kişiye özel subperiostal implant uygulaması ve klinik sonuçları raporlanmaktadır. Sistemik olarak sağlıklı 57 yaşında erkek hasta, dişsizlik ve hareketli protez kullanamama şikâyeti ile başvurmuştur. Yapılan intraoral ve radyolojik incelemeler (Panoramik ve konik ışınlı bilgisayarlı tomografi) sonucunda mandibulada sol posterior ve anterior bölgede kemik hacminin konvansiyonel implantlar için yetersiz olduğu tespit edilmiştir. Hasta, postoperatif konforsuzluk nedeniyle blok greft uygulamasını kabul etmemiştir. Bunun üzerine hastaya kişiye özel subperiostal implant tasarlanarak genel anestezi altında uygulanmıştır. Maksilla posterior dişsiz bölgeye konvansiyonel implant uygulanmıştır. Postoperatif iyileşme sorunsuz seyretmiş, 3 aylık takipte herhangi bir komplikasyon gözlenmemiştir. Radyografik olarak subperiostal implantın stabilitesinin korunduğu, enfeksiyon, mobilite veya rezorpsiyon bulgusunun olmadığı doğrulanmış ardından hastanın protetik restorasyonu tamamlanmıştır. Augmentasyon tekniklerinde tedavi süresinin artması, donör saha morbiditesi ve zigomatik implantlarda görülen orbital komplikasyonlar ile sinüs enfeksiyonu gibi nedenlerle subperiosteal implantların popülerliği artmıştır. Ek olarak diş hekimliğinde dijitalleşmenin artmasına paralel olarak kişiye özel üretimin sağlanabilmesi subperiosteal implantların tercih edilmesine katkı sağlamıştır. Bu olgu, kemik hacmi yetersizliği nedeniyle konvansiyonel implant uygulanamayan ve blok greft istemeyen hastalarda subperiostal implantların klinik önemini vurgulamaktadır.

**Anahtar Kelimeler:** Subperiosteal implant, alveolar kemik kaybı, mandibula

### ABSTRACT

Dental implants are a widely used treatment modality for restoring lost function and aesthetics in patients with missing teeth. However, in severely atrophic jaws, vertical and horizontal bone deficiencies make the placement of conventional implants considerably challenging. Subperiosteal implants present an alternative therapeutic approach for patients with advanced alveolar bone resorption who are not suitable candidates for conventional endosseous implants. This case report presents the application of a patient-specific subperiosteal implant and its clinical outcomes in a patient with severe horizontal mandibular bone deficiency. A 57-year-old systemically healthy male patient was referred with complaints of edentulism and inability to use removable dentures. Intraoral and radiographic examinations (panoramic and cone-beam computed tomography) revealed inadequate bone volume for conventional implant placement in the anterior and left posterior regions of the mandible. The patient declined block graft surgery due to anticipated postoperative discomfort.

Consequently, a custom-designed subperiosteal implant was fabricated and placed under general anesthesia. Conventional implants were placed in the posterior maxillary edentulous region. Postoperative healing was uneventful, and no complications were observed during the three-months follow-up. Radiographic evaluation confirmed the stability of the subperiosteal implant without signs of infection, mobility, or resorption, after which the patient's prosthetic rehabilitation was completed. Given the prolonged treatment duration and donor site morbidity associated with augmentation techniques, as well as complications such as orbital injury or sinus infection reported with zygomatic implants, subperiosteal implants have gained renewed popularity. Furthermore, the integration of digital technologies in dentistry has facilitated patient-specific manufacturing, contributing to the increasing preference for subperiosteal implants. This case highlights the clinical significance of subperiosteal implants as a viable treatment option for patients with insufficient bone volume who refuse block graft procedures and cannot receive conventional implants.

**Keywords:** Subperiosteal implant, alveolar bone loss, mandible

## GİRİŞ

Dental implantlar, diş eksikliği bulunan hastalarda kaybolan fonksiyon ve estetiğin geri kazanılması için yaygın olarak uygulanan bir tedavi biçimidir. (1) Fakat ileri derecede atrofik çenelerde görülen vertikal ve horizontal kemik kayıpları nedeniyle geleneksel implantların uygulanabilmesi oldukça zorlaşır. Bu nedenle çeşitli greft materyalleri kullanılarak ileri augmentasyon teknikleri veya komşu anatomik yapılardan destek alınarak uygulanan gelişmiş implant seçenekleri tercih edilir hale gelmiştir. (2) Öte yandan augmentasyon tekniklerinde tedavi süresinin artması, donör saha morbiditesi ve zigomatik implantlarda görülen orbital komplikasyonlar ile sinüs enfeksiyonu gibi nedenlerle subperiosteal implantların popülerliği artmıştır. (3) Ek olarak diş hekimliğinde dijitalleşmenin artmasına paralel olarak kişiye özel üretimin sağlanabilmesi subperiosteal implantların tercih edilmesine katkı sağlamıştır. (4)

Subperiosteal implantlar, periosteum üzerinde uzanacak şekilde tasarlanarak üst ve alt çene bölgelerinde uygulanabilen, kafes biçimli bir altyapı ile protezi destekleyen dayanaklar olarak geliştirilmiştir. Bu konfigürasyon, protezden gelen stresleri, geniş bir kemik alanında desteklenen yapı üzerinden aktarır. (5) İmplant olanaklarının, intraosseoz (kemik içi) implantların yerleşiminin zorlaştığı durumlarda, özellikle ileri düzey rezorbe olmuş kemik bulunduğu kullanımına olanak tanır. Retansiyon mukoperiosteum aracılığıyla sağlanır ve döküm alt yapı bu mekanizma ile sabitlenir. (6)

Geçmişte subperiosteal implantlar, geleneksel ölçü materyalleri ve döküm yöntemleriyle üretilmekteydi; ancak doku reaksiyonları, uyum zorlukları ve üretim güçlükleri nedeniyle bu yöntem terk edilmiştir. Günümüzde teknolojik ilerlemeler sayesinde, tomografi verileri ve üç boyutlu yazıcılar kullanılarak anatomik yapıya ve ankraj noktalarına uyumlu kişiye özel implantlar üretilebilmektedir. Bu yaklaşım, travma, rezeksiyon veya deformitelere bağlı doku yetersizliklerinin rehabilitasyonunda üretim hatalarını en aza indirip, doku uyumunu en üst düzeye çıkarmaktadır. (7)

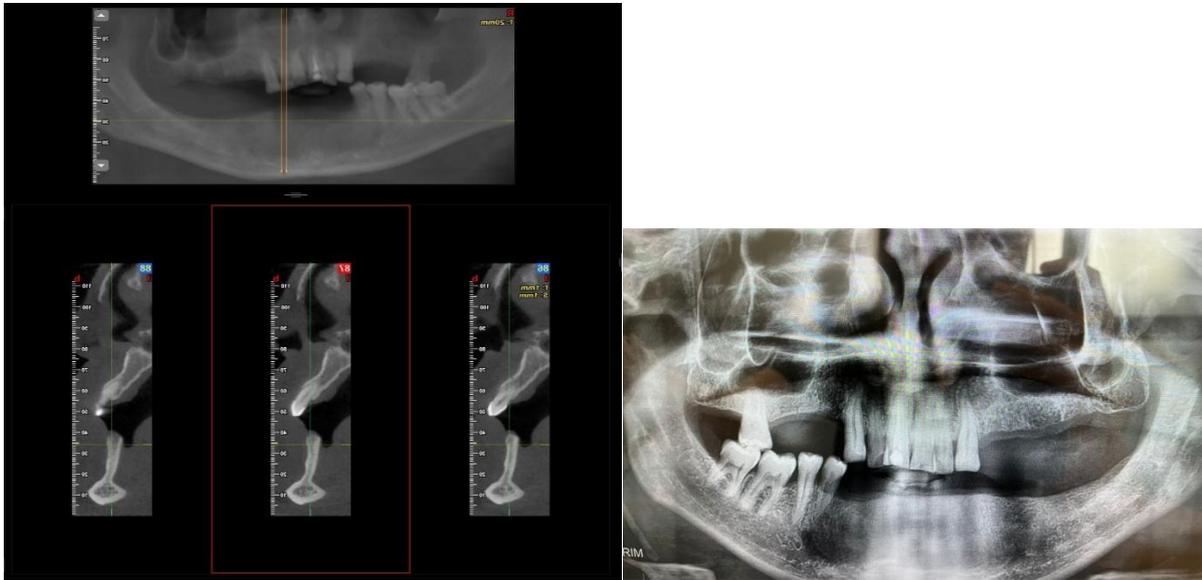
Subperiosteal implantlar, çeşitli klinik koşullar altında tercih edilen bir tedavi seçeneği olarak değerlendirilmektedir. Özellikle standart dental implantların yerleştirilmesi için yeterli kemik hacmine sahip olmayan olgularda bu yöntem ön plana çıkmaktadır. Ayrıca kompleks rejeneratif tekniklerin uygulanamadığı ya da mevcut morbidite nedeniyle hastalar tarafından kabul edilmediği durumlarda da alternatif bir çözüm sunar. Hareketli protezleri tolere edemeyen veya bu protezlerin uygulanamadığı bireylerde subperiosteal implantlar fonksiyonel bir seçenek oluştururken, sabit protez gereksinimlerinde zigomatik implantlara alternatif olarak kullanılabilir. Bununla birlikte, kısmi dişsizlik vakalarında kullanım alanı sınırlı olup, bu endikasyonlarda mevcut klinik verilerin yetersizliği nedeniyle dikkatli bir yaklaşım gerekmektedir.

Öte yandan, cerrahi girişimi kontrendike hale getiren sistemik hastalıkların varlığı, subperiosteal implant uygulamaları için önemli bir engel oluşturmaktadır. Benzer şekilde, cerrahi prosedürü riskli kılan medikal tedaviler veya kullanılan ilaçlar da bu yöntemin uygulanmasını kontrendike hale getirmektedir. (8,9)

## VAKA

Bu olgu sunumunda, mandibulada horizontal yönde ciddi kemik yetersizliği bulunan bir hastada kişiye özel subperiosteal implant uygulaması ve klinik sonuçları raporlanmaktadır.

Sistemik olarak sağlıklı 57 yaşında erkek hasta, dişsizlik ve hareketli protez kullanamama şikâyeti ile Recep Tayyip Erdoğan Üniversitesi Diş Hekimliği Fakültesi'ne başvurmuştur. Yapılan intraoral ve radyolojik incelemeler (panoramik ve konik ışınli bilgisayarlı tomografi) sonucunda mandibulada sol posterior ve anterior bölgede kemik hacminin konvensiyonel implantlar için yetersiz olduğu tespit edilmiştir. (Resim 1.)



**Resim 1.** Panoramik radyografi ve konik ışınli bilgisayarlı tomografi kesitleri

Hasta, postoperatif konforsuzluk nedeniyle blok greft uygulamasını kabul etmemiştir. Bunun üzerine alınan konik ışınli bilgisayarlı tomografi ve modeller üzerinde rehberler ve subperiosteal implantlar kişiye özel olarak hazırlanmıştır. Hasta nazal entübasyon ile genel anestezi altına alınıp, lokal anesteziyi takiben mandibula anteriordan sol posterior bölgeye doğru kret tepesinden insizyon yapılmıştır. Tam kalınlıklı mukoperiosteal flep kaldırılıp rehber aracılığıyla uyumsuz undercutlar frez ile düzeltilmiştir. Hastanın konik ışınli bilgisayarlı tomografi görüntülerinden elde edilip hazırlanan ve kemiğe uyumu tam olan subperiosteal implantlar yerleştirilmiş ve mini vidalar ile fikse edilmiştir. (Resim 2.) İmplantın sabitlenmesinden sonra metal yüzeylerini örtecek şekilde allogreft konulup, hastadan alınan kandan elde edilen PRF membran haline getirilerek greftin üzerine yerleştirilip flep abutmanların etrafında sağlam keratinize doku kalacak şekilde 3/0 ipek sutur ile primer olarak kapatılmıştır. (Resim 3.)



**Resim 2.** Kemiğin uyumlandırılıp subperiosteal implantın yerleştirilmesi



**Resim 3.** Greft ve PRF membran yerleştirilmesi ve cerrahi alanın suture edilmesi

Maksilla posterior dişsiz bölgelere konvensiyonel dental implant uygulanmıştır. Postoperatif iyileşme sorunsuz seyretmiş,3 aylık takipte herhangi bir komplikasyon gözlenmemiştir. Radyografik olarak subperiosteal implantın stabilitesinin korunduğu, enfeksiyon, mobilite veya rezorpsiyon bulgusunun olmadığı doğrulanmış ardından hastanın protetik restorasyonu tamamlanmıştır. (Resim 4 ve 5)



**Resim 4.** Postoperatif OPG ve protezin intraoral klinik görüntü



**Resim 5.** Postoperatif intraoral klinik görünüm

Subperiosteal implantlar, uzun yıllar boyunca sınırlı klinik kullanım alanına sahipken, son dönemde bilgisayar destekli tasarım (CAD) ve üretim (CAM) teknolojilerindeki gelişmeler, yeni biyouyumlu materyallerin kullanıma girmesi ve kemik biyomekaniğinin daha iyi anlaşılması sayesinde yeniden önem kazanmıştır. Günümüzde eklemeli üretim (additive manufacturing) teknikleriyle üretilen modern subperiosteal implantlar, önceki jenerasyonlara kıyasla tek aşamalı cerrahi, anında yükleme ve cerrahi sürenin kısalması gibi önemli avantajlar sunmaktadır.(10,11)

Subperiosteal implantlar özellikle ileri derecede kemik atrofisi bulunan vakalarda, kemik grefti gereksinimini en aza indirerek etkili bir tedavi seçeneği oluşturur. Bu durum, kemik grefti uygulanması halinde görülebilen donör bölge morbiditesinin ortadan kaldırılmasını da sağlar.(10)

Ekstrem kemik defektleri bulunan, örneğin onkolojik rezeksiyon veya travma sonrası ciddi kemik kaybı olan hastalarda, subperiosteal implantlar alternatif bir rehabilitasyon seçeneği olarak öne çıkmaktadır. Geniş yüzeylere yayılan tasarımları sayesinde, bu implantlar çene kemiğinde geniş destek ve stabilite sağlar; böylece çiğneme kuvvetlerinin homojen dağılımı mümkün olur.(10,12,13)

Modern teknolojiler, hasta anatomisine özel implant tasarımını mümkün kılmıştır. Bilgisayarlı tomografi (BT) ve üç boyutlu (3D) baskı teknolojileri kullanılarak, her hastaya özgü implantlar kısa sürede üretilebilmekte ve tedavi süreci önemli ölçüde kısaltılmaktadır. Geleneksel implant tedavilerinde 1–2 yıl sürebilen süreç, modern subperiosteal implantlarda yaklaşık 3–6 aya indirgenmiştir. Ayrıca osteointegrasyon sürecine gerek duyulmaması ve doğrudan yükleme yapılabilmesi, cerrahi ve protetik tedavinin tek seansta tamamlanmasını sağlayarak hastaların fonksiyonel iyileşme hızını ve yaşam kalitesini artırmaktadır.(11,14)

Literatürde subperiosteal implantların sağkalım oranlarına ilişkin çeşitli çalışmalar bulunmaktadır. Carea ve ark. (15), iki yıllık takip sonucunda implantların sağkalım oranını %86 olarak bildirmiştir. Onicã ve ark. (16) tarafından 36 hasta üzerinde yürütülen çalışmada ise üçüncü yıl sonunda %62,3 (küçük komplikasyonlar dahil) ve altıncı yıl sonunda %54,1 oranında sağkalım elde edilmiştir. Benzer şekilde, Mangano ve ark. (17) on hastalık bir yıllık takip çalışmasında erken dönemde %10, geç dönemde ise %20 komplikasyon oranı saptamış; genel olarak yüksek bir sağkalım oranı bildirmiştir.

## SONUÇ

Subperiosteal implantlar uzun yıllardır klinik uygulamalarda yer almasına rağmen, geçmişteki yetersiz klinik başarı oranları nedeniyle zamanla önemini yitirmiştir. Ancak son yıllarda teknolojik gelişmelerin sağladığı tasarım ve üretim iyileştirmeleri, bu implantların yeniden değerlendirilmesine olanak tanımıştır. Güncel literatürde yer alan gözlemsel çalışmalar, bilgisayar destekli tasarım (CAD) ve eklemeli üretim teknolojileri kullanılarak hazırlanan modern subperiosteal implantların kısa dönemde tatmin edici düzeyde sağkalım oranlarına ulaştığını göstermektedir. Hastadan elde edilen

tomografik veriler temel alınarak gerçekleştirilen implant ve protez tasarımı, yapısal uyumun hem kemik dokusu hem de protez komponentleri açısından optimum düzeyde olmasını sağlamaktadır. Bu implant sistemi sayesinde anterior ve posterior bölgelerde belirgin kemik atrofisi bulunan olgularda sinüs lifting veya otojen greft uygulaması gibi ileri cerrahi prosedürlere ihtiyaç duyulmadan tedavi gerçekleştirilebilmekte; ayrıca kemik ogmentasyon tekniklerinin gerektirdiği iyileşme süresine gerek kalmadan, implant yerleştirildiği gün hastaya sabit protezler uygulanabilmektedir.

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## FARKLI CERRAHİ TEKNİKLER KULLANILARAK YAPILAN ALVEOLAR KEMİK AUGMENTASYONLARI: 2 VAKA RAPORU

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### ÖZET

İmplant cerrahisinde mevcut kemiğin implant yerleştirilmesi için elverişli olmadığı durumlarda ya da ileri düzeyde kemik defekti varlığında simfiz veya ramus bölgelerinden elde edilen blok greftler ile ek cerrahiler yapılabilir. Alınan blok greftler ile cerrahi alandaki vertikal ve horizontal kemik yetersizliği probleminin önüne geçilmiş olunur. Mandibular simfiz greft tekniği ulaşılması kolay, iyi kemik kalitesi, kortiko-kansellöz bir kemik greft morfolojisi ve minimal greft rezorpsiyonu gibi özellikler sunarken, ramus greft tekniği ise, kemik kalitesinin daha iyi olması ve daha seyrek postoperatif komplikasyon oluşumu gibi özellikler ile simfiz greft tekniğinden üstün kabul edilir. Her iki cerrahi prosedür de implantların uygun pozisyonda yerleştirilmesi için önemlidir. Bu vaka raporunda dental implant üzerine yapılacak olan protetik restorasyonlar için hastaların mandibular simfiz ve ramus bölgelerinden elde edilen blok greft ile yapılan augmentasyon teknikleri anlatılmaktadır. Mevcut vakalarda Recep Tayyip Erdoğan Üniversitesi Diş Hekimliği Fakültesine dental implant yaptırmak için başvuran hastaların yapılan intra-oral muayeneleri ve radyografik incelemeleri sonucunda ilgili bölgelerde implantı konumlandırarak yeterli kemik olmadığı ve bu durumun otojen blok kemik grefti ile kontrol altına alınabileceği belirlendi. Farklı bölgelerden alınan blok greftler ile yapılan augmentasyonlar sonrası ilgili bölgelere dental implant uygulandı ve protetik restorasyonları tamamlandı. Sonuç olarak, vertikal ve horizontal kemik yetersizliği durumlarında yapılacak olan otojen blok greftler ile daha elverişli dental implant cerrahileri uygulanabilir.

**Anahtar Kelimeler:** Augmentasyon, dental implant, ramus grefti, simfiz greft

### ALVEOLAR BONE AUGMENTATIONS USING DIFFERENT SURGICAL TECHNIQUES: 2 CASE REPORT

#### ABSTRACT

In implant surgery, when the existing bone is not suitable for implant placement or when there is an advanced bone defect, additional surgeries can be performed using block grafts obtained from the symphysis or ramus regions. The vertical and horizontal bone insufficiency problem in the surgical area is prevented with the block grafts taken. While the mandibular symphysis graft technique offers features such as easy access, good bone quality, a cortico-cancellous bone graft morphology, and minimal graft resorption, the ramus graft technique is considered superior to the symphysis graft

technique due to its better bone quality and less frequent postoperative complications. Both surgical procedures are important for the proper positioning of implants. This case report describes augmentation techniques using block grafts obtained from the mandibular symphysis and ramus regions of patients for prosthetic restorations to be performed on dental implants. In the present cases, intraoral examinations and radiographic evaluations of patients who applied to Recep Tayyip Erdoğan University Faculty of Dentistry for dental implants revealed insufficient bone in the relevant areas to place the implants, and it was determined that this situation could be controlled with autogenous block bone grafts. Dental implants were placed in the relevant areas following augmentation procedures using block grafts taken from different regions, and prosthetic restorations were completed. Consequently, autogenous block grafts can be used to perform more favorable dental implant surgeries in cases of vertical and horizontal bone insufficiency.

**Keywords:** Augmentation, dental implant, ramus graft, symphysis graft

## 1. INTRODUCTION

Dental implants are a widely accepted treatment method today for replacing missing teeth. An implant that has osseointegrated properly provides an excellent foundation for the application of implant-supported prostheses. Additionally, sufficient bone volume in terms of height and width is essential for implant surgery. Alveolar ridge resorption following tooth extraction or tooth loss occurs rapidly in the first year and continues at a slower rate in subsequent years (Ghodpage and Suroshe 2023). The decrease in bone volume over the years complicates implant placement in the areas where surgery will be performed. Autogenous bone grafts are a technique that has been used to date and is still considered the gold standard in jaw reconstruction for ridge expansion due to their osteogenic, osteoinductive, and osteoconductive effects (Zouhary 2010, Roshan et al. 2022, Sittitavornwong 2010). Autogenous grafts can be obtained from extra-oral regions such as the iliac crest or intra-oral regions such as the mandibular symphysis, ramus, and edentulous alveolar ridge. The symphysis is the most prominent bone grafting site that can be obtained from the intraoral region (Roshan et al. 2022). In addition to its location and accessibility, it shows less resorption than other bone grafts in the intraoral region (Park et al. 2004). However, the incidence of complications such as pain, swelling, and hematoma is also high in this region after surgery (Hallman et al. 2002, Nkenke et al. 2001, Raghoobar et al. 2001). Additionally, neural disorders such as loss of sensation in the lower lip, teeth, and soft tissues of the jaw may also occur (Misch 2011). The mandibular ramus graft site is considered superior to the symphysis region due to its better bone quality and lower incidence of postoperative complications (Denizci et al. 2011). Ramus bone grafting has been used successfully in many cases (Denizci et al. 2011, Schwartz-Arad et al. 2007, Veis et al. 2004).

The purpose of this case report is to describe vertical-horizontal augmentation techniques using autogenous block grafts obtained from different intraoral regions.

## 2. MATERIAL AND METHODS

### CASE REPORT 1

A 70-year-old woman in good systemic health presented to the RTEU Oral, Dental, and Maxillofacial Surgery Clinic complaining of edentulism in the upper anterior region. The medical history revealed that the patient had previously had prostheses removed from the anterior region and teeth extracted in that area, resulting in a defect. The clinical examination determined that this condition negatively affected chewing, biting, speaking, and aesthetic functions. The patient was first referred for orthopantomography + cone beam computed tomography (CBCT), and the relevant area was evaluated with X-rays. The examinations revealed a horizontal bone deficiency in the region of teeth 11-21 (FIGURE 1A). An augmentation procedure and delayed implant placement were planned for

the patient, along with the harvesting of an autogenous block graft from the mandibular symphysis region.

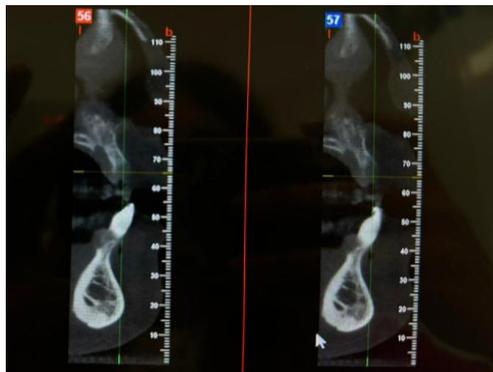


FIGURE 1A.

**Surgical Procedure:** Under local anesthesia, a crestal incision and two vertical release incisions were made on both sides of the 11-21 tooth region. A full-thickness mucoperiosteal flap was raised from the area. Granulomatous tissues were removed, and the recipient site was prepared by ensuring complete visibility of the bone defect. A mucoperiosteal flap was elevated with an incision extending between the lower first premolars on both sides. Osteotomy was performed with a piezoelectric device at least 5 mm away from the root tips and the mandibular border, and the resulting grafts were removed using an osteotome. The grafts, positioned to fit the recipient sites, were placed in the relevant areas (FIGURES 2A-3A).

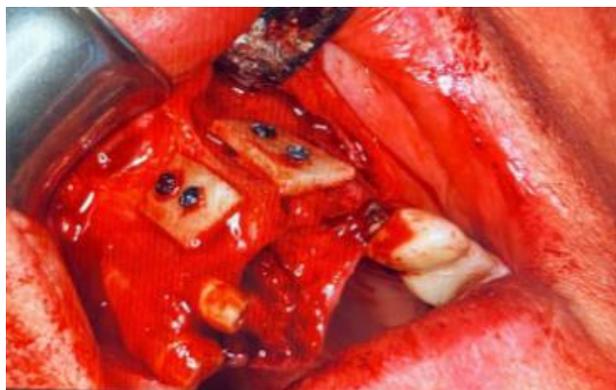


FIGURE 2A.



FIGURE 3A.

It was fixed to the bone using 4 titanium screws (2×10 mm) (FIGURE 2-3) and stabilized by covering it with a collagen membrane (FIGURE 4A). It was then sutured with 3-0 silk suture. Additionally, the donor site was filled with a hemostatic collagen sponge and carefully sutured. Postoperatively, the patient was given antibiotics and analgesic medication. The patient was called for follow-up visits every 3 days. The patient was called for follow-up visits every 3 months to take radiographs to check bone formation. Follow-up examinations showed uneventful wound healing and adequate bone formation (FIGURE 5A). Supported by radiographs, implant surgery and subsequent prosthetic rehabilitation were performed. Thus, the patient was discharged after an 8-month period following placement of the symphysis graft.



FIGURE 4A.

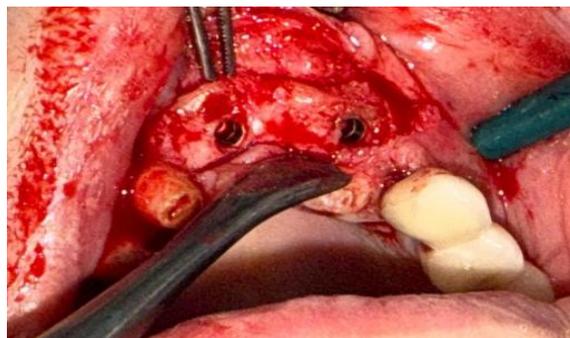


FIGURE 5A.

## CASE REPORT 2

A 42-year-old woman with no systemic health issues presented to the Department of Oral and Maxillofacial Surgery at RTE University with a complaint of edentulism on the right side of the lower jaw. In addition to the intraoral examination, CBCT revealed a knife-edge alveolar ridge in the relevant area. Examination revealed partial edentulism in the region of teeth 44-47 and horizontal bone loss on radiography (FIGURE 1B).

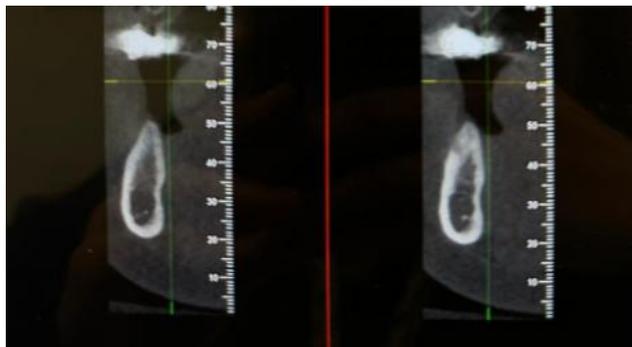


FIGURE 1B.

The patient underwent augmentation of the relevant area along with autogenous block grafting from the mandibular ramus region, and late-stage implantation was planned.

**Surgical procedure:** Under local anesthesia, a crestal incision and two vertical release incisions were made on both sides of the 44-47 tooth region. A mucoperiosteal flap was raised with an incision extending distally from the right mandibular lower first premolar. According to the plan, a ramus graft taken from the right mandibular retromolar region using a piezoelectric device was horizontally augmented with three titanium fixation screws in the area on the same side where implant surgery was planned (FIGURES 2B-3B).



FIGURE 2B.

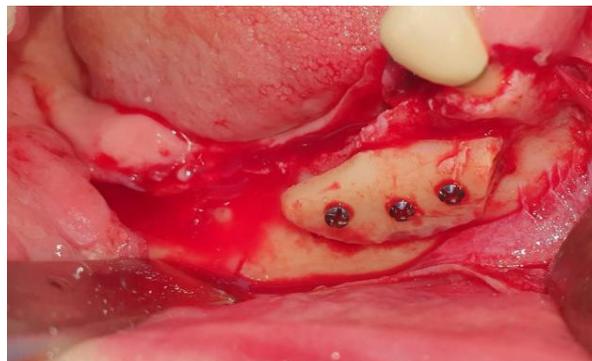


FIGURE 3B.

A fine-grained allograft was applied around the screws in the area between the ramus graft and the alveolar bone and covered with a membrane (FIGURE 4B).



FIGURE 4B.

It was then sutured with 3-0 silk sutures. The patient was given antibiotics and analgesic medication after the surgery. The patient was called for check-ups every 3 days, and the wound area was monitored. After the sutures were removed, the patient was called for check-ups at 1-month intervals. The check-ups were supported by radiographs. No complications were observed in the patient followed up over a 6-month period. Subsequently, implant surgery and prosthetic rehabilitation were performed (FIGURES 5B-6B). Thus, following the placement of the ramus graft, the patient was discharged after an 8-month period.

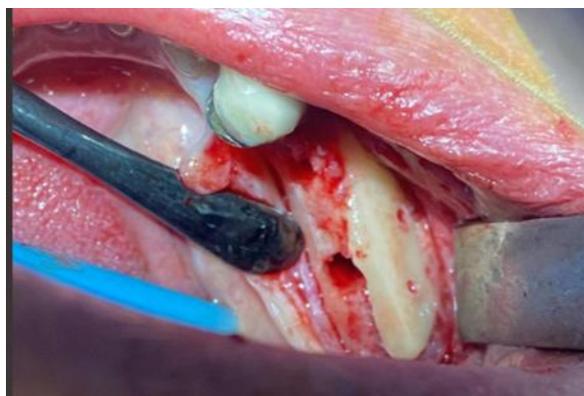


FIGURE 5B.

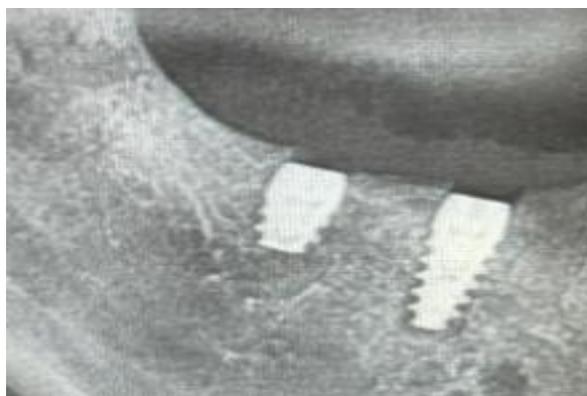


FIGURE 6B.

### 3. RESULTS AND DISCUSSION

Implant surgery and prosthetic rehabilitation require the alveolar ridge to have sufficient width and height. In cases where rehabilitation with direct dental implants is not feasible, augmentations using autogenous block grafts taken from the symphysis and ramus regions were described.

Autogenous block grafts taken from the intraoral region are an ideal choice for surgery as they shorten the operation time due to the proximity of the recipient and donor sites. Furthermore, the mandibular symphysis is an excellent source for obtaining cortico-cancellous bone, which provides faster vascularization and less resorption (Schuler et al. 2005). Surgical access to the symphysis is easy, and no scarring occurs on the skin (Schuler et al. 2005). Furthermore, the ramus graft is also considered a good choice for reconstruction due to the anatomical measurements of the mandibular ramus (Yu et

al. 2022). Although accessibility to the ramus region is more difficult than to the symphysis region, a thicker and longer bone graft can be obtained. Located in the force transmission region of the mandible, the ramus repairs and rebuilds itself more quickly under the effect of applied mechanical stimuli (Schwartz-Arad et al. 2007, Veis et al. 2004). Today, most surgeons and patients prefer bone augmentation from the intraoral region due to its proximity, lower donor site morbidity, and easy access. The most common intraoral sites for augmentation include the ramus, symphysis, retromolar region, and maxillary tuberosity (Roshan et al. 2022).

The symphysis consists of 65% cortical bone and 35% cancellous bone. Due to intramembranous bone formation, grafts taken from the symphysis are thought to have a lower resorption rate. Stern and Barzani reported that the symphysis graft can be harvested as a block measuring approximately 1.5 x 6 cm from the midline or as two paramedian grafts measuring approximately 1.5 x 3 cm (Stern and Barzani 2015). The graft density is D1 or D2 (Desai et al. 2015). These grafts are mostly used for horizontal-vertical alveolar ridge augmentation or to fill osteotomy gaps during orthognathic surgery (Stern and Barzani 2015). The osteotomy cuts made to harvest the symphysis graft are performed according to Misch's 5 Rules, whereby the upper cut is made 5 mm below the root tips, the lower cut is made 5 mm above the lower border, and the vertical cut is positioned at least 5 mm away from the mental foramen (Misch et al. 1992). However, Pommer et al. (2008) proposed new safety limits to reduce the risk of mandibular incisive canal injury, specifying that the graft depth should be 4 mm and the distance to the apices of the teeth should be at least 8 mm (Pommer et al. 2008). The mandibular lower limit should be maintained with a safety distance of 5 mm from the mental foramen (Pommer et al. 2008).

Symphysis grafting may not be performed due to several contraindications, in addition to its advantages and disadvantages. These include a mandible with long anterior teeth, insufficient mandibular height or width, significant vertical bone loss, and a width increase involving more than 4 teeth (Pikos 2005).

As with all other grafts, complications that may occur during surgery include bleeding, mental nerve damage, block graft fracture, and possible bicortical removal. Other post-operative complications include pain, swelling, infection, sensory changes in the lower lip and jaw, jaw ptosis, and neuro-sensory deficits such as dysesthesia in the anterior lower jaw teeth (Pikos 2005).

On the other hand, the anatomical structure of the mandibular ramus has been shown to be a suitable area for harvesting bone grafts for the reconstruction of lateral segmental mandibular defects. The mandibular ramus is a donor site with dense cortical bone content. Healing is slow due to poor vascularization of the area, but resorption is minimal (Fakhry 2011). When a block graft is harvested from the ramus region, a fracture may occur in the mandible, the inferior alveolar or lingual nerves may be traumatized, and paresthesia (less than 1% permanent, 8% temporary) may develop. Various complications such as dehiscence and bleeding at the incision site may also occur, but the risk of complications is still low (Pikos 2000, Misch 1997). Up to 3 weeks after the operation, the patient may experience pain, bruising, swelling, trismus of varying degrees, and, to a lesser extent, postoperative infection (Pikos 2000, Misch 1997, Misch et al. 1992; Pikos 1999). Block grafts can be ground into particles or grafts can be obtained from cortical surfaces using a bone scraper (Bacci et al. 2011, Chiriac et al. 2005).

Although previous studies on the use of ramus grafts exist in the literature, these are mostly limited to smaller grafts designed for alveolar bone reconstruction. The use of intraoral grafts allows the patient to be mobilized earlier by avoiding separate surgical intervention on the limbs and reduces the risk of venous thrombosis (Yu et al. 2022).

In this case presentation, we attempted to obtain bone suitable for implant surgery by applying symphysis and ramus grafts to the relevant areas in cases of vertical and horizontal bone deficiency.

With delayed implantation after surgery, full prosthetic rehabilitation was performed on the patient, achieving a 100% success rate without causing any morbidity.

#### 4. CONCLUSIONS

In conclusion, this case report demonstrates that more favorable implant applications can be achieved with symphysis and ramus graft surgeries in cases of vertical and horizontal bone deficiency.

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## FACTORS THAT INFLUENCE MARKET PRICE OF PROPERTIES IN ALBANIA

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### ABSTRACT

The real estate market in Albania has experienced significant fluctuations over the past years, driven by rapid urbanization, demographic trends etc. According to the latest Bank of Albania survey, housing prices in 2024 rose by 41.4% compared to a year ago. What is noticeable is a high growth, especially in the capital, where a major construction boom continues, as well as new multi-story projects approved for construction, as well as coastal housing. This paper tries to identify some of the core factors that have influenced this market during the recent years focusing on macro factors and others. Through a review of previous studies on this issue, as well as data published by official Albanian institutions, we will try to shed light on this issue, which affects economic researchers, policy-making institutions, and the population, which may face difficulties in affording the purchase of an apartment, especially in the capital. What is most widely discussed among researchers in this field is whether negotiations for Albania's integration into the EU will cause further increases in apartment prices.

**Keywords:** property market; house prices; macro factors.

### 1. INTRODUCTION

The real estate market plays a significant role in the social and economic development of a country, encompassing numerous interrelated factors that make its impact complex and sometimes multidirectional. This complexity is evident in the fact that real estate represents one of the largest components of public expenditure, as well as a major share of overall investment, particularly in the case of Albania where the cost of a house is considered a lifetime investment that will be passed down to future generations. The mentality of Albanians is to own a house and not live in a rented one. This is because during the communist system, housing for young couples was provided by the state if the number of citizens in a house exceeded a certain number. In recent years, the increase in house prices has often made it unaffordable even if financed with bank loans.

The study of real estate prices in Albania was seen as a necessity, given some phenomena in this market, especially in recent years. Some of these facts have to do with the increase in the price of these assets, the increase in the interest of foreign investors to buy property, especially in Tirana and the coastal areas, the improvement of road infrastructure, the construction of tunnels or investments in airports, the construction of luxury areas or towers in the city, as well as Albania's approaches to integrating into the EU. Also noticeable is the construction of sophisticated and modern architecture in some projects considered the most luxurious. While Tirana is known for its very high-rise tower projects, coastal areas are undergoing continuous transformation thanks to projects with special architecture of villas or residences with prices up to 10,000 euros per square meter.

Accurate and objective valuation of residential properties requires real estate professionals to thoroughly understand the current dynamics of the property market. This includes keeping track of developments in construction, as well as recognizing how macroeconomic and demographic factors shape price trends (Golob et al., 2012).

Real estate agencies in Tirana value a property taking in consideration different factors including proximity to the center of the city, the years of construction of the building (apartments built before the 90s during the communist system have lower cubic capacity and smaller surface area, lack of an elevator), internal investment of the apartment, presence of an elevator, residential floor, possibility for parking space, proximity to educational or health institutions, etc. Apartment prices have increased even after the establishment of new reference prices by the state since the tax that the seller will pay is higher. To produce reliable estimates, it is essential to assess both the intrinsic characteristics of the property and the external factors that affect its value. Identifying and analyzing these factors form the foundation for a credible and well-supported property valuation.

According to the INSTAT report for the second quarter of 2025, the construction sector has experienced an increase in costs. Compared to the same quarter of the previous year, the largest increase in prices in the construction sector is observed in the group "Salary expenses" with 6.2%, followed by the groups "Other costs" with 2.3%, "Machinery expenses" with 2.2%, "Transport expenses" with 1.4%, etc. On the other hand, the group "Material expenses" marked a decrease of 0.7% (INSTAT, 2025).

This paper is structured as follows. The following section reviews same literature that explores the complexity of the housing market. The purpose of the literature review is to consolidate existing studies on housing demand, with a particular emphasis on Albania. It examines the main factors influencing housing demand, the challenges confronting the housing sector, and the implications these have for future housing policies and development strategies. Then the further section analyzes recent data of Albanian economy, also price dynamics and key demand-side determinants. The last section is conclusions and recommendation.

## 2. LITERATURE REVIEW

According to the OECD (2020), housing is a fundamental component of inclusive growth. It represents the largest expenditure in household budgets, serves as the main driver of wealth accumulation, and is the primary source of debt for most households. The COVID-19 pandemic further underscored the critical importance of housing, prompting governments to implement a wide range of emergency housing support measures.

Several studies have examined real estate price determinants globally and in emerging markets similar to Albania. Demographic changes, including population growth, migration, and aging, have a significant influence on housing demand. Gong, & Yao (2022) found that life expectancy, international immigration, urbanization and fertility are important factors for predicting future house prices. Urbanization and demographic changes also play significant roles, influencing demand patterns and housing supply (Angel et al., 2012).

According to Francke and Korevaar (2022) historical data indicate that demographic changes are a key and predictable determinant of housing prices. They suggested that a one-percentage-point increase in birth rates is associated with 4–5% rise in house prices 25–30 years later, driven by age-dependent demand for homeownership and limited investor response.

Tripathi, Sabyasachi (2019) study investigates the macroeconomic determinants of rising housing prices from a cross country perspective. The research considered 43 countries in the world from the period of 1970 to 2017 using data from the World Bank and the OECD. Using the random-effect models' analysis the study concludes that different factors including rent, price-to-income ratio, price-to-rent ratio, urbanization, per-capita GDP, inflation, the share of population aged 15-64, GDP growth rate, broad money, and real exchange rate have a positive and statistically significant effect on real house prices.

Ferlan et al. (2017) study indicate that the location in relation to the distance from the city center is the most important influential factor on the property value, similarly as in other countries across the world. Furthermore, the survey results show that the impact of the views and noise on the residential property value in Slovenia is also comparable with other studies.

Kripa & Mucaj (2015) study found a positive relation between the quarterly GDP and the Construction Cost Index, indicating a positive impact of the construction sector in the economy. According to the authors studying the trend of prices in the housing market is a difficult because of the high informality in the Albanian real estate market.

Kraja et.al (2020) surveyed 148 housing units for the years 2017-2018, data collected from real estate agencies in Tirana, the capital of Albania. The independent variables that show a positive effect on the price of housing were: size, bedrooms, elevator, bathrooms, age and mini-municipality 5 (the most famous and expensive mini-municipality of Tirana). In addition, the variables that showed a negative effect on the price were: the floor, balcony and most mini-municipalities. Also a further investigation of Kraja (2024) of the developments of this market found an increasing demand in recent years, for housing in Albania, especially in large cities. These main factors identified which influence in demand were urbanization, migration from rural areas to urban areas, as well as the increase in income and standard of living.

This increase in demand has been influenced by urbanization, migration from rural areas to urban areas, as well as the increase in income and standard of living. However, studying the housing market is very important for the real economy; the further level of study is complicated by many factors: the characteristics of the housing market in a country; the nature and identification of economic shocks such as supply and demand shocks in housing markets, interest rates shocks on housing price movements.

Despite literature reviews, the real estate market is influenced by a series of factors that are complex and unpredictable. A fundamental influence is also the demand and supply for housing, bank lending facilities, foreign investments, etc. The real estate market in Albania has undergone fundamental changes, especially in the last 4-5 years, where an increase of approximately 30-40% in prices has been observed and no matter that the trends are studied, many aspects of this market remain unexplained.

### 3. DATA ON MACRO FACTORS AND ON PROPERTY MARKET IN ALBANIA

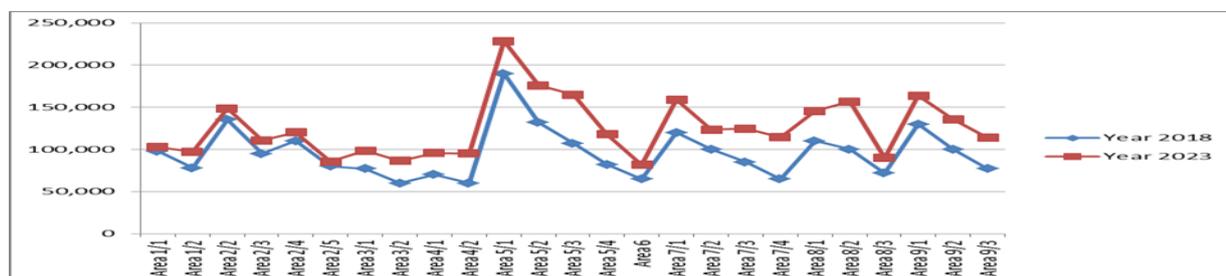
The housing price references in Tirana according to different areas are shown in the table below:

**Table 1:** The increase in reference prices in Tirana of properties in ALL  
(Year 2018 and year 2023)

Area	Year 2018	Year 2023	Increase in %	Area	Year 2018	Year 2023	Increase in %
Area 1/1	97,700	102,800	5	Area 5/4	82,000	117,800	44
Area 1/2	78,000	97,200	25	Area 6	65,000	81,700	26
Area 2/2	135,500	148,400	10	Area 7/1	120,000	159,100	32.5
Area 2/3	95,000	110,600	17	Area 7/2	100,000	123,400	38.5
Area 2/4	110,000	120,300	9	Area 7/3	85,000	124,500	46.5
Area 2/5	80,000	85,700	7	Area 7/4	65,000	114,300	76
Area 3/1	77,000	98,500	28	Area 8/1	110,000	145,650	32.5
Area 3/2	60,000	86,300	44	Area 8/2	100,000	156,700	57
Area 4/1	70,000	95,900	37	Area 8/3	72,000	89,900	25
Area 4/2	60,000	95,300	58	Area 9/1	130,000	163,600	26

Area 5/1	190,000	228,400	20	Area 9/2	100,000	135,800	36
Area 5/2	132,000	175,800	33	Area 9/3	77,000	113,850	46
Area 5/3	107,000	164,800	54				

**Chart 1:** The increase in reference prices in Tirana of properties in ALL (year 2018 and year 2023)

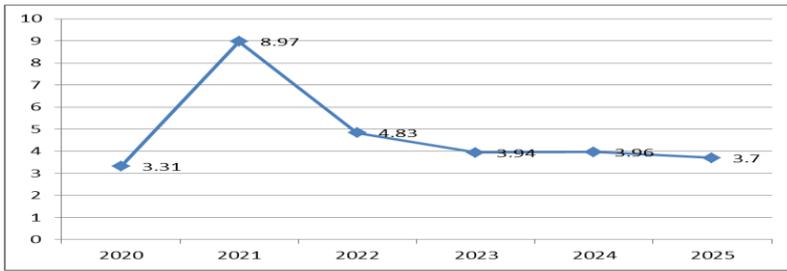


The Ministry of Finance has revised the reference prices of housing in the capital in 2023 (Decision No. 457, dated 7/26/2023). These prices are expected to change again in 2026 after a public consultation to be carried out by representatives of the ministry with interest groups. These changes are expected to more accurately reflect the real price of housing, especially in the capital and in coastal areas where a significant difference in the sales price with the reference price has been verified. In general, agencies operate with unrealistic prices in sales transactions, reducing the income that the state could realize from these transactions. It is also expected that after the determination of the new reference prices, owners will be given the opportunity to revalue their homes against a 3% tax payment so that in the event of a property sale, the tax burden will be lower. The current tax rate on the sale of property in Albania is 15%.

These steps are expected to reduce informality, make these transactions more transparent, and increase tax revenues, but the expected effect will again be an increase in housing prices, especially in the central areas of the capital or on the coast, which are preferred as properties not only for living but also as an investment opportunity by being rented out or offered as units for Airbnb or Booking platforms. The increase in housing prices and the increase in tourism have also led to an increase in rents in these areas.

The Bank of Albania reports that property prices continue to rise at a strong pace. Based on the Fischer index, housing prices across the country increased by 14.6% in the first half of this year compared to the second half of 2024, and by 41.7% compared to the same period a year earlier. In Tirana, the increase was more moderate-the sales price index rose by 5.1% from the previous period and by 32.6% year-on-year. These figures suggest that the most significant price growth has been driven by the country's coastal areas. Rental prices have also gone up during this period, although the Bank of Albania has not published specific numerical data. Information gathered from real estate agents-mainly those operating in Tirana indicates that rental demand has risen overall, exceeding the levels recorded in the previous six months (Bank of Albania, 2025, Report). The average selling price of property in Tirana has reached 124,300 ALL/m<sup>2</sup>, with areas like Farka and the Artificial Lake district commanding prices up to 258,000 ALL/m<sup>2</sup>. In this section we will try to identify through some official data from the Bank of Albania as well as INSTAT some of the macroeconomic indicators and other factors that have influenced the increase in housing prices, especially in Tirana.

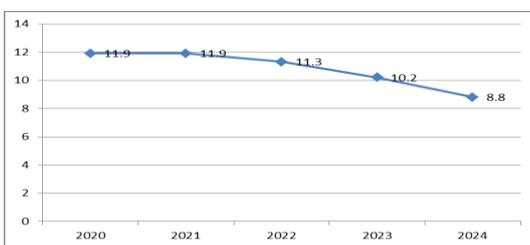
*GDP Growth rate:* Albania's GDP grew by 3.9% in 2023, with a projected slowdown to 3.6% in 2024, indicating a stable economic environment. Albania's economic growth, characterized by an average GDP increase of approximately 3-4% annually in recent years, has bolstered purchasing power, particularly among the urban middle class.



**Chart 2:** GDP growth rate (%)

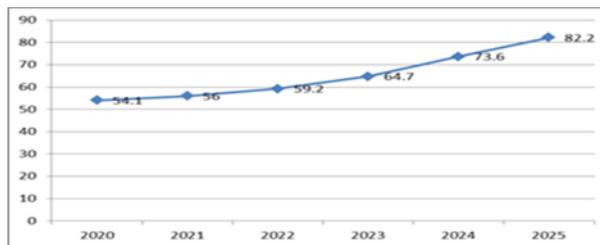
Source: INSTAT 2025

*Unemployment Rate:* The official unemployment rate for the population aged 15 and over was 8.8% in the fourth quarter of 2024, marking a decrease from the previous year.



**Chart 3:** Unemployment rate (%)

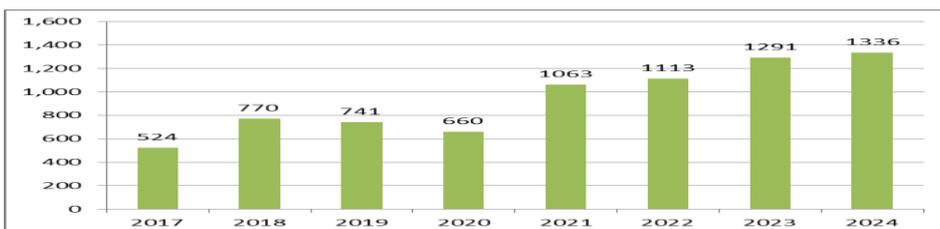
Source: INSTAT 2025



**Chart 4:** Average wages (in /000 ALL)

*Interest Rates:* The Bank of Albania's monetary policy has led to a reduction in inflation to around 2% by the end of 2024, below the central bank's 3% target, suggesting accommodative monetary conditions. Simultaneously, inflationary pressures and changes in interest rates have influenced mortgage affordability. The Bank of Albania's low interest rate policy in the early 2020s encouraged borrowing, fueling demand for residential properties.

*Foreign Purchases:* In the last quarter of 2024, foreign real estate acquisitions reached a record €100 million, up 9% from the same period in 2023. Foreign direct investment, particularly from diaspora Albanians and neighboring countries, has further contributed to property demand, especially in coastal areas popular for holiday homes. Foreign Investment Dominance: Real estate has remained the leading sector for foreign direct investment (FDI) in Albania for three consecutive years. In 2024, foreign purchases totaled €380 million, representing nearly 24% of total foreign investments. Coastal regions have drawn particularly strong interest, largely due to their competitive property prices compared to neighboring countries.



**Chart 5:** Construction permits residential buildings (in units)

Source: INSTAT 2025

*Infrastructure-Driven Demand:* Large-scale infrastructure investments-such as the €1.6 billion Tirana-Durrës highway project and the Llogara Tunnel-have significantly improved national connectivity. These projects have increased property values, especially in suburban and coastal areas.

*Luxury Real Estate Boom:* Demand for high-end properties is surging in major cities like Tirana and Durrës, as well as in coastal destinations including Saranda and Vlorë. This growing segment is fueled by both wealthy local buyers and international investors seeking premium properties at attractive prices. Along the coastline-from Golem to Qerret, Vlorë, Rradhimë, Orikum, and Saranda-foreign nationals dominate property purchases. Most buyers come from landlocked European countries such as the Czech Republic, Poland, and Hungary.

*Policy and EU Integration:* Albania's accelerated progress toward EU accession, supported by legislative reforms and infrastructure modernization, has strengthened investor confidence. These developments have encouraged many European citizens to relocate to Albania. By the end of 2023, there were 21,460 foreigners holding residence permits in the country-an 18.2% increase compared to 2022 (INSTAT, 2023)-and this number has continued to rise throughout 2024 and 2025.

*Urbanization and Demographic Trends:* Tirana, the capital of Albania, has undergone rapid urban expansion, largely driven by internal migration from rural areas in search of better employment and educational opportunities. Over the past decade, the city's population has increased by more than 20%, significantly intensifying housing demand. In response, the construction sector has experienced a boom, marked by the development of multi-story apartment buildings and modern residential complexes.

*Tourism:* Coastal cities such as Durrës and Vlorë have witnessed rising demand, fueled by tourism growth, infrastructure improvements, and heightened interest from both domestic buyers and foreign investors.

#### 4. CONCLUSION AND RECOMMENDATIONS

The real estate market plays a vital role in Albania's economy, influencing household wealth, investment activity, and patterns of urban development. Over the past decade, the country has experienced a sharp rise in property prices, particularly in urban centers such as Tirana and in coastal regions. This upward trend has sparked concerns about housing affordability and the long-term sustainability of the market. Understanding the underlying drivers of these developments is therefore essential for policymakers, investors, and residents.

This paper examines same factors affecting property prices in Albania, with a focus on macroeconomic conditions, urbanization, demographic shifts, and external influences, including the country's EU accession process. Drawing on data from the Bank of Albania and other official sources, the study aims to provide a clearer understanding of the forces shaping the real estate market in recent years. Challenges and risks regarding this sector are connected with affordability of these investments, speculative ones and environmental concerns. The rapid rise in property prices has raised growing concerns about housing affordability, particularly for local residents in major urban centers. As prices continue to outpace income growth, many households face increasing difficulty accessing adequate housing.

At the same time, the influx of foreign investment has fueled worries about speculative activity in the market, where rising demand from international buyers may be inflating prices without a corresponding improvement in local purchasing power.

Understanding the dynamics of Albania's real estate market is essential for stakeholders, including policymakers, investors, and residents. While the market presents opportunities, it also poses

challenges that require careful consideration and strategic planning. Policymakers must strike a balance between promoting investment and ensuring sustainable urban development alongside affordable housing access. Key measures include regulating speculative investments, supporting affordable housing initiatives, and enhancing urban infrastructure to foster a more balanced and inclusive real estate market.

The informality that exists in this market makes it difficult to identify real housing prices. For this reason, the study of this topic also faces difficulties. Other authors have tried to obtain figures from unofficial channels such as agencies that deal with these transactions. In future studies, the challenge will be precisely to identify real housing prices.

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## INVESTMENT STRATEGIES IN OIL TRANSPORTATION: ADAPTING TO CHANGING MARKET CONDITIONS

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### ABSTRACT

Investment strategies in the oil transportation industry of Kazakhstan and foreign countries demonstrate adaptation to changing market and geopolitical conditions. Kazakhstan, which provides over 65 million tons of crude oil exports in 2022, remains dependent on routes through Russia, primarily from the Caspian Pipeline Consortium, which accounted for about 90% of total exports in 2024. This concentration increases the risks to the sustainability of the sector, especially in the context of sanctions policy and changes in global energy flows. In response, the country has stepped up investments in alternative projects, including the development of the Trans-Caspian route, the use of the Baku-Tbilisi-Ceyhan oil pipeline and increased supplies to China, but the capacity of these destinations so far does not exceed 16.5 million tons, which is only a quarter of export volumes. Internationally, oil transportation investment trends are characterized by diversification and digitalization. In the European Union, priority is shifting towards modernizing port infrastructure and integrating with renewable energy sources, while the United States and China are focusing on developing strategic pipelines that provide access to key markets and enhance energy security. In the context of volatile oil prices, which reached the level of \$ 101 per barrel in 2022, as well as increasing competition for transit corridors, investment strategies are becoming long-term and complex. Kazakhstan, which has a unique transit potential, seeks to increase the contribution of the transport and logistics sector to GDP to 6%, which requires active investment attraction, institutional strengthening and expansion of international cooperation.

**Keywords:** investments; oil transportation; Kazakhstan; oil exports; diversification; geopolitics.

### 1. INTRODUCTION

In long-term planning for the development of an enterprise, investment strategy is of particular importance, as it is a key tool for ensuring sustainable growth and improving operational efficiency. An investment strategy is a system of objectives formed on the basis of an enterprise's investment policy, ideology and tasks, and determines the directions of its investment activities (Kumari, 2024).

An investment strategy is a long-term programme of action for an enterprise in the field of investment activity, which includes a system of goals, directions and tools for achieving them, determined by the organisation's overall investment policy. It reflects development priorities, the nature and scale of investment activity, as well as ways of adapting to changes in the external environment (Chen, 2024).

The essence of an investment strategy is to choose the most effective ways to achieve the set goals, taking into account the projected conditions of the organisation's functioning and the state of the investment market as a whole and in its individual segments (Arpaci, 2024). It can be viewed as a plan for the future investment activities of an enterprise, the implementation of which in the long term allows it to achieve its goals, ensure profit growth, and obtain positive economic and social effects (Narayan, 2023).

The relevance of developing an investment strategy is determined by the need to increase the attractiveness of the enterprise to potential investors. However, there is currently no universal model for its construction that is suitable for all sectors of the economy, which determines the importance of research aimed at identifying the principles and methodological foundations for forming a strategy.

The formation of a high-quality investment strategy allows determining the value of the direction of development of the organisation's investment activities, resulting in the achievement of the set investment goals in the long term (Borshch, 2023). Within the framework of the strategy, priority areas and forms of investment activity are formed, its nature and specificity are clarified, and the sequence of stages for the implementation of strategic tasks is built.

The need to develop an investment strategy is due to the peculiarities of the modern market environment, dynamic changes in external conditions, the accelerated pace of scientific and technological progress, as well as the imperfection of investment legislation and the political base with high activity of participants in investment processes (Juddoo, 2023).

An investment strategy is an integral part of the strategic management system of an oil transportation company, reflecting the main directions of its development in the long term (Zhurakhivska, 2023). It involves selecting investment vectors that should correspond to promising plans for diversification and modernisation of production capacities, as well as forming an investment portfolio and securing a resource base for project implementation. The essence of an investment strategy is to identify priority areas for capital investment and to consistently organise the stages of investment activity, which is especially important for oil transportation companies operating in conditions of high capital intensity and significant dependence on external factors (Li, 2023).

The effectiveness of an oil transportation company's investment strategy is largely determined by the degree of its adaptability to changing external conditions, including fluctuations in world oil prices, the political and economic situation, infrastructure development, and the specifics of state investment policy. It must take into account both the company's current position in the market and future stages of its development within its life cycle, which makes it possible to predict economic growth and ensure sustainable long-term operation (Adi, 2023).

The key criterion for the effectiveness of an investment strategy is its impact on the operational goals of the enterprise. The implementation of the set tasks requires a review of the range of services provided, expansion of the geography of oil and petroleum products transportation, development of new technologies for the operation of main pipelines, and the application of innovative methods to improve the reliability of transport systems (Pohrebniak, 2023).

The factors determining the effectiveness of an investment strategy are directly related to the quality of investment management, which is the process of managing all aspects of investment activity. At all stages of strategic planning, it is necessary to take into account a set of criteria that affect the successful functioning of the company: from setting specific goals and selecting a resource base to determining the system of indicators that the enterprise must achieve in the course of implementing the strategy (Erdin, 2019).

The formation of an oil transportation company's investment strategy begins with the coordination of the timing and content of strategic decisions with its overall development programme. An important element is the study of external factors and the investment market environment, including the level of scientific and technological progress in the field of hydrocarbon transportation, the economic and legal conditions for project implementation, and the degree of the company's influence on certain market segments. Considerable attention is paid to assessing the internal capabilities of the enterprise, identifying its strengths and weaknesses using strategic analysis tools, including SWOT analysis, which allows predicting potential threats and assessing the organisation's readiness to take advantage of emerging opportunities (Bellucci, 2023).

An equally important stage is the formation of a system of strategic goals, which serve as the foundation for coordinating and controlling investment activities. These goals include identifying priority areas for investment, the volume of necessary resources, the level of acceptable risk, and prospects for minimising risk. In the process of developing a strategy, various development alternatives are analysed, and based on strategic analysis tools, the optimal option is selected that best suits the tasks and capabilities of a particular company (Davydenko, 2022).

The implementation of an oil transportation company's investment strategy involves determining the areas for the formation of investment resources, selecting sources for attracting them, establishing investment volumes, and developing an investment policy for key aspects of the company's activities. At the same time, the most important condition is the coordination of investment decisions with operational management, which ensures the integrity of the entire management system. For the successful implementation of the strategy, a set of organisational and economic measures is formed, including the creation of an effective management structure, the introduction of an investment culture, the development of a monitoring and control system, and the attraction of highly qualified specialists in the field of investment management (Zhang, 2022).

The final stage is the evaluation of the effectiveness of the investment strategy, which is carried out on the basis of a system of economic and non-economic indicators that reflect not only financial results, but also the quality of project implementation, the degree of innovative development, and the level of the company's sustainability in the market. In the oil transportation industry, this assessment is particularly important, as the effectiveness of investment activities directly affects the reliability of the entire oil and petroleum products transportation system (Jiang, 2022).

Thus, the effectiveness of an oil transportation company's investment strategy is determined by the quality of all stages of its formation and implementation, as well as the degree to which it follows the basic principles of strategic management. It is a key factor in the sustainable development of an organisation and determines its ability to adapt to changes in the external environment and use new opportunities to strengthen its market position.

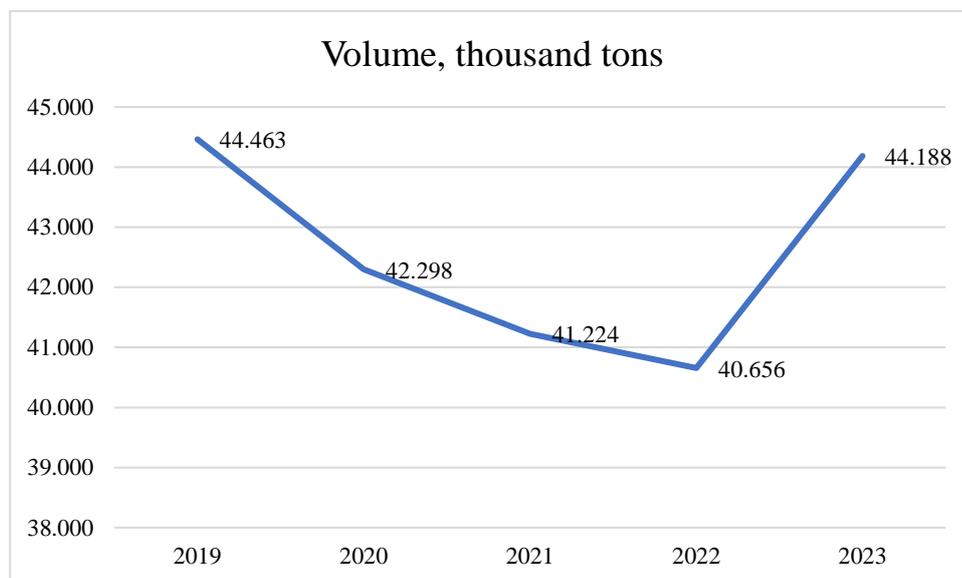
## **2. MATERIALS AND METHODS**

The research materials included statistical data on the financial and operational indicators of oil transportation companies over the past ten years, reports on investment projects in the industry, as well as regulatory documents governing oil transportation and tariff regulation (Cherepovitsyn, 2022). The empirical basis was provided by case studies of completed projects to modernise trunk pipelines and introduce digital oil transport management systems. The opinions of key industry experts were obtained through interviews and questionnaires, which provided high-quality information about changes in market conditions and participants' expectations.

The research methodology was based on a combination of quantitative and qualitative methods. Quantitative analysis included stress tests for changes in oil prices and tariffs (Bogatkina, 2020). Qualitative methods provided depth of understanding: SWOT analysis was used to identify the company's internal strengths and weaknesses.

## **3. RESULTS AND DISCUSSION**

The dynamics of oil transportation via the KazTransOil trunk system reflect the overall state of Kazakhstan's oil transportation sector amid external economic instability and fluctuations in the global hydrocarbon market. During the period under review, from 2019 to 2023, there has been both a decline in transportation volumes and a partial recovery, which allows us to assess the industry's adaptability to changes in the external environment and internal challenges (Figure 1).

**Figure 1.** Oil transportation volumes via the KazTransOil trunk system (2019–2023), thousand tonnes (KazTransOil JSC, 2024), (KazTransOil JSC, 2021)

In 2019, transportation volumes amounted to 44,463 thousand tonnes, after which, against the backdrop of global crises, they fell to 42,298 thousand tonnes in 2020 and 41,224 thousand tonnes in 2021. The minimum value was recorded in 2022 – 40,656 thousand tonnes, which indicates the significant impact of the unfavourable external environment and restrictions on production and exports. In 2023, the figure reached 44,188 thousand tonnes, which is practically the same as in 2019 and indicates a recovery in the oil transportation system. The data demonstrate the stability of the infrastructure and the effectiveness of the measures taken to maintain transit flows, while noting the industry's high dependence on external economic factors.

The export routes for Kazakh oil are presented in Table 1.

**Table 1.** Export routes for Kazakh oil (broken down by destination) (2022–2024), million tonnes (Reuters, 2024), (S&P Global, 2024)

Route/destination	Volume, million tonnes	Note
CPC (Tengiz → Novorossiysk)	55.4 (estimate/government report)	Main east-west export route
Atyrau–Samara (via the Russian Federation)	8.6	Exports via the Russian Transneft system
Sea (port of Aktau → Transcaspian / Baku / BTC)	3.6	Route via the Caspian Sea and further delivery via Baku
Trans-China route (to China)	1.1	Direct export to China (via pipelines)

An analysis of Kazakhstan's oil export routes in 2022–2024 shows the dominance of the Caspian Pipeline Consortium, through which 55.4 million tonnes are transported, accounting for the bulk of

total supplies. The second most important route is Atyrau–Samara, with 8.6 million tonnes, providing access to the Russian pipeline system and European markets. The sea route via the port of Aktau and the Trans-Caspian route shows relatively small volumes of 3.6 million tonnes, but it is this route that plays a strategic role in diversifying exports and reducing dependence on Russian transit capacities. The lowest figures are recorded for the cross-border Chinese route, with a volume of 1.1 million tonnes, which is explained by the limited capacity of the pipeline infrastructure and the specifics of demand in the Chinese market.

Major infrastructure projects affecting Kazakhstan's oil transportation are described in Table 2.

**Table 2.** Major infrastructure projects affecting Kazakhstan's oil transportation – scale and costs (JSC NC KazMunayGas, 2021), (Caspian Pipeline Consortium, 2023)

Project (area)	Brief description	Cost (in specified currency)
Reconstruction and expansion of the Astrakhan–Mangyshlak water pipeline (KazTransOil project, phase 1)	Increased water pipeline capacity; provides industrial and municipal support to the Caspian coast	112.9 billion tenge (including VAT).
Kenkiyak–Atyrau reverse/reverse conversion project (MunaiTas / support for exports to China)	Enabled reverse transportation of up to 6 million tonnes/year; support for exports to the PRC	30.9 billion tenge.
Debottlenecking (CPC) / CPC modernisation (increased throughput capacity)	Programme to increase CPC throughput capacity (de-bottlenecking), significantly increasing export channels	In the past, the investment phase of the expansion was estimated at ~US\$5+ billion; measures implemented in 2019–2024 led to an increase in the design throughput capacity (see CPC reports).
Tengiz expansion project (Tengizchevroil) — impact on transport	Huge investment in production, directly affecting export demand and pipeline capacity	~US\$48 billion (estimated cost of Tengiz expansion, operator's project CAPEX).

Major infrastructure projects in Kazakhstan's oil transportation industry demonstrate the scale of investment and strategic focus on increasing capacity and diversifying export routes. The reconstruction of the Astrakhan–Mangyshlak water pipeline, costing 112.9 billion tenge, is important not only for ensuring industrial and municipal consumption on the Caspian coast, but also for maintaining the sustainability of the region's energy infrastructure. The Kenkiyak–Atyrau reverse flow project, with an investment volume of 30.9 billion tenge, has made it possible to transport up to 6 million tonnes of oil per year to China, strengthening the eastern export vector. The CPC modernisation programme, with an estimated cost of over US\$5 billion, has increased the system's throughput capacity and enabled Kazakhstan to increase supplies through a key export corridor. The Tengiz field expansion project, with investments of around US\$48 billion, has the greatest impact on the industry, creating additional demand for transport capacity and reinforcing the need for further development of trunk infrastructure. The data indicates that strategic investments in transport projects directly determine the export prospects and sustainability of Kazakhstan's oil sector.

#### 4. CONCLUSIONS AND RECOMMENDATIONS

An analysis of investment strategies in Kazakhstan's oil transport industry has revealed the country's high dependence on the Caspian Pipeline Consortium route, through which approximately 90% of oil

exports, or more than 55 million tonnes, passed in 2024. This concentration poses significant risks to the stability of the export system, especially in the context of geopolitical turbulence and sanctions pressure. Alternative routes, including the Trans-Caspian and Chinese routes, together provide no more than 16.5 million tonnes, which is a quarter of the total volume, and this is not enough for a reliable redistribution of export flows in the event of disruptions on the main route.

The implementation of major infrastructure projects with investments of over \$48 billion in the expansion of Tengiz and more than \$5 billion in the modernisation of the CPC demonstrates a strategic focus on increasing production and exports, which increases the load on the transport system. At the same time, individual projects, such as the reconstruction of the Astrakhan-Mangyshlak water pipeline at a cost of 112.9 billion tenge and the Kenkiyak-Atyrau reverse flow at a cost of 30.9 billion tenge, indicate a desire to diversify export destinations and strengthen regional infrastructure.

Given the high volatility of global oil prices, which reached \$101 per barrel in 2022, as well as growing competition for transit routes, Kazakhstan needs to accelerate the development of the Trans-Caspian route and increase its capacity to bring transport volumes to at least 10–12 million tonnes per year. It is recommended to intensify cooperation with Azerbaijan, Georgia and Turkey to expand the use of the Baku-Tbilisi-Ceyhan oil pipeline, as well as to strengthen strategic dialogue with China with the aim of increasing exports to the eastern vector.

The investment strategy for the oil transportation industry should include measures to digitise flow management and introduce monitoring technologies, which will reduce the risk of accidents and increase the efficiency of pipeline operation. To ensure the sustainability of exports, it is necessary to develop institutional mechanisms for attracting investment, including public-private partnerships, and to create incentives for foreign investors. In the long term, it is advisable for Kazakhstan to focus its efforts on increasing the share of the transport and logistics sector in GDP to the planned 6%, which will not only diversify the economy but also strengthen the country's position in the global energy corridor system.

## 5. THANKS AND INFORMATION NOTE

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This article was prepared as part of a study of investment strategies in Kazakhstan's oil transportation industry. The materials presented are based on official company reports, statistical data and publications by international analytical agencies.

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## THE EFFECT OF RISK MANAGEMENT ON BUSINESS PERFORMANCE: EVIDENCE FROM ALGERIAN CONSTRUCTION FIRMS

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### ABSTRACT

Risk management is still in its early stages within Algerian construction companies. The aim of this research is to develop a strategic Risk Management System (RMS) for Algerian business environment and to identify the most effective practices for identify, analyzing, and managing various types of risks, there by supporting the competitiveness of the construction sector.

To achieve this goal, a questionnaire survey was conducted in Algerian companies, the questionnaire was distributed in person and also electronically via email. A total of 113 responses were collected from different Algerian construction companies. The data were analyzed using both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). Furthermore, to explore the correlations between theoretical concepts, stepwise regression analysis was employed. The findings confirm the existence of key factors that positively influence performance improvement.

**Keywords:** Algerian Construction Companies , CFA, EFA, Performance, Risk Management.

### INTRODUCTION

The environment in which construction companies operate has changed significantly over the past decade. Risks have changed and evolved, making them no longer the same.

Today, companies face a wide range of challenges, including technological risks, radioactive hazards, terrorism, as well as data intrusion and cyberattacks.

The inability of companies to control their environment, combined with the accumulation of various risks, provides fertile ground for reflection on risk management.

Although such reflections are not new, the approaches and methods used to study risk management have changed since the 18th century. So, we should

- identify which risk factors that require management?
- What practices are used in the risk management process to address these risks?
- And what is the impact of these factors on the performance of Algerian companies?

This work aims to present a theoretical model of risk management that will enhance the current literature, and will be based on the different risks which, by controlling them, can improve the company's performance.

This model will probably help managers improve their risk management by applying a formal process adapted to their own environment.

## LITERATURE REVIEW

In the construction industry, there has been a significant increase in risk research and management over the last four decades, the project is exposed to various risks due to the involvement of a large number of actors.

Based on the work of Rezakhani (2012) we note that risk classification is an important step in the risk assessment process. Different approaches of risk classification are proposed in the literature. Several studies have proposed a risk classification: Perry & Hayes (1985), Sorrill, Cooper & Chapman (1978), Abdou (1996), Tummala & Bruchett (1999), Tah & Carr (2000), Chapman (2001), Shen, Wu & Ng (2001), Assaf & Al-Hejji (2006), Zeng, An & John Smith (2007), Assaf & Al-Hejji (2006), Megnounif & Kara Zaitri (2010), Nieto-Morote & Ruz-Vila (2011), Gajewska & Ropel (2011), Mehdizadeh Rasool (2012), Rezakhani (2012), Zulqarnain (2014), Renuka, Umarani & Kamal (2014), Kot & Dragon (2015), Sohrabinejad & Rahimi (2015), Lmoussaoui & Jamouli (2015), Violante, Dominguez, & Paiva (2018). We found that there is no common model, this is due to the diversity of studies conducted when choosing the classification. From this analysis, we select six risk groups (*figure 1*) that often come up, which have been prioritized and selected in the studies cited: financial, political, managerial, natural, technical and environmental

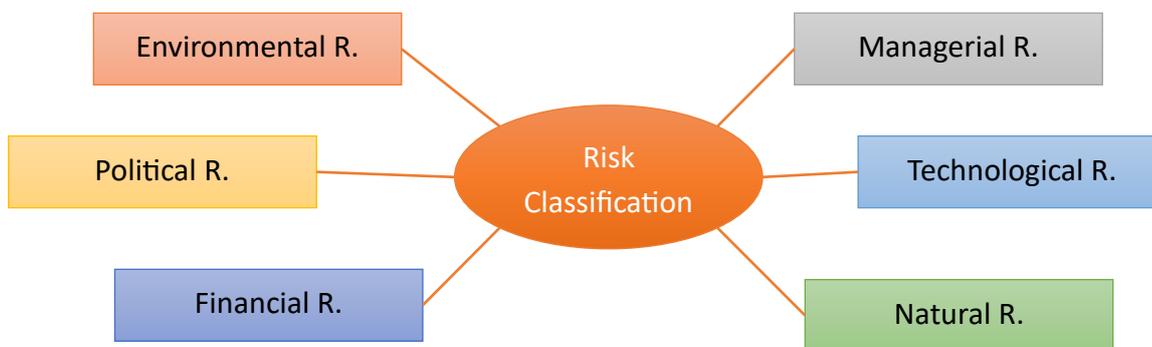


Figure 1 Risk classification

Once the risk classification has been chosen, it is necessary to see how and which are the processes and functions that manage them?

In order to identify, control and manage risks, various authors have developed several RMS models based on theories and concepts.

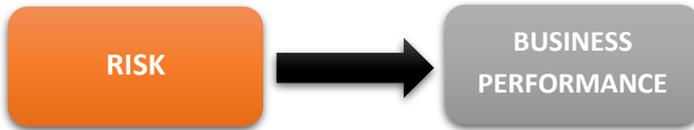
Our research shows that most processes involve four steps: identification, analysis, evaluation, and treatment. These four functions are retained in the proposed model.

We reviewed several studies on risk management systems (RMS) in the construction sector conducted in different countries. We observed that most of these studies focused either on the relationship between risk management and business performance (*Figure 2*) or on the relationship between risks and business performance (*Figure 3*). None of them, however, examined the entire process; the link between risks, risk management, and business performance.



*Jafari et al. (2011) and Mohammed & Knapkova (2016)*

*Figure 2 1st link*



*Hamzaoui (2015), Shendage (2016), Sohrabinejad & Rahimi (2015) and Zou & Zhang (2009)*

*Figure 3 2nd link*

## THEORITICAL MODEL

We have chosen to adopt with a systemic approach, which allows us to see the interactions between the subsystems of each component of our process which has in the input: Risk, the process: The practices of risk management the output will be business performance.

In order to define the internal and external relations of our system and to break down all the parts of the process into functions then into sub-functions, we have chosen, among the different modeling methods, the functional analysis APTE which remains the most appropriate for our research. It is executed in three steps: research and expression of need, external functional analysis and internal functional analysis.

### a- THE RESEARCH AND EXPRESSION OF NEED

In order to define the need that our system satisfies, we used the **horned beast** tool of the APTE method showed in *Figure 4*.

This tool places the overall function of the system studied, **risk management** at the center of the construction company.

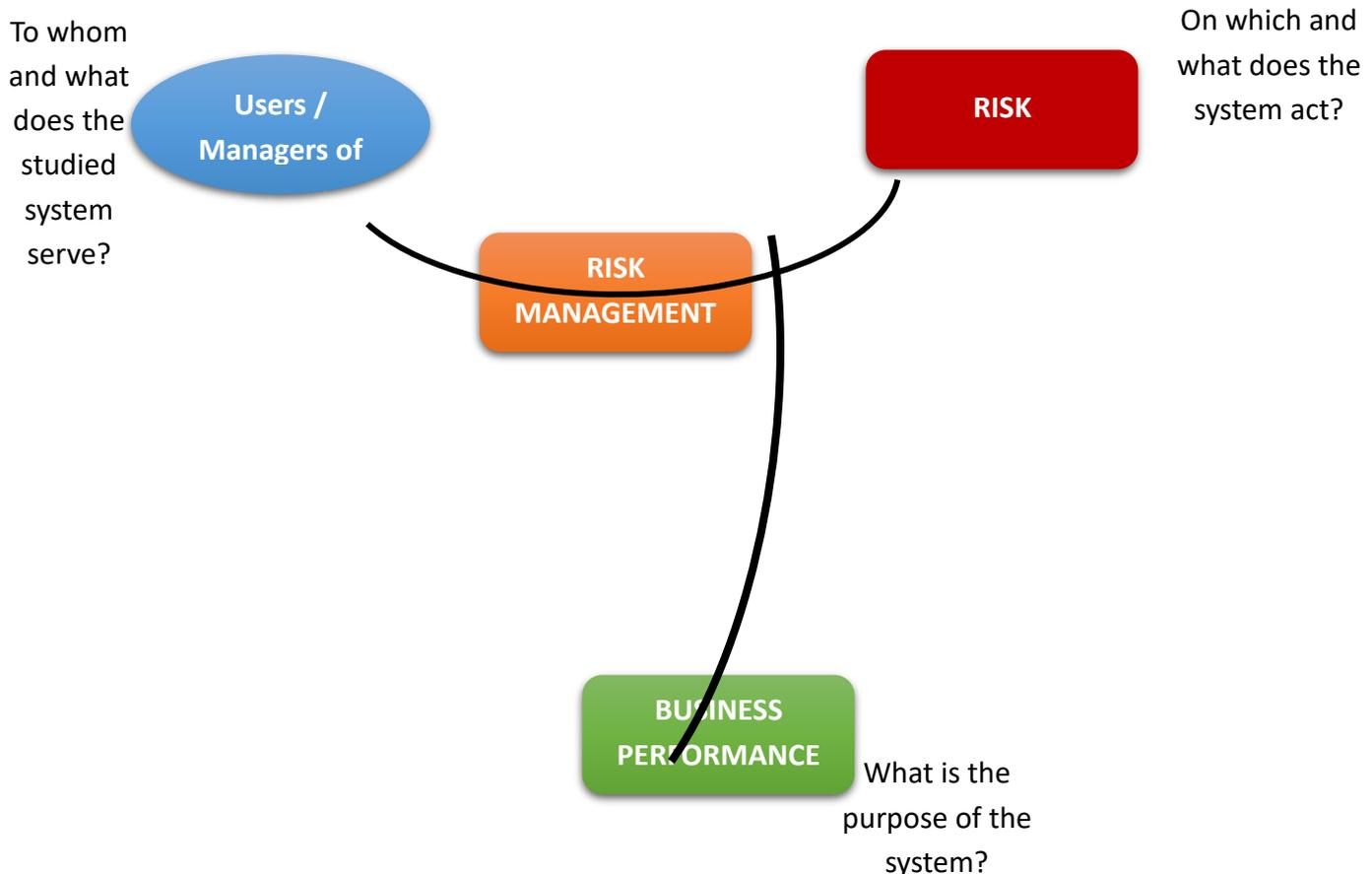


Figure 4 Horned beast

So we have to answer the following three questions:

1<sup>st</sup> : Whom and what does the studied system serve?

- Our system serves users and managers of the company

2<sup>nd</sup> : On which and what does the system act?

- It acts on the risks

3<sup>rd</sup> : What is the purpose of the system?

- Its aims to improve business performance

Those responsible for actions related to risk management are the CEO or director and the employees

The second question leads us to define of the different types of risks, In the literature, different risk classifications are given, depending on the study and the approach chosen.

In our study, we propose to classify risks into to six groups

Finally, the answer to the third question allows us to define the purpose of our system which is performance. We measure performance through four perspectives: financial, customer, internal processes and learning and growth.

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### **b- THE EXTERNAL FUNCTIONAL ANALYSIS**

Through external functional analysis, we can describe the functions of the risk management process that interact within the system.

This study divides the functions of the RMS into four main functions: identification, analysis, evaluation and risk treatment.

The literature provides a wide range of tools and techniques for each of these RMS functions.

A synthesis of this research made it possible to highlight and define the main functions of the RMS.

- For the first function Identify consists of **developing** a list of the risks which may affect the objectives of the project, **classifying** their characteristics according to their causes and consequences and **representing** the results in diagram for a better vision. The acquired expertise is then shared and information about the project will be **collected**.
- The second function Analyse is to **use** the information from the identification to **estimate** the probability of occurrence and the impact of the risk. It also includes **providing** risk data for evaluation and categorization, as well as **establishing** priorities for the planning of risk responses.
- The third function Evaluate consists of **measuring** risks and **comparing** the results with the project's objectives. It also involves **listing** the causes of success or failure and documenting and categorizing risks **to provide feedback**
- And the last function Treat consists of **defining** strategies to reduce the threats, **selecting and establishing** the appropriate risk response plan. These responses should be **evaluated** and **documented** for future use.

### **C- THE INTERNAL FUNCTIONAL ANALYSIS**

The structural representation of the Risk Management System allows analyzing its internal functioning based on the elementary functions.

For the Identification function in figure 5, which has five sub functions, each contains a set of practices. For example, Organizing brainstorming sessions, using checklists to record potential risks, selecting appropriate representation methods, and conducting site visits to collect data.

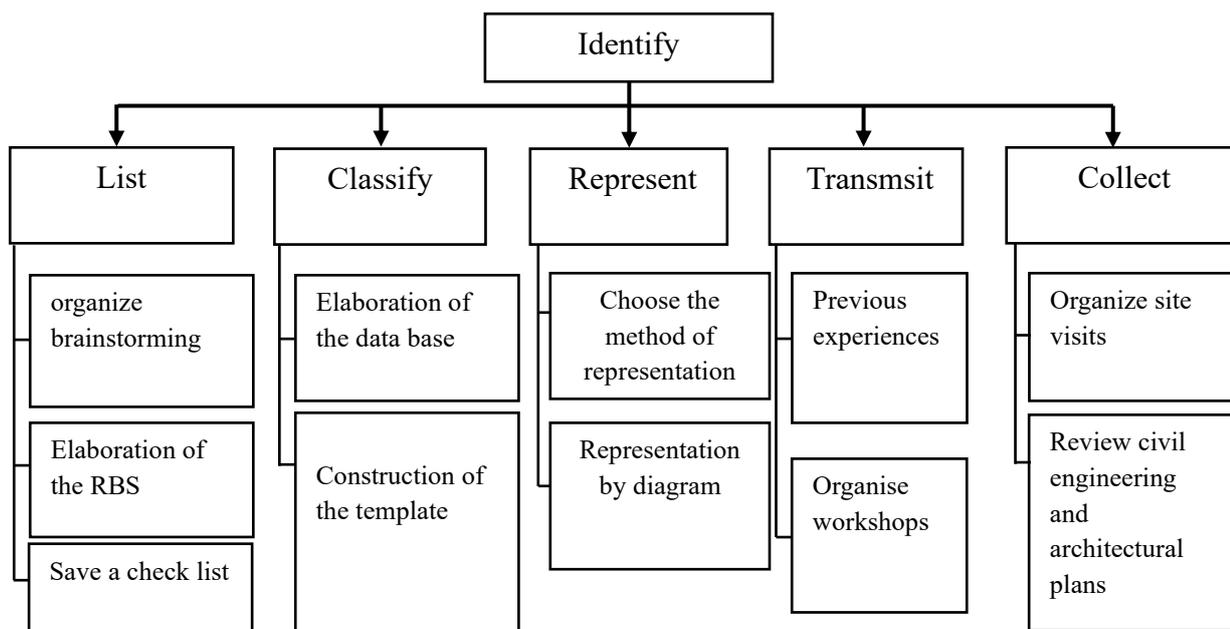


Figure 5 : The practices of the "risk identification" function

For the Analysis function in figure 6, which has four sub-functions, we find: recovering documented information, and collecting expert judgments

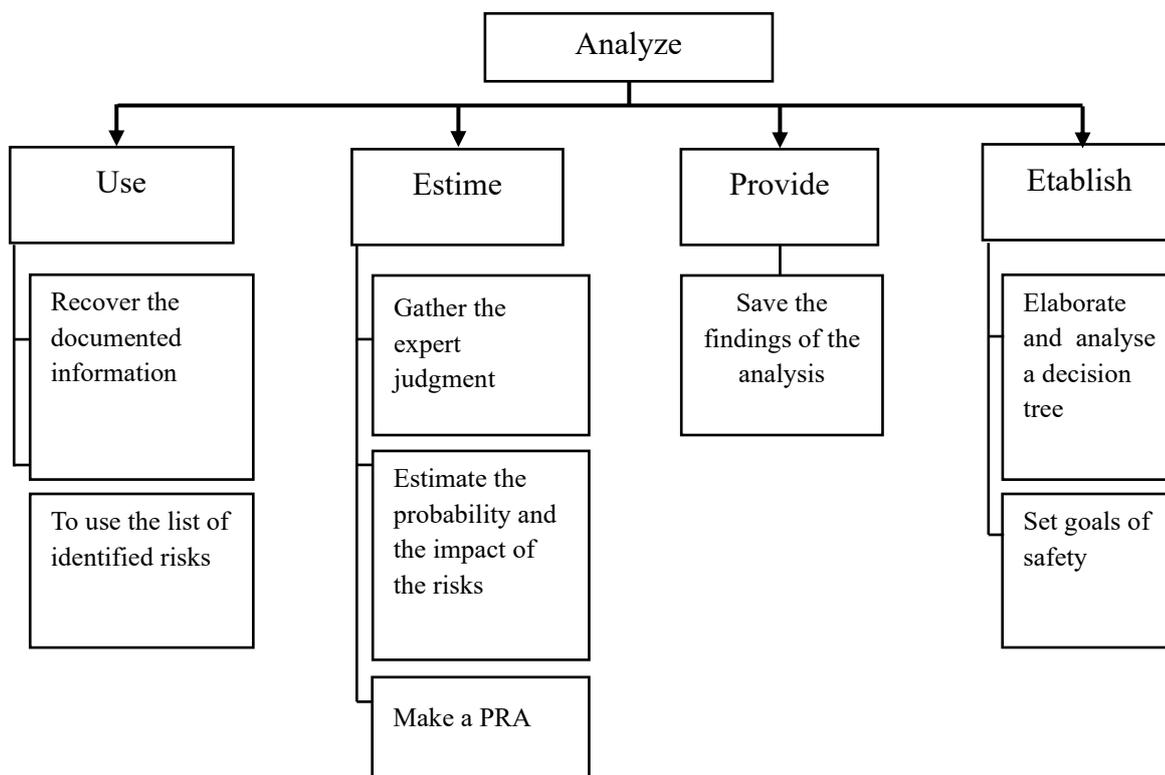


Figure 6 : The practices of the "risk analysis" function

For the Evaluation function, which has four sub-functions, we have: selecting the evaluation method, comparing results, and documenting findings. Figure 7.

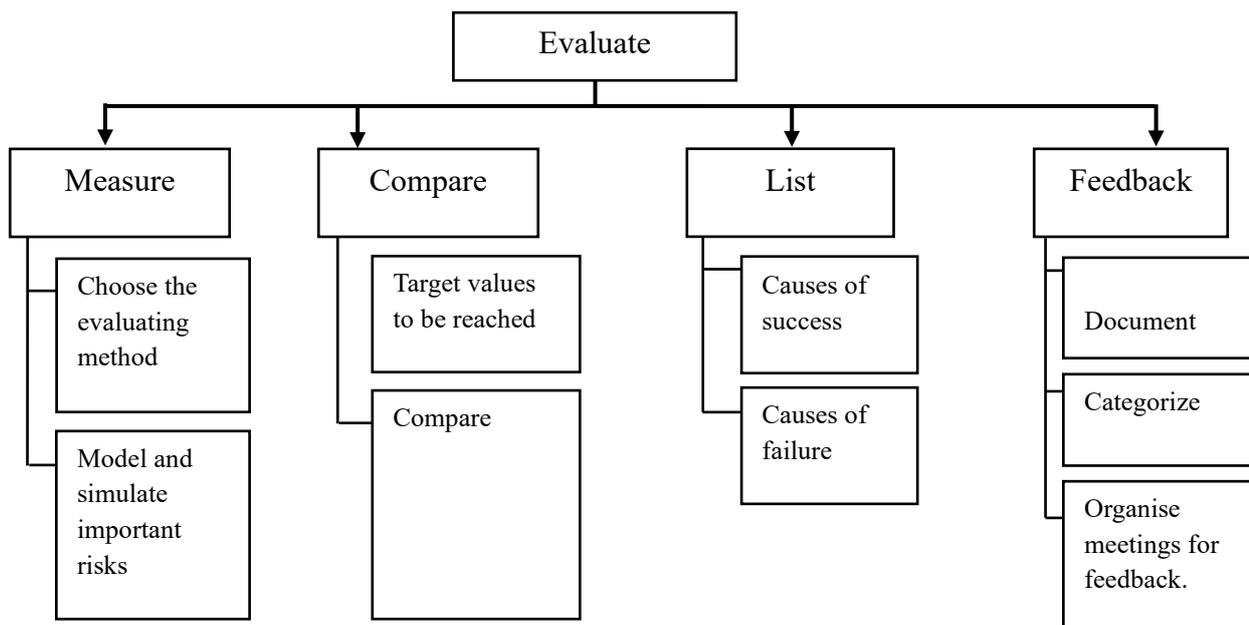


Figure 7 : The practices of the "risk evaluation" function

For last function Treat we have : Using checklists, organizing brainstormings sessions, Listing the advantages and disadvantages of these options. Figure 7.

In sum, our model showed in the next figure, which is based on a process approach, takes as input the different risks: environmental, financial, technical, natural, political, and managerial. These inputs will feed into a process with four main functions: identification, evaluation, analysis, and treatment. The output of this process represents business performance as reflected by the four perspectives: learning, processes, customer, and financial.

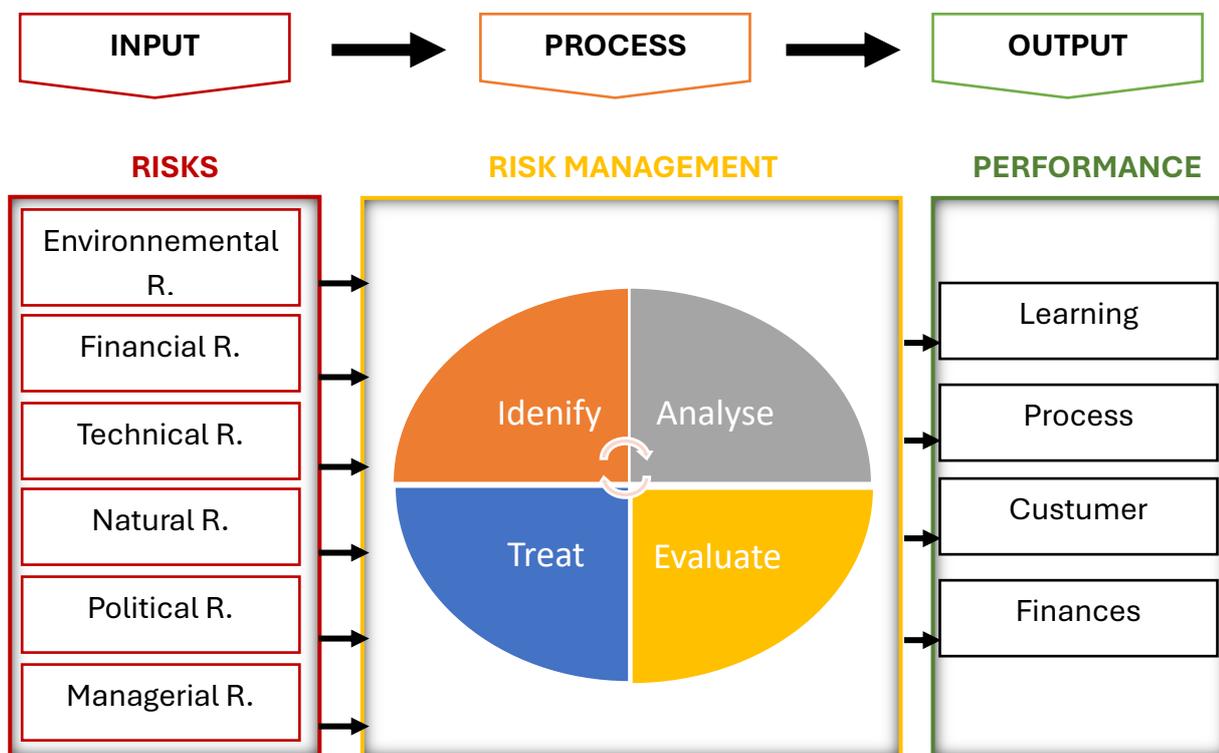


Figure 8 Theoretical model

## CONCLUSION

To achieve the objectives of this work, we began by classifying the different types of risks in the construction sector in the Algerian environment into six groups (Environmental, financial, technical, natural, political and managerial).

Then we opted for a model of four main RM functions: identification, analysis, evaluation and treatment. The systemic vision and functional analysis, accompanied by the APTE method, allowed us to identify the sub-functions of each main function of the process.

Then, based on the different works carried out, we came up with a synthesis of the different tools for each sub-function of the process. All this to achieve the final goal of our system which is "performance". This was framed according to the four main perspectives of the BCS, namely the financial perspective, the customer perspective, the internal business process perspective, and the learning and growth perspective.

The main limit of our research lies in its theoretical nature. So, this theoretical part will be followed by an experimental phase, where the proposed model will be tested by surveys carried out with the collaboration of some Algerian construction companies installed on the national territory. After processing and evaluation of the results, recommendations will be given to improve the implementation of the risk management system within construction companies.

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## ENHANCING SCHOOL EVACUATION STRATEGIES THROUGH PREDICTIVE ANALYTICS AND POPULATION PROFILING

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### ABSTRACT

The evacuation of educational institutions during emergencies is a critical component of crisis management, requiring systematic planning, coordination, and execution to ensure the safety of students, staff, and visitors. Predictive analysis has emerged as a key tool in enhancing evacuation strategies, as it allows institutions to anticipate risks, optimize responses, and adapt plans in real time. Schools and universities face a wide range of potential threats, including natural disasters, fires, armed attacks, technological hazards and other violent incidents, each demanding specific preparedness and response strategies. This study examines the principles and practices of evacuation planning within educational settings, highlighting the importance of risk assessment, infrastructure design, and population management. Special attention is given to the unique challenges of evacuating vulnerable populations such as young children, students or staff with disabilities, and large groups. Traditional static evacuation plans often fail to account for dynamic factors such as crowd density, mobility limitations, or the evolving nature of a threat. Predictive analysis algorithms introduce a data-driven approach, enabling real-time decision-making that is adaptive, inclusive, and efficient. This approach is based on the use of profiling, whereby individuals are categorized based on parameters such as age, physical ability, classroom location, and proximity to exits. This profiling allows the determination of the evacuation priority—ensuring, for example, that young children, students with disabilities, or those located closest to the hazard are directed out first. The predictive system leverages data from various sources, such as sensors, historical incident patterns, and real-time environmental inputs to generate optimized evacuation routes and timetables. Advanced machine learning models support risk forecasting and crowd-flow simulations, in order to refine decision-making protocols.

**Keywords:** crisis management, evacuation process, educational institutes, predictive analysis, population profiling

### 1. INTRODUCTION

The evacuation of educational institutions during emergencies is a crucial aspect of crisis management that requires careful planning, coordination, and execution (ECPFE, 2024, (Mavroulis et al., 2025, Yfantis et al., 2020). Schools and universities are complex social environments, often hosting hundreds or even thousands of individuals at any given time, ranging from very young children to adolescents, educators, staff, and visitors. These populations vary in terms of physical ability, age, familiarity with the premises, and capacity to remain calm under stressful conditions. Emergencies may include natural hazards such as earthquakes or floods, technological accidents like chemical leaks, or human-caused incidents,

including fires and armed intrusions. Each scenario requires a tailored evacuation strategy designed to move people efficiently while protecting vulnerable populations and minimizing panic (ECPFE, 2024).

Traditional evacuation plans are typically static, relying on predetermined routes and uniform procedures, directing all individuals to the nearest exit without accounting for differences in vulnerability or situational dynamics. While these approaches provide a basic framework, they often do not consider real-time changes, such as crowd density, mobility limitations, exit congestion, or the rapid escalation of hazards. Moreover, they rarely differentiate between individuals with varying evacuation needs. These limitations underscore the importance of adaptive, data-driven evacuation strategies (Lei et al., 2025, Elrifaae, 2025).

Advances in predictive analysis, including machine learning, network optimization, and dynamic simulation, support the development of adaptive evacuation models. These systems use profiling to categorize evacuees according to vulnerability and situational risk, ensuring that those least able to self-evacuate or most exposed to danger are given priority. Predictive modeling further allows for pre-event planning, and machine learning algorithms dynamically update evacuation routes as conditions change (Elrifaae, 2025).

The aim of this paper is to examine the application of predictive analysis and profiling in evacuation planning for educational institutions, with particular emphasis on prioritization strategies, and more specifically, who should evacuate first and why.

## 2. RESEARCH AND FINDINGS

### 2.1 State-of-the-art

Research on building evacuation has advanced substantially over the past decade, moving from descriptive studies of crowd behavior and architectural constraints to highly detailed simulations, data-driven modeling, and algorithmic decision support. Early studies focused on how architectural features, such as corridor width, number and placement of exits, and stairwell capacity, along with human decision-making under stress, influence evacuation outcomes (Gountromichou et al., 2014). These studies also consider how public perceptions and training influence evacuation compliance (Hashempour & Zohrevand, 2025). More recent work applies computational modeling and predictive systems to simulate evacuation scenarios with greater precision. Recent implementations of notification strategies in simulation models further improve real-time decision support (Elrifaae, 2025).

Educational environments pose specific challenges. Schools and universities host large numbers of children with diverse maturity levels, dense class-group structures, and staff whose roles shape behavior during emergencies. Children's limited mobility and increased tendency to panic complicate evacuation (Hashempour & Zohrevand, 2025, Najmanová & Ronchi, 2023). These findings have been confirmed in recent studies of school fire drills (Najmanová & Ronchi, 2023). Empirical studies and drill analyses indicate that younger children tend to move slower and require supervision, adult leaders strongly influence compliance, and multi-floor school buildings may lack modern accessibility standards, creating obstacles for individuals with disabilities (Najmanová & Ronchi, 2023, Najmanová et al., 2025, van der Wal et al., 2021). Profiling and post-occupancy evaluations have been used to better understand movement patterns and accessibility challenges (Najmanová & Ronchi, 2023, Najmanová et al., 2025).

Parallel research demonstrates that predictive models can forecast hazard propagation (e.g., smoke, fire growth), estimate crowd-flow dynamics under different start-time and routing

policies, and identify high-risk locations within buildings before and during emergencies. Studies in educational infrastructures indicate that mixed strategies, combining horizontally phased evacuation, vertical phasing, and targeted placement of vulnerable populations near exits, can reduce total evacuation time and improve outcomes for heterogeneous populations. Fire characteristics and emergency evacuation analysis in urban environments provide further insight for educational settings (Zhang, 2024).

These findings have driven the development of evacuation strategies that account for group structures (class-by-class sequencing), adult-guided movement, and infrastructure modifications such as dedicated accessible ramps (Wang et al., 2024). Simulation-based studies have shown that profiling-based evacuation, according to age, mobility, and role, reduces both risks and overall evacuation times (Ntalianis et al., 2010, Wang et al., 2024). Performance-based evacuation planning prioritizing vulnerable groups and providing dedicated exits for mobility-impaired populations improved both fairness and efficiency, with evacuation time reductions of up to 18% (Chen et al., 2024).

Socio-technical and legal considerations are increasingly emphasized. Predictive, profiling-based evacuation systems raise privacy, fairness, and robustness concerns, especially when handling sensitive information about minors or disabilities. These considerations highlight the need for privacy-preserving analytics and strong institutional policies to safeguard sensitive data while maintaining safety benefits.

Overall, the literature demonstrates a transition from static evacuation models to adaptive, profiling-based systems that integrate technology, inclusivity, and real-time responsiveness. Educational institutions, given their population structure, stand to benefit significantly from these advances.

## 2.2. The Proposed Scheme

The proposed evacuation framework is a predictive, data-driven system that combines population profiling, real-time sensing, and adaptive routing to optimize emergency evacuation in educational institutions. Unlike static plans, the system classifies individuals based on age, mobility, classroom location, and proximity to hazards, ensuring those with the lowest evacuation speed, like young children, individuals with disabilities, or staff/students near hazards, receive priority assistance.

The framework collects real-time data on crowd density, environmental hazards (e.g., smoke, temperature, blocked exits), and individual positioning, supplemented by historical data from previous incidents. Predictive modeling and machine learning algorithms allow the system to dynamically update evacuation routes in response to evolving conditions (Alac et al., 2024, Elrifaae, 2025).

Evacuation instructions are communicated through multiple channels, including mobile alerts, classroom smart boards alerts (Ntalianis et al., 2014), and floor-level visual indicators such as LED pathways. This near real-time capability optimizes escape flows, reduces bottlenecks, and enhances safety for vulnerable populations.

The scheme operates within a hierarchical decision-making framework, where school administrators and emergency personnel maintain oversight, and the predictive system provides automated recommendations to accelerate response times. Recent implementations of such frameworks have improved decision speed and compliance in school simulations (Elrifaae, 2025).

### 3. RESULTS AND DISCUSSION

#### 3.1 Evaluation

Because the system remains in a conceptual phase, evaluation is carried out through comparative analysis against established approaches in the literature. The table below summarizes key differences.

**Table 1:** Comparative Analysis of Proposed System vs Others

Feature	Proposed System	Existing Systems in Literature	Comparative Advantage
<b>Prioritization of vulnerable groups</b>	Uses profiling to prioritize young children, individuals with disabilities, and those closest to hazards	Most systems apply uniform evacuation strategies without differentiation (Zhao et al., 2022)	Stronger inclusivity and ethical alignment
<b>Computational requirements</b>	Requires high-performance computing for real-time simulations and sensor integration	Many existing models are less computationally demanding but rely on pre-defined static routes (Gwynne et al., 2022)	More accurate but computationally heavier
<b>Real-time adaptation</b>	Supports near real-time updates based on dynamic environmental inputs	Traditional models often static; some semi-dynamic simulations exist but lack immediate responsiveness (Almatared et al., 2023, Lv et al., 2023)	Faster and more adaptive decision-making
<b>Position tracking</b>	Incorporates IoT sensors and localization for individual-level tracking	Few existing approaches include detailed location-based data (Wang et al., 2022)	Improved accuracy in directing evacuees
<b>Communication</b>	Multi-channel alerts (mobile, signage, LED pathways)	Mostly rely on manual staff guidance and static alarms (McConnell & Parnell, 2022)	Reduced panic, better information delivery

This conceptual comparison illustrates that the proposed system advances inclusivity, adaptability, and accuracy.

### 4. CONCLUSIONS

#### 4.1 Conclusion and Future Work

This paper proposed a predictive evacuation framework for educational institutions, addressing the unique challenges of complex populations and infrastructures. Core features include population profiling, real-time data processing, and adaptive routing algorithms. Unlike static plans, which often apply uniform strategies regardless of individual needs or evolving environmental conditions, the proposed system differentiates evacuation priorities based on vulnerability, mobility, and proximity to hazards.

Through continuous analysis of real-time data from sensors, IoT devices, and building management systems, the scheme dynamically recalculates escape routes, reduces congestion, and enhances overall emergency response efficiency. By embedding inclusivity and adaptability, the system addresses critical gaps in traditional plans and offers a framework aligned with modern principles of crisis management and resilient infrastructure (Kyriakopoulos et al., 2020).

In addition to operational improvements, the framework promotes ethical and equitable evacuation strategies, ensuring that vulnerable populations, including children, individuals with disabilities, and those with limited situational awareness, receive prioritized assistance. This approach not only increases safety outcomes but also aligns with best practices in inclusive emergency management.

Compared to existing evacuation systems, which are largely static or only partially dynamic, the proposed predictive, profiling-based framework offers significant improvements across multiple dimensions. Unlike traditional models that direct all individuals along the same pre-defined routes, this system prioritizes those who are most vulnerable, such as children, individuals with disabilities, and those closest to hazards, ensuring timely assistance and reducing risk. Its real-time adaptation to environmental changes, crowd density, and hazard progression allows for dynamic rerouting, minimizing congestion and bottlenecks, which are common challenges in conventional plans. Furthermore, multi-channel communication through mobile alerts, classroom displays, and LED pathways reduces confusion and panic, enhancing overall compliance. Finally, the integration of ethical, privacy, and inclusivity considerations ensures that evacuation is not only faster and safer but also equitable, addressing gaps often overlooked in traditional approaches. These features collectively make the new system more resilient, efficient, and socially responsible than pre-existing evacuation strategies.

Future work will focus on simulation-based validation to test prioritization algorithms under various hazard scenarios, improvements in computational efficiency, and the integration of ethical and privacy safeguards in line with GDPR and other regulatory standards, establishing clear data governance protocols. Moreover, pilot studies in educational institutions are planned to assess practical feasibility, user compliance, and integration with existing emergency response procedures.

Further research will explore the integration of emerging technologies, such as AI-powered hazard detection, to enhance situational awareness and evacuation precision. Additionally, multi-hazard scenarios, including concurrent fire, earthquake, and human-caused emergencies, will be simulated to evaluate system robustness under complex conditions.

Finally, interdisciplinary collaboration with educators, safety engineers, policymakers, and psychologists will be critical to refine communication strategies, optimize human-technology interaction, and ensure that evacuation protocols are socially and ethically responsible. These efforts aim to translate the conceptual framework into actionable, real-world safety improvements for educational environments globally.

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