



1. Uluslararası PERGE

Bilimsel Arařtırmalar ve İnovasyon Kongresi

21-22 NİSAN 2026
ANTALYA

Editörler:

Prof. Dr. Merter MERT
Doç. Dr. Sevcan YILDIZ



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CONGRESS ID

CONGRESS TITLE

INTERNATIONAL PERGE SCIENTIFIC RESEARCH AND INNOVATION CONGRESS-I

DATE AND PLACE

21-22 APRIL 2026 ANTALYA/ TÜRKİYE ONLINE PRESENTATIONS

ORGANIZATION

ISARC Academy INTERNATIONAL SCIENCE AND ART RESEARCH CENTER

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Scientific Development and Innovative Approach

***INTERNATIONAL PERGE
SCIENTIFIC RESEARCH AND INNOVATION
CONGRESS-I***
April 21-22, 2026 / Antalya, Türkiye

Congress Program

Participant Countries:

Türkiye, Algeria, Georgia, India, Morocco, Ukraine, Usa, Pakistan, Romania, Vietnam

Meeting ID: 873 9806 7600

Passcode: 401188

ZOOM LINK:

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21.04.2026 / Hall-1, Session-1



Ankara Local Time



10⁰⁰ : 11³⁰



Meeting ID: 873 9806 7600



Passcode: 401188

HEAD OF SESSION: Prof. Dr. Merter MERT

TOPIC TITLE	AUTHORS	AFFILIATION
Risk Analysis	Emin Ergun SELÇUK	Tokat Gaziosmanpaşa University
Data Mining	Emin Ergun SELÇUK	Tokat Gaziosmanpaşa University
Macro Primary Balances In Türkiye Based On Recent Foreign Direct Investments And Financial Developments	Prof. Dr. Ahmet Niyazi Özker	Bandirma Onyedi Eylül University
Some Characteristics Of Industrial Sectors In Türkiye During The Period 1932-1939	Prof. Dr. Merter MERT	Ankara Hacı Bayram Veli University
The Number Of Industrial Establishments And Their Importance According To Various Indicators In Türkiye During The Period 1932-1939	Prof. Dr. Merter MERT	Ankara Hacı Bayram Veli University
The Concept Of Migration: The Economic, Financial, And Social Impacts Of Migration	Lect. Dr. Nuh Ekrem YILDIRIM Lect. Mübeyna DOĞAN	Akdeniz University/İnönü University

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21.04.2026/ Hall-2, Session-1



Ankara Local Time



10⁰⁰ : 11³⁰



Meeting ID: 873 9806 7600



Passcode: 401188

HEAD OF SESSION: *Y. Mimar Büşra ARSLAN*

TOPIC TITLE	AUTHORS	AFFILIATION
Evaluation Of The Structural Performance Of The Historical Masonry Minaret Of The Molla Çelebi Mosque In Istanbul, Turkey	Muhammed Ensar YILDIRIM Ömer Faruk ÖZER Ahmet Emre KADIOĞLU Mustafa Enver Çakmak Ferit ÇAKIR	Gebze Technical University
Bio-Computational Integration Model (Bcdım): Towards A Generative Framework For The Integration Of Artificial Intelligence And Biomimicry In Architecture	Velasquez Macias OSCAR MAURICIO Assist. Prof. Hüseyin ZÜLFİKAR	Istanbul Sabahattin Zaim University
Houses With Ghste In Safranbolu	Y. Mimar Büşra ARSLAN	Karabük University
A Comparative Evaluation Of The Seismic Behavior Of Traditional Building Systems: Timber Frame And Masonry Structures	Y. Mimar Büşra ARSLAN	Karabük University
From Traditional Studios to Virtual Environments: Digital Transformation in Algerian Architectural Education	Melik Sami , Khelil Sara , Tallal Abdel Karim Bouzir	Mohamed Khider Biskra University/ALGERIA
Architectural Education Reform in Algeria: Transitioning from Traditional Methods to Modern Approaches	Melik Sami , Khelil Sara , Tallal Abdel Karim Bouzir	Mohamed Khider Biskra University/ALGERIA

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21.04.2026/ Hall-3, Session-2



Ankara Local Time



10³⁰ : 11⁴⁵



Meeting ID: 873 9806 7600



Passcode: 401188

HEAD OF SESSION: *Prof. Dr.Cevdet ŞEKER*

TOPIC TITLE	AUTHORS	AFFILIATION
Linalool Exerts A Modulatory Effect On The Src Protein In Cisplatin-Induced Heart Damage In Rats	Assist. Prof. Dr. Seydi Ahmet ŞENGÜL	Hatay Mustafa Kemal University
Determining The Effect Of Waste Vehicle Tire Biochar On Aggregate Stability And Water Potential Of A Sandy Soils In Wind Erosion-Affected Areas	Sena Nur GEDİZ Prof. Dr.Cevdet ŞEKER	Selçuk University
Evaluation Of The Effects Of Maiz Straw Biochar On The Reaction, Water Holding Capacity, And Aggregation Of Volcanic-Origin Acidic Soil	Kader ÇITAK Prof. Dr.Cevdet ŞEKER	Selçuk University
Impact Of Probiotic And Prebiotic Use On Gastrointestinal Complications After Bariatric Surgery	Damla OĞUZ PhD. Ayşe Semra AKSOY	Bezmialem Vakıf University
Natural Modulation Of The Gut Microbiota In Patients With Food Allergies. Impact Of Alergiplant	Major Gheorghe GIURGIU Prof. Dr. Manole COJOCARU	Deniplant-Aide Sante Medical Center/Titu Maiorescu University/ROMANIA

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21.04.2026/ Hall-4, Session-2



Ankara Local Time



10³⁰ : 12⁰⁰



Meeting ID: 873 9806 7600



Passcode: 401188

HEAD OF SESSION: Assist. Prof. Dr. Ferhat ÖZTÜRK

TOPIC TITLE	AUTHORS	AFFILIATION
Modeling Of Flow Around A Vehicle Geometry Using Potential Flow Theory And The Finite Difference Method And Cfd Validation	Ali BOZKURT	Gazi University
Influence Of Nio Nanoparticles On The Cyclic Voltammetry Performance Of Conductive Carbon-Based Supercapacitor Electrodes	Mohammed T. Al-Hakimi Khaled M. CHAHROUR	Karabük University
Digital Accessibility Within The Context Of Universal Design Principles: Interface Design Standards For Visually Impaired Users	Lect. Ebubekir KOÇAK	Istanbul Esenyurt University
From Drawing To Prompt Engineering: The Transformation Of Technical Skills And The Search For New Curriculum Developments In Visual Communication Design Education	Lect. Ebubekir KOÇAK	Istanbul Esenyurt University
A Contextual Analysis Of The Problems Posed By Pre-Service Mathematics Teachers	Dilara DOK Assist. Prof. Dr. Ferhat ÖZTÜRK	Kırıkkale University
Pre-Service Mathematics Teachers' Views On The Concepts Of Thinking And Empathic Thinking	Assist. Prof. Dr. Ferhat ÖZTÜRK Dilara DOK Assoc. Prof. Dr. Bilge ÖZTÜRK	Kırıkkale University/Bayburt University

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21.04.2026/ Hall-5, Session-2



Ankara Local Time

10³⁰ : 12³⁰



Meeting ID: 873 9806 7600

Passcode: 401188

HEAD OF SESSION: DR.S. SELVAM

TOPIC TITLE	AUTHORS	AFFILIATION
Innovative Strategies For Enhancing Nitrogen Efficiency In Agriculture	ELABBARI Chaimaa , Pr. Labjar Najoua , Oujidane El ouali , EL BOUZIDI Ahmed ,ZINAOUI Badre , Pr.EL Hajjaji souad	Mohammed V University/MOROCCO
Production And Characterization Of Carbon Nanotubes From Biochar Under Microwave Irradiation	Faisal Nazir	THE UNIVERSITY OF AGRICULTURE/PAKISTAN
The Scientific Discourse On Academic Freedom In The 21st Century: A Comprehensive Analysis Of Theoretical Premises, Normative Systems, Challenges, And The Dilemma Of Academic Proficiency In Contemporary Higher Education Reforms And Policies Worldwide	Nodar Sulashvili , Ekaterine Lomia , Vira Kravchenko , Mzia Tsiklauri ,Lolita Shengelia , Levan Gulua , Ada (Adel) Tadevosyan , Nato Alavidze , Marika Sulashvili , Igor Seniuk , Tamar Okropiridze , David Aphkhazava	East European University/Georgian American University/Gr.Robakidze University/Yerevan State Medical University/National University of Pharmacy/GEORGIA/UKRAINE/USA
Overview of the Impact of Artificial Intelligence on Human Resource Management	Luong Hoang Phuoc Hoang Le Buu	Thu Dau Mot University/VIETNAM
Who is Liable When AI Causes Harm? A Comparative Analysis of AI Liability Frameworks Across Jurisdictions	Le Thi Minh	Thu Dau Mot University/VIETNAM
Human Behavior Under Pressure in Attack on Titan	K.NAVEEN RAJAN DR.S. SELVAM	NADAR MAHAJANA SANGAM S VELLAICHAMY NADAR COLLEGE/INDIA
Social Media And Its Impact On Mental Health	S. DHARANI DR.S. SELVAM	NADAR MAHAJANA SANGAM S VELLAICHAMY NADAR COLLEGE/INDIA
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21.04.2026/ Hall-6, Session-3



Ankara Local Time

10³⁰ : 12³⁰



Meeting ID: 873 9806 7600

Passcode: 401188

HEAD OF SESSION: Assist. Prof. Dr. MUHAMMAD FAISAL

TOPIC TITLE	AUTHORS	AFFILIATION
Self-Sovereign Identity (SSI) and Decentralized Identifiers: Empowering Beneficiary Agency in Social Safety Nets	Assist. Prof. Dr. MUHAMMAD FAISAL	Allama Iqbal Open University/PAKISTAN
Neuro-Symbolic AI for Policy Transparency Combining Deep Learning with Logical Reasoning in BISP	Assist. Prof. Dr. MUHAMMAD FAISAL	Allama Iqbal Open University
State-Citizen Communication under the National Food Security Act: Awareness, Access, and Welfare Delivery	Miss Renju A Mr. Abhishek Kumar Verma	Central University of Punjab
Dietary Patterns And Nutritional Status Of Pregnant Women Delivering Low Birth Weight Newborns In El Jadida Province, Morocco : A Case-Control Study	Houda Elfane Sanaa El-Jamal Imane Barakat Halima Daif Chamlal Hamid Firdaous Friki Mohammed El Ayachi Rekia Belahsen	Chouaib Doukkali University/Higher Institute of Professions Nurses and Health Techniques/Mohammed VI University of Health Sciences (UM6SS)/MOROCCO
Synthesis And Characterization Of Ca-Alginate/Cuo Bionanocomposite For Removal Of Reactive Yellow 145 Dye: A Green Approach Towards Sustainability	Dr. Shumaila Kiran Saman Shams	Government College University
To Investigate the Anti-inflammatory Activity of Gold Nano-Rods using CT-26 cell lines and Zebra Fish Model	Ms. Saloni Sharma Dr. K Gowthamarajan,	JSS College of Pharmacy/INDIA
Adherence to the Mediterranean Diet in Patients Undergoing Renal Replacement Therapy in Morocco	Rachida MOUSTAKI , Firdaous FRIKI, Imane BARAKAT , Mohamed MZIWIRA, Rekia BELAHSEN	Chouaib Doukkali University/Hassan II University
Dietary Exposure to Microplastics in Low- and Middle-Income Settings: Exploratory Modeling, Metabolic Implications, and Regulatory Gaps (Focus on North Africa)	Sanaa El-Jamal , Houda Elfane , Imane Barakat, Rekia Belahsen	Chouaib Doukkali University/Higher Institute of Professions Nurses and Health Techniques/MOROCCO

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21.04.2026/ Hall-7, Session-3



Ankara Local Time



10³⁰ : 12³⁰



Meeting ID: 873 9806 7600



Passcode: 401188

HEAD OF SESSION: *DR.Sidra Altaf*

TOPIC TITLE	AUTHORS	AFFILIATION
Enhancing Food Security through the Valorization of Local Cereal Varieties in the Regions of Khenifra and Tetouan, Morocco	Kaoutar Naciri , AbdelMounaim Belahyan, Rekia Belahsen	Chouaib Doukkali University/MOROCCO
Artificial Intelligence Across the Architectural Workflow: From Conceptual Design to Construction Execution	Melik Sami , Khelil Sara , Tallal Abdel Karim Bouzir	Mohamed Khider Biskra University/ALGERIA
AI-Augmented Sustainable Design: Improving Environmental Performance in Contemporary Architecture	Melik Sami , Khelil Sara , Tallal Abdel Karim Bouzir	Mohamed Khider Biskra University/ALGERIA
Exploring the Acoustic Nexus in Urban Neighborhoods: Architecture, Perception, and Environmental Noise Dynamics	Melik Sami , Khelil Sara , Tallal Abdel Karim Bouzir	Mohamed Khider Biskra University/ALGERIA
High-Fidelity Simulation of a NuScale-Like SMR Benchmark Using the OpenMC Code	CHAKROUNE Soukaina, MAGHNOUJ Abdelmajid, EL MAHJOUB Chakir	Sidi Mohamed Ben Abdellah University/Ibn Tofail University/MOROCCO
Antibiotic Resistance Dynamics in UTI: Emerging Trends in Susceptibility Patterns	DR.Muhammad Saleh Faisal, Ayesha Jamil, Waqar Hayat, Kashif Ur Rehman Khalil	Khyber Medical College/PAKISTAN
In Silico Analysis Of Plant Proteins: Unveiling Novel Antimicrobial Strategies Against Viral Infections	DR.Sidra Altaf DR.Tasawar Iqbal	University of Agriculture/PAKISTAN
Therapeutic Potential Of Okra (Abelmoschus Esculentus) Powder In The Management Of Diabetes Mellitus	DR.Sidra Altaf DR.Tasawar Iqbal	University of Agriculture/PAKISTAN

Moderator is responsible for ensuring the smooth running of the presentation, managing the group discussion and dynamics

PHOTO GALLERY

zoom Workplace | Hall 1-Nuh Ekrem Yıldırım adlı kiş...

ISARC academy... | ISARC academy MELİKE KAYA | Hall 1-Nuh Ekrem Yıldırım | Hall 1-Merter Mert | Hall-1, Ahmet Niyazi Özker

SUNUM.GÖÇ - PowerPoint | Oturum açın

► Bu göç olgusu ister gönüllü ister zorlama ister sınırlar aşılsın ister aynı sınırlar içinde gerçekleşsin hem sosyolojik hem ekonomik hem de siyasal pek çok sorunun ortaya çıkmasına neden olmaktadır.

► Birleşmiş Milletler, bir yer değiştirmenin göç sayılabilemesini; hareketliliğin en az bir yıl sürmesi, nispeten uzun/kalıcı bir mesafeyi kapsaması ve de yaşanılan yerin/ülkenin sınırları dışına yapılmış olması gibi üç kritere bağlamıştır.

12 atanmamış katılıma

Ses | Video | Katılımcılar | Sohbet | Tepki ver | Paylaş | Oturum sahibi araçları | Ara odalar | Daha fazla | Odadan çık

zoom Workplace | Hall 1-Merter Mert adlı kişinin ekr...

ISARC academy... | ISARC academy MELİKE KAYA | Hall 1-Nuh Ekrem Yıldırım | Hall 1-Merter Mert | Hall-1, Ahmet Niyazi Özker | Ergun Selçuk

Ötümük Kaydet | perçe 1 • Kaydedildi

BULGULAR

Şekil 1. Sanayi kollarındaki müesseselerin toplam müessese adı içindeki payı (1932-1939, ortalama)

Sanayi Kolu	Ortalama Payı
Sanayi istihacine	0,0223
Ziraat, hayvancılık ve orman sanayi	0,4358
Sanayi inşaatı	0,2291
Sanayi işletme	0,0649
Kağıt ve karton sanayi	0,0287
Sanayi madencilik	0,0463
Emniyet inşaatı sanayi	0,0256
Sanayi kumpanya	0,0378
Sanayi mühendislik	0,0520
Sanayi mühendislik ve diğer müesseseler	0,0576

Ses | Video | Katılımcılar | Sohbet | Tepki ver | Paylaş | Oturum sahibi araçları | Ara odalar | Daha fazla | Odadan çık

zoom Workplace Toplantı Hall1-Merter Mert adlı kişinin ekr. REC

ISARC academy... ISARC academy MELKE KAYA Hall 1-Nuh Ekrem Yıldırım Hall1-Merter Mert Hall-1, Ahmet Niyazi Özker Ergun Selçuk

Otomatik Kaydet perge 1 • Kaydedildi Ara Kaydet Paylaş

Dosya Giriş Ekle Çiz Tasarım Geçişler Animasyonlar Slayt Gösterisi Kaydet Gözden Geçir Görünüm Yardım

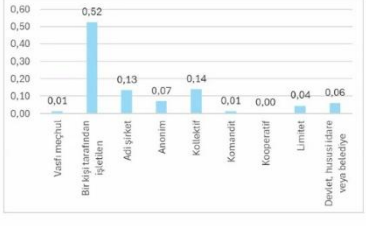
Yapıştır Yeni Slayt Copilot ile Yeni Slayt Sıfırla Bölüm

Pano Fi Slaytlar Yazı Tipi Paragraf Çizim Şekiller Yerleştir Hızlı Stiller Seç Bu ve Değiştir Yazı Tiplerini Değiştir Dikte Eklenler Tasarım Önerileri Copilot

13 14 15 16 17 18

BULGULAR

Şekil 1 Sanayi kullannın farklı vasıflar açısından oranı (1932-1939, ortalama)



Vasıflar	Oran
Vasıflı memurlar	0,01
Bir kişi tarafından işletilen	0,52
Adli işkret	0,13
Anonim	0,07
Kolektif	0,14
Komandifi	0,01
Kooperatif	0,00
Limited	0,04
Devlet teşvitiyle veya devletçe	0,06

Ses Video Katılımcılar 5 Sohbet Tepki ver Paylaş Oturma sahibi araçları Ara odalar Daha fazla Odadan çık

zoom Workplace Toplantı ES Ergun Selçuk adlı kişinin ekranı REC

ISARC academy... ISARC academy MELKE KAYA Hall 1-Nuh Ekrem Yıldırım Hall1-Merter Mert Ergun Selçuk Hall-1, Ahmet Niyazi Özker

Risk Analizi (4) - Microsoft PowerPoint

Dosya Giriş Ekle Tasarım Geçişler Animasyonlar Slayt Gösterisi Gözden Geçir Görünüm

Yapıştır Yeni Slayt Sıfırla Bölüm

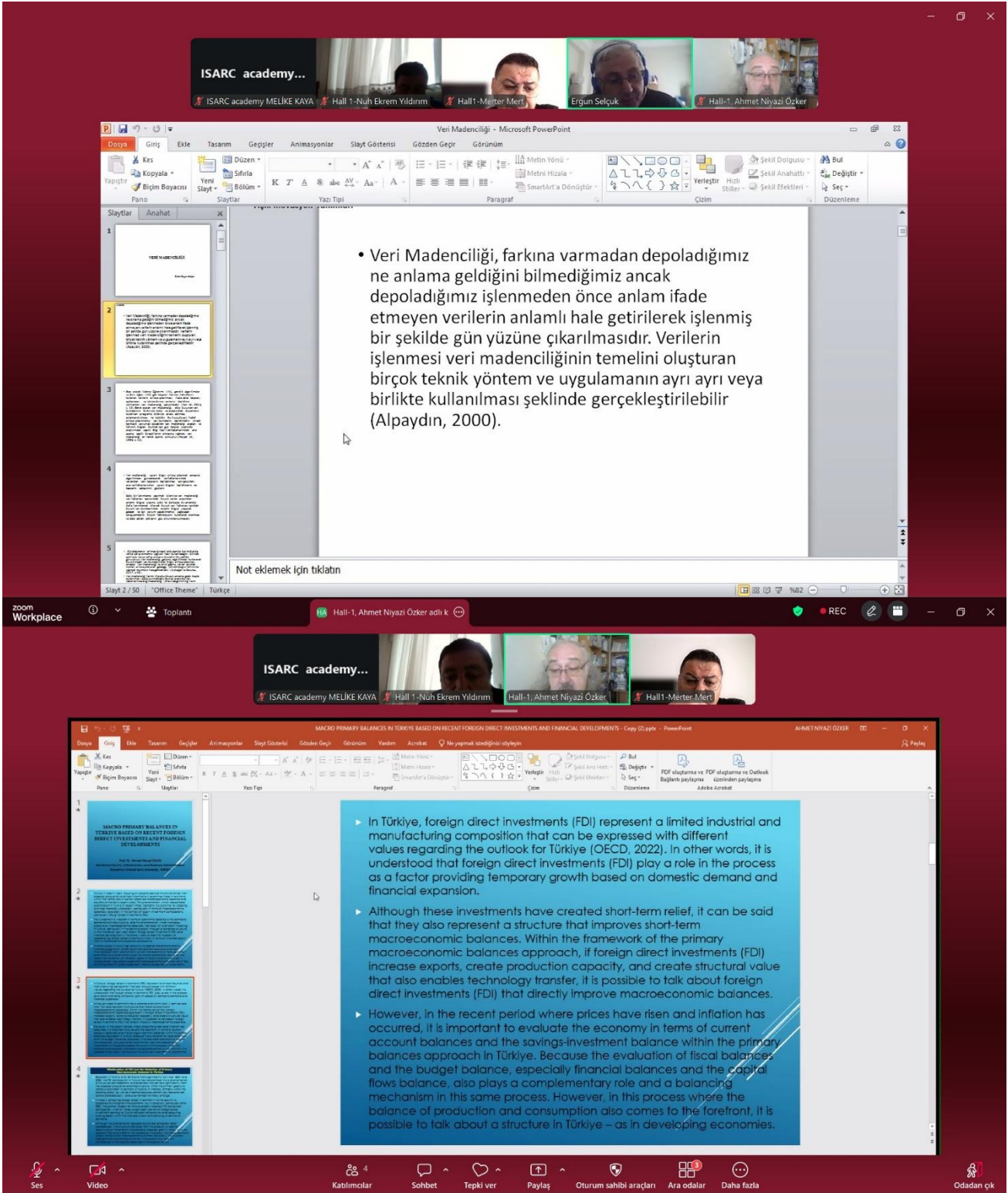
Pano Slaytlar Anahat

1 2 3 4

tanımlandığı görülmektedir (Mahmood, 2012, s. 82). Yapılan birbirinden farklı risk tanımlarının ortak noktası ise risk kavramının bir belirsizlik içermesi ve bu belirsizliğin zarar veya kayba yol açabilme ihtimalidir. Fakat risk ile belirsizlik bir noktada birbirinden ayrılmaktadır. Bu da riskin sayısallaştırılabilmesi özelliğinden kaynaklanmaktadır (Polat, 2017, s. 89). Riskin sayısallaştırılabilmesi ise, riskin yönetilmesi fikrini devreye sokmuştur.

Not eklemek için tıklayın

Ses Video Katılımcılar 5 Sohbet Tepki ver Paylaş Oturma sahibi araçları Ara odalar Daha fazla Odadan çık



The screenshot displays a Zoom meeting interface with a PowerPoint presentation. The top of the screen shows the Zoom meeting controls, including a video icon, a microphone icon, and a 'REC' indicator. The meeting title is 'ISARC academy...'. The participants list includes 'ISARC academy MELIKE KAYA', 'Hall 1-Nuh Ekrem Yıldırım', 'Hall 1-Merter Mert', 'Ergun Selçuk', and 'Hall 1, Ahmet Niyazi Özker'.

The main content is a PowerPoint slide titled 'Veri Madenciliği - Microsoft PowerPoint'. The slide contains the following text:

- Veri Madenciliği, farkına varmadan depoladığımız ne anlama geldiğini bilmediğimiz ancak depoladığımız işlenmeden önce anlam ifade etmeyen verilerin anlamlı hale getirilerek işlenmiş bir şekilde gün yüzüne çıkarılmasıdır. Verilerin işlenmesi veri madenciliğinin temelini oluşturan birçok teknik yöntem ve uygulamanın ayrı ayrı veya birlikte kullanılması şeklinde gerçekleştirilebilir (Alpaydın, 2000).

Below the slide, there is a note: 'Not eklemek için tıklayın'.

The bottom of the screen shows the Zoom meeting controls, including a video icon, a microphone icon, and a 'REC' indicator. The meeting title is 'ISARC academy...'. The participants list includes 'ISARC academy MELIKE KAYA', 'Hall 1-Nuh Ekrem Yıldırım', 'Hall 1, Ahmet Niyazi Özker', and 'Hall 1-Merter Mert'.

The main content is a PowerPoint slide titled 'MACRO PRIMARY BALANCES IN TÜRKİYE BASED ON RECENT FOREIGN DIRECT INVESTMENTS AND FINANCIAL DEVELOPMENTS - Copy 01.pptx - PowerPoint'. The slide contains the following text:

- In Türkiye, foreign direct investments (FDI) represent a limited industrial and manufacturing composition that can be expressed with different values regarding the outlook for Türkiye (OECD, 2022). In other words, it is understood that foreign direct investments (FDI) play a role in the process as a factor providing temporary growth based on domestic demand and financial expansion.
- Although these investments have created short-term relief, it can be said that they also represent a structure that improves short-term macroeconomic balances. Within the framework of the primary macroeconomic balances approach, if foreign direct investments (FDI) increase exports, create production capacity, and create structural value that also enables technology transfer, it is possible to talk about foreign direct investments (FDI) that directly improve macroeconomic balances.
- However, in the recent period where prices have risen and inflation has occurred, it is important to evaluate the economy in terms of current account balances and the savings-investment balance within the primary balances approach in Türkiye. Because the evaluation of fiscal balances and the budget balance, especially financial balances and the capital flows balance, also plays a complementary role and a balancing mechanism in this same process. However, in this process where the balance of production and consumption also comes to the forefront, it is possible to talk about a structure in Türkiye – as in developing economies.



Hasar Mekanizmaları

1. Uluslararası Perge
Bilimsel Araştırmalar ve İnovasyon Kongresi

Yığma Yapılar:

- Kesme çatlakları
- Köşe ayrışmaları
- Duvar yıkılmaları



(Rijit ama kırılğan)

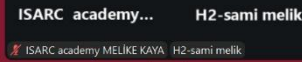
Ahşap Karkas Yapılar:

- Bağlantı noktası hasarı
- Dolgu malzemesi hasarı
- Ancak sistem genelde ayakta kalır



(Sünek ve enerii sönmöyleyici)

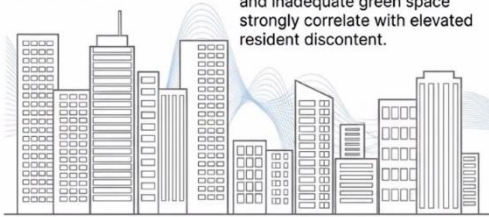
4 atanmamış katılımcı



Results: Architecture and Greenery Override Objective Noise Data

The High-Density Baseline

Peak SPL: >85 dB

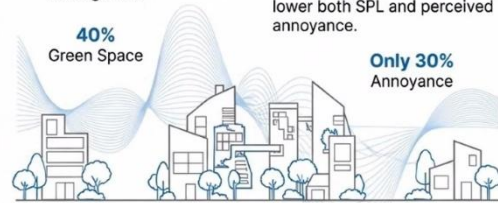


Finding: Compact building styles and inadequate green space strongly correlate with elevated resident discontent.

The Anomaly (The Green Effect)

55 dB
Average SPL

40%
Green Space



Finding: Spatial buffers and low-density profiles drastically lower both SPL and perceived annoyance.

Only 30%
Annoyance

The Vibrancy Phenomenon: Areas with complex architectural layouts and high greenery mitigate annoyance even when SPL is high. Residents perceive these higher noise levels as urban vibrancy rather than discomfort, driven by emotional attachment and acoustic identity.



<p>Ahmet Emre Ka... Ahmet Emre Kadioğlu</p>	<p>HALL2-MUHAM... HALL2-MUHAMMED ENSAR YIL...</p>	<p>Hall-4, Dilara D... Hall-4, Dilara DOK</p>	<p>A Hall-4 Ali Bozkurt</p>	<p>Mustafa Enver... Mustafa Enver Çakmak</p>	<p>Omer Omer</p>
			<p>INVESTIGATION OF REASONS OF THE COLLAPSE REASONS AND STRENGTHENING TECHNIQUES OF MASONRY MINARETS</p> <p>Project Context: Forensic investigation of collapse mechanisms and strengthening techniques for historic masonry minarets.</p> <p>The Challenge: High slenderness, sensitivity to lateral loads, and severe material degradation due to fire exposure.</p> <p>The Objective: Determine the invisible structural compromise and design VGM-compliant retrofitting.</p> <p>Team: Mustafa Enver Çakmak, Muhammed Ensar Yıldırım, Ahmet Emre Kadioğlu, Omer Faruk Ozer, Mehmet Furkan Tuzak. Advisor: Prof. Dr. Ferit Çakır. Date: January 2026</p>		

<p>ISARC academy... ISARC academy MELİKE KAYA</p>	<p>Hall 2 - Mauricio Velasquez</p>	<p>Hall-2 Buğra Arslan</p>	<p>ISARC Academy... ISARC Academy Umida MAV...</p>
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THEORETICAL BACKGROUND

AI in Architecture: From Automation to Optimization

AI entered practice through workflow automation. Today, machine learning and digital twins allow performance prediction at early design stages. Design and analysis are no longer sequential.

<p>1</p> <p>Workflow Automation</p> <p>Parametric scripting and rule-based generation to automate repetitive drafting and documentation tasks.</p> <p>PRIMARY OUTCOME Time reduction</p>	<p>2</p> <p>Generative Exploration</p> <p>Algorithmic generation of multiple morphological alternatives to expand the formal design space.</p> <p>PRIMARY OUTCOME Formal variety</p>	<p>3</p> <p>Performance Prediction</p> <p>Machine learning models and digital twins estimating thermal, energetic and structural behavior.</p> <p>PRIMARY OUTCOME Predictive accuracy</p>	<p>4</p> <p>Real-time Optimization</p> <p>Multi-objective algorithms testing complex geometry against thermodynamic simulations in parallel.</p> <p>PRIMARY OUTCOME Design + analysis in parallel</p>
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INTRODUCTION

THE GLOBAL USED TIRE PROBLEM

The rapid growth of the world's population, the expansion of industrialization to new levels, and the desire to raise living standards are leading to an increase in the volume of solid waste on a global scale. This situation is becoming even more pronounced, particularly in developing countries, due to the rising number of vehicles. The development of the automotive sector is directly linked to national economies, and the tire industry constitutes a significant branch of this sector.



Globally, 1–1.5 billion tires are produced annually. Over 17 million tons of waste tires are generated each year, and this amount is expected to increase significantly by 2030.

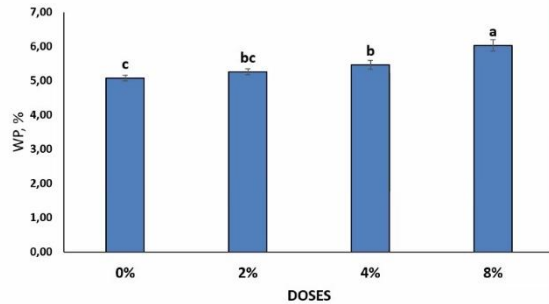


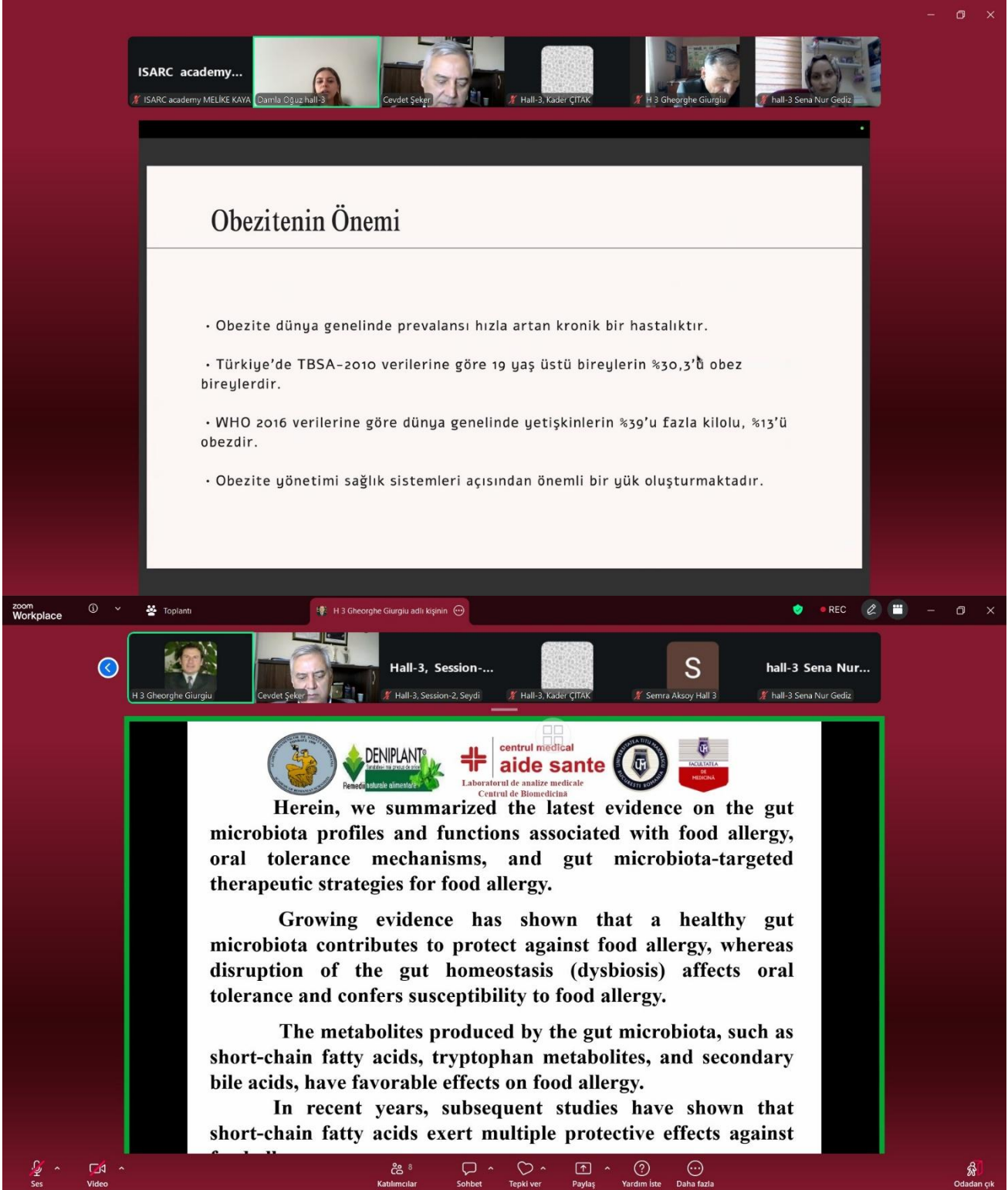
Effects of Biochar Applications on the Wilting Point (WP)

At the wilting point value measured as 5.08% in the control soil, a 3.54% increase was observed with the 2% BK application, a 7.48% increase with the 4% BK application, and an 18.70% increase with the 8% BK application.

This indicates that the applied BK applications resulted in a limited increase in the wilting point value of the sandy loam soil. When compared to the control, the increase was negligible with the 2% BK application, while the 4% BK application fell into the same category as the 2% BK application, and the effect was more pronounced with the 8% BK application.

In this context, while BK applications significantly increased field capacity values, the limited increase in wilting point values is considered a positive characteristic of the materials used as soil conditioners.





The image is a screenshot of a Zoom meeting. At the top, there is a header for 'ISARC academy...' with a logo. Below the header, there is a row of video thumbnails for participants: ISARC academy MELIKE KAYA, Damla Oğuz hall-3, Cevdet Şeker, Hall-3, Kader ÇITAK, H 3 Gheorghe Giurgiu, and hall-3 Sena Nur Gediz. The main content area shows a slide titled 'Obezitenin Önemi' (Importance of Obesity) with a bulleted list of facts. Below the slide, there is a Zoom meeting control bar with icons for audio, video, chat, and other functions. At the bottom, there is a row of video thumbnails for participants: H 3 Gheorghe Giurgiu, Cevdet Şeker, Hall-3, Session-2, Seydi, Hall-3, Kader ÇITAK, Semra Aksoy Hall 3, and hall-3 Sena Nur Gediz. Below this row, there is a slide with logos for DENIPLANT, centrul medical aide sante, and INCALZAREA DE MEDICINA, followed by text summarizing the latest evidence on gut microbiota profiles and functions associated with food allergy.

Obezitenin Önemi

- Obezite dünya genelinde prevalansı hızla artan kronik bir hastalıktır.
- Türkiye'de TBSA-2010 verilerine göre 19 yaş üstü bireylerin %30,3'ü obez bireylerdir.
- WHO 2016 verilerine göre dünya genelinde yetişkinlerin %39'u fazla kilolu, %13'ü obezdir.
- Obezite yönetimi sağlık sistemleri açısından önemli bir yük oluşturmaktadır.

zoom Workplace | Toplantı | H 3 Gheorghe Giurgiu adlı kişinin | REC

H 3 Gheorghe Giurgiu | Cevdet Şeker | Hall-3, Session-2, Seydi | Hall-3, Kader ÇITAK | Semra Aksoy Hall 3 | hall-3 Sena Nur Gediz

Herein, we summarized the latest evidence on the gut microbiota profiles and functions associated with food allergy, oral tolerance mechanisms, and gut microbiota-targeted therapeutic strategies for food allergy.

Growing evidence has shown that a healthy gut microbiota contributes to protect against food allergy, whereas disruption of the gut homeostasis (dysbiosis) affects oral tolerance and confers susceptibility to food allergy.

The metabolites produced by the gut microbiota, such as short-chain fatty acids, tryptophan metabolites, and secondary bile acids, have favorable effects on food allergy.

In recent years, subsequent studies have shown that short-chain fatty acids exert multiple protective effects against

Ses | Video | Katılımcılar | Sohbet | Tepki ver | Paylaş | Yardım iste | Daha fazla | Odadan çık



The image shows a Zoom meeting interface. At the top, the meeting title is "Hall-3, Session-2, Seydi adlı kişiyi". The meeting participants are listed as ISARC academy MELIKE KAYA, Camila Oguz hall-3, Hall-3, Session-2, Seydi, Cevdet Şeker, Semra Aksoy Hall-3, and H 3 Gheorghie Giurgiu. The main content is a PowerPoint presentation titled "SUNUPTB - PowerPoint (Ürün Etiketlendirmedi)". The slide is titled "GİRİŞ" and contains two bullet points. The first bullet point discusses the use of cisplatin in cancer treatment, mentioning its effectiveness against various cancers and its side effects. The second bullet point discusses the use of cisplatin in cancer treatment, mentioning its effectiveness against various cancers and its side effects. The Zoom interface shows 8 participants in the top bar and 5 in the bottom bar. The bottom bar also shows icons for audio, video, chat, and other meeting controls.

ISARC academy MELIKE KAYA Camila Oguz hall-3 Hall-3, Session-2, Seydi Cevdet Şeker Semra Aksoy Hall-3 H 3 Gheorghie Giurgiu

SUNUPTB - PowerPoint (Ürün Etiketlendirmedi) Oturum açın

Dosya Giriş Ekle Tasarım Geçişler Animasyonlar Slayt Gösterisi Kaydet Geçen Geçir Görünüm Yardım Acrotab Ne yapmak istediğinizi söyleyin Paylaş

Yapıyı Düzenle Yeni Slayt Sıfırla Bölüm Slaytlar Yazı Tipi Paragraf Metin Yolu Metin Hizala SmartArt'a Dönüştür Yerleştir Hızlı Silme Şekil Ekleme Şekil Dolduru Şekil Ana Hatları Buton Değiştir Seç PDF Oluşturma Ekleniler Ekleniler

1 2 3 4 5 6

GİRİŞ

- Dünyada en çok kullanılan antikanser ilaçlardan biri sispilatindir. İlk olarak testis ve yumurtalık kanserine karşı kullanılan sispilatın daha sonra serviks, cilt melanomu, mesane, kolorektal, mide, baş ve boyun kanserleri ve üçlü negatif meme kanserinde de kullanılmıştır (Ranasinghe ve ark. 2022). Sispilatın kanser hücrelerinin DNA'suna zarar vererek önemli avantaj sağlarken, iç kulak, kalp, böbrek ve karaciğer gibi en önemli organlarda da toksisiteye neden olduğundan dolayı ciddi dezavantaja sahiptir. Ayrıca, hastalarda normal dokulara toksik yan etkiye neden olması ve tedavi esnasında sispilatine kanser hücreleri tarafından direnç kazanılması, ilacın etkinliğini önemli derecede azaltmaktadır (Zou ve ark. 2023).
- Kanser hastalarında sispilatın kullanımında sınırlanma yapıldığı başka nedenler, ototoksiste, nörotoksiste, gastrointestinal toksiste, nefrotoksiste ve daha az sıklıkla görülen hematolojik toksiste, kardiyotoksiste ve hepatotoksiste gibi tehlikeli yan etkilerin olmasıdır (Zou ve ark. 2023). Oluşan bu yan etkiler hastaların yaşam kalitesinde önemli ölçüde düşişe neden olmaktadır ve ilaç dozunun azaltılması ya da tamamen kesilmesi durumunda kanser karşıtı tedavinin etkinliği de azalmaktadır (Amable, 2016). Sispilatın tedavisi sonucunda oluşan kardiyotoksiste ile kreatin kinaz izoenzim MB, kreatin kinaz, serum plazma konsantrasyonunda laktat dehidrogenaz, plazma kardiyak troponin I'de ve MDA seviyesinde önemli artış olduğu görülmüştür (El-Awady ve ark. 2011). Ayrıca, sispilatın tedavisi sonucunda diyastolik bozukluklar, kardiyak iskemisi (bradikardi), hipertansiyon ve mikroalbuminüri yer almaktadır (Kucharz ve ark. 2016).

Ses Video Katılımcılar Sohbet Tepki ver Paylaş Oturum sahibi araçları Ara odalar Daha fazla Odadan çık

ISARC academy... Hall-4, Dilara DOK adlı kişiyi ekr... Eubekir KOÇAK (HALL-4) Hall-4, Ali Bozkurt

- Düşünmenin çok boyutlu yapısı, bu becerinin farklı türler ve boyutlar çerçevesinde ele alınmasını gerekli kılmaktadır.
- Bu doğrultuda düşünme; **eleştirel düşünme, yaratıcı düşünme, analitik düşünme, yansıtıcı düşünme, üst bilişsel düşünme ve empatik düşünme** gibi çeşitli türler altında incelenmektedir.
- Bu düşünme türleri içerisinde **empatik düşünme**, kendisini başkasının yerine koyarak, karşısındakinin duygu ve düşüncelerini anlamaya çalışma şeklinde ifade edilmektedir (Ekinci & Aybek, 2010; Gökalp, 2024).
- Empatik düşünme bireyin yalnızca kendi bakış açısıyla sınırlı kalmayarak başkalarının duygu, düşünce ve perspektiflerini anlayabilmesini sağlaması açısından ayrı bir öneme sahiptir.

Ses Video Katılımcılar Sohbet Tepki ver Paylaş Oturum sahibi araçları Ara odalar Daha fazla Odadan çık



zoom Workplace

Toplantı

Hall-4, Ali Bozkurt adlı kişinin ekrani

ISARC academy... Hall-4, Dilara D... Hall-4, Ali Bozkurt

ISARC academy MELKE KAYA Hall-4, Mohammed Alhakimi Hall-4, Ali Bozkurt Ebubekir KOÇAK (HALL-4) Hall-4, Dilara DOK



Giriş ve Çalışmanın Amacı

Aerodinamik tasarım süreçlerinde hızlı ve düşük maliyetli sayısal yaklaşımların etkinliği

Ses Video Katılımcılar Sohbet Tepki ver Paylaş Oturum sahibi araçları Ara odalar Daha fazla Odadan çık

zoom Workplace

Toplantı

Hall-4, Mohammed Alhakimi Hall-4, Ali Bozkurt adlı kişinin ekranı

Research Problem

- Low electrical conductivity.
- Possible nanoparticle agglomeration.
- Active sites have a limited level of access.
- Weak electron/ion transport at high loading.
- Need to determine the optimum NiO amount.

Ses Video Katılımcılar Sohbet Tepki ver Paylaş Oturum sahibi araçları Ara odalar Daha fazla Odadan çık

zoom Workplace EK Ebubekir KOÇAK (HALL 4) adlı kiş...

ISARC academy... MELİKE KAYA Ebubekir KOÇAK (HALL 4) Hall-4, Dilara D... Hall-4, Dilara DOK Hall-4, Ali Bozkurt

ÖZET: Tasarım Eğitiminde Paradigma Dönüşümü

Görsel iletişim tasarımı eğitimi, Üretken Yapay Zeka (GenAI) teknolojilerinin etkisiyle ontolojik bir değişim geçirmektedir.

Geçmişin Kriteri
El-göz koordinasyonu ve yazılım odaklı teknik hakimiyet.

Kırılma Noktası
Üretim safhasının algoritmalarla mekanikleşmesi.

Geleceğin İhtiyacı
Düsel yetkinlik, semantik kurgu ve prompt mühendisliği.

Temel Argüman:
Tasarımcının rolü teknik bir uygulayıcıdan, karmaşık görsel sistemleri yöneten bir küratöre evrilmektedir. Tasarım eğitimi, geleneksel görsel kültür ile yapay zeka iş akışlarını sentezleyen hibrit bir pedagojiye acilen ihtiyaç duymaktadır.

zoom Workplace EK Ebubekir KOÇAK (HALL 4) adlı kiş...

ISARC academy... MELİKE KAYA Ebubekir KOÇAK (HALL 4) Hall-4, Dilara D... Hall-4, Dilara DOK Hall-4, Ali Bozkurt

5.4. Gözlemlerden Çıkan Sonuçlar ve Değerlendirme

Eğitim sürecindeki usta-çırak ilişkisi değişmektedir. Öğretim elemanı artık program öğretenden değil, yapay zeka diyalogunda görsel rehberlik eden bir küratördür.

Zanaat Hissi Kaybı
İşi kendisinin yapmadığı hissi ve psikolojik aidiyet sorunu. Fiziksel emeğin kaybı psikolojik bir boşluk yaratır.

Hızın Yarattığı Sıhık
Görselin anında üretilmesi, felsefe ve hikaye kurgulama isteğini köreltebilir. Tasarımın düşünsel boyutu tehlikeydedir.

Yüksek Estetik Standart
Estetik çığa yükselmiştir; ortalama görsel devri bitmiş, olağanüstü görsel standart hale gelmiştir.
Kritik Bulgu: Teknik kalite artık parmak ucundan değil; dil ve zihin derinliğinden beslenmektedir.

zoom Workplace EK Ebubekir KOÇAK (HALL 4) adlı kiş...

zoom Workplace

Toplantı

Hall-4, Dilara DOK adlı kişinin ekr...

ISARC academy... Hall-4, Dilara D... A

ISARC academy MELIKE KAYA Ebubekir KOÇAK (HALL 4) Hall-4 Mohammed Alhakimi Hall-4, Dilara DOK Hall-4, Ali Bozkurt

1. Giriş

- **Problem kurma**, matematik eğitimi alanında son otuz yılda zamanla artan bir ilginin odağı olan (Cai ve Hwang, 2020), öğrencilere ve öğretmenlere çeşitli kazanımlar sağlayan önemli bir beceridir (Kar, 2024).
- Problem kurmanın hem öğrencilere (Abu-Elwan, 2002; Kovács, Báró, Lócska ve Kónya, 2023) hem de öğretmenlere (Abu-Elwan, 1999; Okuyucu ve Uyar, 2025) sunduğu faydalardan biri **matematik ile gerçek hayat arasındaki ilişkiyi kavramalarını ve güçlendirmelerini sağlamaktır.**

Ses Video Katılımcılar Sohbet Tepki ver Paylaş Oturum sahibi araçları Ara odalar Daha fazla Odadan çık

zoom Workplace

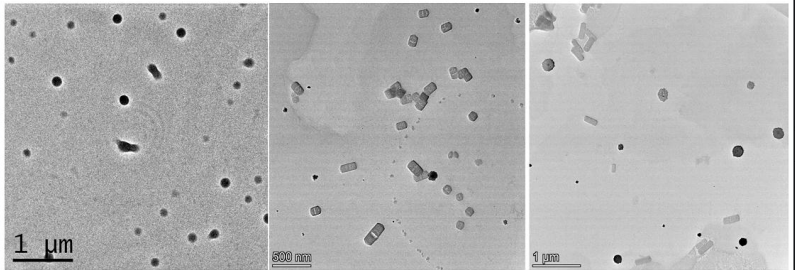
Meeting

Saloni Sharma's screen

Sign in

Results and discussion:

1) SEM images of GNR/ FA Conjugated drug-loaded GNR



The drug-loaded polymeric gold nanorods surface conjugated with folic acid were synthesized using CTAB-mediated synthesis and nano-precipitation method due to the robust nature and smaller nano-size of 55nm the drug will penetrate by controlled release.

Participants (5)

- IA ISARC Academy Umida MAVLY... (Co-host, me)
- S Saloni Sharma
- R Hall-6, Renju A
- Hall-7, Session-3, Dr.Tasawar Iqbal and Dr.Sid...
- K.Naveen rajan, Hall-5, Session-2

ISARC Academy...

ISARC Academy Umida MAVLY...

K.Naveen rajan, Hall-5, Session-2

Saloni Sharma

Hall-7, Session-3, Dr.Tasawar Iq...

Audio Video Participants Chat React Share Host tools Breakout rooms More Leave room

Mute all

19°C Güneşli Ara 10:36 AM 4/21/2026

zoom Workplace Meeting Saloni Sharma's screen

Results and discussion: 2) Zeta Potential

D. PLGA-ZP

GNR-ZP

GNR.D.PLGA.FA-ZP

Compounds	Zeta Potential
D. PLGA	-20.6mV
GNR	89.7mV
D.PLGA.GNR. FA	-21.5mV

The negative surface charge of the entire formulation suggested that due to electrostatic forces of attraction, the D.PLGA (-20.6mV) bound efficiently to GNR(89.7mV), which showed effective binding capacity of the different components.

4

19°C Güneşli Ara

Participants Chat React Share Host tools Breakout rooms More

10:37 AM 4/21/2026

zoom Workplace Meeting Saloni Sharma's screen

Results and discussion: Zebra Fish Model 4d) ROS

PC (H ₂ O ₂)		Ar+GNR	
Arsenic		Ar+D.PLGA.GNR	
Ar+PLGA		Ar+D.PLGA.GNR.FA	
Ar+D.PLGA			

1 unassigned participant

9

19°C Güneşli Ara

Participants Chat React Share Host tools Breakout rooms More


10:40 AM 4/21/2026



zoom Workplace Meeting Hall-7,Session-3, Dr.Tasawar Iqbal

Okra Tasawar Iqbal - PowerPoint (Product Activation failed)

1. Morphology: Botanical and Agricultural Morphology of Okra (Lycopersicon esculentum)

2. 

3. INTRODUCTION

- Okra (Lycopersicon esculentum) is a member of the Solanaceae family.
- It is characterized by its elongated, bumpy fruit and green leaves.
- It is a popular vegetable in many cuisines.

4. About Okra (Botanical and Agricultural)

- Common name: Okra, Ladyfinger, Bhindi.
- Botanical name: Lycopersicon esculentum.
- Family: Solanaceae.
- Origin: West Africa.
- Growth habit: Annual.
- Fruit type: Capsule.
- Color: Green.
- Taste: Bitter.
- Uses: Culinary, Medicinal.

5. Botanical Composition


Click to add notes

Participants: 3, Chat, React, Share, Host tools, Breakout rooms, More, Leave room

19°C Güneşli, Ara, TUR, 10:38 AM 4/21/2026

zoom Workplace Meeting K.Naveen rajan,Hall-5, Session-2

Real-World Applications



Military Personnel

Combat situations, fire or death decisions, leadership under fire

Practical scenarios provide insights into real-life psychology during war, emergencies, and high-stress environments.

Participants (3)

- IA ISARC Academy Umida MAVLY... (Co-host, me)
- K.Naveen rajan,Hall-5, Session-2
- Hall-7,Session-3, Dr.Tasawar Iqbal and Dr.Sidra Altar

ISARC Academy...

ISARC Academy Umida MAVLYAN...

K.Naveen rajan,Hall-5, Session-2

Participants: 3, Chat, React, Share, Host tools, Breakout rooms, More, Leave room

Mute all

19°C Güneşli, Ara, TUR, 10:47 AM 4/21/2026

zoom Workplace Meeting Dr. Muhammad Saleh Faisal's scre

METHODOLOGY

Antibiotic Susceptibility Testing Process

- Urine Culture and Sensitivity Test**
Initial test to identify bacteria
- Colony Collection**
Gathering bacterial colonies for analysis
- Bacterial Identification**
Using Gram staining and API kits
- Antibiotic Preparation**
Preparing antibiotic solutions for testing
- MIC Determination**
Finding the effective antibiotic concentration

Participants: 6
19°C Güneşli Ara TUR 10:59 AM 4/21/2026

ISARC Academy...

Shumaila Asim ISARC Academy Umida MAV...

Dr. Muhammad...
Dr. Muhammad Saleh Faisal Hall-6, Renju A

S
Saloni Sharma H2-sami melik

zoom Workplace Meeting Dr. Muhammad Saleh Faisal's scre

Agar plates of Co-trimoxazole, Levofloxacin, Nitrofurantoin, & Fosfomycin, labeled with concentrations and types of bacteria

Participants: 6
19°C Güneşli Ara TUR 11:00 AM 4/21/2026

ISARC Academy...

Shumaila Asim ISARC Academy Umida MAV...

Dr. Muhammad...
Dr. Muhammad Saleh Faisal Hall-6, Renju A

S
Saloni Sharma H2-sami melik



zoom Workplace Meeting H2-sami melik's screen

The Disconnect in Algerian Architectural Pedagogy

Context
Algerian architecture schools lag behind global pedagogical evolution, remaining tethered to static, traditional methods.

The Impact
This disconnect stifles student creativity and limits professional readiness in an increasingly complex, digitized built environment.

Research Objective:
Map the transition and formulate actionable modernization strategies.

Entrenched Studio Culture
Theory-heavy instruction
Rote memorization
Rigid classical principles

Global Industry Demands
Interdisciplinary practice
BIM & Digital Tools
Sustainability focus

Dr. Muhammad... ISARC Academy...
Dr. Muhammad Saleh Faisal ISARC Academy Umida MAV...
Shumaila Asim Hall-6, Renju A
Saloni Sharma H2-sami melik

19°C Güneşli

zoom Workplace Meeting H2-sami melik's screen

Context & Research Gap

Navigating the Shift from **Physical** to **Virtual** Pedagogy

The Global Shift
Rapid integration of BIM and VR to prepare students for a digital economy.

Problem Space
Friction between modern curriculum demands and local inadequacies in infrastructure, faculty training, and pedagogical adaptation.

The Algerian Context
Historical reliance on hands-on, tactile studio environments.

Objective: Assess current digital adoption, evaluate virtual pedagogy, and propose alignment strategies.

Dr. Muhammad... ISARC Academy...
Dr. Muhammad Saleh Faisal ISARC Academy Umida MAV...
Shumaila Asim Hall-6, Renju A
Saloni Sharma H2-sami melik

20°C Güneşli

Key Findings & Performance Outcomes

Quantifiable Shifts in Student Engagement

The Data Dashboard

- 85%** Increased participation in virtual discussions and collaborative projects.
- 78%** Preference for virtual environments (flexibility & asynchronous access).
- 70%** Reported increased engagement when employing digital tools.
- 65%** Experienced improved access to learning resources.
- 20%** Increase in overall academic grades in virtual environments.

Traditional Studio	Virtual Environment
Tactile engagement	Digital immersion
Synchronous restrictions	Asynchronous flexibility
Limited physical resource access	Broad decentralized resource access

Conclusion & Future Directions

Structuring the Future of Algerian Architectural Education

The Main Conclusion (Current Phase)
Virtual environments successfully support academic journeys and are essential for contemporary professional digital competencies.

Practical Recommendations (Immediate Action)
Urgent institutional investment in robust digital infrastructure and targeted hybrid-model professional development for faculty.

Future Directions (The Horizon)

- Longitudinal studies on long-term educational outcomes.
- Integration of Artificial Intelligence (AI) in design workflows.
- Immersive Virtual Reality (VR) pedagogical applications.

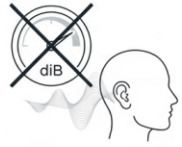
The Urban Noise Crisis Demands a Perceptual Paradigm Shift

The Problem



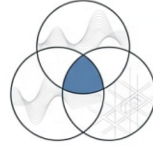
Rapid urbanization drives elevated noise pollution, directly linking to cardiovascular diseases and stress.

The Gap



Current planning prioritizes objective measurable sound (Sound Pressure Level) but critically ignores subjective human perception and coping mechanisms.

The Objective



Define the Acoustic Nexus to link physical architecture with perceptual outcomes and community dynamics.

Defining the Acoustic Nexus: The complex, subjective intersection where physical architectural forms meet human auditory perception and environmental noise dynamics.

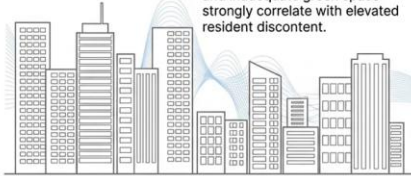
H2-sami melik

H2-sami melik

Results: Architecture and Greenery Override Objective Noise Data

The High-Density Baseline

Peak SPL: >85 dB



Finding: Compact building styles and inadequate green space strongly correlate with elevated resident discontent.

The Anomaly (The Green Effect)

55 dB Average SPL



Finding: Spatial buffers and low-density profiles drastically lower both SPL and perceived annoyance.

40% Green Space

Only 30% Annoyance

The Vibrancy Phenomenon: Areas with complex architectural layouts and high greenery mitigate annoyance even when SPL is high. Residents perceive these higher noise levels as urban vibrancy rather than discomfort, driven by emotional attachment and acoustic identity.

H2-sami melik

H2-sami melik



zoom Workplace Meeting Shumaila Asim's screen Sign in

Optimization parameters for synthesis of Ca-alginate/copper oxide film

Experiment	Concentration of copper oxide (0.02,0.04,0.08 g/mL)	Concentration of Ca-alginate (0.5, 1, 2mg/mL)	Stirring time (30, 60, 90 min)	Yield %
1	0.02	0.5	30	40 %
2	0.02	1	60	55%
3	0.02	2	90	65%
4	0.04	0.5	30	30%
5	0.04	1	60	60%
6	0.04	2	90	70%
7	0.08	0.5	30	35%
8	0.08	1	60	60%
9	0.08	2	90	90%

20°C Güneşli Ara 11:19 AM 4/21/2026

Shumaila Asim



INTERNATIONAL SCIENCE AND ART RESEARCH CENTER

KONU: Kongre Katılımcı Bilgisi

30.04.2026

İLGİLİ MAKAMA

1.ULUSLARARASI PERGE BİLİMSEL ARAŞTIRMALAR VE INOVASYON KONGRESİ 21-22 NİSAN 2026 tarihleri arasında ANTALYA 'de online olarak 9 farklı ülkeden (Türkiye:20 ve diğer Ülkeler:27 Toplam:47 akademisyen/araştırmacıların katılımı ile gerçekleşmiştir. Kongre, 16 Ocak 2020 Akademik Teşvik Ödeneği Yönetmeliğine getirilen '' Tebliğlerin sunulduğu yurt içinde veya yurtdışındaki etkinliğin uluslararası olarak nitelendirilebilmesi için Türkiye dışından en az 5 ülkeden farklı tebliğ sunan konuşmacının katılım sağlaması ve tebliğlerin yarıdan fazlasının Türkiye dışından katılımcılar tarafından sunulması esastır. '' değişikliğine ve Doçentlik kriterlerine uygun düzenlenmiştir.

Bilgilerinize arz edilir.

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HEAD OF İSARC

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RİSK ANALİZİ

Emin Ergun SELÇUK

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ÖZET

Risk analizi, bir organizasyonun karşılaşılabileceği belirsizlikleri tanımlama, ölçme ve bu belirsizliklerin etkilerini azaltmaya yönelik stratejiler geliştirme sürecidir. Amaç, potansiyel tehditleri önceden belirleyip, olası zararları minimize etmek ve karar verme süreçlerini güçlendirmektir. Süreç genellikle birkaç temel adımdan oluşur: riskleri tanımlama (kaynağı, türü ve gerçekleşme olasılığı), mevcut kontrolleri ve savunmaları değerlendirme, riskleri niceliksel veya niteliksel olarak analiz etme, riskleri önceliklendirme ve uygun müdahale planları geliştirme.

Temel yöntemler arasında nitel analiz (SWOC/PESTEL analizleri, olay ağları, senaryo analizi) ve nicel analiz (varyans analizi, beklenen zarar hesapları, olasılık-zarar tabloları, Monte Carlo simülasyonu) bulunur. Ayrıca riskler, stratejik, operasyonel, finansal, uyum ve güvenlik gibi kategorilere ayrılarak ele alınabilir.

Kullanılan araçlar ve çerçeveler arasında risk matrisi (olası ve şiddet düzeyine göre sınıflandırma), hata türü ve etkileri analizleri (FMEA), kritik kontrol noktaları (HACCP benzeri kalite güvence yaklaşımları), iç kontrol sistemi değerlendirmesi ve risk tablosu yönetimi yer alır.

Risk analizi, kriz yönetimi planları ve sigorta/finansal önlemler ile entegre edilerek örgütlerin dayanıklılığını artırır. Uygulamada paydaşlar arası iletişim ve hesap verebilirlik kritik öneme sahiptir; riskler sadece bir yere ait değildir, tüm organizasyonu etkiler. Etik ve yasal uyum da göz ardı edilmemelidir. Başarılı bir risk analizi, sürekli izleme, güncelleme ve organizasyon genelinde risk kültürünün yerleşik hale getirilmesi ile sürdürülebilir hale gelir.

Anahtar Kelimeler: Risk analizi, belirsizlik, süreç

RİSK ANALYSIS

SUMMARY

Risk analysis is the process of identifying and measuring the uncertainties an organization may face and developing strategies to reduce the effects of these uncertainties. The aim is to identify potential threats in advance, minimize possible damages and strengthen decision-making processes. The process usually consists of several basic steps: identifying risks (source, type,

and likelihood of occurrence), evaluating existing controls and defenses, analyzing risks quantitatively or qualitatively, prioritizing risks, and developing appropriate response plans.

Basic methods include qualitative analysis (SWOC/PESTEL analyses, event networks, scenario analysis) and quantitative analysis (variance analysis, expected loss calculations, probability-loss tables, Monte Carlo simulation). Additionally, risks can be divided into categories such as strategic, operational, financial, compliance and security.

Tools and frameworks used include risk matrix (classification by likelihood and severity), failure mode and effects analyzes (FMEA), critical control points (HACCP-like quality assurance approaches), internal control system assessment and risk table management.

It increases the resilience of organizations by integrating with risk analysis, crisis management plans and insurance/financial prevention. In practice, communication and accountability between stakeholders is critical; Risks do not only belong to one place, they affect the entire organization. Ethical and legal compliance should also not be ignored. A successful risk analysis becomes sustainable through continuous monitoring, updating and establishing a risk culture throughout the organization.

Key Words: Risk analysis, uncertainty, process

1.GİRİŞ

Risk analizi, belirli bir hedefe yönelik potansiyel tehlike ve belirsizlikleri sistematik olarak tanımlama, nicelleştirme ve önceliklendirme sürecidir. Bu süreç, işletmelerden kamu politikalarına kadar geniş bir yelpazede karar vericilere güvenilir bilgiler sunar; beklenmedik olayların etkisini azaltmak ve kaynakları etkin kullanmak amacıyla kullanılır. İlk adım olarak riskleri tanımlama ve sınıflandırmayı içeren risk tanımlama süreci, ardından olasılık ve etki üzerinden riskleri nitel veya nicel yöntemlerle değerlendiririz. Nitel analizler, uzman görüşlerine ve senaryolara dayanırken, niceliksel yöntemler olasılık dağılımları, kritik kontrol noktaları ve maliyet-fayda analizi gibi araçlarla karar destek sağlar. Sonuç olarak risk toleransı ve kabul edilebilirlik kriterleriyle önleyici, azaltıcı ve paylaşım stratejileri geliştirilir. Günümüzde belirsizliğin artması ve karmaşık sistemlerin çoğalması nedeniyle risk analizi, sadece bir teknik araç olmaktan çıkıp bütünleşik karar süreçlerinin temel bir unsuru haline gelmiştir.

2. RİSK ANALİZİ

Risk analizi, iş yerlerinde meydana gelebilecek olası tehlikelerin belirlenmesi, bu tehlikelerin iş kazalarına ya da meslek hastalıklarına yol açma ihtimallerinin incelenmesi ve bu durumlara karşı alınması gereken önlemlerin tespit edilmesi sürecidir. Risk analizi, iş sağlığı ve güvenliği

kapsamında oldukça önemli bir yer tutar, çünkü bu analiz sayesinde tehlikeler önceden saptanarak, hem çalışanların hem de iş yerinin güvenliği artırılabilir. İyi bir risk analizi çalışması, iş yerinde alınacak önlemlerin daha etkin ve verimli bir şekilde planlanmasını sağlar. Bu bağlamda, risk analizi yöntemleri, tehlikelerin doğru bir şekilde sınıflandırılması ve her tehlikeye yönelik uygun tedbirlerin alınması için gereklidir (Demir, 2020: 42).

3. RİSK ANALİZ YÖNTEMLERİ

Risk analizi yöntemleri; nicel (kantitatif) ve nitel (kalitatif) olmak üzere ikiye ayrılmaktadır. Nicel risk analizi yöntemlerinde risk hesaplaması yapılırken sayısal veriler kullanılmaktadır. Analizi değerlendirilmesinde, tehdidin ortaya çıkma ihtimali ve tehdidin yaratacağı etki gibi değerler sayısal olarak analiz edilerek matematiksel ve mantıksal yöntemler ile sürece yönelik risk değerleri oluşturulur. Analizinin temel faktörü olarak;

Risk= Tehdidin olma ihtimali x Tehdidin etkisi formülü kullanılmaktadır (İncesu, 2014).

Nitel risk değerlendirme yöntemleri ise sayısal veriler yerine sözel mantığa dayanan analiz yöntemleridir. Yöntemi uygulayan uzmanlar, sezgi ve mesleki tecrübelerine dayanarak riskleri tahmin eder ve öncelikli olan riskleri tanımlar. Tahminde bulunulan riskler tanımlanırken veya hesap aşamasında sayısal veriler ve matematiksel skorlama değil de düşük, çok düşük gibi tanımlayıcı veriler kullanılır. Yapılan tahminler, çoğunlukla sistematik olarak öznel değerlendirmelere dayanır. Yöntemi uygulayan uzmanın, yorum ve sezgisel kabiliyetinin iyi olması metodun güvenli tarafta kalmasını etkiler. Bahsedilen tahmin ve sezgisel yaklaşımlardan ötürü, nitel risk değerlendirme yöntemlerini, önemli ve tehlike potansiyeli yüksek yerlerde tek başına kullanmak doğru değildir (Zengin, 2020).

Risk analizi yöntemi olarak 150'den fazla literatürde yöntem kullanılmaktadır. Bunlardan genellikle en çok tercih edilenleri şu şekildedir;

- Birincil Risk Analizi Yöntemi
- Ön Tehlike Analizi Yöntemi
- Olursa Ne Olur? Analizi Yöntemi
- İş Güvenliği Analizi Yöntemi
- Hata Türleri, Etkileri ve Kritiklik Analizi Yöntemi
- Tehlike ve İşletilebilirlik Analizi Yöntemi
- Olay Ağacı Analizi Yöntemi
- Neden – Sonuç Analizi Yöntemi
- Fine Kinney Yöntemi
- Risk Değerlendirme Tablosu Yöntemleri (X tipi ve L tipi Matris)
- Hata Ağacı Analizi Yöntemi
- Erken Uyarı Modeli Yöntemi
- Zürih Tehlike Analizi Yöntemi (İncesu, 2014).

4.RİSK ANALİZİNİN AVANTAJLARI

Risk analizinin sunduğu başlıca avantajlar şu şekilde sıralanabilir (Türk Standartları Enstitüsü, n.d);

- Gelecekte karşılaşılabilecek zor durumları öngörür,
- Riskler ortaya çıkmadan önlem alınması sağlanır,
- Sürpriz ve kayıplar en aza indirilir,
- Hızlı ve etkili karar almaya yardımcı olur,

- Zaman tasarrufu sağlar,
- Kaynak israfını önler,
- Risklerin makul seviyelerde tutulmasını sağlar,
- İş sürekliliği sağlar,
- Hedefleri gerçekleştirme ihtimalini artırır,
- Proaktif (öngörücü) yönetimi teşvik eder,
- Kuruluş genelinde riski belirleme ve ele alma ihtiyacının farkında olunmasını sağlar,
- Fırsatların ve tehditlerin analizini sağlar,
- İlgili yasal ve mevzuat şartlarına ve uluslararası normlara uyum sağlamaya yardımcı olur,
- Paydaş güvenini ve itimadını iyileştirmeye yardımcı olur,
- Karar verme ve planlama için güvenilir bir temel oluşturur,
- Riskin ele alınması için kaynakları etkin bir şekilde tahsis etme ve kullanma kolaylığı sağlar,
- Operasyonel etkinliği sağlar ve verimliliği artırır,
- Kaybın önlenmesini ve vaka yönetimini iyileştirir.

5. RİSK ANALİZİ UYGULAMALARI

İş Sağlığı ve Güvenliği Risk Değerlendirmesi Yönetmeliğine (RDY) göre risk değerlendirmesi; tüm işyeri için tehlikeleri tanımlama, riskleri belirleme ve analiz etme, risk kontrol tedbirlerinin kararlaştırılması, dokümantasyon, yapılan çalışmaların güncellenmesi ve gerektiğinde yenileme aşamalarından oluşur (Akpınar ve Çakmakkaya, 2014).

Risk analizinin aşamaları şu şekildedir (Kahraman ve Demirer, 2010);

- Araştırma ve gözlem yapmak
- Tehlikeleri tanımlamak
- Riskleri belirlemek
- Riskleri değerlendirmek
- Kontrol önlemlerini belirlemek
- Gerekli önlemleri almak
- Süreçleri dokümante etmek

6. RİSK ANALİZİ İLE İLGİLİ ÇALIŞMALAR

Sakallı vd. (2022) tarafından sağlık, eğitim, sanayi-üretim, hizmet ve diğer olmak üzere 6 sektörde 317 kişiyle güvenlik ikliminin güvenlik performansına etkisinin incelendiği

çalışmasında; yaş, cinsiyet, aylık gelir, medeni ve eğitim durumu, çocuk sahipliği ve sektöre dağılımına göre karşılaştırma yapılmıştır. Araştırma sonucunda güvenlik ikliminin güvenlik performansına doğrudan olumlu şekilde etkilediği bulunmuştur (Sakallı vd., 2022).

Donat (2024) tarafından Balıkesir ili Susurluk ilçesinde, Sağlık Bakanlığı'na bağlı kamu sağlık kuruluşlarında görev yapan 255 çalışandan gönüllü olarak katılım sağlayan 247 personel ile yürütülen çalışmada; iş güvenliği kültürü ve güvenlik iklimi algısının güvenli davranışlar üzerindeki etkisi incelenmiştir. Araştırma sonuçlarına göre, güvenlik kültürü bileşenlerinden “güvenlik farkındalığı” ve “raporlama kültürü” düzeyleri arttıkça çalışanların güvenli davranış eğilimlerinin de arttığı belirlenmiştir. Öte yandan, güvenlik iklimi algısının güvenli davranışlar üzerinde anlamlı bir etkisinin bulunmadığı sonucuna ulaşılmıştır (Donat, 2024).

Çalış Boyacı ve Gencer (2018) tarafından Geleneksel risk modeliyle uyumlu, Glickman vd. (2007) tarafından geliştirilen demiryolu risk modeli temel alınarak bazı değişikliklerle Türkiye'ye uyarlanmıştır. Türkiye Cumhuriyeti Devlet Demiryolları İşletmesi Genel Müdürlüğü (TCDD)'nden elde edilen veriler doğrultusunda demir yolu taşımacılığındaki risk değeri hesaplanmıştır.

Yorulmaz ve Sezen'in 2023, yılında yapmış oldukları çalışmada denizcilik sektöründe uygulanan risk analizi yöntemlerini araştırmışlardır ve buna ek olarak Fine Kinney yaklaşımı ile bir uygulama gerçekleştirmişlerdir. Literatürün taranması sonucu elde edilen 10 adet risk unsuru denizcilik alanında uzman bir kişinin görüşleri dâhilinde Fine Kinney metodu uygulanmıştır. Çalışmanın sonuçlarına göre gemi yapısında meydana gelen bozulmalar ölüm riskinin en yüksek olduğu risk olarak belirlenmiştir. Deniz haydutluğu ve çevre kirliliği risklerinin en az risk puanına sahip olduğu görülmüştür (Yorulmaz ve Sezen, 2023).

Bayram ve Kaya 2022'de Trabzon limanında belirlenen tehlikenin Fine-Kinney yöntemi ile risk analizini gerçekleştirmiştir. Buna göre; 13 tane “Tolerans Gösterilemez Risk”, 19 tane “Esaslı Risk”, 40 tane “Önemli Risk” olmak üzere toplam 72 tane risk tespit edilmiştir (Bayram ve Kaya, 2022).

SONUÇ

Risk analizi karar süreçlerinin temel taşı olarak yerini güçlendirir: potansiyel tehlikeleri erken belirlemek, belirsizlikleri ölçmek ve bu bilgilere dayanarak etkili önleyici, azaltıcı ve paylaşım stratejileri geliştirmek için vazgeçilmez bir araçtır. Hem nitel hem de niceliksel yaklaşımların entegrasyonu, farklı paydaşların bakış açılarını harmonize eder ve kaynakları en verimli şekilde kullanmamızı sağlar. Ancak risk analizi dinamik bir süreçtir; değişen koşullar, yeni veriler ve teknolojik gelişmeler doğrultusunda sürekli izleme, güncelleme ve yeniden değerlendirme

gerektirir. Nihai hedef, organizasyonların dayanıklılığını artırırken karar vericilere güvenilir bilgi ve esneklik sunmaktır. Bu nedenle risk analizi, bir kez yapılacak bir çalışma olmaktan çıkıp kurumsal kültürün ve stratejik planlamanın sürekliliğini sağlayan entegre bir uygulamaya dönüşmelidir.

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VERİ MADENCİLİĞİ

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ÖZET

Veri madenciliği, büyük veri kümeleri içinden gizli desenleri, kalıpları ve ilişkileri keşfetmek için istatistiksel yöntemler, makine öğrenimi ve veri analitiği tekniklerini kullanan disiplinlerarası bir süreçtir. Amaç, ham veriden anlamlı ve uygulanabilir bilgiler çıkararak karar süreçlerini desteklemektir. Süreç genellikle şu adımları kapsar: problem tanımlama, veri toplama ve entegrasyonu, ön işleme (eksik değerler, aykırı değerler, ölçeklendirme), keşifsel veri analizi, modelleme (sınıflandırma, kümeleme, regresyon, ilişki kuralı madenciliği, boyut indirgeme gibi yöntemler), model değerlendirme ve seçim, modelin üretime alınması ve izlenmesi.

Kullanılan başlıca teknikler arasında sınıflandırma (ör. müşteri kredi skoru tahmini), kümeleme (ör. benzer müşterilerin segmentasyonu), ilişki kuralı madenciliği (alışveriş sepeti analizi), regresyon, anomali tespiti ve boyut indirgeme (ör. PCA) bulunur. Veri tipleri yapısal (veri tabanı tabloları) ve yapısal olmayan (metin, görüntü, ses) olabilir; bu durum ön işleme ve modelleme yaklaşımlarını belirler.

Uygulama alanları oldukça çeşitlidir: pazarlama ve müşteri davranışı analitiği, dolandırıcılık tespiti, sağlık hizmetleri, finansal risk yönetimi, üretim ve siber güvenlik. Ayrıca veri madenciliğinde etik ve gizlilik önemli bir konudur; tarafsızlık, önyargı azaltma ve veri güvenliği gibi hususlar dikkate alınmalıdır.

Başarılı bir veri madenciliği projesi için kaliteli veri, uygun problem tanımı, doğru tekniklerin seçimi ve sonuçların sürdürülebilir şekilde işletmelere entegrasyonu kritik rol oynar.

Anahtar Kelimeler: Veri, madencilik, süreç, teknik

DATA MİNİNG

SUMMARY

Data mining is an interdisciplinary process that uses statistical methods, machine learning, and data analytics techniques to discover hidden patterns, patterns, and relationships within large data sets. The aim is to support decision processes by extracting meaningful and actionable information from raw data. The process generally includes the following steps: problem definition, data collection and integration, preprocessing (missing values, outliers, scaling), exploratory data analysis, modeling (methods such as classification, clustering, regression,

association rule mining, dimensionality reduction), model evaluation and selection, putting the model into production and monitoring.

Major techniques used include classification (e.g., customer credit score prediction), clustering (e.g., segmentation of similar customers), association rule mining (shopping cart analysis), regression, anomaly detection, and dimensionality reduction (e.g., PCA). Data types can be structured (database tables) and unstructured (text, image, audio); This determines the preprocessing and modeling approaches.

Application areas are quite diverse: marketing and customer behavior analytics, fraud detection, healthcare, financial risk management, manufacturing and cybersecurity. Additionally, ethics and privacy are important issues in data mining; Issues such as impartiality, bias reduction and data security should be taken into account.

For a successful data mining project, quality data, appropriate problem definition, selection of the right techniques and sustainable integration of the results into businesses play a critical role.

Key Words: Data, mining, process, technique

1.GİRİŞ

Veri madenciliği, büyük veri depolarında saklanan ham veriden değerli içgörülerini ortaya çıkarmayı amaçlayan disiplinli bir süreçtir. İstatistik, yapay zeka ve veritabanı teknolojilerini bir araya getirerek desenleri, eğilimleri ve ilişkileri keşfeder. İş dünyasında karar destek, risk analizi ve müşteri davranışlarını anlamada kritik rol oynar. Veri temizleme, özellik mühendisliği ve modelleme adımlarıyla güvenilir sonuçlar üretmeyi hedefler. Günümüzde makine öğrenimi teknikleriyle otomatikleştirilen analizler, öngörü ve öneri sistemlerinin temelini oluşturur.

2.VERİ MADENCİLİĞİ TANIMI

Durmuşoğlu (2017: 1112) veri madenciliğini; “veri içerisinde var olan ilişkilerin ve kalıpların keşfedilmesi için birbirini izleyen bilgisayar destekli faaliyetlerin bir bütünlük içerisinde uygulanması” olarak tanımlamaktadır. Bu tanımlar birlikte değerlendirildiğinde, veri madenciliğinin, ham verilerden yararlı bilgiler elde etmeye odaklanan bir süreç olduğu görülmektedir. Veri madenciliği, gizli örüntüleri ve ilişkileri bulmak, analitik modeller oluşturarak, sınıflandırma ve tahmin işlemleri gerçekleştirilerek ve madencilik sonuçlarını görselleştirme araçlarıyla sunarak bilgi keşfini desteklemektedir (Han vd., 2012: 154).

3.VERİ MADENCİLİĞİNİN TARİHİ

1960'lı yıllardan önce basit dosyalama yöntemleri mevcuttu. 1970'li yıllarda ise bu yöntemler “Veri Tabanı Yönetim Sistemleri” ile değiştirilmiştir. Ayrıca bu sistemlerin yanında hiyerarşik

ağ veritabanı sistemleri, ilişkisel sistemler, B-ağaçları, sorgu işleme ve optimizasyon sistemleri de devreye girmiştir (Yılmaz, 2023, s. 38). 1980’li yılların başına kadar devam eden bu dönem, gelişmiş veri tabanı ve web tabanlı sistemlerin ortaya çıkmasıyla sona ermiştir. 1980’li yıllarda başlayıp günümüzde de devam eden “İleri Veritabanı Sistemleri”; zamansal sistemler, mekânsal sistemler, multimedya sistemleri, bilgi odaklı sistemler, ilişkisel ve nesne sistemlerinden oluşmaktadır (Tüminçin, vd., 2019, s.351).

4. VERİ MADENCİLİĞİ UYGULAMALARI

Veri madenciliğinin en önemli amacı ortaya çıkarma, keşif ve öğrenmedir. Kullanılan en temel bilim dallarından birisi makine öğrenmesidir. Makine öğrenimi, bilgisayarların datalarını hangi şekilde istifade ederek öğrenebileceklerini veya performanslarını nasıl geliştirebileceklerini inceleyen çalışmadır. Ana araştırma alanı karmaşık veri modellerini keşfetmek ve otomatik olarak akıllı kararlar vermektir (Savaş vd., 2012: 17). Veri madenciliğinin sektörel entegrasyonu, organizasyonların karar verme süreçlerini optimize etmekte ve operasyonel verimliliği artırmaktadır. İleri düzey analitik yöntemler ve yapay zekâ teknolojileri ile desteklenen bu uygulamalar, kurumsal süreçlerin dijital transformasyonunda kritik bir rol oynamaktadır (Laudon ve Laudon 2020). Gerçek hayattaki gözlem ve deneylerden elde edilen kanıtlanmış bilimsel yöntemler ile elde edilen veriler üzerinde çeşitli modeller denenip oluşturulan çözümleri problemleri alanlara uygulamak ve sonuç almak amacıyla kullanılmaktadır (Tekerek 2011).

5. VERİ MADENCİLİĞİNİN SÜRECİ

Veri seçimi ilk aşamadır ve veri tabanından önemli görülüp seçilen ya da belirlenen hedef verinin seçiminden oluşmaktadır. Ön İşleme aşamasında verilere ilişkin yanlışlık ya da eksiklik olmaması için verinin çıkarılması, temizlenmesi veya eksik verinin tamamlanması ile yeni değişken tanımları bu aşamada yapılır. Verinin dönüştürülmesi adımı veri madenciliği içinde yer alan değişik yöntemler aracılığı ile veri uygun bir biçimde değişime uğrattır (Akpınar 2014). Veri Madenciliği adımları sırasında çeşitli yöntemler ile bu seviyeye kadar gelen veriye, değerlendirme ve yorum yapmaya elverişli ve ilgili konuda bilgiye ulaştırabilecek iş ve işlemler uygulanır. Bilginin ortaya çıkmasından önceki son adım belirlenen örüntülerin değerlendirilip yeterli bilgi içerip içermediğinin yorumlanmasıdır (Şeker 2013).

6. VERİ MADENCİLİĞİ YÖNTEMLERİ

Veri Madenciliği yöntemlerini ana iki başlığa ayırabiliriz. Bunlar denetimli ve denetimsiz yöntemlerdir. Veri madenciliğinde net ifade edilmiş veya kesin tanımlamalar için denetimli (supervised) ifadesi kullanılır. Henüz tanımlanmamış veya netlik kazanmamış sonuçlar için

denetimsiz (unsupervised) ifadesi kullanılır (Bigus ,2000).Bu iki terimi birbirinin tersini ifade etmektedir. Bu iki yöntem tüm süreç açısından değerlendirildiğinde;

- Denetimsiz yöntemler analiz aşamasında verileri tanımak ilişkileri kurmak bunları anlamak için kullanılan ve daha sonra kullanılacak teknikler için öneri vermeyi amaçlar,
- Denetimli yöntemler ise ham veriden anlamlı bilgiyi çıkarmak için kullanılmaktadır, şeklinde ifade edilebilir. Denetimli ve denetimsiz yöntemler birbirini tamamlar niteliktedir. Bu yüzden doğru bilgiye ulaşmak için eldeki denetimsiz yöntemle elde edilen bilginin denetimli bir başka yöntemle teyit edilmesiyle geçerliliğinin kontrol edilmesi gerekmektedir.
- Denetimli (Supervised) Veri Madenciliği yöntemleri:
 - En yakın k komşuluk (k-Nearest-Neighbor)
 - K-ortalamlar kümeleme (K-means clustering)
 - Regresyon modelleri (Regression models)
 - Kural çıkarımı (Rule induction)
 - Karar ağaçları (Decision trees)
 - Sinir ağları (Neural networks)
- Denetimsiz (Unsupervised) Veri Madenciliği yöntemleri:
 - Aşamalı kümeleme (Hierarchical clustering)

Kendi kendini düzenleyen haritalar (Self organized maps) olarak sınıflandırılabilir (Akgöbek, 2006).

7. VERİ MADENCİLİĞİ MODELLERİ

7.1.Sınıflandırma

Sınıflama ve regresyon, veri analizi yöntemleri olarak önemli veri sınıflarını ortaya koyar ve gelecekteki eğilimleri tahmin eder. Sınıflama, kategorik değerleri tahmin ederken, regresyon sürekli değerler için uygulanır. Örnek olarak, Spesifik kategorize algoritması kredi kuruluşu olan bankalar finansal talep başvurularını daha emniyetli ya da sakıncalı olarak ayırıştırarak analitik müşterilerinin harcamalarını tahmin eder. Genel olarak prosedürler arasında bayes temelli yaklaşım, derin sinirsel ağ sistemi ve tahmin ağaçları yer alır. Karar ağaçları, veri madenciliğinde düşük maliyetli, kolay yorumlanabilir ve iyi entegre olabilen bir sınıflama tekniği olarak en yaygın kullanıma sahiptir (Kesavaraj vd., 2013: 3).

7.2.Örüntü Madenciliği

Örüntü madenciliği, büyük ve karmaşık veri kümelerinde gizli veya öngörülemez ilişkileri ortaya çıkararak, verilerdeki anlamlı desenleri bulur ve iş süreçlerine değerli bilgiler sağlar.

Örüntü madenciliğinde amaç, bir veri kümesindeki benzer davranışları, düzenleri veya ilişkileri belirlemek ve bunları karar verme süreçlerinde kullanılabilir hale getirmektir (Gan vd., 2019: 1306).

7.3.Kümeleme

Kümeleme, verileri benzerliklerine göre gruplara ayırma işlemidir ve birçok alanda, özellikle veri madenciliği, istatistik ve makine öğreniminde kullanılır. Kümeleme, sınıflama modelinden farklı olarak, verilerin önceden belirlenmiş sınıflara sahip olmamasıyla karakterizedir. Bu uygulamalar arasında müşteri gruplarının keşfi, biyolojik sınıflandırmalar ve şehir planlaması gibi örnekler bulunmaktadır. Kümeleme analizinin önemi, veri miktarının artmasıyla birlikte yükselmektedir ve farklı kümeleme algoritmaları, verinin türüne ve amacına göre seçilmektedir. Ana kümeleme yöntemleri arasında modele dayalı, segmentasyon, grid yapılı, kademeli sistem ve veri yığılı algoritmalar yer almaktadır (Amelio ve Tagarelli, 2018: 412).

8.VERİ MADENCİLİĞİ ARAÇLARI

Veri madenciliği araçları çoklukla veri işleme aşamasının en önemli parçalarından biridir. Veri madenciliği çalışmasında veri erişimi, veri ön işleme, modelleme, değerlendirme ve sonuçların görselleştirilmesi gibi farklı aşamalar bulunmaktadır. Araçlardan hangilerinin kullanılacağı, ihtiyaçlara, verinin türüne ve analiz amaçlarına bağlıdır. Günümüz veri analizi teknolojileri ve yazılımları, büyük veri kümelerinin etkili yönetimini ve analizini hedeflemektedir. Veri madenciliği süreçlerinin başarılı yönetimi için uzmanlaşmış yazılım araçlarının kullanımı kritik önem taşır. Araştırmacıların ihtiyaçlarına uygun programları seçmeleri, zaman yönetimi, kullanım etkinliği ve sonuç doğruluğu bakımından fayda sağlar. Bununla birlikte, veri analizi yazılımlarının ücretsiz sunulması, kullanıcılar için önemli bir motivasyon kaynağıdır. Özellikle bilimsel araştırmalarda ticari amaç gütmeyen ve açık kaynak kodlu veri madenciliği araçlarının tercih edilmesi rasyonel bir yaklaşımdır (Doğan 2017).

9.VERİ MADENCİLİĞİ İLE İLGİLİ YAPILMIŞ ARAŞTIRMALAR

Hasan ve ark.'nın (2018), çalışmalarının amacı, havayolu şirketi sık uçuş programına ait veri tabanından üyelerin bilgilerini MİY için çıkarmaktır. veri madenciliği metodolojileri kullanılarak üyeler, puanları, milleri, etkinlik sayıları ve sektör puanlarına göre kümelenebilir; bu parametreler kümeleme algoritması için girdi olarak değerlendirilmektedir. Ayrıca, Kurumsal politikalar, operasyonel süreçler ve havayolu destinasyonları arasındaki bağlantıların belirlenmesinde kullanılmaktadır.

Afşin (2019), çalışmasında havayolu sektöründeki bir firmanın müşteri verilerini veri madenciliği teknikleriyle analiz ederek müşteri davranışlarının anlaşılabilirliğini göstermeyi

amaçlamıştır. Beş bölümden oluşan çalışmanın ilk bölümünde müşteri memnuniyeti, ikinci bölümde veri madenciliği süreç gelişimi ele alınmıştır. Üçüncü bölümde kümeleme analizi yöntemleri incelenmiş, dördüncü bölümde 2015 yılında toplanan 114988 müşteri verisi SPSS-22 ile analiz edilmiştir. Yolcuların memnuniyet, cinsiyet, yaş gibi genel özelliklerine göre yapılan kümeleme analizi sonucunda üç farklı müşteri profili oluşmuştur. Son bölümde, her küme için hizmet kalemleri değerlendirilmiş ve havayolu firmasının hizmet kaliteleri hakkında önerilerde bulunulmuştur.

10. VERİ MADENCİLİĞİ KULLANIM ALANLARI

10.1. Pazarlama ve Satış

Pazarlama ve satış departmanları, veri madenciliğini kullanarak müşteri davranışlarını analiz edebilir ve pazarlama stratejilerini geliştirebilirler. Veri madenciliği ile müşteri tercihleri ve alışveriş alışkanlıkları analiz edilerek hedef kitleye yönelik etkili reklam kampanyaları oluşturulabilir. Ayrıca, müşteri segmentasyonu yaparak farklı müşteri gruplarına özelleştirilmiş teklifler sunulabilir (Sinap, 2024, s.72).

10.2. Müşteri İlişkileri Yönetimi

Müşteri ilişkileri yönetimi, veri madenciliğinin yoğun olarak kullanıldığı bir alandır. Müşteri verileri analiz edilerek müşteri davranışları ve tercihleri hakkında bilgi elde edilebilir. Bu bilgiler, müşteri sadakati ve memnuniyeti artıracak stratejilerin geliştirilmesine yardımcı olur (Kuruca, vd., 2022, s.97).

10.3. Finans ve Bankacılık

Finans ve bankacılık sektörü, veri madenciliğinin sıklıkla kullanıldığı bir alandır. Veri madenciliği ile müşteri risk analizleri, dolandırıcılık tespiti, kredi değerlendirmeleri ve tahkimat analizleri gibi birçok işlem gerçekleştirilebilir (Kou vd., 2004, s.751). Örneğin, müşteri verileri analiz edilerek riskli müşterilerin tespiti ve dolandırıcılık olaylarının önlenmesi mümkün hale gelir. Ayrıca, kredi değerlendirmeleri ve tahkimat analizleri gibi finansal kararlar, veri madenciliği teknikleri kullanılarak daha doğru ve hızlı bir şekilde yapılabilir (Zaki, vd., 2024, s.80).

10.4. Sağlık Sektörü

Sağlık sektörü, veri madenciliğinin kullanıldığı önemli alanlardan biridir. Veri madenciliği teknikleri, hastalık teşhisi, epidemiyolojik analizler, ilaç keşfi ve tedavi planlamaları gibi konularda sağlık çalışanlarına yardımcı olur (Koçak ve Ergün, 2023, s.26).

11. SONUÇ

Veri madenciliği, ham veriden değerli bilgiler çıkararak karar destek süreçlerini güçlendirir. İstatistik, yapay zekâ ve veri tabanı teknolojilerinin entegrasyonu, güvenilir ve öngörülebilir sonuçlar sağlar. Temizlenmiş veriyle kurulan modeller, iş süreçlerinde verimliliği artırır ve rekabet avantajı sunar. Ancak etik, gizlilik ve adil kullanım konuları da dikkate alınmazsa riskler doğurabilir. Dolayısıyla başarılı uygulamalar için veri yönetişi, şeffaflık ve sürekli iyileştirme temel taşlarıdır.

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MACRO PRIMARY BALANCES IN TÜRKİYE BASED ON RECENT FOREIGN DIRECT INVESTMENTS AND FINANCIAL DEVELOPMENTS

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ABSTRACT

This study aims to analyse the composition of foreign direct investments (FDI) directed towards Türkiye in recent years, focusing on specific sectoral structures rather than classical production-oriented investments, it examines these investments within the framework of certain observed macroeconomic balance and equilibrium trends in recent years. This phenomenon, which necessitates examination in Türkiye in recent times, highlights the potential for creating a critical financial vulnerability, particularly in terms of macroeconomic balances, especially in the context of recent investment compositions, particularly foreign direct investments (FDI). The fundamental problem in terms of economic balance is the domestic demand-oriented structure, and this phenomenon, which increases pressure on macroeconomic balances, has taken on a different meaning in Türkiye, particularly in the banking sector, through a reshaped structure in the interaction between recent foreign direct investments (FDI) and financial developments. Therefore, it also reveals the necessity of recalibrating foreign direct investments inflow in terms of financial depth from a macroeconomic balance perspective. In other words, Türkiye's high sensitivity to capital movements and its financial integration, exhibiting a more pronounced and externally finance-dependent economic structure, has become a more significant and effective phenomenon, even for market economies. However, the recent normalization of monetary policy in Türkiye and the increase in precautionary regulations regarding macroeconomic balances have had a limiting effect on credit expansion, making foreign direct investments (FDI) in Türkiye – and especially stock market investments – an attractive phenomenon that needs to be seriously questioned. At this stage, while portfolio investments from foreign financing sources are expected to generate volatility, foreign direct investments (FDI) are expected to provide a more stable source of financing. Given the recent macroeconomic fluctuations in Türkiye, the current structure suggests that it will continue to generate potential inconsistencies between long-term sustainable growth targets and short-term financial stability.

Key Words: Foreign Investments (FDI), Investment Compositions, Macro Balances; Primary Fiscal Balance; Financial Developments.

JEL Codes: E61; F21; F32.

1. INTRODUCTION

In Türkiye, foreign direct investments (FDI) represent a limited industrial and manufacturing composition that can be expressed with different values regarding the outlook for Türkiye (OECD, 2022). In other words, it is understood that foreign direct investments (FDI) play a role in the process as a factor providing temporary growth based on domestic demand and financial expansion (Borensztein, Eduardo et al., 1998). Although these investments have created short-term relief, it can be said that they also represent a structure that improves short-term macroeconomic balances (De Mello, 1999). Within the framework of the primary macroeconomic balances approach, if foreign direct investments (FDI) increase exports, create production capacity, and create structural value that also enables technology transfer, it is possible to talk about foreign direct investments (FDI) that directly improve macroeconomic balances. However, in the recent period where prices have risen and inflation has occurred, it is important to evaluate the economy in terms of current account balances and the savings-investment balance within the primary balances approach in Türkiye. (Türkiye Cumhuriyet Merkez Bankası, 2024; World Bank, 2024a).

Because the evaluation of fiscal balances and the budget balance, especially financial balances and the capital flows balance, also plays a complementary role and a balancing mechanism in this same process. However, in this process where the balance of production and consumption also comes to the forefront, it is possible to talk about a structure in Türkiye – as in developing economies – that is extremely sensitive to capital movements, especially due to its dependence on external financing. When the issue is evaluated with the balance of payments data from the Central Bank of the Republic of Türkiye (CBRT), it is observed that the short-term presence of foreign direct investment, which continues to be an important element within the external financing items in Türkiye, is a significant factor. Currently, a significant portion of foreign direct investment in Turkey is concentrated in the finance and banking sector. The structural changes in the acquisition of real estate, the services sector, and existing assets also reveal that a significant portion of foreign direct investments (FDI) in Türkiye is also involved (UNCTAD, 2023; OECD, 2022).

In contrast, the limited export-oriented investments and productivity-enhancing capital formations in terms of establishing high-technology industries and moving to an advanced

production stage indicate that foreign direct investments (FDI) have not created a significant export capacity, especially in terms of the current account balance. This structure, which does not reduce dependence on imported goods, also does not expand Türkiye's industrial base. Therefore, it should be emphasized that despite the increase in foreign direct investments (FDI), primary macroeconomic balances are not positively affected and continue structurally, and that it does not have a significant positive impact on the changes in the current account deficit, which continues with its fluctuating course throughout 2025. In particular, the fact that portfolio investments represent higher quality and longer-term capital, resulting in lower risks and less volatility, suggests that foreign direct investments (FDI) are not speculative. In this context, it is also highlighted that although foreign direct investments (FDI) in Türkiye, especially in banking, finance acquisitions and real estate investments, is a short-term financial resource, these items do not actually create real capacity, and although there is nominal capital inflow, the real growth capacity remains limited and does not increase (World Bank, 2024a). This phenomenon creates an effect on financial depth and market valuation rather than growth in Türkiye, and means that foreign direct investment contributes to GDP, but its contribution to productivity is limited. In other words, there are FDI movements and a process of volatility in Türkiye, but it seems that these investments are not sufficiently improving the structural quality of real economic growth in Türkiye. In this respect, it appears that Turkey has recently experienced pressure on domestic demand through credit expansion; however, long-term productivity and potential target economic growth have remained limited (International Monetary Fund, 2023a).

2. FDI IN TÜRKİYE AND THE PARADOX OF THE RECENT MACROECONOMIC PRIMARY EQUILIBRIUM PROBLEM

Before framing the paradox of foreign direct investment (FDI) in Türkiye, it is necessary to establish a paradoxical conceptual framework for examining the paradoxical relationship between FDI and Türkiye, particularly in recent times. This factual framework primarily aims to make sense through the approach of investors establishing production facilities, developing partnerships, and placing long-term capital in Türkiye, or securing long-term capital returns from abroad, thereby creating a permanent capital investment. In this context, this phenomenon, which is included in classical economic theory, has key positive effects such as increasing the capital stock, creating employment, contributing to financing the current account deficit, increasing export capacity, supporting foreign exchange reserves, and thus acting as a source of external financing for healthcare in Türkiye (OECD, 2022).

2.1. Misallocation of FDI and the Distortion of Primary Macroeconomic Balances in Türkiye

Especially in Türkiye after 2018 and more significantly between 2021 and 2025, the FDI composition in Türkiye has transformed into a phenomenon of structural contradictions and practices that deviate significantly from the classical production-oriented structure. While the primary goal is to achieve significant investment efficiency in finance, primarily within the banking sector, as well as in combined procurement services and real estate, paradoxically, various dynamics inevitably emerge. In theory, attracting foreign direct investment into the country is expected to strengthen the economy, but in practice, particularly after 2021, the primary reason for this is a directly incorrect FDI distribution composition. In other words, a significant portion of foreign direct investment coming to Türkiye has been directed towards acquiring existing assets within the financial system and catering to domestic demand (UNCTAD, 2023; OECD, 2024).

It is also a significant observation that price increases have been transformed into speculative gains, influencing the FDI composition. This means that instead of increasing production, monetary liquidity has increased, and with domestic demand exceeding expectations, financial markets have recently, especially after 2021, engaged in speculative activities aimed at achieving high profits. In the context of the risks facing Türkiye, the structure in which domestic demand, driven by FDI and credit expansion, has increased has made significant demand inflation inevitable (Borensztein et al., 1998). On the other hand, the current account deficit problem, in terms of primary macroeconomic balances, is unavoidable because production is not being created, and investments are increasing import-dependent domestic demand, leading to increased imports and consequently, increasing current account deficit positions. Furthermore, when the issue is considered from the perspective of structural vulnerability, the changes and increases in FDI values in Türkiye after 2021 have resulted in sectoral structures replacing production and the financialization of the economy.

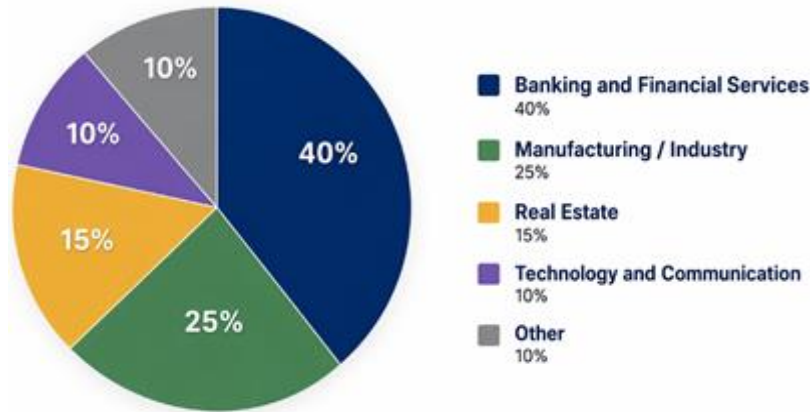
That is, the shift of foreign direct investments to the financial sector has led to a situation where the financialization of the economy and exchange rate sensitivity have further increased, and capital outflow risks have risen even higher (OECD, 2024). In terms of real impact, this real development after 2021 can be explained by a structural profile effect that is even greater than it appears, almost as a growing bubble risk (World Bank, 2023). Although this phenomenon appears to provide temporary relief, paradoxically, this structure deviates from the productive capital accumulation mechanism predicted by classical growth theory in Turkey based on FDI,

and it seems that excessive increases in domestic demand directly affect other macroeconomic primary balances. This situation highlights the importance of not only the quantity but also the composition of FDI, and as observed in the case of Turkey, especially in the period after 2021, although FDI inflows appear quantitatively positive, they do not qualitatively support the macroeconomic primary balance (Rodrik, 2018).

2.2. Foreign Direct Investments (FDI) Sectoral Distribution and Relationship to The Recent Structural Scale Effect Locations

One of the most important characteristics of foreign direct investment (FDI) in Türkiye is that its sectoral distribution reflects not only technical knowledge but also the level of institutional confidence, production capacity, and structural character of recent economic developments in Türkiye, directly reconciling these phenomena with recent market expectations. It is crucial to emphasize that FDI, particularly as an important indicator of Türkiye's recent development goals, implies questioning the amount of FDI investment, the sectors it flows into, and the profitability and sustainability of the investment capital. In Türkiye, this has been observed to be concentrated in the financial services, banking, real estate, logistics, trade, and service sectors, especially in recent years. This situation reveals that while capital inflows continue, Türkiye still faces some deep structural problems in terms of its capacity to attract foreign investment. When evaluated in terms of structural investment depth, this phenomenon, which carries different meanings, is one of the fundamental elements determining Turkey's economic growth model and also affects primary macroeconomic balances (World Bank, 2023). It reveals that FDI market investments are more concentrated in the financial system and directed towards existing short-term returns such as real estate. Graph 1 below illustrates the distribution composition of recent foreign direct investment in Türkiye within this framework:

SECTORAL DISTRIBUTION OF FDI IN TÜRKİYE (AVERAGE FOR 2022-2024)



Source Investment and Finance Office of the Presidency of the Republic of Türkiye (2025). *International direct investment statistics report*. Ankara: Investment and Finance Office of the Presidency of the Republic of Türkiye, https://www.invest.gov.tr/en/news/news-from-turkey/pages/turkiyes-fdi-inflows-reach-usd-11.3-billion-in-2024-defying-global-downturn.aspx?utm_source=chatgpt.com (Accessed April, 12. 2026); Türkiye Cumhuriyet Merkez Bankası (2024a) *Ödemeler dengesi istatistikleri ve uluslararası yatırım pozisyonu raporları*. Ankara: Türkiye Cumhuriyet Merkez Bankası (TCMB), 2024; UNCTAD (2024). *World investment report 2024*. Geneva: United Nations Publications, 2024.

Graphic 1. Recent Distribution of FDI in Türkiye by Sector

As seen in Graph 1 above, the FDI composition in Türkiye points to a structure that aims for higher returns, particularly through financial mechanisms that offer higher returns. This situation, with an approach where financial intermediation mechanisms are prioritized over real production, also shapes the creation of an investment portfolio based on asset prices and market valuations in the asset market. The predictability and financial reliability of investments, when directed towards financial areas with the aim of maximizing expected returns, has transformed into capital accumulation that makes areas with higher financial returns more advantageous. This point indicates that Türkiye is evolving towards a consumption-based, financialized structure with limited production depth (Hausmann et al., 2011).

This structure, which offers limited contributions to creating long-term productive capacity, while easing pressure on foreign exchange reserves in the short term, has recently highlighted the fact that foreign capital inflows are not critically important in terms of transforming into a development-oriented production relationship and concentrating their presence in economic sectors. This phenomenon, which is observed to be subject to significant deviations and negative scale effects, or in other words, the fact that FDI, while coming to Türkiye, is largely directed towards financial and service sectors rather than production, has recently revealed that despite the large amount of capital, it is far from being a true measure of development and lacks a transformative quality towards production. In Türkiye, a recent FDI investment flow that does

not produce, transfer technology, or create productivity—while quantitatively high, qualitatively limited—is an unavoidable phenomenon whose contribution to GDP, especially in the context of recent inflationary processes, must be considered (International Monetary Fund, 2023b).

2.3. Macroeconomic Gains versus Long-Term Structural Constraints of Foreign Capital Inflows in Türkiye

In Türkiye, although foreign capital inflows, particularly in terms of FDI, have created macroeconomic gains since 2021, their insufficient long-term impact on production transformation has created a significant handicap. This handicap can also be considered a long-term structural constraint imposed by foreign countries. These constraints can be evaluated as follows, alongside the gains from FDI inflows into Türkiye: In terms of gains, it can be said that foreign inflows have created various positive effects in Türkiye in the long term. This increase in foreign capital is understood as an important factor in raising market confidence in the country. On the other hand, the Credit Default Swap (CDS) premium, which defines the risk of default and is expressed as an insurance cost in the market against the risk of corporate debt default in Türkiye, has led to a decrease in these risk premiums for global lenders, thus providing a short-term gain for Turkey. The decrease in CDS risk premiums, the reduction in borrowing costs, and the resulting decline in government bond interest rates can be considered a short-term positive effect of foreign capital inflows into Türkiye, particularly in terms of economic gains for primary macroeconomic balances (European Bank for Reconstruction and Development, 2024). On the other hand, the inflow of foreign direct investment provides foreign exchange liquidity, creating a positive process and contributing to the country's economic strength, while also supporting foreign exchange reserves in the short term. In this context, the paradoxical reasons for these constraints can be observed in Table 1 below, along with the corresponding positive and negative impact values:

Table 1. Structural Benefits and Risks of FDI on Türkiye's Macroeconomic Primary Balances

Positive Effects	Negative Effects
Lowers country risk premium and financing costs	Does not ensure structural long-term growth
Increases foreign currency inflows	Provides limited expansion in real productive capacity
Supports financial market liquidity and depth	Does not permanently improve current account balance

Reduces pressure on foreign exchange reserves

May generate inflationary domestic demand pressures

As seen in Table 1 above, the distribution of structural impacts of FDI inflows on the exchange rate in Türkiye, where current account deficits persist, reflects the position of persistent structural vulnerabilities and the effects of FDI inflows on the exchange rate. This structure, which also provides relief in the exchange rate market, reduces short-term balance of payments pressure, but is also understood as the reason for some critical discussions that are not very impactful in economies like Turkey with current account deficits. Another short-term benefit is the positive impact of increasing financial depth, leading to the expansion of the capital market and increased liquidity, thereby supporting the banking system and making the financial system deeper and more active (Moran, 2011).

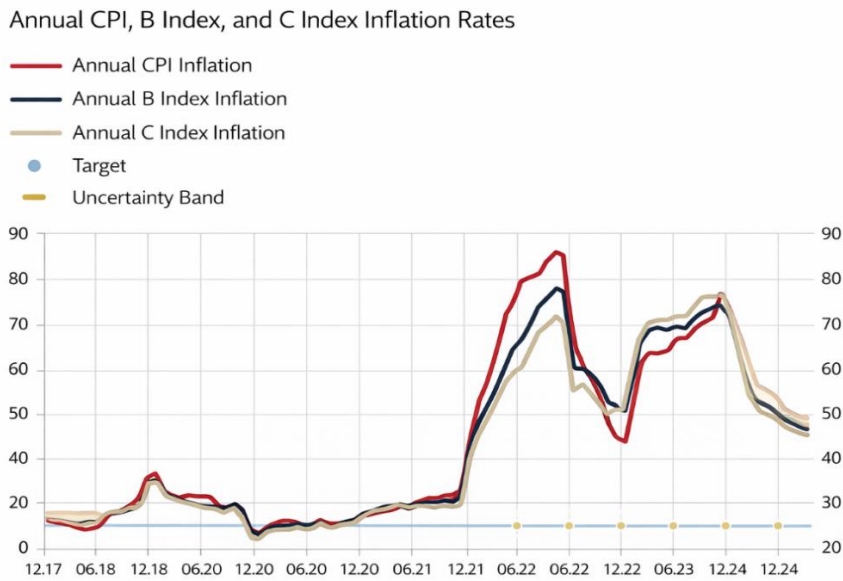
However, this positive structure regarding the deepening and activation of the financial system in the short term has inevitably brought to the forefront a structure that could not be translated into long-term development after 2018. In terms of long-term structural constraints, the positive real impact of quantitative investments in real estate and financial assets on GDP has become a process that does not actually represent much meaning. In other words, the inability to permanently resolve the current account deficit and the inflationary pressures causing price increases instead of the targeted financing solution have brought to the forefront the fact that this has become a fundamental FDI paradox in Türkiye. This structure has also transformed into an application method where a fragile economic growth model with chronic current account deficits has inevitably taken its place in the process, especially in the period after 2021; While this implementation method also functions as a stabilizing buffer mechanism, it has not been able to transform into a production engine that will drive development. Although it supports financial stability in the short term, it has created a constraint that prevents it from attracting foreign capital and instead redirecting incoming capital to productive sectors (Bank for International Settlements, 2023).

2.4. Foreign Direct Investments (FDI) Contribute to GDP, and Relationship to the Recent Inflationary Process

When recent foreign direct investment (FDI) in Türkiye is evaluated in conjunction with recent inflation, some significant impact mechanisms emerge. This phenomenon should be considered not merely as a positive technicality of capital movement, but as an event that creates significant fluctuations in GDP with varying values. In this respect, although FDI represents an increase in investment volume in an economy, its impact on GDP is often indirect, given its focus on

speculative short-term investments during the recent inflationary period. In this context, evaluating the FDI position in Türkiye after 2021 in conjunction with the inflationary process, and considering the very high inflation rates observed recently, it is evident that foreign capital flows have not transformed into a production capacity powered by labour demand and financial transactions. Instead, they have entered a significant imbalance process, creating a multi-layered macroeconomic consequence with negative effects on primary macroeconomic balances (International Monetary Fund, 2019).

Therefore, FDI has shown a two-way structure recently; while meeting the need for foreign exchange reserves in the economy reduces exchange rate pressure, the Turkish economy, which has a significant dependence on imported inputs in terms of its production structure, has shown a very weak structure in terms of playing a balancing role in the general price level through exchange rate pass-through/volatility. For this reason, although inflows of foreign direct investment have the potential to create a disinflationary effect in the short term, significant deviations in market prices related to increasing import costs in the medium and long term have become inevitable. This inevitability also indicates that while the positive contribution of FDI to GDP in Türkiye may be favorable in the short term, this speculative structure is far from supporting price stability, leading to price increases and changes. Graph 2 below presents a meaningful table expressing the contradictory structure of FDI positions in Türkiye, despite their increasing volume, with foreign economic and monetary policies, as a comparison of inflation target and core inflation indicators:

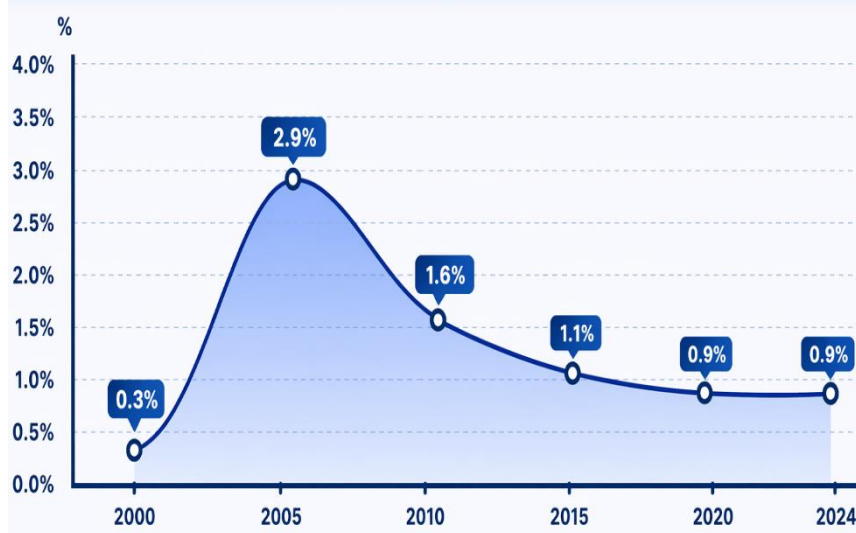


Source: Türkiye Cumhuriyet Merkez Bankası (2024b). *Enflasyon raporu 2024-IV*. Ankara: Türkiye Cumhuriyet Merkez Bankası (TCMB), 2024.

Graphic 2. Comparison of Inflation Target Band and Core Inflation Indicators

It is important to emphasize that Graph 2 above, especially when evaluated in terms of foreign direct investment (FDI) in Türkiye recently, reveals a striking set of macro-financial signals. In particular, the recent superficial price movements and capital flows in Türkiye, as well as the structural reading of market expectations regarding risk, show a relatively stable structure between 2017 and 2020, but also indicate short-term fluctuations. Therefore, this low macro-volatility suggests that the risk premium has been brought under control. However, as a divergence from the index, it is necessary to mention a currency risk situation where policy determination has weakened, particularly in terms of its impact on FDI, and expectations have become unanchored. The emergence of exchange rate risk costs and the fact that foreign direct investment has not completely stopped, but its compositional distribution is distorted, makes it striking and important to mention the recent period in 2023-2024, where inflation increased, risk premiums rose, and long-term foreign direct investment signals decreased (Türkiye Cumhuriyet Merkez Bankası. 2024).

In terms of financial liquidity, this structure, where liquidity in the markets has further increased, indicates a situation where strategic production has decreased, but external financial inflows have increased, affecting primary macroeconomic balances (Institute of International Finance, 2024). This structure, despite a perceived recovery with partial interventions and partial normal improvements following the high inflation experienced after 2023 and 2024, points to a situation where primary macroeconomic structural risks persist. Especially in the years after 2022, and particularly between 2023 and 2024, this situation, even though inflation appeared to be falling, remained at high levels, negatively impacting primary macroeconomic balances in Türkiye. This is seen as a process of index divergence affecting the Consumer Price Index (CPI), the Core Inflation Index (B), and critical indicators for FDI quality in Türkiye. Comparing Türkiye's primary inflation structure and inflation expectations with target values, as macroeconomic primary balances in Türkiye, underscores our focus on the real impact of foreign direct investment on Gross Domestic Product (GDP) in the context of economic growth. Graph 3 below shows the change in foreign direct investment on GDP between 2000 and 2024:



Source: World Bank (2024b). *Foreign direct investment, net inflows (% of GDP) – Türkiye*. Indicator: BX.KLT.DINV.WD.GD.ZS. Washington, DC: World Bank. 2024; The Global Economy (2024). *Turkey: Foreign direct investment, percent of GDP*. Retrieved from TheGlobalEconomy Database, 2024.

Graphic 3. Temporal Change in the Share of Foreign Direct Investment in Turkey's GDP (2000–2024)

As seen in Graph 3 above, particularly in Türkiye, periodic divergence and structural breaks are observed, creating a significant difference between the rapid growth and capital withdrawal phases between 2000 and 2005. This periodic divergence, with a jump from 0.3% to 2.9% in the graph, can be explained academically as a typical period of capital liberalization and global liquidity abundance between 2000 and 2005. This phenomenon, which also signifies a decrease in the country's risk premium, can undoubtedly be considered a period in which foreign direct investment (FDI) inflows accelerated and gained momentum (World Bank, 2024c). This period, which also saw an increase in the investor confidence index, reached a maximum integration level of 2.9% in 2005; this peak point, along with excessive foreign capital inflows, also indicates that asset price increases turned into a speculative structure. Simultaneously, this situation, where risks to the financial sector became riskier for the real sector, saw a sharp decline to 1.6% between 2005 and 2010; this structure, also influenced by the 2009 global financial crisis, resulted in a reassessment of long-term investments and a shift in capital flows. This process, described as a risk repricing process, gradually weakened from 2010 to 2015, falling to 1.1%; the ratio of foreign direct investment to GDP decreased to 1.1% in 2015. Even in the current state of the global crisis, this situation justifies a perception that financial and institutional quality is being questioned and that macroeconomic stability problems directly affect foreign investment. The fall of the FDI ratio to GDP to 0.09 in 2024 marked a significant deviation in terms of macroeconomic balances, and the decrease of foreign direct investment

as a percentage of GDP to 0.9%, along with high inflation and exchange rate volatility, created political uncertainty. In other words, Turkey's FDI/GDP ratio peaked in 2005 and subsequently declined, stabilizing at approximately 0.9% in recent years. Undoubtedly, this macroeconomic structural change indicates an increasing national financial risk, highlighting short-term financial flows as a process of deviation and pointing to a negative situation that also negatively affects macroeconomic primary economic equilibrium positions by limiting long-term production investments (Bank for International Settlements, 2021).

3. DISCUSSION

✓ When evaluating the ratio of foreign direct investment to Gross Domestic Product (GDP) in Türkiye, particularly in the period after 2000, some striking observations highlight a significant institutional capacity and macroeconomic stability process. While this issue emphasizes the significant positive impact of foreign direct investment (FDI) flows into Turkey between 2000 and 2005, this classical capital attraction phase did not become sustainable; it introduced striking and significant inefficient financial disruptions and risk potentials into the process, especially in later years (International Monetary Fund, 2019).

✓ The decline of the FDI/GDP ratio to 1.6% in subsequent years, and the significant decrease in this potential, especially in the period after 2005, coupled with the global financial crisis of 2008 and 2009, which led to a more selective global approach that exaggerated risk potentials, affected both the amount of capital inflows into Türkiye and the distribution composition of foreign resources within the country. This structure, when evaluated in other words, the recent decline of the FDI/GDP ratio to 1.1% in 2024 and beyond, indicates not only a quantitative decrease but also a decline in the quality of foreign investment, with a greater focus on speculative gains.

✓ In this context, one of the most striking findings of the study is undoubtedly the critical observation that a bidirectional, contradictory structure has emerged in Türkiye regarding growth and price stability. In other words, the easing of short-term financial pressures by increasing foreign exchange liquidity, the increase in consumption margins related to business demand expansion, and the manipulation of the recent inflation process towards price increases all contribute to this situation. This channel, particularly with the FDI/GDP ratio falling to 0.9% in 2024 and beyond, reveals a significant loss of attractiveness for long-term investments. Considering this issue in conjunction with recent inflation and current account deficits, it can be said that Türkiye's dependence on external financing has increased.

✓ While short-term investments perceive financial returns positively, in the medium and long term, this structure—the FDI/GDP ratio—makes it inevitable that policies aimed at increasing capital inflows should not be pursued; rather, the quality of incoming capital should be evaluated according to investment quality standards. This assessment, examined within the framework of recent investment trends in Türkiye, has also necessitated a review of expectations regarding FDI/GDP ratios, highlighting their potential to have lasting effects on stability. Specifically, the recent deviations in macroeconomic balances in Türkiye, particularly the negative impacts of high inflation, current account deficit, and economic growth on the quality of foreign capital investments, are a direct consequence of the perception surrounding external approaches. This, in turn, suggests that speculative foreign investments will further increase, creating a more disruptive effect on the composition of FDI investments. This phenomenon and its inherent contradictions have also brought to the forefront the need for more reformist approaches to economic policies in Turkey in recent times.

4. CONCLUSION

The fact of FDI/GDP that points to a complex and contradictory relationship between foreign investments in Türkiye and the inflationary process, because even if quantitative growth figures for foreign direct investment rise, it is clear and obvious that it serves as a mechanism that disrupts price stability and does not create a structural positive effective transformation based on inflationary alterations. In particular, the demand pressure and liquidity expansion created by increased domestic demand due to the entry of foreign financial direct investments, which do not create production capacity; it appears to be obvious, appear to directly and significantly strengthen the inflationary process, triggering inflation, and have been a significant handicap to economic growth in recent Turkey. This bidirectional and contradictory structure regarding economic growth and price stability in Türkiye also reveals that price stability is directly related not only to monetary policy but also to certain factors related to investment, such as the quality and composition of direct investment.

Despite the winning position of short-term investments in the current structure, the existence of a more fragile growth path in longer-term flows is often overlooked. This approach reveals that the resulting financial structural breaks become even clearer and more pronounced in the medium to long term, impacting macroeconomic stability. As a result, macroeconomic balances are directly related to primary macroeconomic balances supported by institutional structures. This situation, which also reveals the impact of global financial crises, has turned into a rather striking phenomenon, pointing to the inevitability of a significant decline in the Turkish

economy, where expectations of strong integration with global capital are not positively affected by the anticipated transformations. In this context, the primary priority in approaches aimed at contributing to real growth in FDI/GDP should be not simply increasing FDI inflows, but rather directing these investments towards productive sectors, concentrating them in technology-intensive areas, and restructuring them to create long-term economic value.

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1932-1939 DÖNEMİNDE TÜRKİYE'DE SANAYİ KOLLARININ VASFI**Prof. Dr. Merter MERT**

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ORCID:0000-0001-5359-1041**ÖZET**

Bu çalışmada Türkiye'de 1930'lu yıllardaki on sanayi kolunun (sanayii istihraciye, ziraat, hayvanatı ehliye ve av mahsulatı sanayii, sanayii nesciye, sanayii haşebiye, kâğıt ve karton sanayii, sanayii madeniye, ebniye inşaatı sanayii, sanayii kimyeviye, sanayii muhtelite, sanayii muhtelif ve gayri muayyene) vasfı incelenmiştir. Bu çalışmadaki temel amaç, 1930'lu yıllardaki Türkiye sanayisini betimlemeye dönük çalışmalara katkıda bulunmaktır. Bu amaç çerçevesinde, 1932-1939 dönemindeki sanayi kollarının vasfı incelenmiştir. Sanayi kollarının vasfından kasıt, sanayi kollarının; bir kişi tarafından işletilen, adi şirket, anonim, kolektif, komandit, kooperatif, limitet ve devlet, hususi idare veya belediye olarak sınıflandırılmasıdır. Çalışmada söz konusu sınıflandırmaya ilişkin oransal hesaplamalar yapılmıştır. Veriler 1932-1939 dönemini kapsamaktadır. Çalışmanın bulgularına göre, 1932-1939 dönemindeki müesseselerin ortalama olarak % 6'sı devlet, hususi idare veya belediye kapsamında iken ortalama % 7'si anonim, ortalama % 13'ü adi şirket, ortalama % 14'ü kolektif ve ortalama % 52'si bir kişi tarafından işletilen müessesedir. Sanayi kolları açısından değerlendirme yapıldığında; devlet, hususi idare veya belediye kapsamındaki müesseselerin en fazla olduğu sanayi kolu ortalama % 47'lik oranla sanayii muhtelif ve gayri muayyenedir. Anonim müesseseler açısından en fazla pay ortalama % 47 ile sanayii istihraciyenin olmuştur. Sanayii nesciyedeki müesseselerin ortalama % 70'i bir kişi tarafından işletilen müessesedir. Çalışmanın bulguları, devletçi politikaların uygulandığı kabul edilen dönemdeki esas odak noktasının devlet müesseseleri olmayabileceğine işaret etmektedir.

Anahtar Kelimeler:Türkiye İktisat Tarihi, Sanayileşme, Kalkınma.**SOME CHARACTERISTICS OF INDUSTRIAL SECTORS IN TURKIYE DURING THE PERIOD 1932-1939****ABSTRACT**

This study examines the characteristics of ten industrial sectors in Türkiye during the 1930s (extraction industry, agriculture, animal husbandry and hunting products industry, textile industry, wood industry, paper and cardboard industry, mining industry, building industry, chemical industry, mixed industry, other industries). The main aim of this study is to contribute to descriptive studies of Turkish industry in the 1930s. Within this framework, the

characteristics of industrial sectors during the 1932-1939 period are examined. By "industrial sector characteristics," we mean the classification of industrial sectors as: single-person operated, ordinary company, joint-stock company, collective, limited partnership, cooperative, limited liability company, and state or municipality-owned. In the study, proportional calculations related to this classification have been made. The data covers the period 1932-1939. According to the findings, during the 1932-1939 period, an average of 6% of the establishments were under the control of the state or municipalities, while an average of 7% were joint-stock companies, an average of 13% were ordinary companies, an average of 14% were collective companies, and an average of 52% were single-person operated institutions. When evaluated by industrial sectors, the sector with the highest percentage of state-controlled or municipal establishments was the other industries, with an average of 47%. In terms of joint-stock companies, the largest share was in the extraction industry, averaging 47%. In the textile industry, an average of 70% of the establishments were single-person operated. The study's findings suggest that the primary focus during the period considered to be one of statist policy implementation may not have been state institutions.

Keywords: Turkish Economic History, Industrialization, Development.

GİRİŞ

Bu çalışma, 1930'lu yıllar Türkiye sanayisinde faaliyet gösteren on sanayi kolunun vasıflarını inceleyerek dönemin iktisadi görünümünü betimleyen veri kümesine katkı sunmayı amaçlamaktadır. 1932-1939 dönemini kapsayan bu araştırmada; sanayi kollarının bir kişi tarafından işletilen müesseseler, adi şirketler, anonim, kollektif, komandit, kooperatif ve limitet şirketlerin yanı sıra devlet, hususi idare veya belediye ortaklığı şeklindeki hukuki ve idari sınıflandırılması esas alınmıştır. Bu sınıflandırma çerçevesinde yapılan oransal hesaplamalar, dönemin sanayisinin mülkiyet ve işletme yapısını verilerle ortaya koymaktadır. Buna benzer bir sınıflandırma ile sanayileşme arasındaki ilişkilere dair bir literatür de mevcuttur (örneğin bkz. Cassis vd. 1995, Church 1993, Deakin 2009, Suzuki 1980).

Türkiye'ye özgü olarak ise çalışmada elde edilen bulguların bazı tartışmalara işaret etmesi beklenmektedir. Örneğin, devletçi iktisat politikalarının uygulandığı dönem olarak kabul edilen bir dönemde (örneğin bkz. Boratav, 1998) devlet, hususi idare veya belediye ortaklığı vasfındaki müesseselerin oranı ne idi? Özel müteşebbislerin yerine kamu şirketlerinin etkin olduğunun kabul edildiği 1932-1939 döneminde bir kişi tarafından işletilen müesseselerin oranı ne idi? Çalışmada bu ve benzer sorulara cevap aranmıştır.

İzleyen bölümde yöntem kısaca gösterilmiş, ardından gelen başlıkta ise bulgulara yer verilmiştir. Son bölüm ise sonuç bölümüdür.

YÖNTEM

Çalışmada 1930’lu yıllar Türkiye sanayisinde faaliyet gösteren on sanayi kolunun vasıflarını incelemek için önce sanayi kollarındaki müessese adedine ilişkin bilgi verilmiştir. Ardından, sanayi kollarının farklı vasıflar (bir kişi tarafından işletilen müessese, adi şirket, anonim, kolektif, komandit, kooperatif, limitet ve devlet, hususi idare veya belediye) açısından oranı dönem ortalaması olarak verilmiştir. Ayrıca, bunlardan bazılarının yıllar içindeki seyri de şekil olarak gösterilmiştir. Daha sonra, söz konusu oran hesaplaması her bir sanayi kolu için ayrı ayrı yapılmıştır.

İzleyen başlıkta bulgular sunulmuştur.

BULGULAR

Bu başlık altında, çalışmanın bulgularına Tablo 1’den başlayarak yer verilmiştir. Buna göre, müessese adedinin en fazla olduğu sanayi kolu ziraat, hayvanatı ehliye ve av mahsulatı sanayii iken ikinci sırada sanayii nesciye yer almıştır.

Tablo 1. Sanayi kollarındaki müessese sayısı

	Sanayii istihraciye	Ziraat, hayvanatı ehliye ve av mahsulatı sanayii	Sanayii nesciye	Sanayii haşebiye	Kâğıt ve karton sanayii	Sanayii madeniye
1932	17	651	351	134	41	85
1933	18	614	335	115	41	77
1934	23	594	300	103	35	73
1935	26	525	266	74	31	57
1936	25	482	265	59	30	43
1937	32	484	244	59	32	44
1938	33	462	242	56	34	42
1939	37	468	249	53	37	41

Kaynak: Yazar tarafından oluşturulmuştur.

Tablo 1 (devamı). Sanayi kollarındaki müessese sayısı

	Ebniye inşaatı sanayii	Sanayii kimyeviye	Sanayii muhtelite	Sanayii muhtelif ve gayri muayyene	Toplam
1932	31	76	48	39	1473
1933	36	54	68	39	1397
1934	32	51	56	43	1310
1935	31	44	54	53	1161
1936	32	41	61	63	1101
1937	30	38	70	83	1116
1938	29	35	72	98	1103
1939	28	37	71	123	1144

Kaynak: Yazar tarafından oluşturulmuştur.

Tablo 1’in ardından bulgulara şekiller ile devam edilmiştir. Şekil 1’de tüm sanayi kolları için toplulaştırılmış bulgular sunulmuştur. Buna göre, 1932-1939 döneminde tüm sanayi

kollarındaki müesseselerin ortalama olarak yarısından fazlası (% 52'si) bir kişi tarafından işletilen müessesedir. Müesseselerin ortalama yaklaşık % 14'ü kolektif, % 13'ü adi şirket ve % 7'si anonimdir. Devlet, hususi idare ve belediyenin oranı ise yaklaşık % 6'dır. Şekil 2'ye göre, tüm sanayi kollarındaki müesseseler içinde bir kişi tarafından işletilen müesseselerin payı 1932 yılında yaklaşık % 56 iken 1939 yılında bu oran % 46'ya gerilemiştir.

Sanayi kolları ayrı değerlendirildiğinde şu tespitler yapılabilir:

i) Sanayii istihraciyede ortalama olarak en yüksek pay anonim müesseselerindir; anonim müesseseler bu sanayi kolunun yaklaşık yarısını meydana getirmiştir (bkz. Şekil 4). Diğer taraftan, bu müesseselerin payı dönem başında yaklaşık % 65 iken dönem sonunda % 35'e gerilemiştir (bkz. Şekil 4).

ii) Ziraat, hayvanatı ehliye ve av mahsulâtı sanayiinde baskın olan işletme türü bir kişi tarafından işletilen müessesedir (bkz. Şekil 6). Bunu adi ve kolektif şirket izlemiştir. Bu üç işletme türünün payı ortalama yaklaşık % 87'dir (bkz. Şekil 6).

iii) Sanayii nesciyede de benzer bir durum vardır; işletmelerin % 70'i bir kişi tarafından işletilen, % 12'si kolektif ve % 5'i adi şirket niteliğindedir (bkz. Şekil 8).

iv) Sanayii haşbiyedeki işletmelerin % 53'ü bir kişi tarafından işletilen, % 19'u kolektif ve % 13'ü adi şirket niteliğindedir (bkz. Şekil 10).

v) Kâğıt ve karton sanayiindeki işletmelerin % 47'si bir kişi tarafından işletilen, % 14'ü kolektif ve % 12'si adi şirket niteliğindedir (bkz. Şekil 12). Bu sanayi kolundaki işletmelerin % 13'ü ise devlet, hususi idare veya belediye niteliğindedir (bkz. Şekil 12).

vi) Sanayii madeniyedeki müesseselerin % 41'i bir kişi tarafından işletilen, % 22'si kolektif ve % 13'ü anonim müessese niteliğindedir (bkz. Şekil 14).

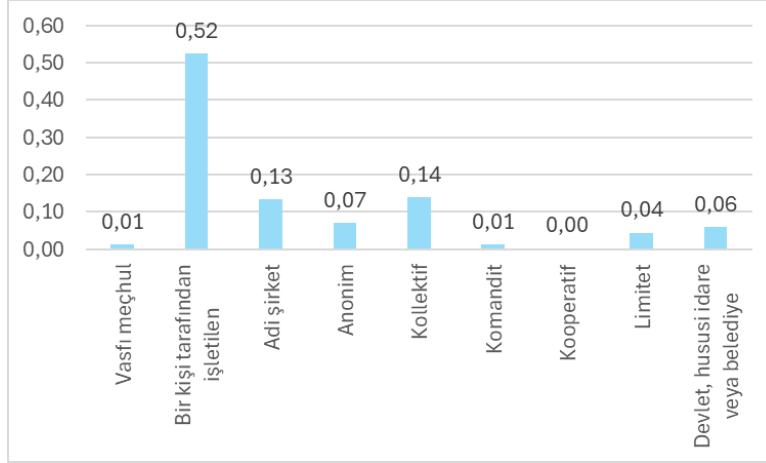
vii) Ebniye inşaatı sanayiinde bir kişi tarafından işletilenlerin oranı ortalama % 45, anonim müesseselerin oranı ortalama % 23 ve kolektif müesseselerin oranı ortalama % 13'tür (bkz. Şekil 16).

viii) Sanayii kimyeviyedeki işletmelerin % 50'si bir kişi tarafından işletilen, % 22'si kolektif ve % 15'ianonim müessese niteliğindedir (bkz. Şekil 18).

ix) Sanayii muhtelitedeki müesseselerin % 47'si bir kişi tarafından işletilen, % 18'i adi şirket ve % 14'ükolektif müessese niteliğindedir (bkz. Şekil 20).

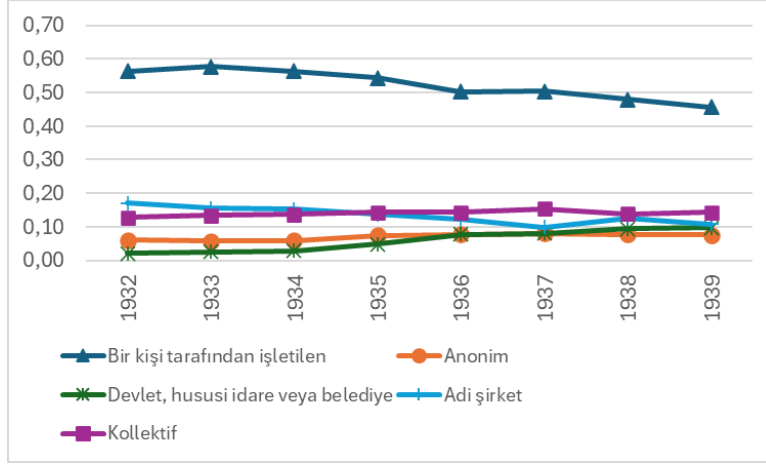
x) Sanayii muhtelif veya gayri muayyenedeki durum diğerlerinden farklıdır. Bu sanayi kolundaki müesseselerin ortalama yaklaşık % 47'si devlet, hususi idare veya belediye niteliğindedir (bkz. Şekil 22). Daha sonra % 17 ile anonim müessese ve % 13 ile bir kişi tarafından işletilen müessese gelmektedir (bkz. Şekil 22).

Şekil 1 Sanayi kollarının farklı vasıflar açısından oranı (1932-1939, ortalama)



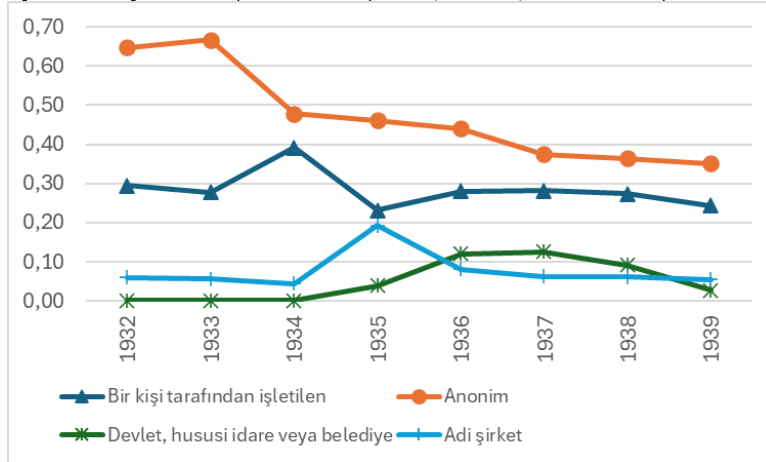
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 2 Sanayi kollarının farklı vasıflar açısından oranı



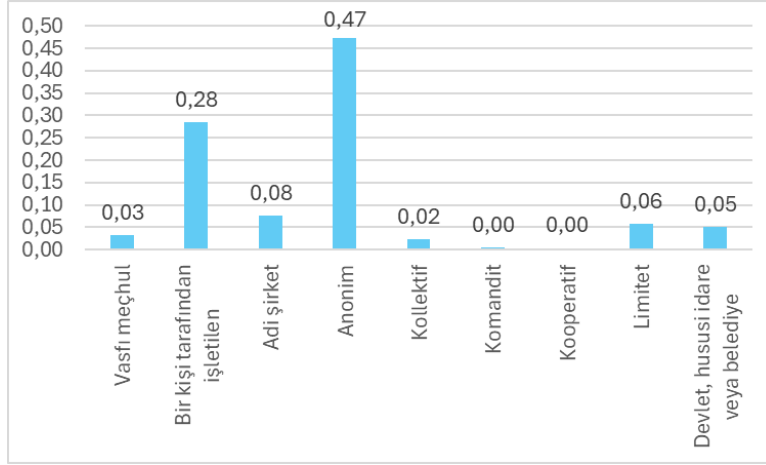
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 3 Sanayii istihraciyede bir kişi tarafından işletilen, anonim, devlet ve adi şirket vasıflarının oranı



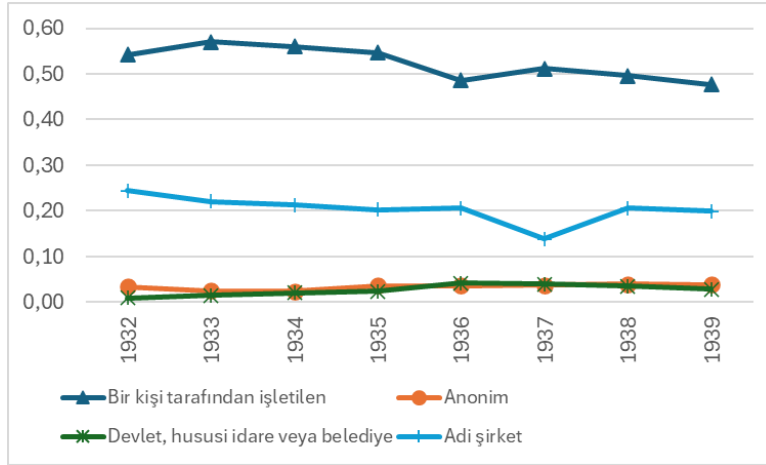
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 4 Sanayii istihraciyede farklı vasıfların oranı (1932-1939, ortalama)



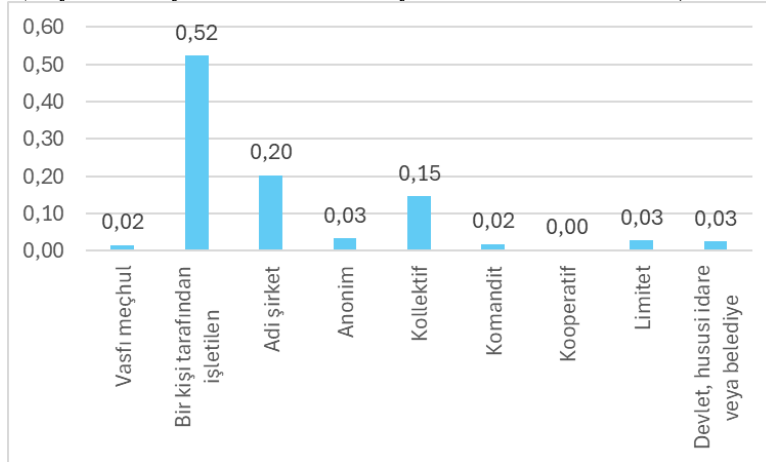
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 5 Ziraat, hayvanatı ehliye ve av mahsulatı sanayiinde bir kişi tarafından işletilen, anonim, devlet ve adi şirket vasıflarının oranı



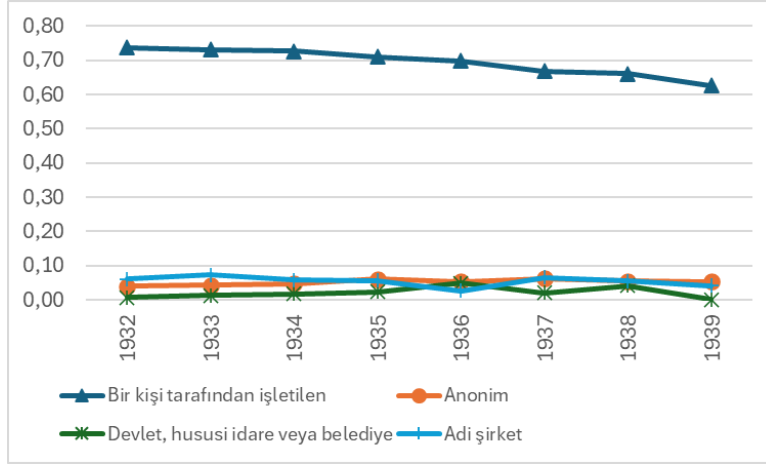
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 6 Ziraat, hayvanatı ehliye ve av mahsulatı sanayiinde farklı vasıfların oranı (1932-1939, ortalama)



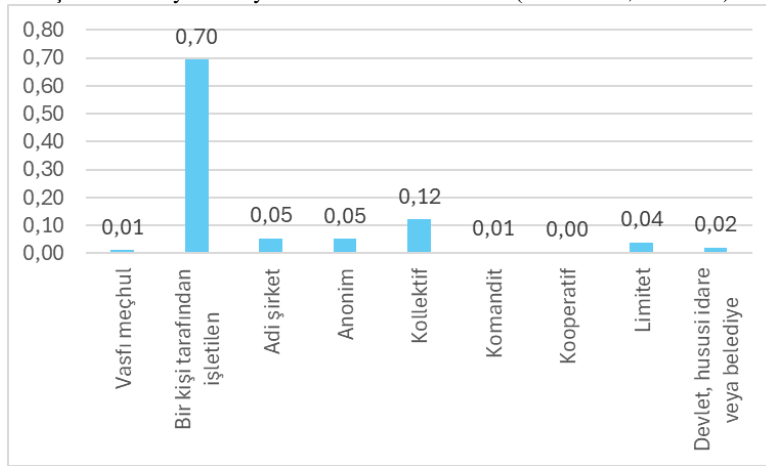
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 7 Sanayi nesciyede bir kişi tarafından işletilen, anonim, devlet ve adi şirket vasıflarının oranı



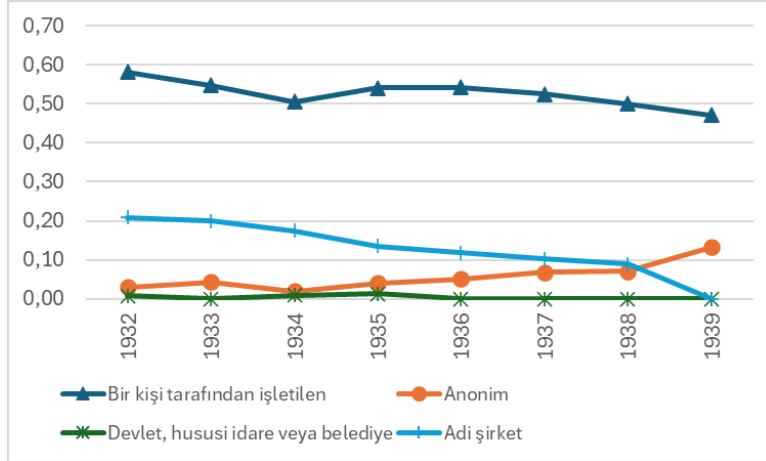
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 8 Sanayii nesciyede farklı vasıfların oranı (1932-1939, ortalama)



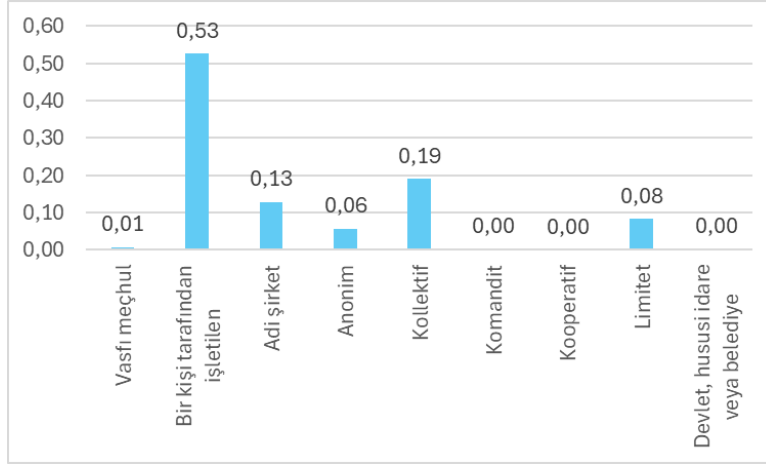
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 9 Sanayii haşebiyede bir kişi tarafından işletilen, anonim, devlet ve adi şirket vasıflarının oranı



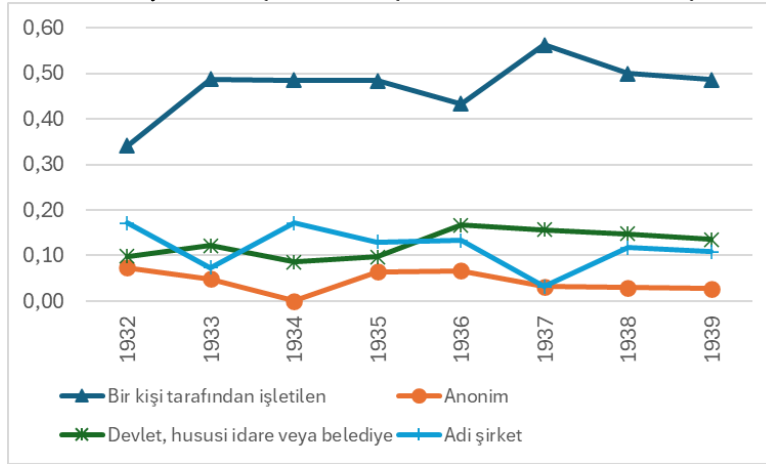
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 10 Sanayii haşebiyede farklı vasıfların oranı (1932-1939, ortalama)



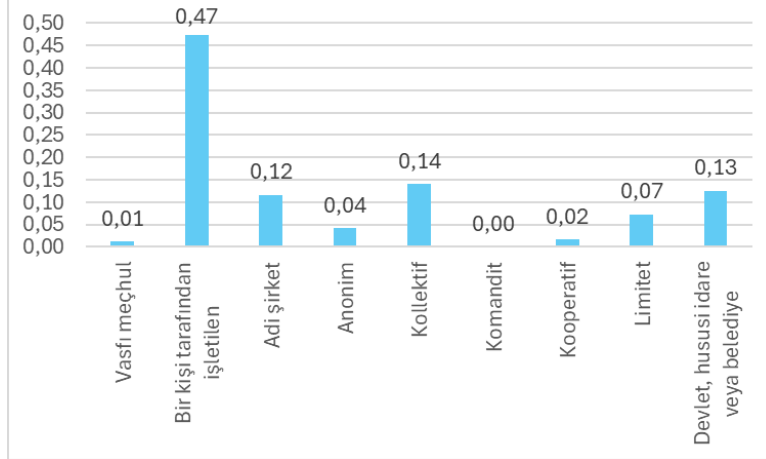
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 11 Kâğıt ve karton sanayiinde bir kişi tarafından işletilen, anonim, devlet ve adi şirket vasıflarının oranı



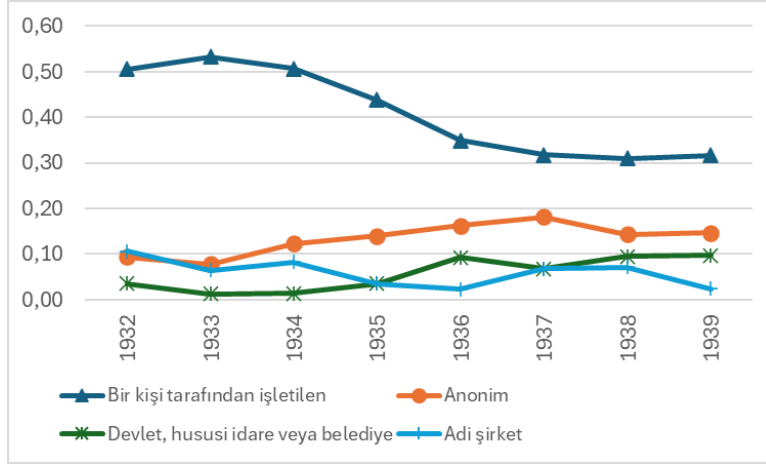
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 12 Kâğıt ve karton sanayiinde farklı vasıfların oranı (1932-1939, ortalama)



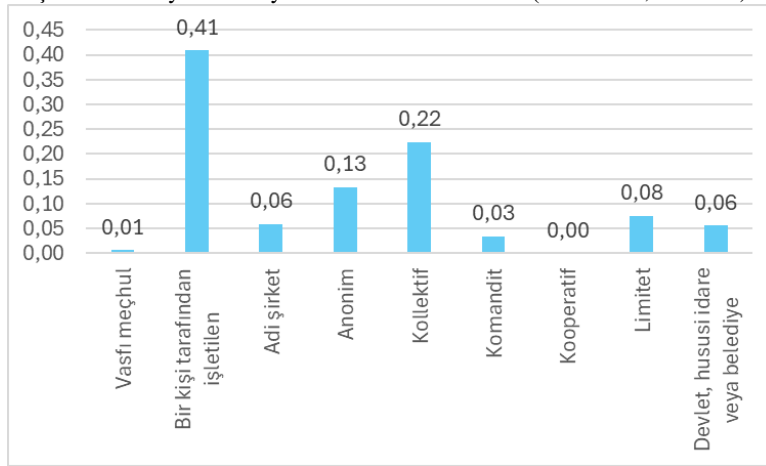
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 13 Sanayii madeniyede bir kişi tarafından işletilen, anonim, devlet ve adi şirket vasıflarının oranı



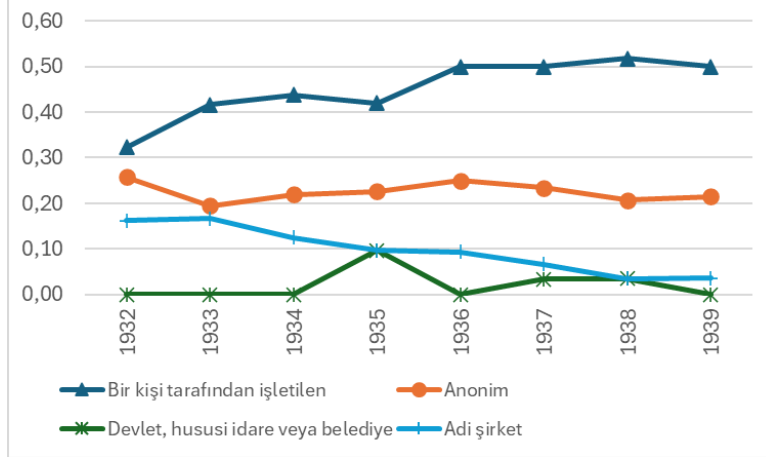
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 14 Sanayi madeniyede farklı vasıfların oranı (1932-1939, ortalama)



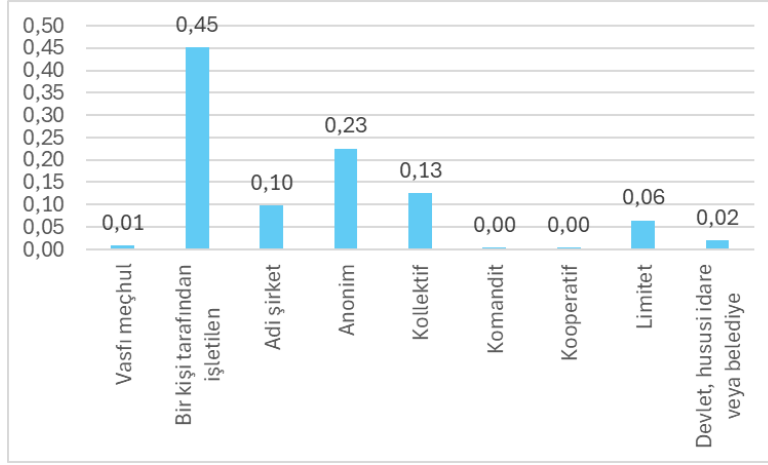
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 15 Ebniye inşaatı sanayiinde bir kişi tarafından işletilen, anonim, devlet ve adi şirket vasıflarının oranı



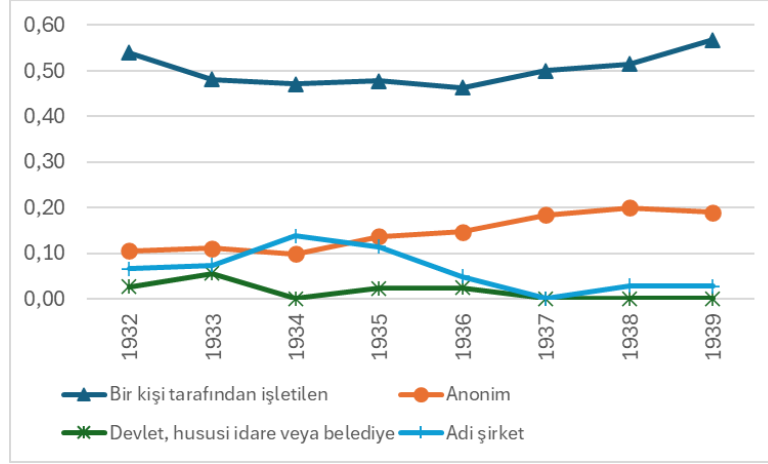
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 16 Ebniye inşaatı sanayiinde farklı vasıfların oranı (1932-1939, ortalama)



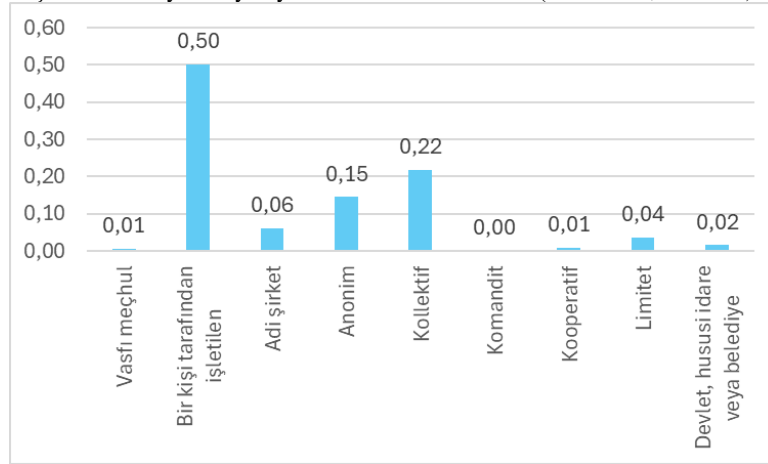
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 17 Sanayii kimyeviye de bir kişi tarafından işletilen, anonim, devlet ve adi şirket vasıflarının oranı



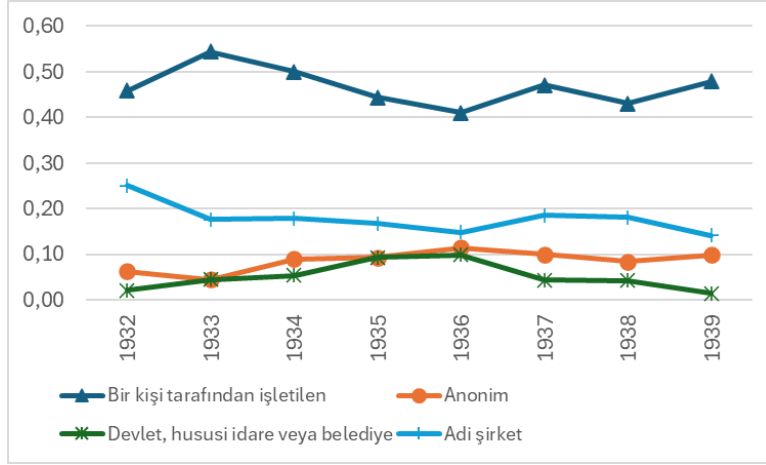
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 18 Sanayii kimyeviye de farklı vasıfların oranı (1932-1939, ortalama)



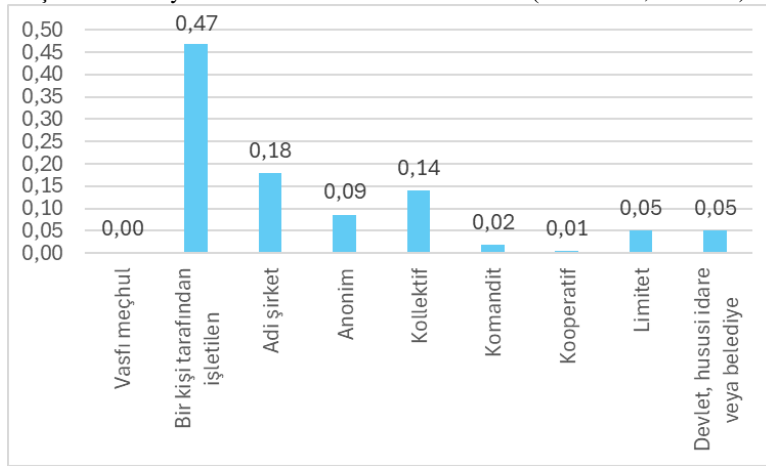
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 19 Sanayii muhtelide de bir kişi tarafından işletilen, anonim, devlet ve adi şirket vasıflarının oranı



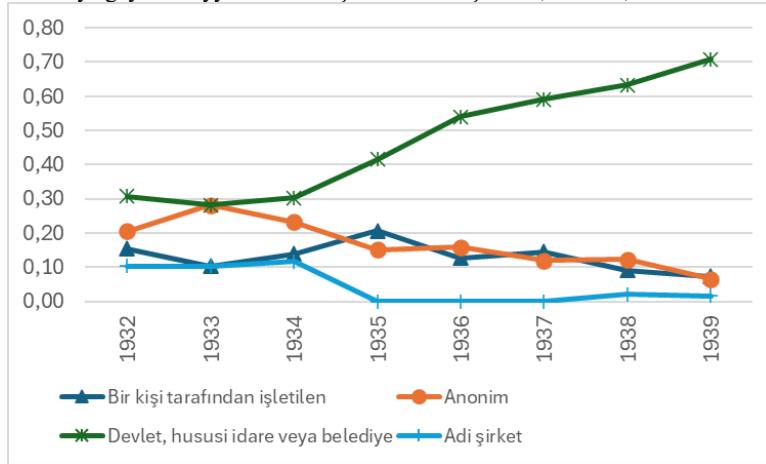
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 20 Sanayii muhtelifte farklı vasıfların oranı (1932-1939, ortalama)



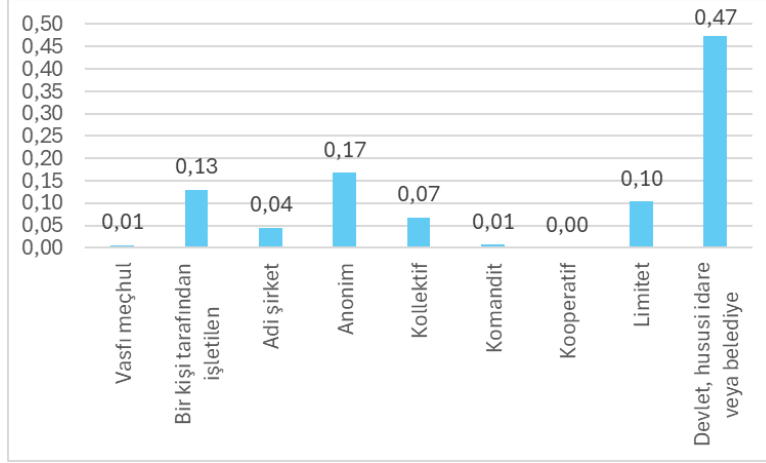
Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 21 Sanayii muhtelif veya gayri muayyenede bir kişi tarafından işletilen, anonim, devlet ve adi şirket vasıflarının oranı



Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 22 Sanayii muhtelif veya gayri muayyenede farklı vasıfların oranı (1932-1939, ortalama)



Kaynak: Yazar tarafından oluřturulmuřtur.

SONUÇ

Çalıřmanın bulgularına göre, 1932-1939 yılları arasındaki müesseselerin ortalama % 52 gibi büyük bir çoğunluğunun şahıřlar tarafından iřletildiđi, bunu %14 ile kollektif řirketlerin, %13 ile adi řirketlerin, %7 ile anonim řirketlerin ve % 6 ile kamu (devlet, hususi idare veya belediye) bünyesindeki iřletmelerin takip ettiđi görölmektedir.

Sanayi kolları açasından yapılan deđerlendirmelerde ise kamusal müesseselerin en yoğun olduđu alan % 47'lik oranla sanayii muhtelif veya gayri muayyene kolu iken, anonim řirketlerin % 47'lik bir payla en fazla sanayii istihraciye kolunda kümelenildiđi tespit edilmiřtir. Ayrıca, sanayii nesciye kolundaki iřletmelerin % 70 gibi baskın bir oranla şahıř iřletmesi statüsünde olduđu belirlenmiřtir.

Arařtırmadan elde edilen bu veriler, devletçi politikaların ađırlık kazandıđı kabul edilen söz konusu dönemde, sanayinin esas odak noktasının yalnızca devlet müesseseleri olmayabileceđine iřaret etmektedir.

İzleyen çalıřmamızda bu durumun tartıřılması hedeflenmektedir.

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1932-1939 DÖNEMİNDE TÜRKİYE'DE SANAYİ KOLLARININ MÜESSESE SAYISI VE FARKLI GÖSTERGELER AÇISINDAN AĞIRLIĞI

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ÖZET

Bu çalışmanın amacı 1930'lu yıllardaki Türkiye sanayisinde mevcut olan durumu tespit etmeye dönük veri kümesine katkıda bulunmaktır. Bu amaç doğrultusunda, çalışmada 1932-1939 dönemindeki sanayi kollarının neler olduğu, bunlara ilişkin müesseselerin adedi, kuruluş tarihlerine göre oranları, farklı göstergeler açısından toplam içindeki ağırlıkları incelenmiştir. Çalışmada kullanılan yöntem betimsel analizdir. Kullanılan veriler teşvik-i sanayi kanunundan istifade eden müesseselere ilişkin veri setidir ve 1932-1939 dönemini kapsamaktadır. Ayrıca, önceki çalışmalarımızdaki bulgulara da başvurulmuştur. Çalışmanın bulgularına göre, 1932-1939 döneminde on sanayi kolu vardır: sanayii istihraciye, ziraat, hayvanatı ehliye ve av mahsulatı sanayii, sanayii nesciye, sanayii haşebiye, kâğıt ve karton sanayii, sanayii madeniye, ebniye inşaatı sanayii, sanayii kimyeviye, sanayii muhtelite, sanayii muhtelif veya gayri muayyene. Toplam müessese adedi içindeki pay göstergesi açısından ziraat, hayvanatı ehliye ve av mahsulatı sanayii ortalama % 44 ile ilk sırada iken onu ortalama % 23 ile sanayii nesciye ve ortalama % 6,5 ile sanayii haşebiye takip etmiştir. Bir başka bulguya göre, 1932-1939 dönemindeki müesseselerin ortalama % 20'si 1923'ten evvel, ortalama % 55'i 1923-1931 döneminde ve ortalama % 23'ü 1932-1939 döneminde kurulmuştur. Ortalama % 2'sinin ise kuruluş tarihi meçhuldür. 1923'ten evvel kurulan müessese oranının en yüksek olduğu sanayi kolu % 50 ile kâğıt ve karton sanayii olmuştur. Çalışmada elde edilen bulgular, önceki çalışmalarımızdaki bazı bulgularla birleştirilerek dönemin anlaşılması için gerekli veriler çoğaltılmıştır.

Anahtar Kelimeler:Türkiye İktisat Tarihi, Sanayileşme, Kalkınma.

THE NUMBER OF INDUSTRIAL ESTABLISHMENTS AND THEIR IMPORTANCE ACCORDING TO VARIOUS INDICATORS IN TURKIYE DURING THE PERIOD 1932-1939

ABSTRACT

The aim of this study is to contribute to the dataset aimed at determining the existing situation in Turkish industry in the 1930s. To this end, the study examines the industrial sectors in the 1932-1939 period, the number of related establishments, their proportions according to their establishment dates, and their weights within the total in terms of different indicators. The

method used in the study is descriptive analysis. The data used is a dataset related to establishments benefiting from the Industrial Incentives Law and covers the period 1932-1939. Furthermore, findings from our previous studies have also been consulted. According to the findings of the study, there were ten industrial sectors in the 1932-1939 period: extraction industry, agriculture, animal husbandry, and hunting products industry, textile industry, wood industry, paper and cardboard industry, mining industry, building industry, chemical industry, mixed industry, and other industries. In terms of their share within the total number of establishments, agriculture, animal husbandry, and hunting products industry ranked first with an average of 44%, followed by textile industry with an average of 23% and wood industry with an average of 6.5%. Another finding indicates that, on average, 20% of the establishments in the 1932-1939 period were founded before 1923, 55% between 1923-1931, and 23% between 1932-1939. The founding date of approximately 2% is unknown. The industry with the highest percentage of establishments founded before 1923 was the paper and cardboard industry with 50%. The findings of this study have been combined with some findings from our previous studies to provide more data necessary for understanding the period.

Keywords: Turkish Economic History, Industrialization, Development.

GİRİŞ

Bu çalışma, 1930'lu yıllar Türkiye'sinin sanayi yapısını ortaya koymak amacıyla mevcut veri kümesine katkı sunmayı hedeflemektedir. 1932-1939 dönemini inceleyen bu kısa araştırmada; mevcut sanayi kollarının sınıflandırılması, müessese sayıları, işletmelerin kuruluş tarihlerine göre dağılım oranları ve çeşitli göstergeler üzerinden toplam içindeki ağırlıkları incelenmiştir. Teşvik-i Sanayi Kanunu'ndan yararlanan işletmelere ait verilerin betimsel analiz yöntemiyle incelendiği çalışmada, ayrıca, önceki araştırmamızın bulgularından da yararlanılmıştır.

Çalışmada müessese sayılarının incelenmesi, sanayi kollarının sanayi içindeki ağırlığına ilişkin önceki çalışmalara ek tespitlerin ve bazı verimlilik çıkarımlarının yapılabilmesi için gereklidir. İşletmelerin kuruluş tarihine göre incelenmesi ise iki açıdan bilgi verecektir. Birincisi, devletçi olarak nitelendirilen politikaların baskın olduğu dönem ile liberal politikaların uygulandığının iddia edildiği önceki dönem arasında bir sürekliliğin olup olmadığına dair incelemelere ilişkindir. Benzer şekilde, devletçi olarak nitelendirilen politikaların baskın olduğu dönem ile Cumhuriyetin ilanından önceki dönem arasında bir sürekliliğin olup olmadığına dair incelemelere ilişkindir. İşletmelerin kuruluş tarihine göre incelenmesinin vereceği ikinci bilgi, dönemin yeni yatırımlarının hangi sanayi kollarına yöneldiğinin tespiti ile ilgilidir.

Bu çerçevede izleyen bölümlerde sırasıyla yöntem, bulgular ve sonuç açıklanmıştır.

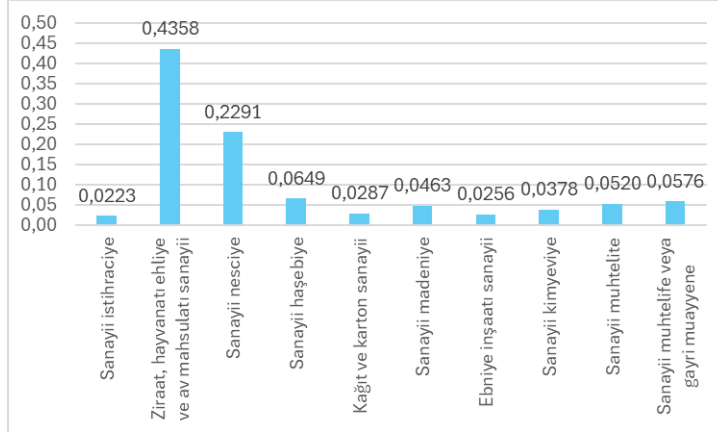
YÖNTEM

Çalışmada farkı sanayi kollarının ağırlığına ilişkin saptamalar yapabilmek amacıyla, önce her yıl için sanayi kollarındaki müesseselerin toplam müessese adedi içindeki payı, ardından, her bir sanayi kolu için söz konusu değerlerin aritmetik ortalaması hesaplanmıştır. İkinci olarak, önce her yıl için müesseselerin toplam içindeki payı açısından; teessüs tarihi meçhul, 1923'ten evvel kurulan, 1923-1931 arası kurulan, 1932-1939 arası kurulan olmak üzere dört ayrı oran hesaplanmıştır. Ardından, bunların dönem ortalaması alınmıştır. Bu ikinci hesaplama sanayi kolları için de yapılmıştır. Son olarak, iki farklı yöntemle 1932-1939 döneminin her yılı için kurulan yeni müessese adedi tespit edilmiştir. Ayrıca, bir sanayi kolu açısından her yıl için tespit edilen yeni müessese adedi o yılın toplam yeni müessese adedine oranlanıp dönem ortalaması da hesaplanmıştır.

BULGULAR

Bu başlık altında Şekil 1'den başlayarak çalışmanın bulgularına yer verilmiştir. Şekil 1'e göre, 1932-1939 döneminde toplam müessese adedi içindeki payı en yüksek olan sanayi kolu ortalama yaklaşık % 44 ile ziraat, hayvanatı ehliye ve av mahsulâtı sanayii iken onu ortalama yaklaşık % 23 ile sanayii nesciye izlemiştir. Diğer sekiz sanayi kolunun payı ise % 10'un altındadır.

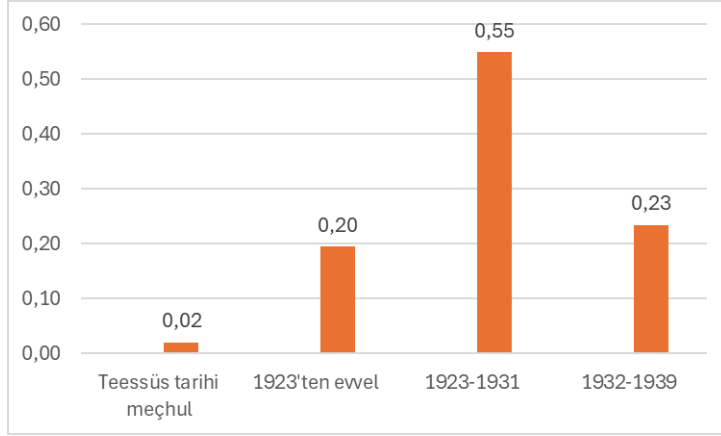
Şekil 1 .Sanayi kollarındaki müesseselerin toplam müessese adedi içindeki payı (1932-1939, ortalama)



Kaynak: Yazar tarafından oluşturulmuştur.

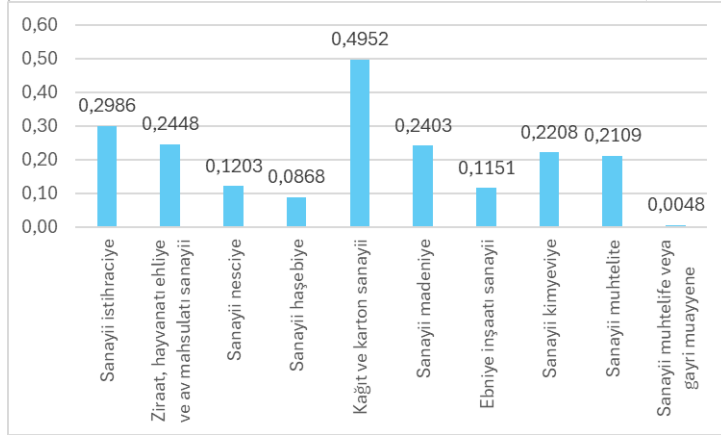
Şekil 2'ye göre, 1932-1939 döneminde faaliyet gösteren kuruluşların ortalama yaklaşık % 20'si 1923'ten evvel, % 55'i 1923-1931 döneminde kurulmuştur. Kuruluşların ortalama yaklaşık % 23'ü ise 1932-1939 döneminde kurulmuştur. Alt sanayi kolları açısından değerlendirildiğinde, kâğıt ve karton sanayindeki 1932-1939 döneminde faaliyet gösteren kuruluşların yaklaşık yarısı 1923'ten evvel kurulmuştur (bkz. Şekil 3).

Şekil 2. Müesseselerin kuruluş tarihlerine göre payı (1932-1939, ortalama)



Kaynak: Yazar tarafından oluşturulmuştur.

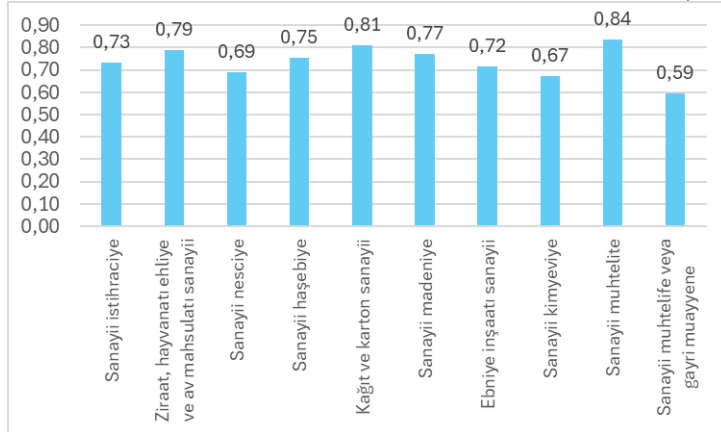
Şekil 3. Sanayi kollarındaki müesseselerin 1923'ten evvel kurulanlarının oranı (1932-1939, ortalama)



Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 4'e göre, 1932-1939 döneminde sanayi kollarındaki müesseselerin yarısından fazlası 1932 öncesinde kurulmuştur. Sanayii muhtelite de faaliyet gösteren müesseselerin ortalama yaklaşık % 84'ü, kâğıt ve karton sanayiindekilerin yaklaşık ortalama % 81'i, ziraat, hayvanatı ehliye ve av mahsulâtı sanayiindekilerin yaklaşık ortalama % 79'u 1932 öncesinde kurulmuştur.

Şekil 4. Sanayi kollarındaki müesseselerin 1932 öncesi döneminde kurulanlarının oranı (1932-1939, ortalama)



Kaynak: Yazar tarafından oluşturulmuştur.

Tablo 1, Tablo 2 ve Tablo 3'te, 1932-1939 döneminin her yılı için kurulan yeni müessese adetlerine ilişkin hesaplama sonuçları verilmiştir. Söz konusu tablolarda her bir sanayi koluna ilişkin iki sütun vardır. Soldaki sütun ilk yöntem kullanılarak yapılan saptama iken, sağdaki

sütun ikinci yöntem kullanılarak yapılan hesaplama. Tablolara göre, 1932-1939 döneminde kurulan yeni müessese adedi ortalama olarak en fazla ziraat, hayvanatı ehliye ve av mahsulâtı sanayiindedir. Ardından sanayii nesciye ve sanayii muhtelif ve gayri muayyene gelmiştir.

Tablo 1. 1932-1939 döneminin her yılı için kurulan yeni müessese adedi I

Yıl	Sanayii istihraciye		Ziraat, hayvanatı ehliye ve av mahsulâtı sanayii		Sanayii nesciye	
	1	2	1	2	1	2
1932	0	2	24	30	31	37
1933	1	2	14	18	15	24
1934	1	3	19	22	17	22
1935	1	4	13	17	14	19
1936	1	4	19	29	15	15
1937	3	3	17	22	11	20
1938	1	4	21	21	11	21
1939	1	1	18	18	10	10

Kaynak: Yazar tarafından oluşturulmuştur. Tablo 2. 1932-1939 döneminin her yılı için kurulan yeni müessese adedi II

Yıl	Sanayii haşebiye		Kâğıt ve karton sanayii		Sanayii madeniye	
	1	2	1	2	1	2
1932	8	11	2	2	6	6
1933	5	6	0	0	2	5
1934	2	3	1	3	3	3
1935	2	3	0	2	2	2
1936	3	7	1	5	0	1
1937	3	4	2	2	3	3
1938	1	1	1	3	1	2
1939	6	6	1	1	1	1

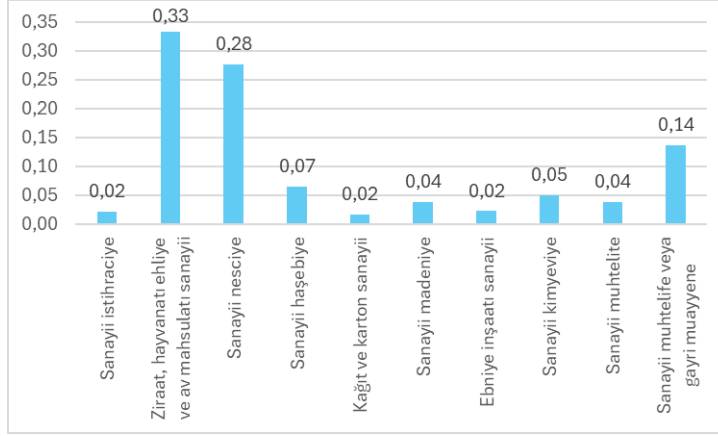
Kaynak: Yazar tarafından oluşturulmuştur. Tablo 3. 1932-1939 döneminin her yılı için kurulan yeni müessese adedi III

Yıl	Ebniye inşaatı sanayii		Sanayii kimyeviye		Sanayii muhtelif ve gayri muayyene		Sanayii muhtelif ve gayri muayyene	
	1	2	1	2	1	2	1	2
1932	2	4	8	8	3	3	4	6
1933	2	3	3	3	3	5	2	4
1934	0	2	4	4	0	4	4	12
1935	1	3	3	4	1	2	6	10
1936	2	2	1	1	3	4	8	11
1937	3	3	2	2	2	5	10	14
1938	0	1	1	2	2	2	9	13
1939	0	0	1	1	3	3	15	15

Kaynak: Yazar tarafından oluşturulmuştur.

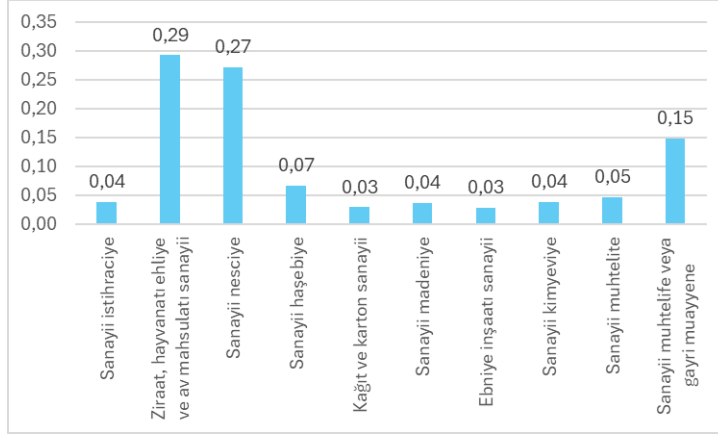
Şekil 5 ve Şekil 6'da bir sanayi kolunda söz konusu dönemde her yıl için kurulan yeni müesseselerin o yıl içindeki toplam yeni müessese içindeki payına ilişkin dönem ortalaması gösterilmiştir. Şekil 5 ilk yöntem kullanılarak oluşturulmuştur. Şekil 6 ise ikinci yöntem kullanılarak hesaplanmıştır. Buna göre, her iki şekilde de ilk sırada ziraat, hayvanatı ehliye ve av mahsulâtı sanayii vardır. Onu sanayii nesciye ve sanayii muhtelif ve gayri muayyene izlemiştir.

Şekil 5. 1932-1939 döneminin her yılı için kurulan yeni müessese oranı I (ortalama)



Kaynak: Yazar tarafından oluşturulmuştur.

Şekil 6. 1932-1939 döneminin her yılı için kurulan yeni müessese oranı II (ortalama)



Kaynak: Yazar tarafından oluşturulmuştur.

Tablo 4 ve Tablo 5'te Şekil 5 ve Şekil 6'ya kaynaklık eden bulgular gösterilmiştir. Tablo 4 ve Tablo 5'te yola çıkarak da yukarıdaki saptamalar tekrarlanabilir.

Son olarak, Tablo 7'de önceki çalışmalarımızın sonuçları yer almaktadır. Tablo 7 incelendiğinde dönemin öne çıkan sanayi kolları ziraat, hayvanatı ehliye ve av mahsulâtı sanayii, sanayii nesciye ve sanayii istihraciyedir.

Tablo 4. 1932-1939 döneminin her yılı için kurulan yeni müessese oranı I

Yıl	Sanayii istihraciye		Ziraat, hayvanatı ehliye ve av mahsulâtı sanayii		Sanayii nesciye	
	Oran	Oran	Oran	Oran	Oran	Oran
1932	0,0000	0,0183	0,2727	0,2752	0,3523	0,3394
1933	0,0213	0,0286	0,2979	0,2571	0,3191	0,3429
1934	0,0196	0,0385	0,3725	0,2821	0,3333	0,2821
1935	0,0233	0,0606	0,3023	0,2576	0,3256	0,2879
1936	0,0189	0,0506	0,3585	0,3671	0,2830	0,1899
1937	0,0536	0,0385	0,3036	0,2821	0,1964	0,2564
1938	0,0208	0,0571	0,4375	0,3000	0,2292	0,3000
1939	0,0179	0,0179	0,3214	0,3214	0,1786	0,1786

Kaynak: Yazar tarafından oluşturulmuştur.

Tablo 5. 1932-1939 döneminin her yılı için kurulan yeni müessese oranı II

Yıl	Sanayii haşebiye		Kâğıt ve karton sanayii		Sanayii madeniye	
	Oran	Oran	Oran	Oran	Oran	Oran
1932	0,0909	0,1009	0,0227	0,0183	0,0682	0,0550
1933	0,1064	0,0857	0,0000	0,0000	0,0426	0,0714
1934	0,0392	0,0385	0,0196	0,0385	0,0588	0,0385
1935	0,0465	0,0455	0,0000	0,0303	0,0465	0,0303

1936	0,0566	0,0886	0,0189	0,0633	0,0000	0,0127
1937	0,0536	0,0513	0,0357	0,0256	0,0536	0,0385
1938	0,0208	0,0143	0,0208	0,0429	0,0208	0,0286
1939	0,1071	0,1071	0,0179	0,0179	0,0179	0,0179

Kaynak: Yazar tarafından oluşturulmuştur.

Tablo 6. 1932-1939 döneminin her yılı için kurulan yeni müessese oranı III

	Ebniye inşaatı sanayii		Sanayii kimyeviye		Sanayii muhtelite		Sanayii muhtelif ve gayri muayyene	
	1932	0,0227	0,0367	0,0909	0,0734	0,0341	0,0275	0,0455
1933	0,0426	0,0429	0,0638	0,0429	0,0638	0,0714	0,0426	0,0571
1934	0,0000	0,0256	0,0784	0,0513	0,0000	0,0513	0,0784	0,1538
1935	0,0233	0,0455	0,0698	0,0606	0,0233	0,0303	0,1395	0,1515
1936	0,0377	0,0253	0,0189	0,0127	0,0566	0,0506	0,1509	0,1392
1937	0,0536	0,0385	0,0357	0,0256	0,0357	0,0641	0,1786	0,1795
1938	0,0000	0,0143	0,0208	0,0286	0,0417	0,0286	0,1875	0,1857
1939	0,0000	0,0000	0,0179	0,0179	0,0536	0,0536	0,2679	0,2679

Kaynak: Yazar tarafından oluşturulmuştur.

Tablo 7. İlgili sanayi kolunun tüm sanayi kollarının ortalama alternatif büyüklükler toplamı içindeki yüzde payı

Sıra	Sanayi kolu	İlgili sanayi kolunun tüm sanayi kollarının ortalama beygir gücü toplamı içindeki yüzde payı	İlgili sanayi kolunun tüm sanayi kollarının ortalama işgücü toplamı içindeki yüzde payı	İlgili sanayi kolunun tüm sanayi kollarının ortalama reel istihlal kıymeti toplamı içindeki yüzde payı	İlgili sanayi kolunun tüm sanayi kollarının ortalama yurtiçi katma değer toplamı içindeki yüzde payı	İlgili sanayi kolunun tüm sanayi kollarının ortalama katma değer toplamı içindeki yüzde payı	İlgili sanayi kolunun ortalama ithalata bağımlılık oranı	İlgili sanayi kolunun ithalata bağımlılık oranına ortalama katkısı
1	Ziraat, ehli hayvanlar ve av mahsulâtı sanayii	29,718	23,214	55,962	59,217	52,719	4,0647	2,292075
2	Sanayii istihraciye	21,276	22,063	8,420	8,473	14,410	0,0414	0,003279
3	Sanayii nesciye	15,080	28,977	15,871	13,928	13,688	17,1942	2,630601
4	Sanayii muhtelif ve gayri muayyene	9,850	2,114	1,935	6,476	4,041	4,7012	0,375222
5	Ebniye inşaatı sanayii	6,042	3,170	2,435	2,687	4,335	3,1081	0,075859
6	Sanayii haşebiye	5,737	5,539	2,429	2,835	2,879	6,2382	0,145331
7	Sanayii muhtelite	4,911	6,833	6,027	1,658	2,464	19,4176	0,297400
8	Sanayii madeniye	3,330	4,103	2,778	1,663	2,394	47,1732	1,349154
9	Kâğıt ve karton sanayii	3,311	2,654	1,858	1,193	1,829	40,5658	0,688497
10	Sanayii kimyeviye	0,744	1,332	2,285	1,871	1,242	13,0007	0,309571

Kaynak: Mert (2024) ve Mert (2025)'ten yararlanılarak oluşturulmuştur.

SONUÇ

Araştırma bulgularına göre, ilgili dönemde Türkiye sanayisi; sanayii istihraciye, ziraat, hayvanatı ehliye ve av mahsulâtı sanayii, sanayii nesciye, sanayii haşebiye, kâğıt ve karton sanayii, sanayii madeniye, ebniye inşaatı sanayii, sanayii kimyeviye, sanayii muhtelite ve muhtelif olmak üzere on ana koldan oluşmaktadır. Toplam müessese adedi içindeki payları açısından ziraat, hayvanatı ehliye ve av mahsulâtı sanayii ortalama % 44'lük payla ilk sırada yer alırken; bu sanayi kolunu % 23 ile sanayii nesciye ve % 6,5 ile sanayii haşebiye takip etmektedir. Ziraat, hayvanatı ehliye ve av mahsulâtı sanayii ve sanayii nesciye açısından elde edilen bulgular, önceki çalışmalarımız ile uyumludur. Ayrıca, 1932-1939 dönemindeki yeni müesseselerin ortalama yaklaşık % 61'i ziraat, hayvanatı ehliye ve av mahsulâtı sanayii ve

sanayii nesciyeye ilişkin müesseselerdir. Bir başka deyişle, yeni yatırımların yarısından fazlası da bu sanayi kollarına yapılmıştır.

Diğer taraftan, sanayii istihraciyenin müessese oranı düşük olmasına rağmen tüm sanayi kollarının ortalama beygir gücü toplamı, ortalama işgücü toplamı, ortalama reel istihsal kıymeti toplamı içindeki yüzde payı gibi büyüklüklerde yüksek oranlara sahip olması bu sanayi kolunun işletme başına büyüklükler açısından yüksek değerlere sahip olduğunu göstermektedir.

Müesseselerin tarihsel kökenleri incelendiğinde ise, 1932-1939 yılları arasında faal olan işletmelerin ortalama % 20'sinin 1923'ten önce, % 55'inin 1923-1931 arasındaki Cumhuriyet'in ilk döneminde, % 23'ünün ise 1932-1939 yılları arasında kurulduğu, % 2'sinin kuruluş tarihinin ise meçhul olduğu saptanmıştır. Özellikle kâğıt ve karton sanayii, % 50'lik bir oranla 1923 öncesi kurulan işletmelerin en yoğun olduğu sanayi kolu olarak dikkat çekmektedir. Bu sonuçlar, 1930'lu yıllardaki devletçi politikaların önceki dönemlerin birikimi üzerine inşa edildiğini ve dönemler arasında bir süreklilik olduğunu ortaya koymaktadır.

İlerleyen çalışmada mevcut çalışmamızın genişletilmesi hedeflenmektedir.

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GÖÇ KAVRAMI: GÖÇÜN EKONOMİK, MALİ VE SOSYAL ETKİLERİ

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ÖZET

Hem gelişmiş hem de az gelişmiş tüm ülkeleri kapsayan göç olgusu, insanlık tarihi kadar eskidir. Eğer göç ülke sınırları içinde gerçekleşiyorsa iç göç, diğer ülkelere doğru gerçekleşiyorsa dış göç olarak isimlendirilmektedir. Dünya genelinde milyonlarca insanın göç ettiği göz önüne alındığında, ülkelerin önde gelen gündem maddelerinden birisi olmuştur.

Literatürde birçok tanımı yapılan göç kavramının en genel tanımı şu şekildedir: Göç; birçok nedene bağlı olarak bir yerden başka bir yere yapılan kısa, orta veya uzun dönemli geriye dönüş veya sürekli yerleşim hedefi güden toplumsal, coğrafik ve kültürel bir yer değiştirme hareketidir. Milyonlarca insanın vatanlarını / yaşadıkları coğrafyaları farklı nedenlerle yasal veya yasadışı olmayan yollarla göç etmesi, göç olgusuna küresel bir özellik kazandırmaktadır. Bu göç olgusu ister gönüllü ister zorlama ister sınırlar aşılmsın ister aynı sınırlar içinde gerçekleşsin hem sosyolojik hem ekonomik hem de siyasal pek çok sorunun ortaya çıkmasına neden olmaktadır.

Göç üzerinde etkili olan başlıca sosyo-ekonomik unsurlar; yoksulluk, işsizlik, eğitim, kişi başına gelir, nüfus artış hızıdır.

Uluslararası göçler, göç eden ve göç alan ülkeler olmak üzere birçok tarafı etkilemektedir. Göçlerin ekonomik etkileri sadece işsizlik oranları ve işgücü arzı üzerinden değerlendirilemez. Göçler; ülkelerde mali sürdürülebilirlik, kamu maliyesi, bütçe, sosyal güvenlik sistemleri de olmak üzere birçok yönden etki meydana getirmektedir. Göçün kamu maliyesi üzerindeki etkileri; kısa dönemde barınma, eğitim, sağlık, sosyal yardım gibi alanlarda harcamaları artırarak kamu giderlerinde artışa yol açmasıdır. Uzun dönemde ise, göçmenlerin istihdama katkısı, tüketim artışı, girişimcilik faaliyetleri ve vergi gelirlerinde genişleme yoluyla kamu maliyesine yapmış olduğu pozitif etkidir. Ayrıca, uzun dönemde üretim ve tüketimden kaynaklanan vergi tabanı genişlemektedir. Bu çalışmanın amacı, göçlerin başlıca ekonomik, mali ve sosyal etkilerini incelemektir.

Anahtar Kelimeler: Uluslararası göçler, yoksulluk, kişi başına gelir, istihdam.

THE CONCEPT OF MIGRATION: THE ECONOMIC, FINANCIAL, AND SOCIAL IMPACTS OF MIGRATION

ABSTRACT

The phenomenon of migration, which encompasses both developed and developing countries, is as old as human history itself. If migration occurs within a country's borders, it is referred to as internal migration; if it occurs toward other countries, it is referred to as external migration. Given that millions of people migrate worldwide, it has become one of the top items on the agenda for countries.

While the concept of migration has been defined in various ways in the literature, its most general definition is as follows: Migration is a social, geographical, and cultural movement involving a change of location from one place to another, driven by various reasons, with the aim of either a short-, medium-, or long-term return or permanent settlement. The fact that millions of people migrate from their homelands or regions of residence for various reasons, through both legal and illegal means, gives the phenomenon of migration a global character. This migration phenomenon—whether voluntary or forced, whether across borders or within the same borders—gives rise to numerous sociological, economic, and political issues.

The primary socio-economic factors influencing migration include poverty, unemployment, education, per capita income, and population growth rate.

International migration affects many parties, including both sending and receiving countries. The economic impacts of migration cannot be assessed solely in terms of unemployment rates and labor supply. Migration has effects in many areas, including fiscal sustainability, public finance, the budget, and social security systems. The effects of migration on public finance include, in the short term, an increase in public expenditures due to higher spending in areas such as housing, education, health, and social assistance. In the long term, however, migration has a positive impact on public finance through migrants' contributions to employment, increased consumption, entrepreneurial activities, and expanded tax revenues. Additionally, the tax base expands in the long term due to increased production and consumption. The aim of this study is to examine the primary economic, financial and social impacts of migration.

Keywords: International migration, poverty, per capita income, employment.

EVALUATION OF THE STRUCTURAL PERFORMANCE OF THE HISTORICAL MASONRY MINARET OF THE MOLLA ÇELEBİ MOSQUE IN ISTANBUL, TURKEY

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ABSTRACT

This study focuses on the seismic assessment and strengthening of the masonry minaret of the Molla Celebi Mosque. The dynamic characteristics of the minaret were determined experimentally through Operational Modal Analysis (OMA), using ambient vibration testing (free vibration response under natural excitation) and forced vibration testing (controlled excitation to increase response levels) conducted in real-time on-site. Acceleration-time records were transformed into the frequency domain by Fast Fourier Transform (FFT) to obtain the frequency-Fourier amplitude spectrum; here, the first prominent peak at the lowest frequency was interpreted as the dominant (fundamental) frequency. A three-dimensional finite element model was created in SAP2000, and the model was calibrated by updating the modulus of elasticity through trial-and-error until the numerical frequency matched the measured dominant frequency. While a typical modulus of elasticity for stone masonry is approximately 8500 MPa, the calibrated value was found to be 2120 MPa, indicating a significant stiffness degradation. Based on the calibrated model, three strengthening alternatives (FRP, TRM, and steel mesh jacketing) were implemented, and the resulting displacement demands were compared with the performance regions given in the General Directorate of Foundations (VGM) guidelines to support the selection of an effective and heritage-compatible strengthening solution.

Keywords: Minaret, Operational Modal Analysis, Finite Element Model, Strengthening, Molla Celebi Mosque

1. INTRODUCTION

Historic masonry minarets are slender structures that are highly sensitive to lateral effects such as wind and earthquakes (**Doğangün et al., 2008; Ural et al., 2012**). Their seismic performance depends heavily on their geometry, boundary conditions, and the mechanical properties of the masonry, which can degrade over time due to environmental exposure or extreme events (**Livaoğlu & Doğangün, 2006**). In this project, the minaret of the Molla Celebi Mosque is considered, with a specific focus on structural assessment via Operational Modal Analysis (**Brincker & Ventura, 2015**) and subsequent strengthening following material degradation caused by fire.



FIGURE 1: The Masonry Minaret of Molla Celebi Mosque by Architect Sinan

Based on post-earthquake reconnaissance studies and existing literature (**Bayraktar et al., 2010**), the reasons for the collapse of masonry minarets under seismic loads can primarily be attributed to the following:

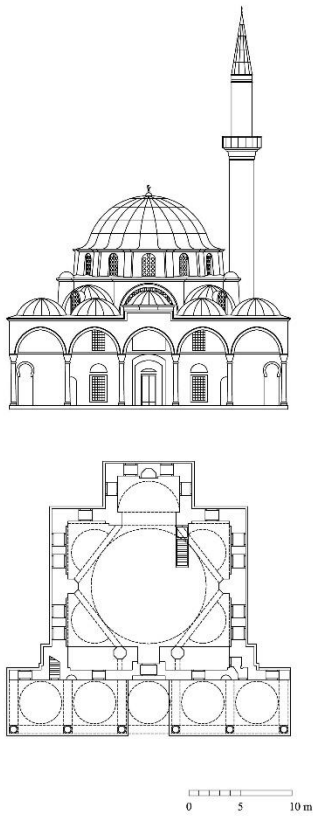
High Slenderness and Dynamic Sensitivity: Due to their geometry, they are extremely sensitive to lateral loads, which govern their dynamic behavior (**Doğangün et al., 2008**).

Low Tensile Strength: The tensile strength of masonry units and mortar is very low; seismic oscillations lead to rapid crack propagation and a loss of global stability.

Material Degradation: As observed in the Molla Celebi example, extreme events such as fire weaken the structure significantly by reducing the Modulus of Elasticity of the material.

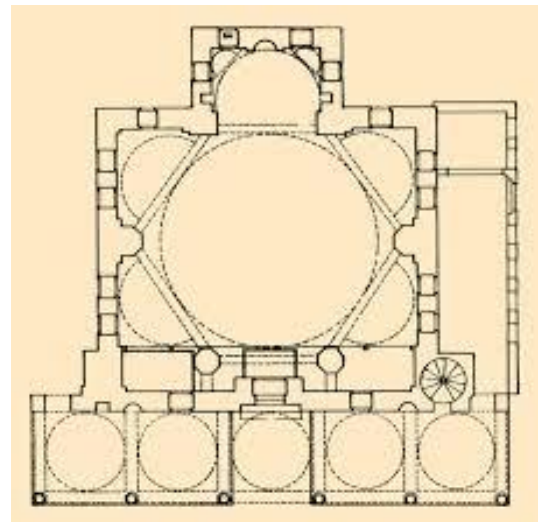
Regions of Discontinuity: Sudden geometric changes, such as the transition from the pedestal to the transition segment (boot), cause severe stress concentrations, making these areas highly vulnerable to shear and bending failures (Livaoglu & Dogangun, 2006).

FIGURE 2: CAD Drawings of the Molla Celebi
1986



Mosque (ARCHNET ARCHIVE)

FIGURE 3: Aptullah Kuran, Mimar Sinan,



2. MATERIAL AND METHODS

2.1. Operational Modal Analysis (OMA) and Field Tests

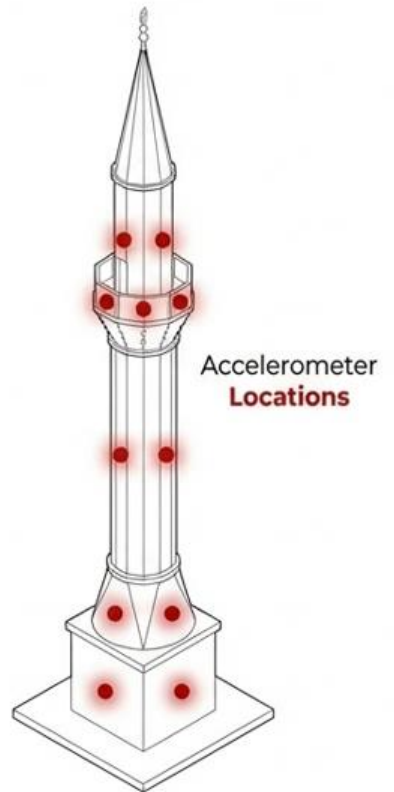


FIGURE 4: The Location of Accelerometers

Operational Modal Analysis (OMA) aims to determine modal parameters (natural frequencies, mode shapes, and damping) from structural responses measured under operational conditions. The vibration response was measured on-site using accelerometers, and two complementary types of tests were performed: Ambient Vibration Test (AVT) and Forced Vibration Test (FVT).

2.2 Acceleration-Time Records and FFT Processing

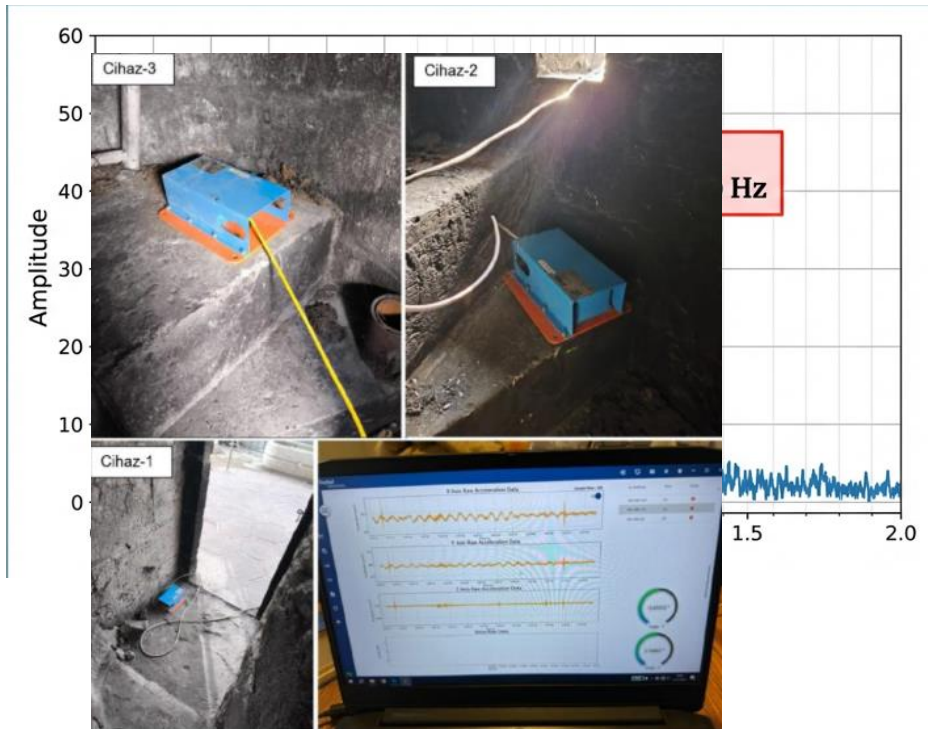


FIGURE 5: The Graph of The Amplitude vs Frequency

FIGURE 6 : The Record of Vibrations

Both tests produced acceleration-time records that were monitored in real-time on the field. The records in the time domain were converted to the frequency domain using the Fast Fourier Transform (FFT). In the resulting spectrum, the first prominent peak at the lowest frequency was taken as the dominant (fundamental) frequency of the minaret.

2.3. SAP2000 Finite Element Model and Calibration

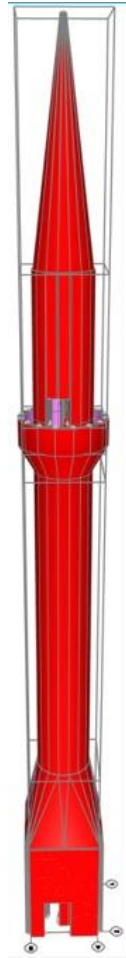


FIGURE 7 : The model on SAP2000 for Masonry Minaret

The three-dimensional finite element model of the minaret was developed in the SAP2000 software. The calibration process was carried out by updating the masonry modulus of elasticity (E) through trial-and-error until the numerical dominant frequency matched the experimentally determined dominant frequency.

2.4. Strengthening Alternatives

Three different strengthening alternatives (FRP wrapping, TRM, and Steel Mesh jacketing) were modeled on the calibrated model. The alternatives were defined through equivalent stiffness/material property modifications in accordance with the adopted modeling assumptions.

3. RESULTS AND DISCUSSION

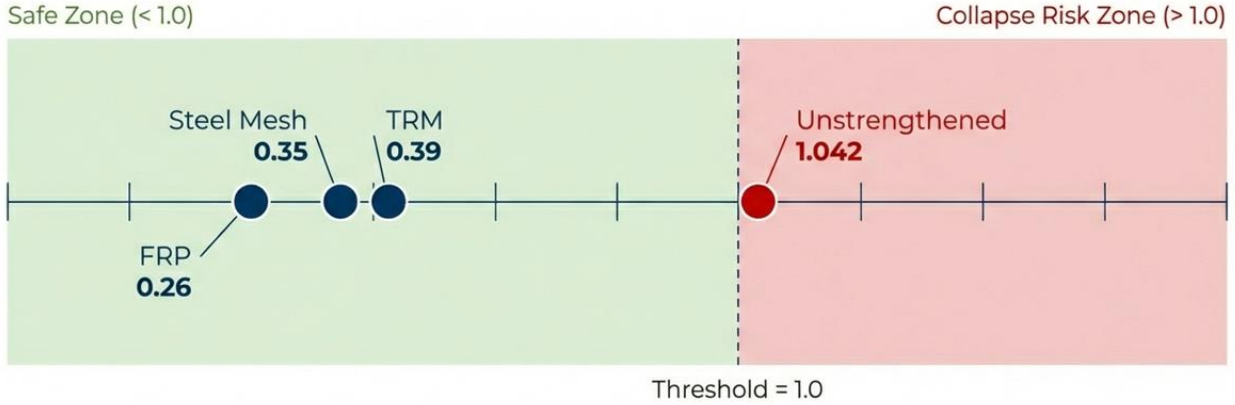


FIGURE 8: The Ratio of The Displacement Analysis Results

3.1. Frequency and Modulus of Elasticity Calibration

While the typical modulus value for stone masonry is approximately 8500 MPa, the calibrated value after measurements was obtained as $E=2120$ MPa, indicating a significant stiffness degradation post-fire. The relevant findings are presented in Table 1.

Table 1. Frequency values

Item	Testlerden (OMA/FFT)	Kalibre Edilen FE Modeli
Dominant frequency, f_1 (Hz)	X: 0.469, Y: 0.453	X: 0.058, Y: 0.050
Elastic Modulus, E (MPa)	8500 MPa	2120 MPa

3.2. Displacement Demands and Performance Evaluation

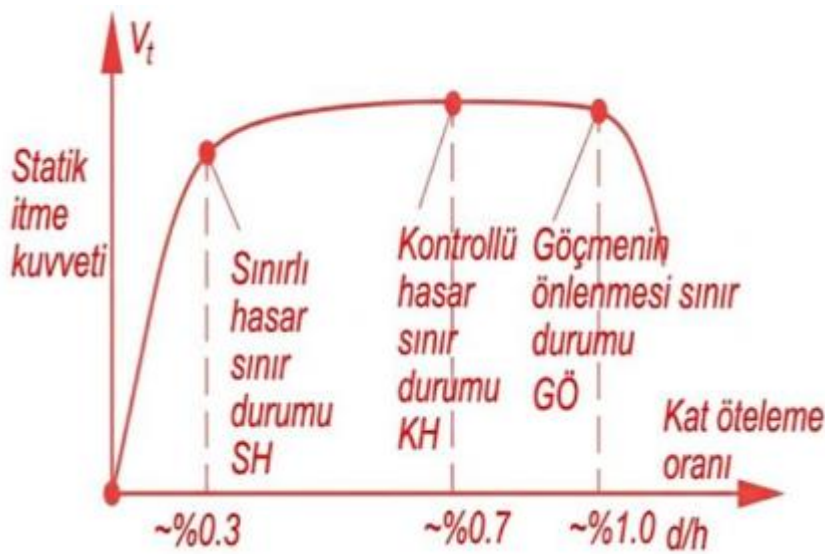


FIGURE 9: Seismic performance levels and force-displacement curve according to VGM Guidelines (2017)

The maximum displacement values obtained from the analyses for the unstrengthened and strengthened cases were compared with the performance limits specified in the VGM guidelines (Table 2). The strengthening interventions significantly reduced the lateral displacement of the structure in all scenarios, bringing them within safe limits.

Table 2. The maximum displacement values and performance limits

Case	Maximum Displacement (cm)	VGM Region Rate (%)
Not Strengthening	41.69 cm	1.042
FRP Strengthening	10.49 cm	0.26
TRM Strengthening	15.55 cm	0.39
Steel Mesh Strengthening	13.91 cm	0.35

Maximum Displacement / Total Height × 100

Not reinforced:

$$41.69 \text{ cm} / 4000 \text{ cm} \times 100 = 1.042$$

FRP reinforcement:

$$10.49 \text{ cm} / 4000 \text{ cm} \times 100 = 0.26$$

TRM reinforcement:

$$15.55 \text{ cm} / 4000 \text{ cm} \times 100 = 0.39$$

STEEL reinforcement:

$$13.91 \text{ cm} / 4000 \text{ cm} \times 100 = 0.35$$

4. CONCLUSIONS

In-situ Operational Modal Analysis (OMA) tests, including both Ambient Vibration Testing (AVT) and Forced Vibration Testing (FVT), were conducted to accurately capture the dynamic characteristics of the minaret under real field conditions. These experimental measurements were complemented by advanced signal processing techniques, particularly the application of Fast Fourier Transform (FFT), which enabled the precise identification of the dominant (fundamental) frequency of the structure. The experimentally obtained dynamic parameters were then used as a benchmark for calibrating the numerical model developed in SAP2000, ensuring that the analytical model closely represents the actual structural behavior.

During the calibration process, particular attention was given to the mechanical properties of the masonry material, especially the modulus of elasticity, which plays a critical role in

governing the global stiffness and dynamic response of the structure. By iteratively updating the modulus of elasticity within the finite element model, a calibrated value of approximately 2120 MPa was obtained. This value is significantly lower than the typical modulus of elasticity for intact stone masonry, which is generally around 8500 MPa. The substantial reduction in stiffness is indicative of severe material degradation, most likely resulting from fire exposure, which can lead to microcracking, loss of bonding within the mortar, and deterioration of the stone-mortar interface. This degradation not only affects the stiffness but also has critical implications for the load-carrying capacity and seismic performance of the structure.

Following the successful calibration of the numerical model, a series of strengthening strategies were investigated to enhance the structural performance of the minaret. Three different intervention techniques were considered: Fiber Reinforced Polymer (FRP) wrapping, Textile Reinforced Mortar (TRM) application, and steel mesh reinforcement. Each of these methods offers distinct advantages in terms of stiffness enhancement, ductility improvement, constructability, and compatibility with existing masonry materials. The effectiveness of these strengthening techniques was evaluated by implementing them within the calibrated finite element model and analyzing the resulting structural response under seismic loading conditions. Displacement demands and overall structural performance were assessed in accordance with the relevant provisions of the VGM (General Directorate of Foundations) guidelines, which are commonly applied for the evaluation and restoration of historical masonry structures. The results demonstrated that all three strengthening alternatives contributed to a significant reduction in lateral displacements and improved the overall seismic performance of the structure, with varying degrees of effectiveness depending on the technique used.

In addition to the technical evaluation, the proposed strengthening interventions were also assessed from a broader engineering perspective, considering economic feasibility, environmental impact, and compliance with social and legal requirements. Cost-effectiveness was evaluated in terms of material and application costs, while environmental compatibility was considered by examining the sustainability and reversibility of the intervention methods. Furthermore, the proposed solutions were designed to ensure public safety by significantly enhancing the structural reliability of the minaret under potential seismic events.

Overall, the integration of experimental testing, numerical modeling, and performance-based evaluation provides a comprehensive framework for the assessment and strengthening of fire-damaged masonry structures. The study highlights the importance of model calibration using real field data and demonstrates how different strengthening techniques can be systematically

compared to achieve optimal structural performance while satisfying practical and regulatory constraints.

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BIO-COMPUTATIONAL DESIGN INTEGRATION MODEL (BCDIM): TOWARDS A GENERATIVE FRAMEWORK FOR THE INTEGRATION OF ARTIFICIAL INTELLIGENCE AND BIOMIMICRY IN ARCHITECTURE

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Abstract

This study examines the need to connect environmental performance and computational design within current architectural practice. Biomimicry draws on principles found in biological systems, while artificial intelligence (AI) enables data-driven design processes; yet the two have rarely been brought together in a structured way. This research aims to develop a working framework for translating biomimetic principles into architectural design using AI-based tools. A qualitative approach was followed, grounded in a systematic, thematic, and comparative review of existing literature. Peer-reviewed sources in biomimicry, artificial intelligence, and computational design were examined, with attention paid to where these fields overlap, where they diverge, and what design strategies might transfer between them.

The review makes clear that there is no established method for translating biological principles into computational workflows, a gap that persists across the literature. In response to this, the Bio-Computational Design Integration Model (BCDIM) is proposed here as a theoretical and practical framework, organized around three stages: biological observation, principal abstraction, and AI-driven design generation.

This study offers a structured, reproducible model for incorporating biomimicry into AI-supported architectural design, one that may prove useful wherever performance-driven or environmentally responsive architecture is the goal.

Keywords: Artificial intelligence, biomimicry, generative design, bio-computational integration (BCDIM), reverse design, adaptive envelopes, topological optimization.

1. Introduction

Architectural practice today faces two demands that are difficult to separate: reducing the environmental burden of the built environment and making genuine use of the computational tools now available to designers. These challenges have generally been treated in isolation, leading to fragmented approaches that struggle to respond to complex environmental conditions

(Das et al., 2024; Manmatharasana et al., 2025). The consequence is a body of work that is technically sophisticated but ecologically shallow.

Advances in artificial intelligence and computational design have widened the capacity to process large amounts of data and to explore many design alternatives simultaneously (Li et al., 2025; Rodríguez Melchor et al., 2025). Even so, these tools tend to be used without a strong ecological grounding; they are applied to optimize specific parameters rather than engage with environmental systems in a deeper sense. Efficiency is pursued, but coherence is not always achieved.

Alongside this, biomimicry has grown as a design approach that draws on the functional behavior of biological systems rather than their appearance (Flórez-González et al., 2024; Metwally, 2025). The logic here is straightforward: organisms have been refined over long periods to perform well under specific conditions, and those principles can, at least in theory, be transferred to built form. In practice, though, biomimicry has remained largely conceptual, with little connection to the computational workflows that now define architectural production. A few exceptions exist, such as work on microbial membranes for building envelopes (Abdallah & Estevez, 2025), but these remain isolated.

The gap, then, is not a lack of knowledge on either side; it is the absence of a method that connects the two. How biological principles might be systematically fed into AI-driven design processes is a question the existing literature does not adequately answer.

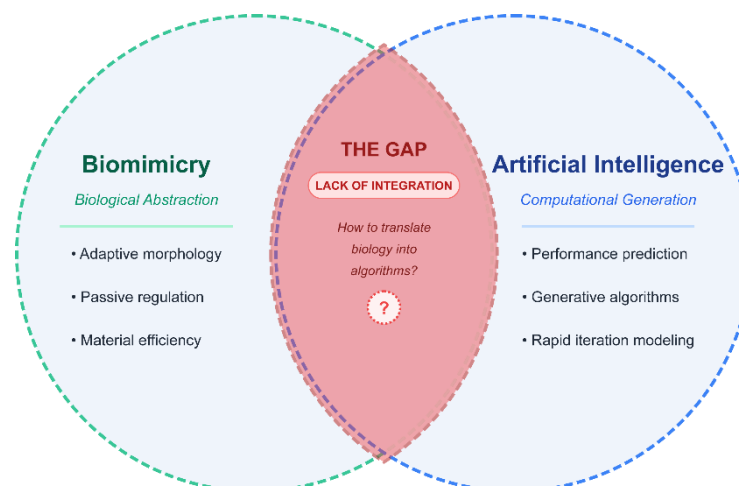


Figure 1. Intersection of biomimicry and artificial intelligence in architectural design. The diagram illustrates the current methodological gap between biological research and computational generative processes.

This study sets out to address that gap by proposing a framework that treats biomimicry and

artificial intelligence as complementary rather than parallel. Two questions guide the work: How can AI support the translation of biomimetic principles into architectural design? Moreover, which dimensions of environmental and structural performance stand to benefit most from that integration?

2. Methodology

This research follows a qualitative approach, grounded in a systematic, thematic, and comparative review of the literature. The goal is to examine where biomimicry and artificial intelligence meet in architectural design and to identify how that intersection can be formalized into a workable method.

The work was carried out in three stages.

In the first stage, a selection of peer-reviewed sources was assembled. Three areas were covered: artificial intelligence in architecture (Memon et al., 2025; Talebian et al., 2025), computational and generative design, and biomimicry understood in terms of functional principles rather than formal resemblance (Llorens Vargas & Hernandis Ortuño, 2023). Sources were chosen for their relevance to performance-driven design and their engagement with biological principles in a built context. The decision to exclude empirical testing at this stage was deliberate; the aim was first to establish whether a coherent conceptual foundation exists before any applied work could be meaningfully designed.

In the second stage, a thematic analysis was conducted across the selected sources. Recurring concepts were identified, among them biological abstraction, generative algorithms, reverse design, adaptive systems, and performance simulation (Liu et al., 2026; Mirwais et al., 2025; Yang, 2025), and were used to organize the analysis and map relationships across different bodies of work. The process was iterative: themes were refined as reading progressed, and some connections only became visible after multiple passes through the material.

A comparative analysis followed, aimed at understanding where biomimetic approaches and AI-based design processes align and where they diverge. This step was the most revealing; it is here that the specific methodological gap emerged most clearly: the absence of any established procedure for translating biological strategies into computational design frameworks.

In the third stage, the analysis findings were integrated into a single model, the Bio-Computational Design Integration Model (BCDIM). This model organizes the design process into three stages (biological observation, principle abstraction, and AI-driven generative application) and is intended as a foundation for future applied research rather than a finished instrument.

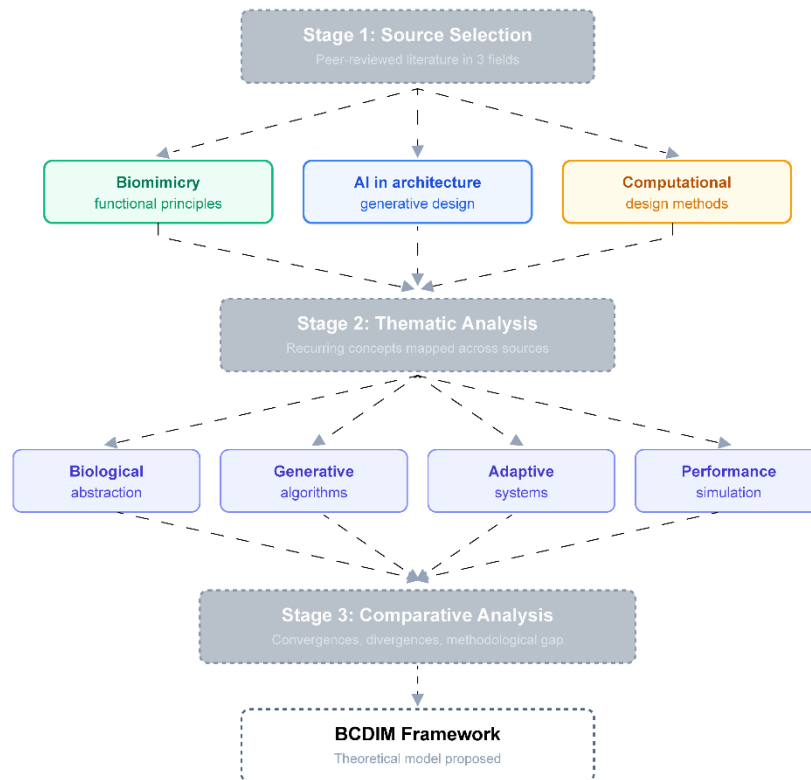


Figure 2. Methodological workflow of the research. The flowchart details the three-stage process: source selection, thematic and comparative analysis, and the synthesis of the Bio-Computational Design Integration Model (BCDIM).

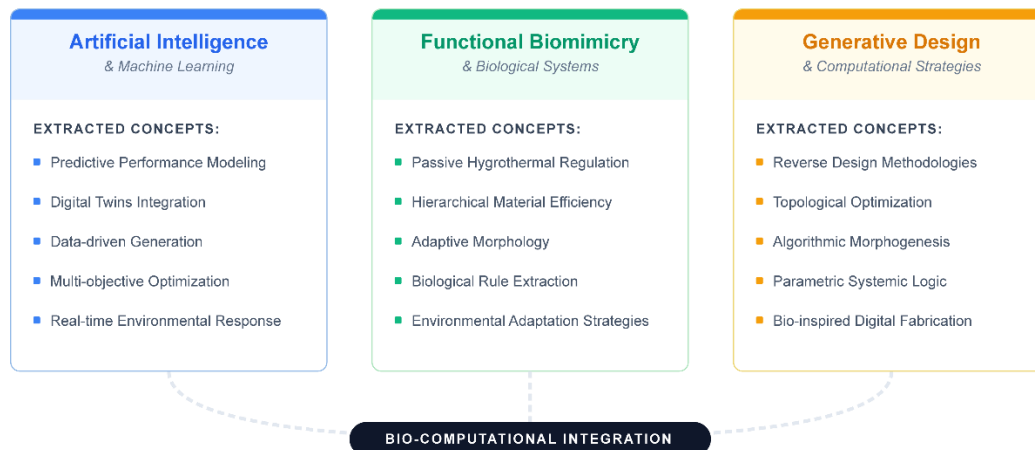


Figure 3. Thematic landscape of literature review. The diagram maps the key conceptual clusters and extracted themes across the core research domains, highlighting the theoretical foundation of the BCDIM framework.

It should be noted that this study is theoretical and exploratory. No empirical testing was conducted, and no claim is made that the framework has been validated in practice. What is offered here is a conceptual structure; one that, it is hoped, others will find useful for testing and extending.

3. Theoretical Background

3.1 Biomimetics in architecture: from visual imitation to functional efficiency

Biomimetics has been used for a long time in a narrower sense than it should. For much of the past decade, the dominant approach was visual: natural forms were taken and applied to facades or building elements because they looked interesting. This approach has a name in literature (biomorphosis), and its limitations are now fairly well understood. A roof designed to look like a leaf and a roof designed to function like a leaf are very different things, even if the distinction sounds minor at first (Flórez-González et al., 2024). The first is decoration; the second is engineering.

Table 1. Conceptual distinction between Biomorphosis and Functional Biomimicry.

Evaluation Criteria	Biomorphosis (Formal Imitation)	Functional Biomimicry (Performance-Oriented)
Starting Point & Focus	<i>Morphological imitation. Direct copying of natural shapes, proportions, or macroscopic textures.</i>	<i>Functional abstraction. Extraction of behavioral rules, material logic, and operative mechanics.</i>
Primary Objective	<i>Symbolic representation and aesthetic metaphor. Seeking visual affinity with nature.</i>	<i>Performance optimization and environmental adaptation. Solving specific architectural problems.</i>
System Dynamics	<i>Static application. Translates into fixed facades, structural shells, or decorative elements.</i>	<i>Dynamic responsiveness. Translates into adaptive envelopes and variable-density structures.</i>
Architectural Outcome	<i>"A building designed to look like an organism."</i>	<i>"A building designed to function like an organism."</i>

Source: Elaborated by the author based on Flórez-González et al., 2024.

When biological systems are studied for how they solve problems of climate adaptation and survival, those solutions can be grouped into categories: material, structure, form, and process (Llorens Vargas & Hernandis Ortuño, 2023). That classification matters because it is what turns biological inspiration from something arbitrary into something systematic. It makes it possible to position nature not as a catalog of shapes, but as a technological model; something that can be learned from methodically rather than mined for aesthetics (Metwally, 2025). Reading this literature, it becomes clear that the field has moved considerably, yet a great deal of what organisms do still lacks an architectural equivalent.

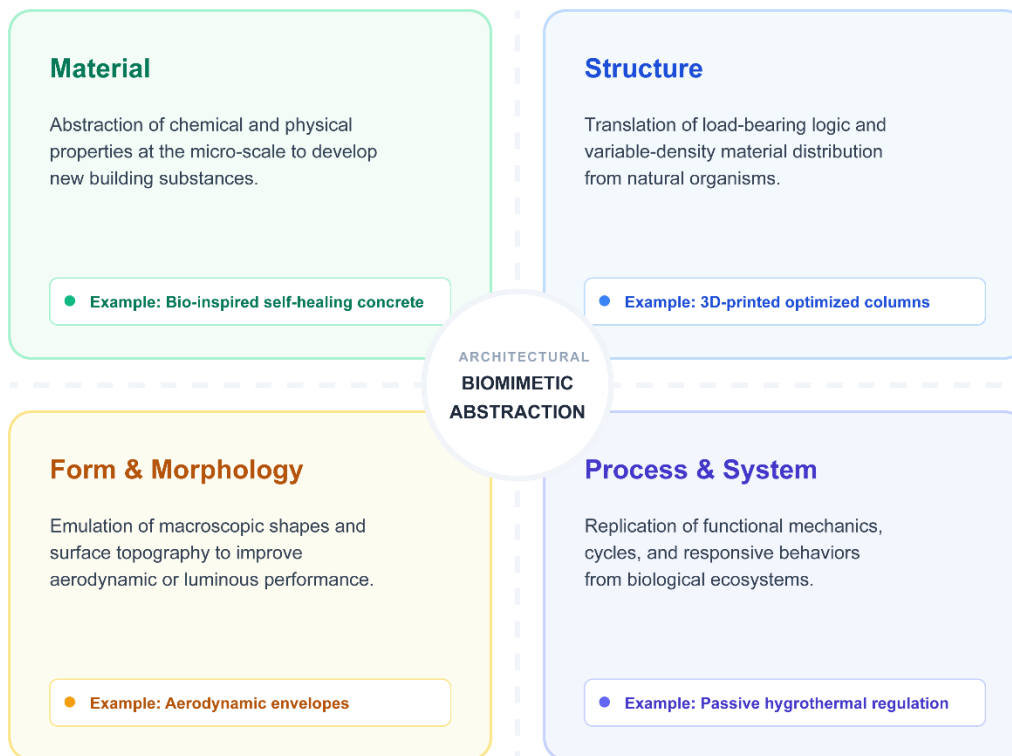


Figure 4. *Categorization of biomimetic design factors.* The diagram illustrates the classification of biological solutions into material, structural, formal, and procedural categories (adapted from Llorens Vargas & Hernandis Ortuño, 2023).

3.2 Artificial intelligence in architectural design: toward generative optimization

AI entered architectural practice through workflow automation. Being able to generate many design alternatives quickly in the early stages of a project was a real gain, both in time and in the range of options available to explore (Lu, 2024; Memon et al., 2025). That much is well established. What is less often discussed is what comes after: the capacity to predict how a building will actually perform before it is built. Machine learning models and digital twins have enabled the estimation of thermal, structural, and energy behavior with reasonable accuracy at early stages of design (Talebian et al., 2025). For designers, this changes which decisions can be made and when.

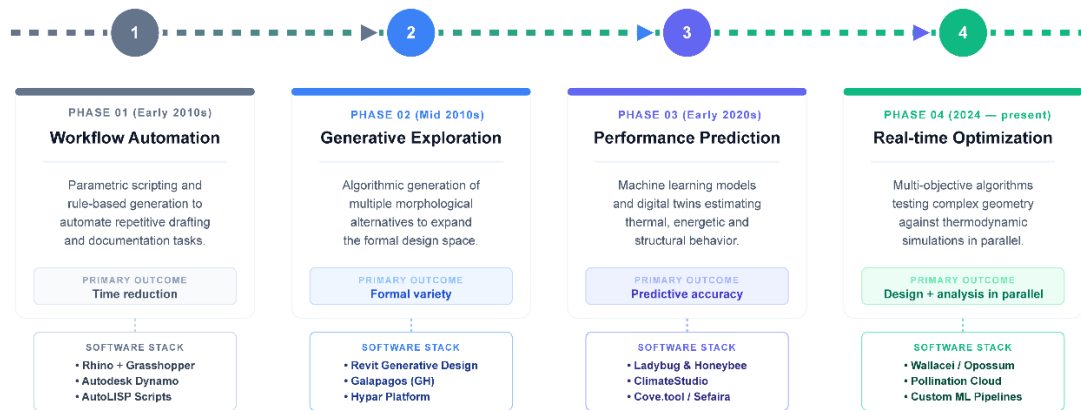


Figure 5. *Evolutionary trajectory of AI in architectural practice.* The timeline traces the shift from basic workflow automation to advanced generative optimization and real-time performance prediction.

Multi-objective optimization algorithms now allow design choices to be tested against performance simulations in parallel rather than sequentially (Das et al., 2024; Yang, 2025). Design and analysis are no longer two separate phases that happen one after the other. What that shift means for how architects are trained and how practice is organized is a question that has not received enough attention.

4. Integration of Artificial Intelligence and Biomimetics

Bringing AI and biomimicry together is not simply a matter of combining two useful tools. What changes is the underlying logic of the design process. Biomimicry identifies which biological principles might be transferable to architecture; AI provides the computational capacity to simulate, test, and develop those principles at a scale that manual methods cannot reach. Each depends on the other in a specific way: biomimicry without AI tends to stay conceptual, producing ideas that are difficult to implement; AI without biomimicry optimizes forms without any meaningful reference to how natural systems actually work.

4.1 Reverse design and bio-inspired materials

One of the clearest applications of this integration is in materials. Reverse design is a methodology that starts from a desired function and works backward to identify the material structure capable of producing it. In that process, AI functions as a search engine across a space of possibilities that would otherwise be too large to navigate (Liu et al., 2026). Biological systems provide the models: the hierarchical structure of bone, which combines strength and lightness with very little material; and the self-healing properties of certain organic tissues, which respond to damage without external input.

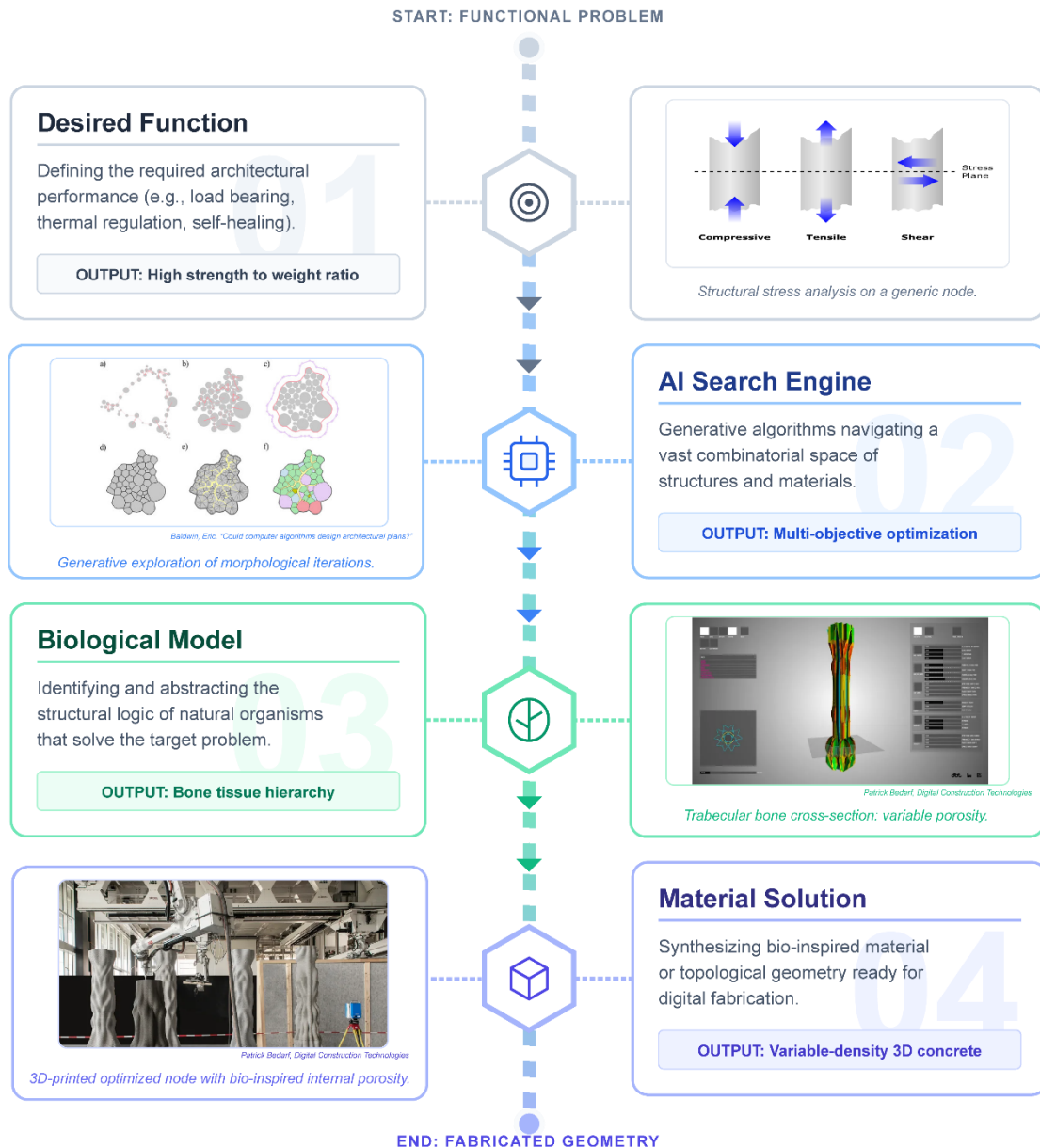


Figure 6. Reverse design methodology for bio-inspired materials. The diagram demonstrates the AI-driven search process mapping desired functional outputs to structural biological models. Source: Elaborated by the author based on Liu et al., 2026. Images adapted from ArchDaily (2020) and Digital Building Technologies (2019).

Mirwais et al. (2025) document advances in bio-inspired cements that incorporate principles of biological mineralization and are processed through generative algorithms to identify optimal mixtures for different climatic conditions. What matters about that work is not just the technical outcome but the method: AI does not replace the researcher who identifies the relevant biological model; it expands their capacity to explore and test variations of that model at a speed that changes the kinds of questions that can usefully be asked. That distinction (between replacing judgment and extending capability) tends to get lost in broader discussions about AI

in design.

4.2 Adaptive envelopes and biological skins

The building envelope is where the interaction between a building and its environment is most direct and continuous, which is why it is also where the integration of biomimicry and AI has the most immediate potential. The biological references here are genuinely striking. Cactus skin regulates temperature and captures moisture—the scales of certain fish control water flow with minimal resistance. The wings of the blue Morpho butterfly produce color not through pigment but through structures that manipulate light. None of these have straightforward equivalents in conventional construction, and most architects working on envelopes are not systematically drawing on them.

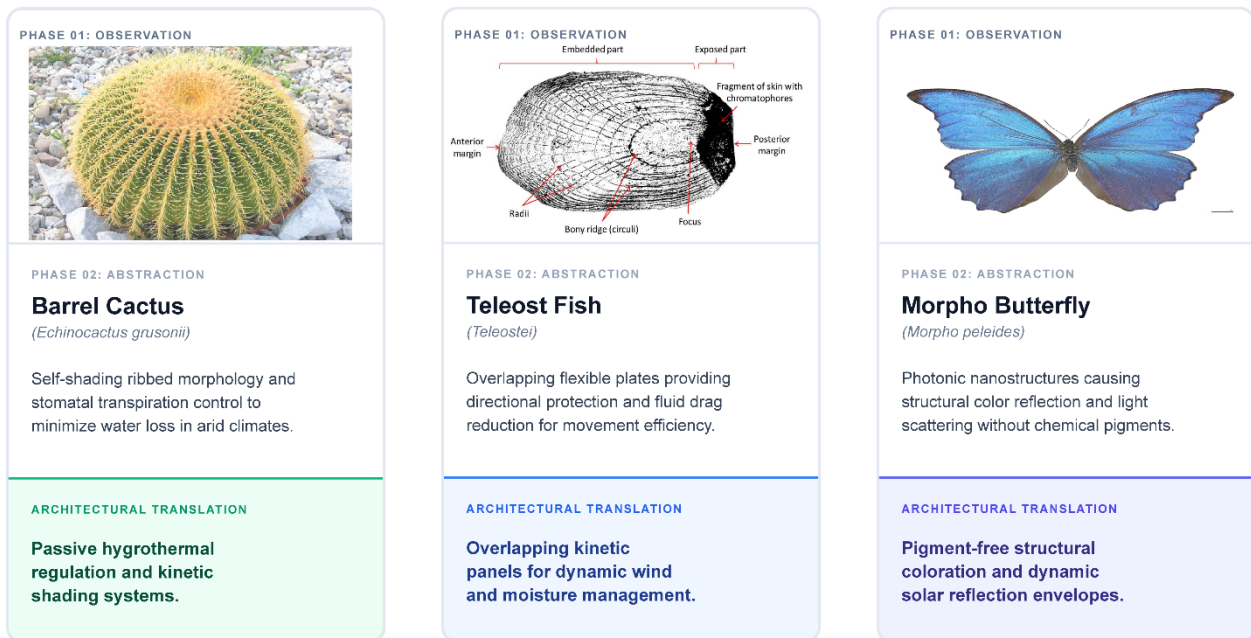


Figure 7. *Biological references for adaptive building envelopes.* Comparative visualization of natural systems (e.g., cactus skin, fish scales, Morpho butterfly wings) alongside their abstracted architectural principles. Source: Elaborated by the author, 2026. Images adapted from Graf (n.d.), Necropsy Manual (n.d.), and Wikipedia contributors (n.d.).

Abdallah and Estevez (2025) developed a bio-digital Mashrabiya system that incorporates living microbial membranes capable of filtering air particles and regulating interior humidity. What is relevant from a methodological standpoint is that the generative algorithms used not only designed the lattice geometry but also simulated the behavior of microbial colonies under different environmental conditions before the system was built. That sequence (biological observation, abstraction of the principle, computational simulation, verification of behavior) is the same sequence proposed by the model presented in this study. Seeing it instantiated in a

built project, even a prototype, makes the argument for the framework considerably more concrete.

AI is also being used to design envelopes that change geometry or material properties in response to real-time climate variables. Das et al. (2024) document machine learning systems that predict the thermal behavior of dynamic facades with approximately 94% accuracy, making this kind of analysis viable from the early stages of conceptual design. For architects, that means envelope decisions no longer need to be deferred to later technical phases; they can inform the shape of a project from the outset. That is a significant shift in when and how performance is considered.

4.3 Structural optimization through generative topological design

Natural structures solve load-bearing problems in ways that engineering took a long time to understand and replicate. Material is placed where it is needed and removed where it is not; that is the operating principle behind bird bones, leaf veins, and honeycomb structures. All of them achieve high efficiency with minimal material use. Applied to structural design, this principle, called topological optimization, produces results that look very different from those of conventional structural engineering.

Combined with 3D concrete printing (3DCP), generative topological optimization enables the fabrication of structural elements that conventional construction methods cannot produce (Mirwais et al., 2025). Yang (2025) documents material reductions of up to 40% in columns and beams designed through this approach, with no loss of load-bearing capacity. That figure is significant, but it is worth being specific about what it means: the algorithm optimizes within the parameters it is given. Someone must decide which biological model to use as a reference, under what load conditions, and which performance criteria matter most. The optimization is computational; the judgment about what to optimize is not.

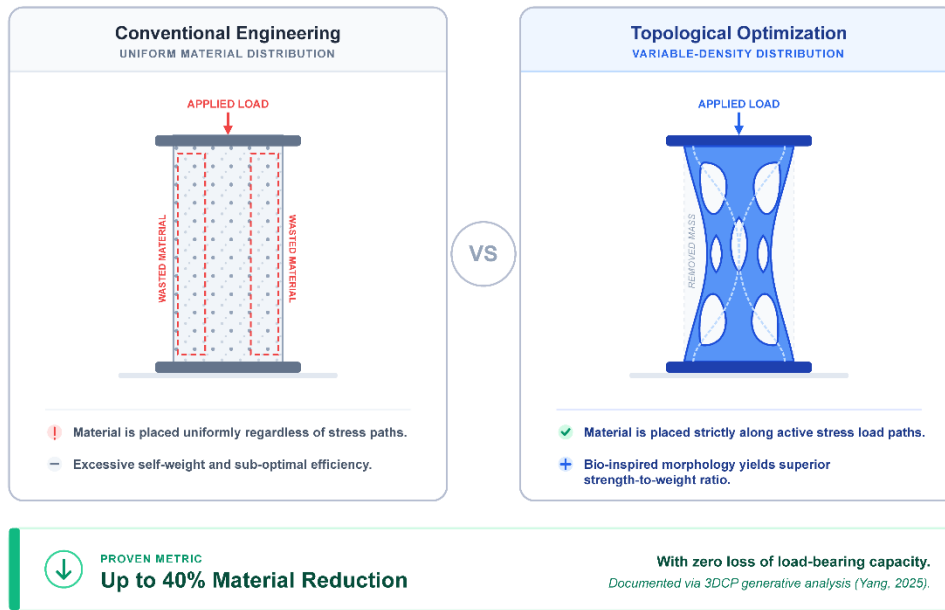


Figure 8. Impact of generative topological optimization on structural elements. The comparison highlights the material reduction achieved by transitioning from uniform to variable-density material distribution (data from Yang, 2025).

5. The Bio-Computational Design Integration Model (BCDIM)

Building on the analysis developed in the preceding sections, the Bio-Computational Design Integration Model (BCDIM) is proposed here as an iterative methodological framework for bringing biomimetic principles and artificial intelligence processes together in architectural design practice.

The model is not structured as a linear sequence of steps. Instead, it operates as a closed loop in which each phase informs the others: the biological reference can be revised, the computational parameters adjusted, and the performance criteria refined as results are obtained. That feedback structure is what makes the model iterative rather than procedural.

Four interdependent phases are identified:

- In the first phase, **biological observation**, natural organisms or ecosystems are studied for the adaptive strategies they use to solve problems comparable to those of a given project (thermal regulation, load distribution, moisture control, among others). The architect operates here as a researcher. Empirical data from functional biology are collected and assessed for their potential to be scaled to an architectural context (Llorens Vargas & Hernandis Ortuño, 2023). This is not a search for interesting shapes; it is a search for documented performance under specific environmental conditions.
- In the second phase, **functional abstraction**, the behavioral logic of the selected

biological reference is extracted, without reproducing its morphology. Form is separated from function (Flórez-González et al., 2024). What is carried forward is not the appearance of the organism but the operative principle behind its performance. The efficiency of bone tissue, for example, is not abstracted as a contour to be imitated; it is understood as a principle of variable-density material distribution in response to mechanical stress. That principle is then translated into a parametric, systemic logic that can be computationally encoded.

- In the third phase, **algorithmic generation**, the abstracted principle is introduced into computational design environments as a parametric rule. From that point, artificial intelligence and generative algorithms are used to explore the design space. Multiple morphological iterations are computed that would be impossible to generate manually (Das et al., 2024; Yang, 2025). What is significant about this phase is not the volume of alternatives produced, but the fact that all of them are constrained by a biologically derived performance principle rather than by formal preferences.
- In the fourth phase, **performance evaluation and feedback**, the generated iterations are subjected to thermodynamic, structural, or luminous stress simulations. Machine learning models and digital twins are used to evaluate results (Talebian et al., 2025), discard inefficient options, and feed findings back into the preceding phases so that generation parameters can be adjusted. When an acceptable level of performance is reached, the resulting geometry can be exported directly to digital fabrication or robotic manufacturing protocols (Mirwais et al., 2025). The fabrication dimension is not an afterthought; it is built into the evaluation criteria from the beginning.

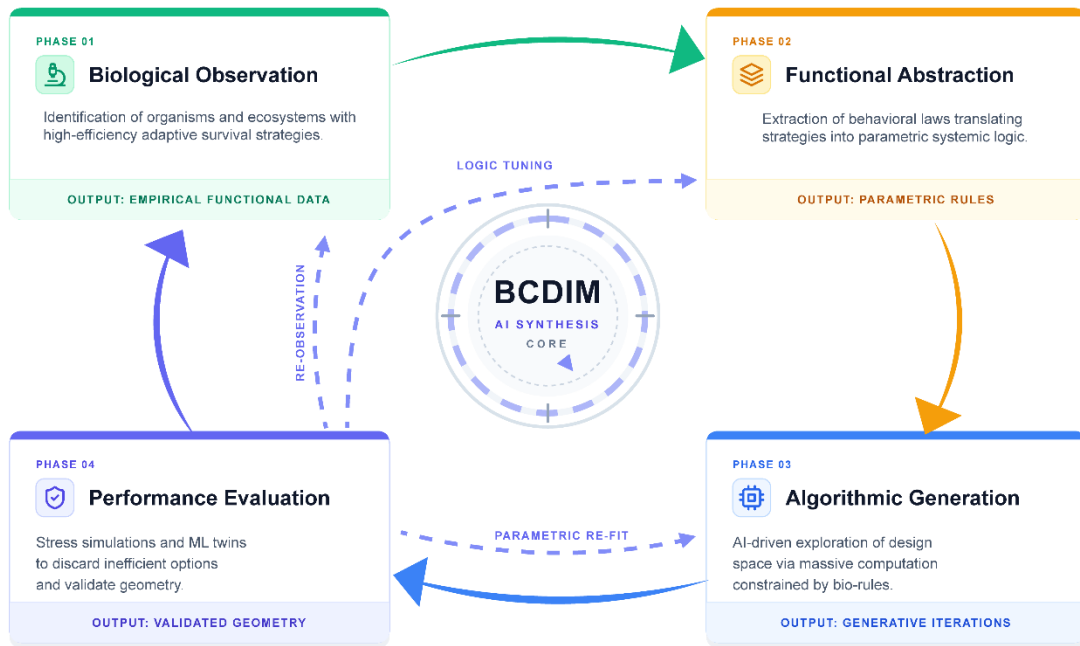


Figure 9. *The Bio-Computational Design Integration Model (BCDIM).* The iterative closed-loop framework illustrates the continuous feedback between biological observation, functional abstraction, algorithmic generation, and performance evaluation.

To illustrate how these phases operate together, consider the design of an adaptive facade inspired by cactus skin. In the biological observation phase, two documented properties are identified: the capacity to regulate surface temperature and to capture atmospheric moisture (Metwally, 2025; Varshabi et al., 2022). In the functional abstraction phase, these properties are translated into a passive hygrothermal regulation principle that does not depend on mechanical systems. In the algorithmic generation phase, multiple facade configurations are developed using generative algorithms that respond to climatic variables across different seasons and orientations. In the performance evaluation phase, thermal simulations are used to assess which configurations achieve the lowest energy consumption while maintaining interior comfort within acceptable ranges. The process does not produce a single correct answer; it produces a set of verified options among which a judgment-based selection can be made. That is precisely the point: the algorithm narrows the field; the architect still decides.

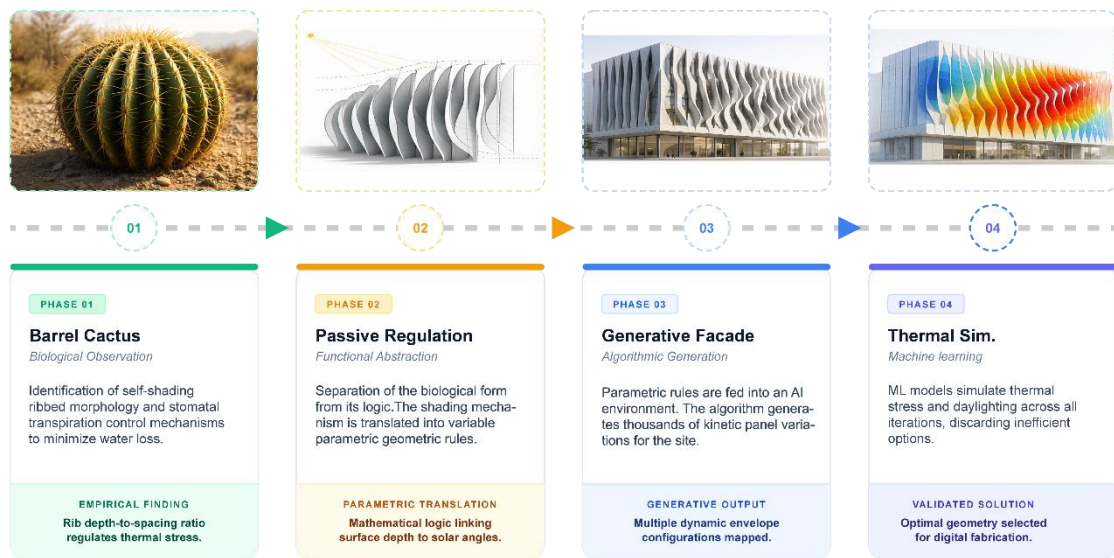


Figure 10. Application of the BCDIM framework. A step-by-step walkthrough demonstrating the translation of the hygrothermal regulatory properties of cactus skin into an AI-optimized adaptive facade.

6. Discussion

The BCDIM is proposed not as a conceptual contribution alone, but as an operational framework for structuring decision-making in complex design processes around biological, computational, and performance criteria simultaneously. The implications of the model extend to both design practice and architectural education, though they are accompanied by limitations that warrant careful examination.

6.1 Operational advantages and the shifting professional role

When performance data are available from the earliest stages of design, the margin of error in early decisions is reduced. That has consequences beyond efficiency. The type of question an architect can usefully ask changes: instead of developing two formal alternatives and testing which performs better afterward, it becomes possible to define an acceptable performance threshold first and let the algorithm identify which geometries reach it. The sequence of design reasoning is reversed, and with it the relationship between form and performance.

The professional role that follows this process is closer to that of a director of a complex system than to that of a drafter. Parameters are defined, results are evaluated, and judgment is applied when the algorithm produces solutions that are technically correct but contextually inadequate. Memon et al. (2025) document this shift in AECO sector design teams, where architects working with generative tools report spending more time defining criteria and less time producing geometry. That redistribution of intellectual labor is not straightforwardly a loss; if it is well managed, it can improve the quality of design decisions rather than diminish them.

Whether it is being well managed in practice is a different question, and one that the literature has not examined in sufficient depth.

6.2 Technical and constructive limitations

The reliability of the model's outputs depends directly on the quality of the data used to train and calibrate the evaluation algorithms. A machine learning model trained on data from buildings in temperate climates may produce considerably inaccurate predictions when applied to arid or tropical contexts. That is not a minor calibration problem; it is the kind of error that can affect a building's performance throughout its operational life. In language models, analogous failures are called hallucinations. In predictive energy performance models, the equivalent phenomenon has more concrete and lasting consequences, though it receives less attention in the literature.

The gap between the digital model and the built object remains a separate and largely unresolved problem. Geometries that topological optimization algorithms can generate are often difficult to fabricate with available means, even where 3D concrete printing is accessible. Material variability, drying times, and construction tolerances introduce complexities that computational models tend to simplify or set aside (Mirwais et al., 2025). That gap is not closed by more sophisticated software. It requires closer integration between design and fabrication teams from early project phases, which in most practice contexts does not yet happen as a matter of course.

6.3 Open ethical and professional questions

There are questions this study cannot resolve, but that would be irresponsible to leave unmentioned.

The first concerns authorship. When an architectural solution is produced by an algorithm operating within parameters defined by an architect, the question of who owns the design has no settled answer, either legally or philosophically. That ambiguity is unlikely to be resolved quickly, and the profession has been slow to engage with it.

The second concerns bias. AI models learn from the data made available to them, and the data available in architecture reflects decades of production concentrated in particular climates, economies, building types, and cultural contexts. An algorithm trained on that body of work will tend to reproduce those concentrations rather than correct for them. The outputs may be optimized relative to the training data while remaining poorly suited to the contexts where they are actually applied.

The third question is perhaps the most uncomfortable for the profession: what happens to

judgment when design decisions are progressively delegated to the algorithm? The position taken in this study is that judgment does not disappear; rather, it shifts toward defining parameters and evaluating results. That shift, however, requires a different kind of formation than most architecture programs currently offer. How architects are taught to work with these tools, and what they are taught to remain responsible for, is a question that professional education has not yet answered in any consistent way.

7. Conclusion

This study began with an observation that the reviewed literature consistently confirmed: biomimicry and artificial intelligence have each advanced considerably, but without a consolidated method connecting them. That disconnection is not only an academic problem. It has direct consequences for the ability to bring the efficiency of natural systems into architectural practice.

The answer to the first research question is as follows. AI supports the translation of biomimetic principles into architectural design because it operates precisely where biomimicry has always encountered its greatest difficulty: the complexity of simulating, optimizing, and materializing functional principles that biological systems execute through processes no human designer could replicate by hand. In that sense, AI does not replace the architect. What it does is expand the architect's capacity to work with the kind of complexity that living systems involve.

On the second question, the performance dimensions that stand to benefit most from this integration are those related to the adaptive envelope (thermal regulation, solar control, air filtration) and those linked to structural material efficiency. These are also the dimensions with the greatest impact on the environmental life cycle of buildings, making the proposed approach not only technically relevant but also strategically important for architecture that aims to operate at net-zero emissions. That connection between technical method and environmental outcomes is worth stating clearly, because it is not always made explicit in the literature on computational design.

The BCDIM proposed here is not a fixed procedure. It is a methodological framework that attempts to clarify where each component of the process intervenes and, more importantly, where human judgment remains irreplaceable. Biology provides the principles; the architect determines which are relevant to a given context; the algorithm explores and simulates. Without that distinction, there is a real risk of confusing the sophisticated use of computational tools with the genuine practice of performance-oriented biomimicry. The two are not the same thing, and treating them as equivalent does not serve the field.

Several questions remain unanswered that this study could not resolve. How much of the model can be validated in built cases? How do the selected biological principles transfer across different climatic and cultural contexts? How should architecture education respond to the shift in professional role that this approach implies? These are not loose ends; they are the directions the research needs to take next. The fact that they remain unanswered is not a weakness of the framework; it is precisely what makes it a starting point rather than a conclusion.

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SAFRANBOLU GLİSTELİ KONUTLARI

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ÖZET

Bu çalışma, Safranbolu geleneksel konutlarında yaygın olarak görülen ancak mevcut literatürde sınırlı biçimde ele alınan “gliste” yapı elemanının tanımlanması ve mimari bağlamda değerlendirilmesini amaçlamaktadır. Geleneksel Türk konut mimarisi üzerine yapılan çalışmaların büyük ölçüde plan tipolojileri ve yapım sistemleri üzerine yoğunlaştığı; buna karşın gliste sistemi gibi özgün yapı bileşenlerinin yeterince incelenmediği görülmektedir. Bu durum, söz konusu elemanın mimari ve kültürel önemine rağmen literatürde yeterli görünürlük kazanamadığını ortaya koymaktadır. Ayrıca, geleneksel konutların değerlendirilmesinde yapı elemanları ölçeğinde yapılan çalışmaların sınırlı olması, bu tür özgün sistemlerin bütüncül bir yaklaşımla ele alınmasını zorlaştırmaktadır. Bu bağlamda çalışma, gliste sisteminin mekânsal konumu, yapım özellikleri ve işlevsel niteliklerini ortaya koymanın yanı sıra, saha gözlemleri ve yerel kullanıcı bilgileri doğrultusunda zaman içerisindeki kullanım değişimini de değerlendirmektedir. Araştırma yöntemi; literatür taraması, yerinde gözlem ve mimari rölyeve analizlerine dayanmaktadır. Bu süreçte farklı yapılardan elde edilen veriler incelenmiş ve sistemin kullanımına ilişkin benzerlikler ile farklılıklar ortaya konulmuştur. Elde edilen bulgular, gliste sisteminin yalnızca bir cephe elemanı olmadığını; geçmişte özellikle depolama ve kurutma gibi gündelik yaşam pratikleri ile doğrudan ilişkili, çok işlevli bir yapı bileşeni olarak kullanıldığını göstermektedir. Günümüzde ise bu işlevlerin büyük ölçüde ortadan kalktığı ve sistemin çeşitli müdahalelerle dönüşüme uğradığı tespit edilmiştir. Sonuç olarak bu çalışma, gliste sisteminin mimari ve işlevsel özelliklerini ortaya koyarak literatürde tanımlanmasına katkı sağlamak ve Safranbolu konutlarında bu elemanın belirleyici rolü dikkate alınarak “glisteli konutlar” kavramının değerlendirilmesine yönelik bir yaklaşım sunmaktadır.

Anahtar kelimeler: Safranbolu, geleneksel konut, gliste, ahşap karkas sistem, glisteli konutlar

HOUSES WITH GLISTE IN SAFRANBOLU

ABSTRACT

Earthquakes are among the most significant natural hazards affecting structures, and the response of different construction systems to seismic effects varies considerably. This study aims to comparatively evaluate timber frame and masonry structural systems within the scope

of traditional construction techniques in terms of their seismic performance. The study is based on a comprehensive literature review and examines the seismic behavior, damage mechanisms, and fundamental structural characteristics of these systems. The findings indicate that masonry structures generally exhibit low ductility and brittle behavior. Due to their weak tensile strength, these structures are more vulnerable to damage mechanisms such as cracking, separation, and collapse under seismic effects. In particular, construction details, material quality, and the adequacy of the load-bearing system play a decisive role in their performance. In contrast, timber frame systems are found to be more advantageous due to their lightweight nature, higher ductility, and greater energy dissipation capacity. However, factors such as inadequate connection details, heavy roofing systems, and material deterioration may negatively affect their performance. Accordingly, timber frame structures can respond to seismic forces in a more controlled and balanced manner thanks to their lightweight and ductile characteristics, whereas masonry structures tend to exhibit more brittle behavior due to their low ductility and insufficient tensile strength. Overall, timber frame systems demonstrate superior seismic performance compared to masonry structures; however, it is also concluded that material properties, construction quality, and connection details are critical factors influencing the structural behavior of both systems.

Keywords: Traditional construction systems, timber frame structure, masonry structure, earthquake effects, structural behavior

1. GİRİŞ

Geleneksel konut mimarisi, bulunduğu coğrafyanın iklimsel koşulları, topoğrafik özellikleri ve kültürel birikimi doğrultusunda biçimlenen; yerel üretim tekniklerinin mekâna yansısıyla şekillenen bir yapı türüdür (Eldem, 1968; Küçükerman ve Güner, 1995). Anadolu coğrafyasında gelişen geleneksel konutlar, bu bağlamda hem mekânsal organizasyon hem de yapı elemanları açısından zengin ve çeşitlilik gösteren bir mimari birikimi temsil etmektedir. Bu birikimin önemli örneklerinden biri olan Safranbolu konutları, günümüze ulaşan özgün dokusu ve karakteristik mimari özellikleri ile öne çıkmaktadır (Günay, 1998; Bayazıt, 2014). Ancak Safranbolu konutları üzerine yapılan çalışmalar incelendiğinde, araştırmaların büyük ölçüde plan şemaları ve yapı sistemleri üzerine yoğunlaştığı; buna karşın bazı özgün yapı elemanlarının yeterince detaylı biçimde ele alınmadığı görülmektedir (Yurdakul, 2007; Sayın, 2014). Bu durum, geleneksel konut mimarisinin çoğunlukla genel mekânsal kurgu üzerinden

değerlendirildiğini ve yapı elemanları ölçeğinde yapılacak incelemelerin sınırlı kaldığını göstermektedir.

Bu bağlamda, özellikle zemin kat ve hayat mekânı ile ilişkili olarak kullanılan ve yarı geçirgen bir yapı özelliği gösteren gliste sistemi, dikkat çeken ancak literatürde sınırlı biçimde ele alınan bir yapı bileşeni olarak öne çıkmaktadır (Kaya, 1996). Mevcut çalışmalarda gliste elemanı çoğunlukla tanımlayıcı düzeyde ele alınmakta; ancak bu elemanın konut içerisindeki mekânsal konumu, yapım özellikleri ve kullanım biçimleri üzerine kapsamlı bir değerlendirmeye yer verilmemektedir. Bu durum, gliste sisteminin bağımsız bir inceleme konusu olarak ele alınmasını gerekli kılmaktadır.

Geleneksel konutların dışı kapalı ancak kontrollü biçimde çevre ile ilişki kuran mekânsal kurgusu dikkate alındığında, gliste sisteminin bu ilişkiyi düzenleyen ara elemanlardan biri olduğu anlaşılmaktadır (Günay, 1998; Atık, 2011). Zemin katlarda sınırlı açıklık ihtiyacına yanıt veren bu sistem, tamamen kapalı yüzeyler ile dış çevre arasında geçirgenlik sağlayan bir ara çözüm olarak değerlendirilebilir. Bu yönüyle gliste, yalnızca teknik bir yapı elemanı değil, aynı zamanda mekânsal organizasyonu etkileyen bir bileşen olarak önem kazanmaktadır.

Bu çalışma, Safranbolu konutlarında yer alan gliste sisteminin tanımlanmasını, mekânsal konumunun ve yapım özelliklerinin ortaya konulmasını ve saha gözlemleri doğrultusunda kullanımındaki değişimlerin değerlendirilmesini amaçlamaktadır. Bu kapsamda gliste sistemi, yalnızca bir yapı detayı olarak değil, geleneksel konutun mekânsal kurgusu ile ilişkili bir ara eleman olarak ele alınmakta ve iç mekân ile dış çevre arasındaki ilişkiyi düzenleyen bir bileşen olarak değerlendirilmektedir.

Çalışma kapsamında elde edilen bulgular, gliste sisteminin geçmişte gündelik yaşam pratikleri ile doğrudan ilişkili çok işlevli bir yapı elemanı olduğunu; günümüzde ise bu işlevlerin büyük ölçüde ortadan kalktığını ve sistemin dönüşüme uğradığını göstermektedir. Ayrıca gliste sisteminin Safranbolu konutlarında belirli bir yaygınlığa sahip olması, bu elemanın konut karakterini tanımlayan önemli bileşenlerden biri olarak değerlendirilmesi gerektiğini ortaya koymaktadır.

Bu doğrultuda çalışma, gliste sisteminin belirleyici olduğu yapıların “glisteli konutlar” olarak ele alınmasını önermekte ve geleneksel konutların yalnızca plan tipolojileri üzerinden değil, özgün yapı elemanları üzerinden de değerlendirilebileceğine yönelik alternatif bir yaklaşım sunmaktadır. Bu yönüyle çalışma, Safranbolu konutları üzerine yapılan araştırmalarda yapı elemanları ölçeğinde yeni bir inceleme alanı açmakta ve gliste sisteminin literatürde tanımlı ve geliştirilebilir bir mimari kavram haline gelmesine katkı sağlamayı amaçlamaktadır.

2. YÖNTEM

Bu çalışma, nitel araştırma yaklaşımı çerçevesinde ele alınmış olup, literatür incelemesi, saha gözlemleri ve mimari rölöve analizlerine dayanmaktadır. Araştırmanın kuramsal altyapısı, geleneksel Türk konut mimarisi ve Safranbolu konutları üzerine yapılmış çalışmaların incelenmesi ile oluşturulmuştur. Çalışma kapsamında Safranbolu’da yer alan geleneksel konutlar, özellikle zemin kat açıklık türleri bağlamında ele alınmış; bu doğrultuda gliste sisteminin varlığı, mekânsal konumu ve kullanım biçimi üzerine odaklanılmıştır. İncelemeler, gliste sistemine sahip örneklerin plan ve cephe düzlemindeki özelliklerinin belirlenmesi ve bu sistemin yapı içerisindeki yerleşiminin anlaşılması üzerine yoğunlaşmıştır.

Mimari rölöve projeleri üzerinden yapılan analizler, gliste sisteminin konut içerisindeki konumunu ve yapım özelliklerini ortaya koymaya yönelik olarak kullanılmıştır. Çalışma kapsamında kullanılan zemin kat planları, Mimar Elif Hacıoğlu’nun arşivini paylaştığı rölöve proje çizimlerinin düzenlenmesiyle oluşturulmuştur. Bu süreçte farklı yapılardan elde edilen veriler değerlendirilerek sistemin genel karakteri ve tekrar eden özellikleri tanımlanmıştır.

Saha gözlemleri ve yerel kullanıcı bilgileri doğrultusunda, gliste sisteminin geçmişteki kullanım biçimleri ile günümüzde geçirdiği dönüşüm süreci de ele alınmıştır. Bu sayede çalışma, gliste sistemini yalnızca fiziksel özellikleri üzerinden değil, aynı zamanda kullanım pratikleri ve zaman içerisindeki değişimi bağlamında değerlendirmektedir.

Elde edilen bulgular, gliste sisteminin Safranbolu konutlarında sınırlı örneklerle temsil edilen bir uygulama olmadığını, belirli bir yaygınlığa sahip olduğunu göstermektedir. Bu durum, söz konusu yapı elemanının konutların mekânsal ve yapısal kurgusu içerisinde dikkate alınması gereken bir bileşen olduğunu ortaya koymaktadır.

3. SAFRANBOLU GLİSTELİ KONUTLARI

Yapılan incelemeler, gliste sisteminin Safranbolu geleneksel konutlarında belirli bir yaygınlığa sahip olduğunu ve konutların mekânsal kurgusu içerisinde yerleşik bir bileşen olarak değerlendirilebileceğini göstermektedir. Bu durum, söz konusu yapı elemanının yalnızca sınırlı sayıda örnekte görülen istisnai bir uygulama olmadığını, aksine belirli bir kullanım mantığına dayanan ve geleneksel konut düzeni içerisinde kendine özgü bir yer edinen bir sistem olduğunu ortaya koymaktadır.

Safranbolu geleneksel konutları genellikle iki ve üç katlı olarak inşa edilmiş olup, üç katlı örneklerin çoğunlukta olduğu görülmektedir. Bu konutlarda zemin katlar, yapının taşıyıcı sistemini oluşturması ve servis işlevlerini barındırması nedeniyle estetik kaygılardan ziyade

işlevsel gereklilikler doğrultusunda biçimlenmiştir. Bu bağlamda zemin katlar, üst katlara kıyasla daha kapalı, daha az açıklıklı ve daha sağlam bir karakter sergilemektedir.

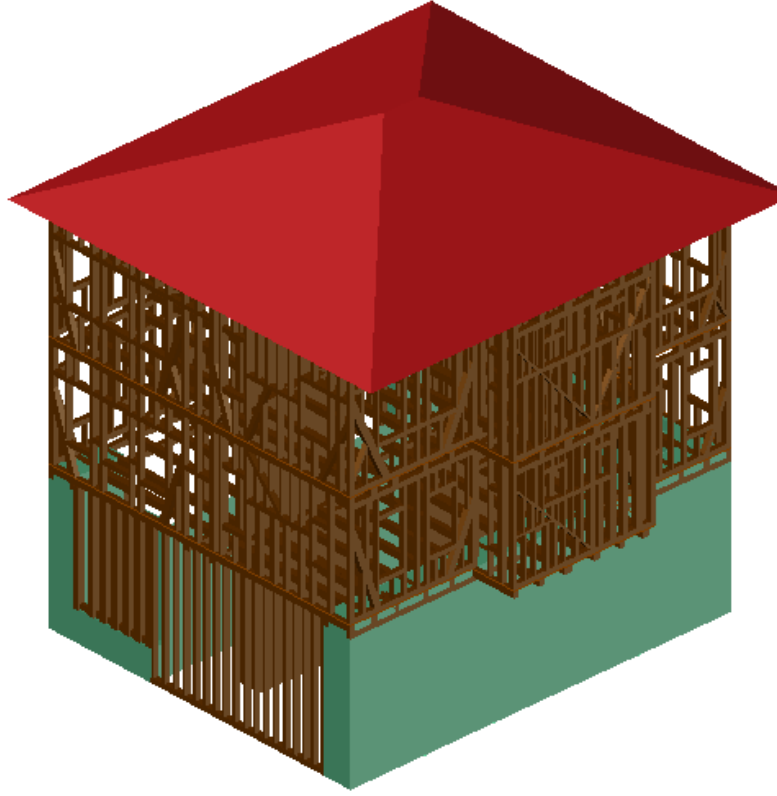
Parsel yapısının düzensiz olduğu durumlarda, zemin katların düzgün geometrik formlar göstermediği ve yer yer açılı plan çözümlerinin tercih edildiği görülmektedir. Bu durum, geleneksel konutların yalnızca iç mekânsal ihtiyaçlara göre değil, aynı zamanda topoğrafya ve parsel koşullarına uyum sağlayacak şekilde esnek bir plan anlayışı ile kurgulandığını göstermektedir. Bu bağlamda Safranbolu konutları, çevresel veriler ile mekânsal organizasyonun birlikte şekillendiği bütüncül bir tasarım yaklaşımını yansıtmaktadır.

Zemin katlar çoğunlukla taş duvarlı olarak inşa edilmiş olup, “tömek” olarak adlandırılan sınırlı açıklıklar ve gliste elemanı dışında büyük ölçüde penceresizdir. Bu durum, Safranbolu konutlarının dışı kapalı karakterini açıkça ortaya koymaktadır. Ancak bu kapalılık mutlak bir yalıtım anlamına gelmemekte; belirli noktalarda kontrollü açıklıklar aracılığıyla dış çevre ile sınırlı bir ilişki kurulmaktadır. Bu bağlamda gliste sistemi, kapalı zemin kat yüzeyleri içerisinde kontrollü bir geçirgenlik sağlayan önemli bir yapı elemanı olarak öne çıkmaktadır.

Glistenin sağladığı yarı geçirgen yapı, hem doğal aydınlatma hem de havalandırma açısından işlevsel bir çözüm sunarken, aynı zamanda mahremiyetin korunmasına da olanak tanımaktadır. Bu yönüyle gliste, tamamen kapalı bir zemin kat anlayışı ile tamamen açık bir cephe yaklaşımı arasında bir denge kuran ara bir çözüm olarak değerlendirilebilir.

3.1. Glistenin Tanımı

Glisteli sistem, Safranbolu geleneksel konutlarında özellikle zemin kat ve hayat mekânı ile ilişkili olarak kullanılan, ahşap dikmelerin belirli aralıklarla yerleştirilmesiyle oluşturulan yarı geçirgen bir yapı elemanıdır (Kaya, 1996). Dikmeler arasında oluşturulan bir dolu bir boş düzen, hem yapısal bir ritim oluşturmakta hem de kontrollü bir geçirgenlik sağlamaktadır. Glisteli sistemin genel kurgusu ve farklı uygulama biçimleri cephe üzerinden açık biçimde izlenebilmekte olup, gliste yükseltilmiş duvar üstünde yapıldığı gibi, zemine kadar inen örnekleri de bulunmaktadır. Buna göre çalışma kapsamında oluşturulan 3 boyutlu çizim ile iki sistemin bir arada gösterildiği örnek Şekil 1’de verilmiştir.



Şekil 1. Glisteli sistemin farklı uygulama biçimlerini gösteren analitik çizim

Cephe uygulamalarında yükseklik, genişlik ve yapım tekniği açısından farklılıklar gösterdiği belirlenen glisteli sistemi sabit bir tipolojiye sahip değildir. Yapı ve kullanım koşullarına bağlı olarak çeşitlenebilen esnek bir karakter sergilediğini ortaya koymaktadır. Bu farklı uygulamalara ilişkin örnekler Şekil 2’de sunulmaktadır.

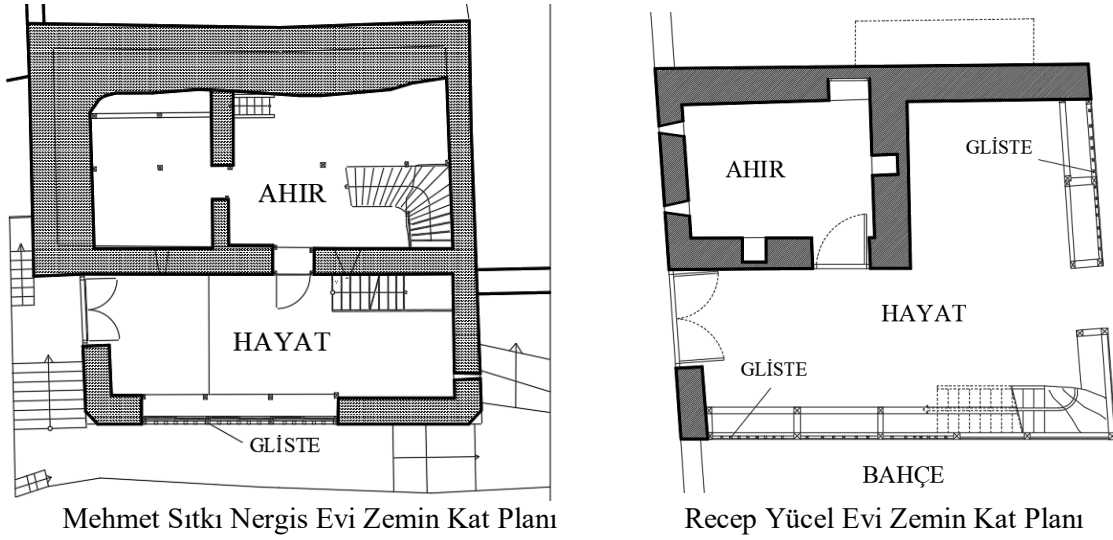


Şekil 2. Glisteli sistemin farklı uygulama örnekleri

Bu bağlamda gliste, yalnızca bir cephe elemanı olarak değil, iç mekân ile dış çevre arasında geçiş sağlayan ve mekânsal sürekliliği destekleyen bir ara yüz olarak değerlendirilebilir. Bu yönüyle hem yapım tekniğinin bir parçası hem de mekânsal organizasyonu şekillendiren bir bileşen olarak önem kazanmaktadır.

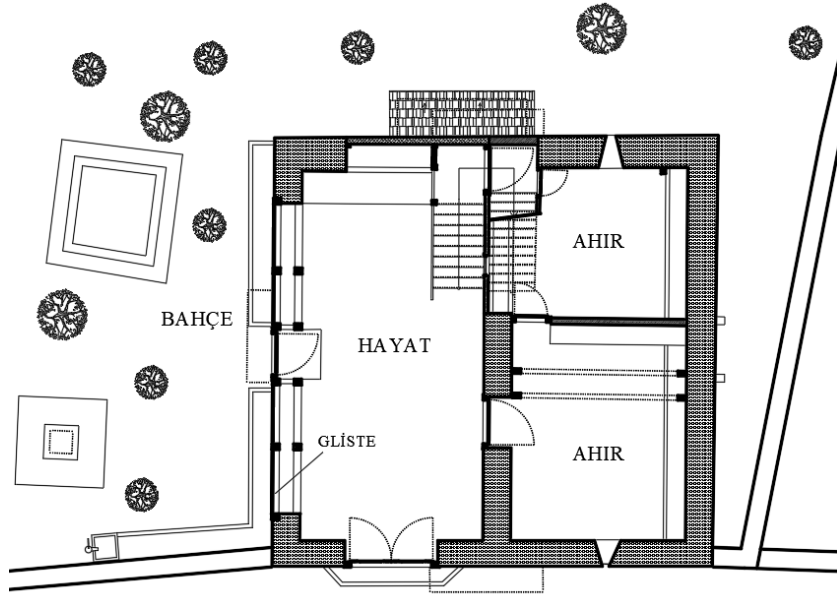
3.2. Mekânsal Kullanımı

Zemin katta yer alan “hayat” mekânı, konutun hem servis alanı hem de geçiş mekânı olarak işlev görmektedir. Bu mekân, sokak ve bahçe ile ilişki kuran bir ara alan niteliği taşımakta ve üst katlara ulaşım da genellikle buradan sağlanmaktadır. Zemin kat planları incelendiğinde, glistenin hayat mekânı ile doğrudan ilişkili olarak konumlandığı görülmektedir (Şekil 3).



Şekil 3. Glistenin hayat mekânı ile ilişkili konumu

Glisteli sistemin bu mekânda, özellikle bahçeye açılan yüzeylerde konumlandığı görülmektedir. Bu yerleşim, Safranbolu konutlarının genel olarak sokağa kapalı, ancak bahçe ile daha kontrollü ve geçirgen bir ilişki kuran mekânsal anlayışını ortaya koymaktadır. Şekil 4’te Ali Demirezen Evi örneğinin zemin kat planı üzerinden glistenin hayat ve bahçe mekanlarıyla arasındaki ilişki görülmektedir.



Şekil 4. Gliste sisteminin hayat ve bahçeye ilişkisi

Bu bağlamda gliste, iç mekân ile dış mekân arasında doğrudan bir açıklık oluşturmak yerine, kontrollü bir ilişki kuran bir ara yüz olarak işlev görmektedir. Böylece hem mahremiyet korunmakta hem de mekânsal süreklilik sağlanmaktadır (Şekil 5).



Şekil 5. Safranbolu Kaymakamlar Gezi Evi'nin gliste örneği

3.3. Yapım Özellikleri

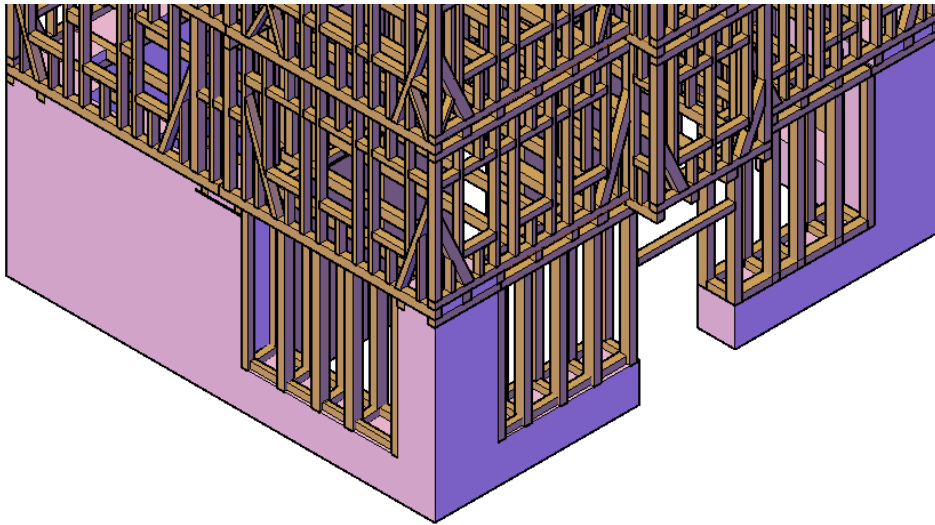
Glisteli sistem, hayat mekânının belirli cephelerinde yer alan ve yerden yaklaşık 60–80 cm yükseltilmiş duvarlar üzerine yerleştirilen ahşap dikmelerden oluşmaktadır. Bu yükseltilmiş duvar “bahna”, dikmeler arasındaki boşluklar ise “kur” olarak adlandırılmaktadır.

Ahşap dikmelerin belirli aralıklarla yerleştirilmesiyle oluşturulan sistem, modüler bir düzen ve tekrar eden bir ritim ortaya koymaktadır. Bu durum, geleneksel yapı üretiminde ölçü ve oran kavramlarının bilinçli bir şekilde kullanıldığını göstermektedir.

Farklı yapılarda dikme aralıkları ve yüksekliklerde değişiklikler gözlemlenmekle birlikte, sistemin temel kurgusunun büyük ölçüde benzer olduğu anlaşılmaktadır. Bu durum, glisteli sistemin hem standart bir yapı mantığına sahip olduğunu hem de kullanıcı ihtiyaçlarına göre esneklik gösterebildiğini ortaya koymaktadır.

Çalışma kapsamında incelenen rölöve projeleri, gliste sisteminin yalnızca tanımsal bir yapı elemanı olmadığını, aynı zamanda belirli bir yapı mantığı ve mekânsal düzen içerisinde tekrar eden bir bileşen olduğunu ortaya koymaktadır. Zemin kat planları incelendiğinde, glisteli yüzeylerin çoğunlukla “hayat” mekânı ile ilişkili olarak konumlandığı ve bu mekânın dış çevre ile kurduğu ilişkinin önemli bir parçasını oluşturduğu görülmektedir.

Cephe çizimleri üzerinden yapılan değerlendirmelerde ise gliste sisteminin, taş zemin kat duvarı üzerinde yer alan ve değişen aralıklarla tekrarlanan düşey ahşap elemanlar aracılığıyla oluşturulduğu anlaşılmaktadır. Bu düzen, hem yapı sisteminde modüler bir yaklaşımın varlığını göstermekte hem de sistemin görsel olarak cephe karakterinin bir parçası haline geldiğini ortaya koymaktadır. Glisteli sistemin yapı tekniği ve taşıyıcı sistemle kurduğu ilişki, çalışma kapsamında oluşturulan üç boyutlu analitik çizim üzerinden bütüncül olarak değerlendirilebilmektedir. Şekil 6’da sunulan bu çizim, gliste elemanlarının yalnızca cephe yüzeyine ait bir açıklık sistemi olmadığını, ahşap karkas yapı ile birlikte kurgulanan ve taşıyıcı sistemle doğrudan ilişki kuran bir bileşen olduğunu açık biçimde ortaya koymaktadır.



Şekil 6. Glistenin ahşap karkas sistemdeki konumu ve taşıyıcı elemanlarla ilişkisi

Bununla birlikte bazı örneklerde gliste boşluklarının çapraz ahşap elemanlarla kapatılarak “muşabak” formuna dönüştüğü görülmektedir . Bu durum, sistemin sabit bir formdan ziyade farklı kullanım ihtiyaçlarına göre değişebilen esnek bir yapıya sahip olduğunu göstermektedir (Şekil 7).



Şekil 7. Glisteli sistemin çapraz ahşap elemanlarla oluşturulan muşabak formu

Plan ve cephe verilerinin birlikte değerlendirilmesi, gliste sisteminin rastlantısal bir uygulama olmadığını; aksine belirli mekânsal ve yapısal prensiplere dayanan, tekrar eden ve konut tipolojisi içerisinde yerleşik bir eleman olduğunu ortaya koymaktadır.

3.4. İşlevsel Özellikleri ve Kullanım Amaçları

Glisteli sistemin temel işlevleri, hayat mekânının havalandırılması ve doğal ışık almasının sağlanmasıdır (Günay, 1989). Bununla birlikte saha gözlemleri ve yerel bilgiler, bu sistemin geçmişte daha kapsamlı bir kullanım alanına sahip olduğunu göstermektedir. Özellikle bahnelar üzerinde odun, yiyecek ve benzeri malzemelerin depolandığı ve doğal hava akımı ile kurutulduğu bilinmektedir. Bu kullanım biçimi, glisteli sistemin gündelik yaşam pratikleri ile doğrudan ilişkili olduğunu ortaya koymaktadır. Bu yönüyle gliste, yalnızca bir yapı elemanı değil, aynı zamanda üretim, depolama ve yaşam pratiklerinin mekânsal karşılığı olarak değerlendirilebilir. Glisteli sistem, yarı geçirgen yapısı sayesinde doğal aydınlatma ve havalandırma açısından işlevsel bir çözüm sunmaktadır. Glisteli sistemin detay düzeyde incelenmesi, bu elemanın bahna üzerine yerleştirilen düşey ahşap dikmelerden oluştuğunu ve belirli bir ritim içerisinde tekrar ettiğini göstermektedir. Bu düzen, hem yapım tekniğinin modüler karakterini ortaya koymakta hem de sistemin cephe üzerindeki düzenli ifadesini güçlendirmektedir.

3.5. Zaman İçinde Dönüşüm

Saha gözlemleri, glisteli sistemlerin zaman içerisinde değişime uğradığını göstermektedir. Geleneksel kullanımda açık ve geçirgen olan bu sistemlerin, günümüzde bazı yapılarda cam veya farklı malzemeler ile kapatıldığı görülmektedir. Günümüzde yapım sistemleri okunabilen ve glistesi farklı tekniklerle kapatılarak kullanıma devam eden konak örnekleri Şekil 8’de verilmiştir.



Mahir Ağa Konağı



Kaymakamlar Gezi Evi

Şekil 8. Glistesi günümüzde kapatılarak kullanılan konak örnekleri

Bu dönüşüm, geleneksel yaşam biçiminin değişmesi ve özellikle depolama ile kurutma gibi işlevlerin ortadan kalkması ile ilişkilidir. Bu bağlamda gliste, yalnızca fiziksel bir yapı elemanı değil, aynı zamanda değişen yaşam kültürünün mekâna yansması olarak da değerlendirilebilir.

4. SONUÇ

Bu çalışmada elde edilen bulgular, gliste sisteminin Safranbolu geleneksel konutlarında yalnızca bir yapı detayı olarak değil, mekânsal organizasyonu doğrudan etkileyen bir bileşen olarak değerlendirilmesi gerektiğini ortaya koymaktadır. Glistenin özellikle zemin kat ve hayat mekânı ile ilişkili olarak konumlanması, bu elemanın iç mekân ile dış çevre arasında kontrollü bir geçiş sağladığını göstermektedir. Bu yönüyle gliste, geleneksel konutlarda mahremiyet ile dışa açıklık arasında kurulan dengenin mekânsal karşılıklarından biri olarak değerlendirilebilir. Glisteli sistemin yarı geçirgen yapısı, geleneksel konutlarda tamamen kapalı ya da tamamen açık bir cephe anlayışı yerine, ara çözümlerin geliştirildiğini ortaya koymaktadır. Bu durum, geleneksel mimaride çevresel koşullar, kullanıcı ihtiyaçları ve toplumsal değerlerin birlikte şekillendirdiği esnek bir tasarım yaklaşımının varlığına işaret etmektedir. Bu bağlamda gliste, yalnızca teknik bir çözüm değil, aynı zamanda sosyal ve kültürel gereksinimlerin mekâna yansması olarak değerlendirilebilir.

Saha gözlemleri ve yerel kullanıcı bilgileri doğrultusunda, gliste sisteminin geçmişte depolama, kurutma ve havalandırma gibi işlevler doğrultusunda aktif biçimde kullanıldığı anlaşılmaktadır. Bu durum, glistenin gündelik yaşam pratikleri ile doğrudan ilişkili bir yapı elemanı olduğunu göstermektedir. Günümüzde ise bu işlevlerin büyük ölçüde ortadan kalktığı ve sistemin cam gibi farklı malzemelerle kapatılarak dönüştürüldüğü görülmektedir. Bu dönüşüm, geleneksel konut mimarisinin sabit bir yapı olmadığını, aksine değişen yaşam biçimleri ile birlikte dönüşen dinamik bir süreç olduğunu ortaya koymaktadır.

Elde edilen bulgular, gliste sisteminin Safranbolu konutlarında istisnai bir uygulama olmadığını ve belirli bir yaygınlığa sahip olduğunu göstermektedir. Bu durum, glistenin konut karakterinin oluşumunda önemli bir rol üstlendiğini ve değerlendirmelerde göz ardı edilmemesi gereken bir yapı elemanı olduğunu ortaya koymaktadır.

Bu doğrultuda, gliste sisteminin belirleyici olduğu yapıların “glisteli konutlar” olarak ele alınması önerisi, geleneksel konutların yalnızca plan tipolojileri üzerinden değil, özgün yapı elemanları üzerinden de değerlendirilebileceğine işaret eden alternatif bir yaklaşım sunmaktadır. Bu öneri, geleneksel konut çalışmalarında kavramsal çerçevenin genişletilmesine katkı sağlamakta ve yapı elemanı ölçeğinde yapılacak analizlerin önemini vurgulamaktadır.

Sonuç olarak bu çalışma, Safranbolu konutlarında yer alan gliste sistemini tanımlayarak ve mimari bağlamda konumlandırarak literatürde sınırlı biçimde yer alan bu yapı elemanını görünür hale getirmektedir. Bu yönüyle çalışma, geleneksel konut mimarisine ilişkin araştırmalarda yapı elemanları ölçeğinde yeni bir inceleme alanı açmakta ve gliste sisteminin literatürde tartışılabilir ve geliştirilebilir bir kavram haline gelmesine katkı sağlamaktadır. Bu yönüyle çalışma, gliste sisteminin yalnızca Safranbolu özelinde değil, benzer geleneksel konut örneklerinde de araştırılabilir bir yapı elemanı olduğunu ortaya koymaktadır.

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GELENEKSEL YAPI SİSTEMLERİNDE DEPREM DAVRANIŞININ KARŞILAŞTIRMALI DEĞERLENDİRİLMESİ: AHŞAP KARKAS VE YIĞMA YAPILAR

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ÖZET

Deprem, yapıların maruz kaldığı en önemli doğal etkenlerden biri olup, farklı yapım sistemlerinin bu etki karşısındaki davranışları büyük ölçüde değişkenlik göstermektedir. Bu çalışmada, geleneksel yapım sistemleri içerisinde yer alan ahşap karkas ve yığma yapı sistemlerinin deprem etkileri açısından karşılaştırmalı olarak incelenmesi amaçlanmıştır. Çalışma, literatür taramasına dayalı olarak gerçekleştirilmiş olup, söz konusu yapı sistemlerinin deprem karşısındaki davranış özellikleri, hasar türleri ve temel yapısal karakteristikleri ele alınmıştır. Elde edilen bulgular, yığma yapıların genel olarak düşük süneklik özelliklerine sahip olduğunu ve gevrek davranış sergilediğini ortaya koymaktadır. Bu tür yapıların, çekme dayanımlarının zayıf olması nedeniyle deprem etkileri altında çatlak oluşumu, ayrışma ve göçme gibi hasar mekanizmalarına karşı daha hassas olduğu görülmektedir. Özellikle yapım detayları, malzeme kalitesi ve taşıyıcı sistemin yeterliliği bu yapıların performansını doğrudan etkilemektedir. Buna karşılık, ahşap karkas sistemlerin hafif olması, yüksek süneklik göstermesi ve deprem enerjisini sönmüleyebilme kapasitesinin daha yüksek olması nedeniyle deprem etkileri karşısında daha avantajlı olduğu belirlenmiştir. Bununla birlikte, bu sistemlerde de bağlantı detaylarının zayıf olması, ağır üst örtü kullanımı ve malzeme yıpranması gibi faktörler performansı olumsuz yönde etkileyebilmektedir. Bu doğrultuda, ahşap karkas yapıların hafiflikleri, yüksek süneklikleri ve enerji sönmüleme kapasiteleri sayesinde deprem etkilerini daha kontrollü bir şekilde karşıladığı; yığma yapıların ise düşük süneklik ve zayıf çekme dayanımları nedeniyle daha kırılğan bir davranış sergilediği belirlenmiştir. Genel olarak, ahşap karkas yapıların deprem performansı açısından daha avantajlı olduğu, ancak her iki sistemde de malzeme özellikleri, yapım kalitesi ve bağlantı detaylarının yapı davranışında belirleyici rol oynadığı sonucuna ulaşılmıştır.

Anahtar kelimeler: Geleneksel yapım sistemleri, ahşap karkas yapı, yığma yapı, deprem etkileri, yapı davranışı

A COMPARATIVE EVALUATION OF THE SEISMIC BEHAVIOR OF TRADITIONAL BUILDING SYSTEMS: TIMBER FRAME AND MASONRY STRUCTURES

ABSTRACT

Earthquakes are among the most significant natural hazards affecting structures, and the response of different construction systems to seismic effects varies considerably. This study aims to comparatively evaluate timber frame and masonry structural systems within the scope of traditional construction techniques in terms of their seismic performance. The study is based on a comprehensive literature review and examines the seismic behavior, damage mechanisms, and fundamental structural characteristics of these systems. The findings indicate that masonry structures generally exhibit low ductility and brittle behavior. Due to their weak tensile strength, these structures are more vulnerable to damage mechanisms such as cracking, separation, and collapse under seismic effects. In particular, construction details, material quality, and the adequacy of the load-bearing system play a decisive role in their performance. In contrast, timber frame systems are found to be more advantageous due to their lightweight nature, higher ductility, and greater energy dissipation capacity. However, factors such as inadequate connection details, heavy roofing systems, and material deterioration may negatively affect their performance. Accordingly, timber frame structures can respond to seismic forces in a more controlled and balanced manner thanks to their lightweight and ductile characteristics, whereas masonry structures tend to exhibit more brittle behavior due to their low ductility and insufficient tensile strength. Overall, timber frame systems demonstrate superior seismic performance compared to masonry structures; however, it is also concluded that material properties, construction quality, and connection details are critical factors influencing the structural behavior of both systems.

Keywords: Traditional construction systems, timber frame structure, masonry structure, earthquake effects, structural behavior

1. GİRİŞ

Deprem, yapıların güvenliğini doğrudan etkileyen en önemli doğal afetlerden biri olup, meydana gelen sarsıntılar sonucunda farklı yapı türlerinde çeşitli hasar mekanizmalarının ortaya çıkmasına yol açmaktadır. Yapıların deprem etkileri altındaki sismik performansı; malzeme özellikleri, taşıyıcı sistemin davranışı, yapı tekniği ve mimari tasarım gibi çok sayıda faktörün birlikte etkisi altında şekillenmektedir. Günümüzde çelik ve beton gibi malzemeler kullanılarak geleneksel yapı formlarının taklit edilmesine yönelik yaklaşımlar

bulunsa da, malzeme deęiřimi yapıların mekanik özelliklerini ve deprem karşısındaki davranışını önemli ölçüde deęiřtirmektedir (Qi vd., 2023).

Geleneksel yapım sistemleri, tarihsel süreç içerisinde farklı coęrafi ve kültürel koşullara uyum sağlayarak gelişmiş ve günümüze kadar ulaşmış önemli bir yapı mirasını temsil etmektedir (Langenbach, 2007). Dünya genelinde farklı bölgelerde karşılaşılan yığma ve ahşap karkas yapı sistemleri, bu bağlamda yaygın olarak kullanılan ve deprem davranışları açısından dikkatle incelenen iki temel yapı türüdür. Bu sistemler, özellikle deprem riskinin yüksek olduğu bölgelerde geliştirilmiş olup, uzun yıllar boyunca elde edilen deneyimlerin bir sonucu olarak şekillenmiştir.

Bu kapsamda yığma yapılar, yüksek rijitlik özelliklerine sahip olmalarına karşın düşük süneklikleri nedeniyle deprem etkileri altında kırılğan davranış sergileme eğilimindedir (Korkmaz, 2007). Özellikle düşük çekme dayanımları nedeniyle düzlem dışı etkiler karşısında hassas olan bu yapılar, ani göçme riski açısından önemli bir dezavantaj taşımaktadır (Li vd., 2025; Korkmaz, 2007). Bu durum, yığma yapıların deprem etkileri altında performanslarının sınırlı kalmasına neden olmaktadır.

Buna karşılık, dünyada Hımış (Türkiye), Pombalino (Portekiz), Dhajji Dewari (Hindistan/Pakistan) ve Chuandou (Çin) gibi farklı isimlerle bilinen ahşap karkas yapılar, farklı coęrafyalarda geliştirilmiş ve deprem etkilerine karşı daha uyumlu davranışlar sergileyen sistemler olarak öne çıkmaktadır (Gani vd., 2021; Vasconcelos vd., 2015; Langenbach, 2007). Bu yapıların hafif olmaları ve esnek bağlantı detaylarına sahip olmaları, deprem enerjisini sönümleyebilme kapasitelerini artırmaktadır. Ayrıca, deneysel çalışmalar ahşap karkas sistemlerde kullanılan dolgu malzemesinin çerçeveye ek rijitlik kazandırdığını ve bağlantı bölgelerinde oluşan sürtünme ile sismik enerjinin tüketilmesine katkı sağladığını ortaya koymaktadır (Poletti ve Vasconcelos, 2014; Ali vd., 2012; Xie vd., 2021). Bu yapıların, büyük deprem olaylarında modern betonarme yapıların önemli ölçüde hasar gördüğü durumlarda dahi ayakta kalabildięi saha gözlemleriyle de desteklenmektedir (Doęangün vd., 2006; Gülhan ve Güney, 2000; Hicyılmaz vd., 2012).

Bununla birlikte, dünya genelinde hem yığma hem de ahşap karkas yapı sistemlerinin deprem davranışları üzerine yapılan çalışmalar, bu iki sistemin farklı avantaj ve dezavantajlara sahip olduğunu ortaya koymaktadır. Günümüzde çelik ve betonarme sistemler ile geleneksel yapı davranışının yeniden oluşturulmasına yönelik çalışmalar yapılmakta; ancak malzeme farklılıkları nedeniyle bu sistemlerin deprem karşısındaki davranışı geleneksel sistemlerden önemli ölçüde ayrılmaktadır. Bu durum, özellikle enerji sönümleme ve süneklik açısından

belirgin farklılıkların ortaya çıkmasına neden olmaktadır (Qi vd., 2023). Bu bağlamda ahşap karkas sistemler, sahip oldukları doğal esneklik ve bağlantı davranışı sayesinde deprem mühendisliği açısından önemli bir alternatif olarak değerlendirilmektedir.

Öte yandan, her iki yapı sisteminin deprem performansı; uygulama kalitesi, bağlantı detaylarının durumu ve yapının bulunduğu topoğrafik koşullara bağlı olarak değişiklik gösterebilmektedir. Özellikle eğimli araziler üzerine inşa edilen tarihi ahşap yapılarda, kolon yüksekliklerindeki farklılıkların burulma etkilerini artırdığı ve bu durumun üst katlarda yapısal zayıflıklara yol açtığı gözlemlenmiştir (Pan vd., 2023). Ayrıca, geleneksel sistemlerde dolgu duvarların deprem dayanımını artırıcı etkisi bulunmakla birlikte, yüksek şiddetli deprem etkileri altında bu duvarlarda düzlem dışı göçme riskinin ortaya çıkabileceği belirtilmektedir (Meireles vd., 2012; Qu vd., 2015). Bunun yanında, geleneksel sistemlerde deprem davranışının büyük ölçüde esnek bağlantı detaylarına bağlı olduğu; modern uygulamalarda kullanılan rijit birleşimlerin ise yapıların sünek davranışını olumsuz etkileyebileceği ifade edilmektedir (Qi vd., 2023).

Bu çalışma kapsamında, dünya genelinde yaygın olarak görülen geleneksel yapı sistemleri içerisinde yer alan ahşap karkas ve yığma yapıların deprem etkileri altındaki davranışları karşılaştırmalı olarak incelenmektedir. Çalışmanın temel amacı, söz konusu iki yapı sisteminin literatür doğrultusunda değerlendirilmesi ve deprem performansları açısından karşılaştırmalı bir çerçeve sunulmasıdır.

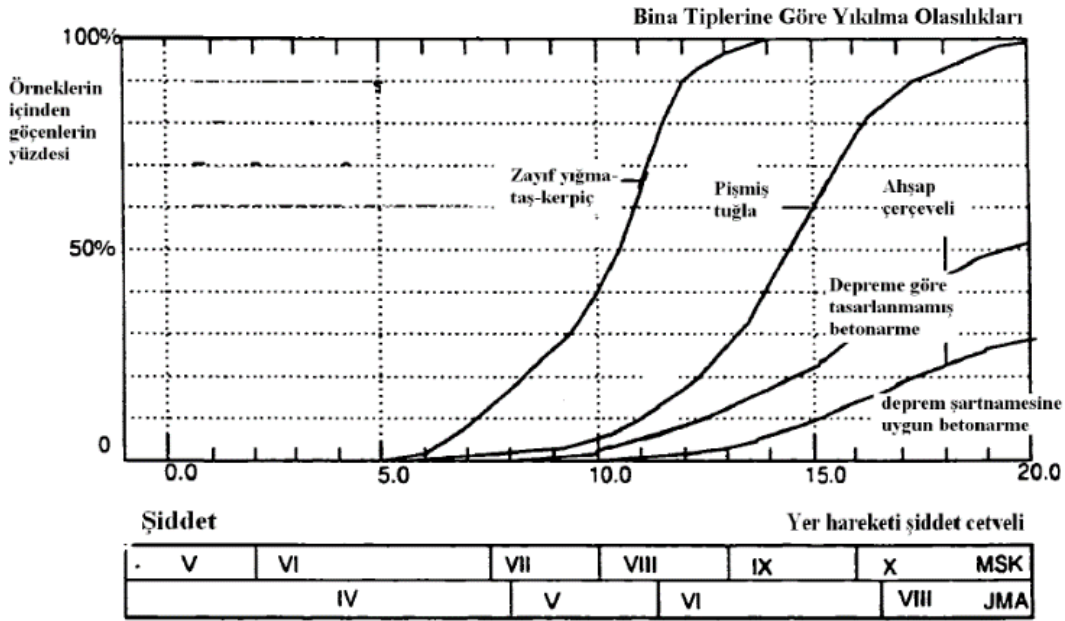
2. KAVRAMSAL ÇERÇEVE

Deprem yükleri; rüzgâr yükü, toprak basıncı ya da çarpma etkisi gibi diğer yatay yüklerden farklı olarak yapıya dışarıdan etki eden kuvvet değildir. Yapıların kendi ağırlığından dolayı meydana gelen deprem yükleri, yapının her bir kısmının ağırlığının, söz konusu noktaya etki ettiği yatay yüküdür (Ünay, 2002: 59). Yapıların yumuşak zemin üzerine inşa edilmesi, ikincil strüktür elemanlarının birlikte çalışmaması, asimetric yapı tasarımı, bacaların taşıma performansının düşük olması, strüktürel bağlantıların yeterli olmaması, ağır çatıların kullanılması, ahşabın zamana bağlı olarak haşere ve çürüme gibi sebeplerle güç kaybetmesi ve deprem sonrasında gerçekleşebilecek yangınlara karşı dayanıksız olması, ahşap yapıların deprem karşısındaki davranışlarını etkileyen faktörler arasındadır (Dışkaya, 2004: 58).

Yapılar, depremlerden dolayı ve doğrudan olmak üzere iki şekilde etkilenmektedir. Dolaylı etkiler; deprem sonrası meydana gelen yangın ve su baskınları gibi olayların yapılara zarar vermesidir. Doğrudan etkiler ise, deprem sebebiyle oluşan yüzey kırığı, çökmesi yer kayması, toprak ve çamur akması, sıvılaşma ve tsunaminin yapılarda sebep olduğu hasarlar ile sarsıntı

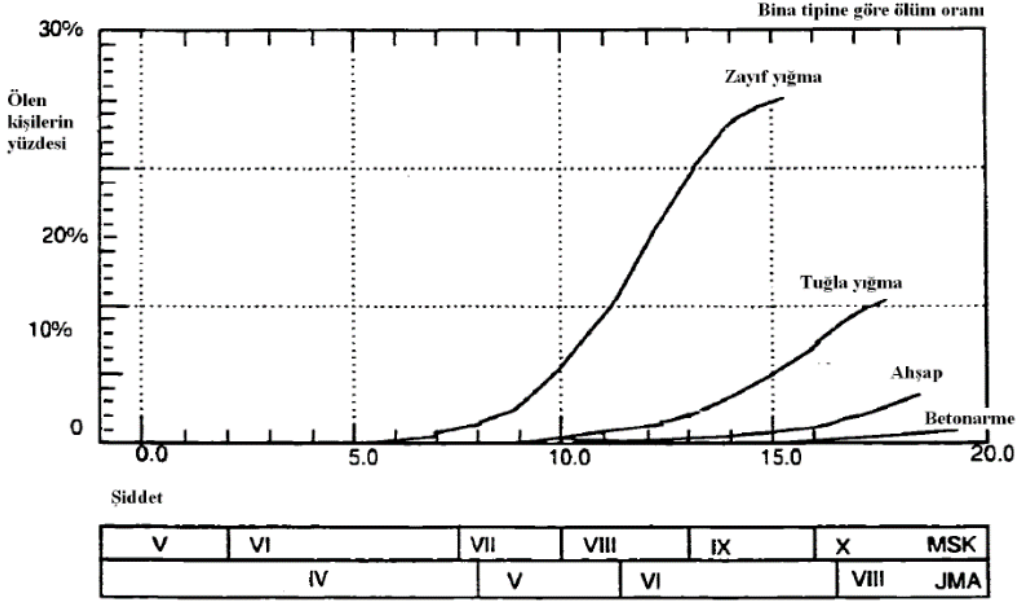
esnasında meydana gelen hasarlardır (Aksoy, 2003: 9). Yeni yapılaşmalarda deprem tehlikesinin dikkate alındığı kadar, mevcut ve tarihi yapıların değerlendirilip güçlendirilmesinde bu konunun yeterince üzerinde durulmaması, yapıların depreme maruz kalması durumunda birçok kayıplara sebebiyet vermektedir (Arslan, 2006: 15). Yapılar üzerinde, hafif hasar, orta hasar, ağır hasar ve yıkıntı olmak üzere dört farklı deprem hasarı tanımlanmaktadır (Aksoy, 2003: 32, 33).

Korkmaz (2007)'in aktarmış olduğu bir çalışmaya göre, kırsal yapıların deprem davranışları kapsamında, yapıların türüne göre yıkılma olasılıkları Şekil 1'de verilmiştir. Buna göre, taş veya kerpiçten yapılmış zayıf yığma yapıların yıkılma olasılığı, az şiddetli depremde en yüksek orana sahip olup, pişmiş tuğladan yapılmış yığma yapılarda daha azdır. Devamında en yüksek yıkılma oranına sahip olan grup ahşap yapılar, deprem şartnamesine uygun yapılmış betonarme yapıların yıkılma olasılığı en az olarak belirlenmiştir.



Şekil 1. Bina türüne göre yıkılma olasılıkları (Korkmaz, 2007: 44)

Yine Korkmaz (2007)'in aktarmış olduğu bir çalışmaya göre, kırsal yapıların deprem davranışları kapsamında, yapıların türüne göre ölüm oranları da Şekil 2'de görülmektedir. Şekle göre daha az şiddetli depremlerden dolayı zayıf yığma yapılardaki ölüm olasılığı oranı en yüksekken, tuğla yığma yapılarda kerpiç ya da taştan yapılmış yığma yapılara göre daha azdır. Devamında en yüksek ölüm oranı ahşap yapılarda olup, deprem şartnamesine göre tasarlanmış betonarme yapılardaki ölüm oranı en azdır. Şekil 2'de verildiği gibi yapıların türüne göre yıkılma olasılıkları ve ölüm olasılıklarına bakıldığında, bina yıkılma olasılığı ve ölüm oranlarındaki olasılıkların doğru orantılı olduğu görülmektedir.



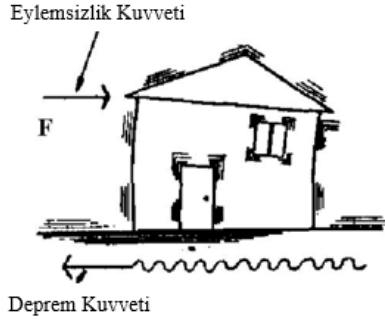
Şekil 2. Bina türüne göre ölüm oranları (Korkmaz, 2007: 44)

Yapıların depreme karşı dayanımlarını etkileyen mimari tasarım kriterleri;

- Yapının genel geometrik formu,
- Deprem dayanımı bakımından sakıncalı mimari detaylar ve
- Tehlike oluşturan taşıyıcı olmayan elemanlar şeklinde üç ana başlıkta ele alınmaktadır.

Yapının genel geometrik formu, yapıların boyutları, şekilleri ve oranları ile birlikte, taşıyıcı elemanlarının boyutları ve arsa üzerindeki konumlarını kapsamaktadır. Yapıların taşıyıcı sistem elemanlarının konumları ve birleşim detayları ise bazı durumlarda deprem dayanımı bakımından sakıncalı detayları oluşturmaktadır. Bununla birlikte, depreme karşı yeterli dayanımı bulunmayan elemanlar ile kurgulanan taşıyıcı sistemler de yapılarda hasara ve can kayıplarına yol açabilmektedir (Ünay, 2002: 59).

Deprem kuvvetleri altında yapılar, ileri ve geri yer hareketleri karşısında eylemsizlik etkisi göstermektedir. Herhangi bir yapıda, Şekil 3'teki gibi yerin bir tarafa doğru hareket etmesi ile yapı yerinde kalmak isteyerek eylemsizlik kuvvetini oluşturmaktadır. Yapı tasarımlarında da depreme karşı dayanım sağlanması için bu eylemsizlik kuvvetine karşı gerekli olan detaylandırmalar ve boyutlandırmalar yapılmaktadır (Korkmaz, 2007: 42).



Şekil 2. Yapıda oluşan eylemsizlik kuvveti (Korkmaz (2007)'den düzenlenmiştir)

Yapıların depreme karşı dayanımları için ülkelerin şartnamelerinde genel prensipler belirlenmekte olup, ülkemizdekiler şu şekildedir: Gerçekleşme ihtimali yüksek, düşük şiddetteki depremlerde, taşıyıcı olan veya olmayan yapı elemanlarının hasar görmemesi gerekmektedir. Bununla birlikte, orta şiddetteki depremlerde taşıyıcı olmayan elemanların hasar görmesine izin verilirken, taşıyıcı sistemi önemli oranda hasar görmemelidir. Gerçekleşme ihtimali düşük olan şiddetli depremlerde ise can kaybının olmaması ön planda tutularak, yapının elastik sınırlar dışında büyük deplasman yapması mümkünken, yapının tamamının yıkılmasına izin verilmeden taşıyıcı sistemin fazla hasar görmesi kabul edilmektedir (Ünay, 2002: 61, 62). Yığma ve karkas yapılar, yapım sistemlerinin türüne bağlı olarak depreme karşı farklı davranışlar sergiler (Korkmaz, 2007: 18,19).

Tablo 1. Yapım sistemlerine göre deprem davranışları (Korkmaz (2007)'den düzenlenmiştir)

Yapım Sistemleri		Deprem Davranışı
Karkas Yapılar	Ahşap Karkas Yapılar	Hımış Süneklik ve sönüm kapasitesi düşük olup, Özellikle, üst örtüsü ağır olan yapılar yatay yüklere karşı dayanıklı değildir.
	Betonarme Yapılar	Bağdadi Süneklik ve sönüm kapasitesi artırılmış olup, çıtalara dolguların dağılmasını engellemektedir.
	Kerpiç	Tasarıma, detaylara, işçiliğe ve yönetmeliklere uyulmasına göre yapıların deprem davranışı değişiklik göstermektedir.
Yığma Yapılar	Taş	Dayanım artırmak için hatıllarla taşıyıcılık kapasitesi desteklenmekte olup, yatay yüklere karşı mukavemetsizdir.
	Harman Tuğlası	Harçlı ve özenli bir şekilde sağlam inşa edildiğinde dayanıklıyken, kalitesiz olduğunda depreme karşı tehlike oluşturmaktadır.
	Delikli Fabrika Tuğlası	İyi detaylandırma, kaliteli harç ve donatılı hatıllar ile bu yapıların mukavemeti artmaktadır.
		Zayıf bir malzeme olup, taşıyıcı olmayan duvar dolgusunda kullanılır.

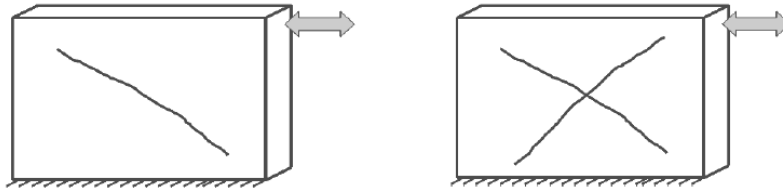
Kerpiç, taş, tuğla, briket ve gaz beton gibi malzemelerle inşa edilen yığma yapılar; hımiş ve bağdadi sistemlerin oluşturduğu ahşap iskeletli yapılar ile betonarme karkas yapılar, kullanılan malzeme türü ve yapım tekniğine göre depreme karşı farklı performans göstermektedir. Yapı türlerine göre deprem davranışları Tablo 1’de sunulmaktadır. Devamında, yığma ve iskeletli yapıların deprem davranışları detaylı olarak verilmektedir.

3. BULGULAR

3.1. Yığma Yapıların Deprem Davranışı

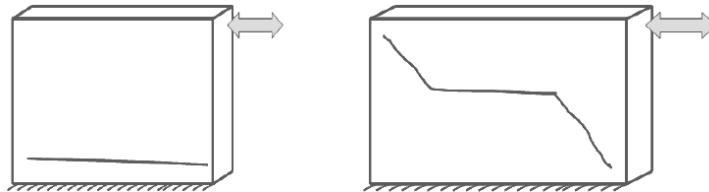
Tarihi yığma yapılar düşük süneklığe sahiptir ve sert ve kırılğan yapısal bileşenleri, genellikle şiddetli depremler sırasında ciddi şekilde hasar görmektedir (İlerisoy ve Soyluk, 2012: 736). Yığma yapı malzemelerinin basınç dayanımı orta ve iyi iken, çekme dayanımı düşük olup, tuğla ve kerpiç malzemeler bu gruba giren gevrek malzemelerdir ve oldukça düşük ötelemelerde bile çatladıkları görülür. Duvar gibi yapısal elemanlarda eğilme kuvveti etkisiyle çekme gerilmesi, basınç gerilmesinden fazla olduğunda çatlama meydana gelir ve kesme dayanımı aşıldığında bu çatlak genişleyerek yarık hâlini alır. Bu çatlama sonrası, yapı bir bütün gibi davranamaz ve bağımsız hareket eden bölümler şeklinde artan deplasmanlarda kısmi ya da bütünsel göçmelere sebep olur (Korkmaz, 2007: 45).

Duvarlarda yatay yüklerin etkisiyle çekme gerilmelerinin kayma emniyet gerilmesi değerini aşması sonucu çapraz kesme çatlakları oluşur. Bu tür çatlaklar çoğunlukla düşey yük kuvvetinin fazla olduğu alt katlarda oluşmaktadır (Şekil 4) (Timur, 2001: 3).



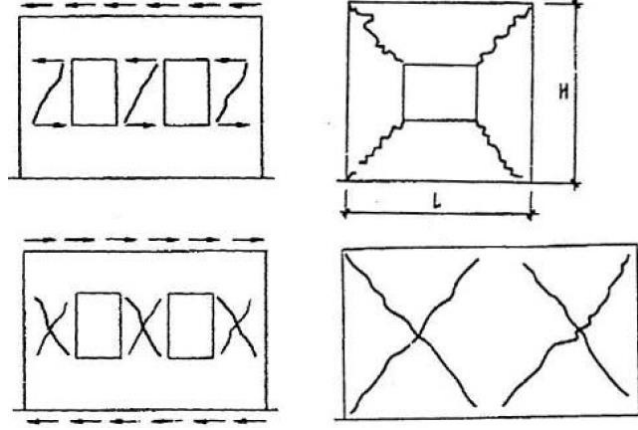
Şekil 4. Duvarda diyagonal çatlak (kesme çatlak) (Korkmaz, 2007: 48)

Düşey yük kuvvetinin alt katlara göre daha düşük olduğu üst katlarda ise, aynı yük etkisiyle duvarda yatay çatlaklar oluşur (Şekil 3.5) (Timur, 2001: 3).



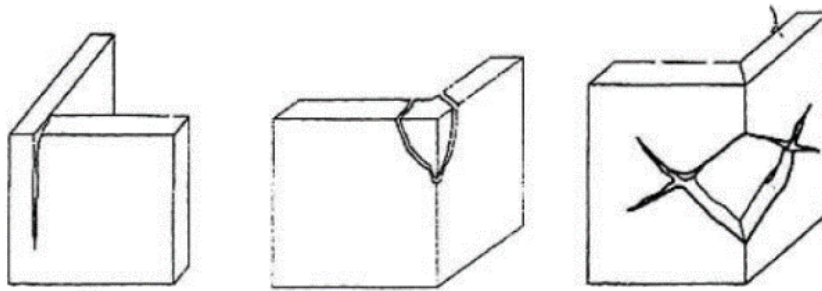
Şekil 5. Duvarda kayma çatlak (Korkmaz, 2007: 49)

Yığma yapı duvarlarında pencere boşluklarının bulunduğu durumlarda, boşluklar arasındaki duvar kısımlarında da boşluksuz duvarlarda olduğu gibi çapraz kesme çatlakları oluşur (Şekil 6) (Timur, 2001: 3).



Şekil 6. Duvarda kesme çatlakları (Arslan, 2006: 30)

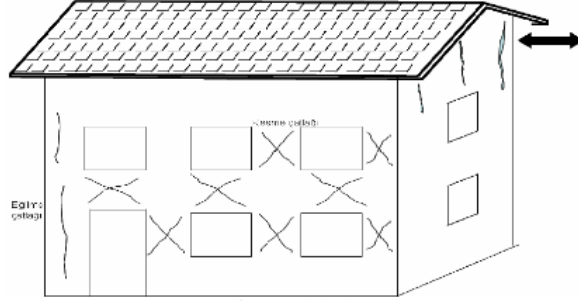
Yığma yapılarda genellikle düşey yüklerin sebep olduğu bir hasar söz konusu değilken, taşıyıcı elemanların yeterli kalınlıkta olmaması sebebiyle düşey basınç kuvveti altında düşey çatlaklar (burkulma çatlakları) görülebilmektedir. Kubbe ve kemerlerin kullanıldığı yapılarda ise basıklığa bağlı olarak mesnetlerde oluşacak yanıl kuvvetler nedeniyle hasar oluşabilmekteyken, gergi, kasnak, ağırlık kulesi ve payanda gibi elemanların kullanılması ile bu kuvvetlerin etkisi azaltılabilmektedir. Ayrıca, yapı planlarının da asimetric olması ve kütle merkezi ile rijitlik merkezinin olması gerektiği kadar birbirine yakın bulunmaması, yapı elemanlarının burkulmasına ve hasar almasına sebep olmaktadır (Timur, 2001: 3).



Şekil 7. Yığma yapı köşe hasar biçimleri (Arslan, 2006: 33).

İki yönlü kuvvet oluşması sebebiyle yığma yapıların köşelerinde, duvarlar birbirlerini düzlem dışına itme kuvveti uygularlar. Bu iki yönlü uygulanan kuvvet altında yapı köşelerinde çatlaklar oluşmaktadır. Bu çatlakların genişlemesi ile duvarlar dağılmakta ve yapının dökülmesi üst üste yığılarak göçebilmektedir (Şekil 7, 8) (Arslan, 2006: 32, 33). Yığma yapıların inşa edildiği

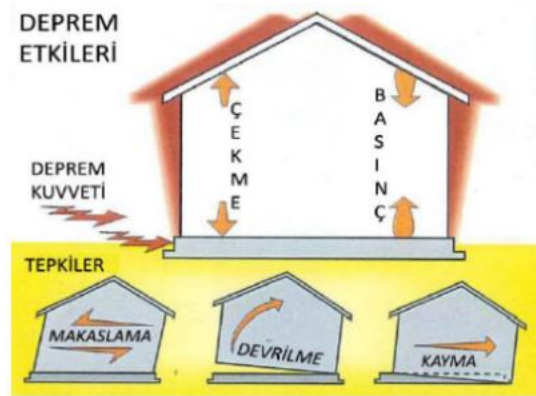
zeminlerin özellikleri ile birlikte, yapıların temel derinliklerinin yetersiz olması sebebiyle oluşabilecek oturmalar da yapılarda hasar meydana getirebilmektedir (Timur, 2001: 3).



Şekil 8. Yığma yapılarda olası hasar ve çatlaklar (Korkmaz, 2007: 56, 57).

3.2. İskeletli Yapıların Deprem Davranışı

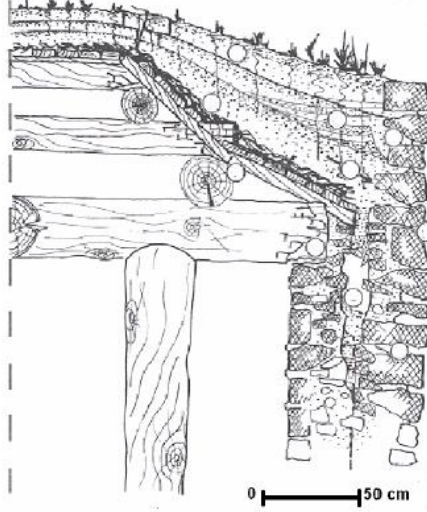
Ahşap iskeletli yapılar, deprem dayanımı bakımından yığma yapılara oranla daha iyi bir performans sergilemekte olup, daha sünek ve daha hafiftir (Korkmaz, 2007: 61). Deprem kuvvetleri, diğer yapı türlerinde olduğu gibi ahşap yapılarda da çeşitli kuvvet etkilerini meydana getirmekte olup, ahşap yapıların üzerinde basınç ve çekme gerilmelerinin ortaya çıkmasına da neden olmaktadır. Bu basınç ve çekme gerilmeleri, yapıların makaslama, devrilme ve kayma gibi tepkilerini oluşturmaktadır ve yapıların deprem kuvvetleri ile karşılaştığında hasar almasına sebep olmaktadır (Şekil 9) (Ohanesyan, 2012: 104, 105).



Şekil 9. Ahşap yapılarda deprem kuvvetine karşı oluşan tepkiler (Ohanesyan, 2012: 105).

Anadolu'nun bazı bölgelerinde, ahşap kiriş ve düşey elemanların düğüm noktalarında herhangi bir bağlayıcı eleman (çivi, kama vb.) kullanılmaması, oldukça küçük yer hareketlerinde bile düğüm noktalarının dağılmasına ve çatının göçmesine neden olmaktadır. Bu sistemde hasarı

önlemeye yönelik olarak, çatı kirişlerinin en az 50 cm dışarıya doğru uzatılması ile daire kesit yerine dikdörtgen kesitli kirişler kullanılması önerilmektedir (Korkmaz, 2007: 61) (Şekil 10).



Şekil 10. Doğu Anadolu'da ahşap iskeletli taş yapı örneği (Korkmaz, 2007: 61).

Hıms yapıların ana taşıyıcı sistemini oluşturan ahşap dikme ve kirişlerin arasındaki boşlukların taş, tuğla ve kerpiç blokları gibi malzemelerle doldurulması, deprem esnasında dolgu malzemelerinin arasında oluşan sürtünme kuvveti ile yapının enerji tüketme kapasitesi artmaktadır. Bu yapılar büyük bir depreme maruz kaldıklarında, ahşapla aynı esnek davranışa sahip olmayan dolgu malzemeleri parçalanıp dökülebilmekte ve can kayıplarına sebebiyet verebilmektedir. Bu yapı sisteminde, ahşap iskeletlerin kendi arasında ve dolgu malzemeleriyle olan bağlantıların iyi sağlanması gerekmektedir (Korkmaz, 2007: 62). Hıms yapılarda, hasarın ilk başta dolgu malzemesinde başlayarak daha sonra çerçeveye iletildiği ve deprem esnasında ahşap çerçevenin hasarı dolgudan daha fazlaysa, duvarların çerçeve tarafından itileceği belirtilmektedir. Dolgu ve iskelet arasında bağlayıcı kullanılmadığında ise iskelet sistemin dolguyu boşaltacağı ifade edilmiştir (Aksoy, 2003: 41) (Şekil 11).



Şekil 11. Hımsış sistemiyle inşa edilmiş yapıda deprem hasarı örneği (Korkmaz, 2007: 63).

Bağdadi yapıların deprem karşısında gösterdiği performans, hımsış yapılara göre daha iyidir. Bağdadi yapıların boşluklarının hımsış yapılar gibi ağır bir malzemeye doldurulmaması, iç ve dış sıvaların bağdadi çıtalarının üzerlerine yapılması, bu yapıların hafifliğini ve sünekliğini artırmakta olup, yapının büyük yer değiştirmelerine karşı şekil ve dayanımını koruyabilmesini sağlamaktadır. Bu yapı sisteminde de ahşap iskeletlerin bağlantı noktalarının iyi yapılması gerekmektedir (Korkmaz, 2007: 63) (Şekil 12). Bununla birlikte, ahşap yapıların, deprem anında veya sonrasında genellikle, temellerinde, zemin katlarında, taşıyıcı iskeletlerinde, dolgu veya kaplama malzemelerinde, çatılarında ve bacalarında hasarlar oluşmaktadır (Ohanesyan, 2012: 113).



Şekil 12. Bağdadi sistemle inşa edilmiş yapıda deprem hasarı örneği (Korkmaz, 2007: 63).

Elde edilen sonuçlar bütüncül olarak değerlendirildiğinde, yığma ve ahşap karkas yapı sistemlerinin deprem etkileri altındaki davranışlarının büyük ölçüde malzeme özellikleri, taşıyıcı sistemin davranışı ve bağlantı detaylarıyla ilişkili olduğu anlaşılmaktadır. Yığma

yapıların yüksek rijitlik göstermesine karşın düşük süneklik ve sınırlı çekme dayanımı nedeniyle deprem yükleri altında ani ve kırılğan hasar mekanizmalarına yatkın olduğu; buna karşılık ahşap karkas yapıların daha düşük kütleyle sahip olmaları, sünek davranış özellikleri ve daha yüksek enerji sönümleme kapasiteleri sayesinde sismik etkileri daha dengeli bir şekilde karşılayabildiği görülmektedir. Bununla birlikte, her iki yapı türünde de performansın yalnızca sistemin türüne bağlı olmadığı, uygulama kalitesi, detaylandırma ve kullanılan malzeme özelliklerinin de belirleyici olduğu ortaya çıkmaktadır. Özellikle yığma yapılarda bağlantı zayıflıkları ve yetersiz malzeme özellikleri hasar düzeyini artırırken, ahşap karkas sistemlerde doğru tasarlanmış ve iyi uygulanmış bağlantı detaylarının yapının bütünsel davranışını sürdürülebilmesinde kritik rol oynadığı anlaşılmaktadır. Bu doğrultuda, geleneksel yapı sistemlerinin deprem performanslarının karşılaştırmalı olarak ele alınması, her iki sistemin güçlü ve zayıf yönlerinin birlikte değerlendirilmesini gerekli kılmaktadır.

4. SONUÇ

Bu çalışmada, geleneksel yapı sistemleri kapsamında yer alan yığma ve ahşap karkas yapıların deprem etkileri altındaki davranışları literatür bulguları doğrultusunda karşılaştırılmıştır. Elde edilen değerlendirmeler, yığma yapıların yüksek rijitliklerine rağmen düşük süneklik ve sınırlı çekme dayanımları nedeniyle sismik etkiler altında daha kırılğan bir davranış sergilediğini göstermektedir. Buna karşılık, ahşap karkas sistemlerin düşük kütleleri, sünek karakterleri ve enerji sönümleme kapasiteleri sayesinde deprem etkilerini daha dengeli ve kontrollü biçimde karşılayabildiği anlaşılmaktadır.

Hasar oluşumu bakımından yığma yapılarda çatlakların hızla ilerleyerek ayrışma ve göçmeye dönüşme eğiliminde olduğu; ahşap karkas yapılarda ise hasarın çoğunlukla birleşim bölgelerinde yoğunlaştığı, buna rağmen sistem bütünlüğünün daha uzun süre korunabildiği görülmektedir. Ayrıca, kütle farkına bağlı olarak yığma yapıların daha yüksek atalet kuvvetlerine maruz kaldığı, ahşap karkas yapıların ise hafiflikleri sayesinde daha düşük deprem yükleri ile karşılaştığı belirlenmiştir. Bu durum, ahşap karkas sistemlerin sismik davranış açısından avantajlı olmasına katkı sağlamaktadır. Ahşap karkas ve yığma yapı sistemlerinin deprem davranışı açısından öne çıkan farklılıkları Tablo 2’de özetlenmiştir.

Tablo 2. Ahşap karkas ve yığma yapı sistemlerinin deprem davranışı açısından karşılaştırılması

Kriter	Ahşap Karkas Yapılar	Yığma Yapılar
Yapısal Davranış	Sünek ve esnek davranış gösterir	Rijit ve gevrek davranış gösterir
Süneklik (Ductility)	Yüksek	Düşük
Ağırlık (Kütle)	Hafif yapı sistemi	Ağır yapı sistemi
Atalet Kuvvetleri (Deprem Yüğü)	Daha düşük atalet kuvveti	Daha yüksek atalet kuvveti
Enerji Sönümlenme Kapasitesi	Yüksek (bağlantı ve sürtünme ile)	Düşük
Malzeme Davranışı (Basınç/Çekme)	Çekme ve basınçta dengeli	Basınç dayanımı iyi, çekme dayanımı zayıf
Hasar Mekanizması	Bağlantı noktalarında lokal hasar	Çatlak, ayrışma ve ani göçme
Hasarın Gelişimi	Kademeli	Ani ve kırılğan
Sistem Bütünlüğü	Uzun süre korunabilir	Çatlak sonrası hızla bozulur
Bağlantı Detaylarının Önemi	Kritik (iyi tasarım performansı artırır)	Zayıf detaylar hızlı hasara yol açar
Zemin ve Plan Düzensizliğine Tepki	Daha toleranslı	Daha hassas
Göçme Davranışı	Kademeli göçme (can güvenliği avantajlı)	Ani göçme (riskli)
Genel Sismik Performans	Daha avantajlı	Daha dezavantajlı

Değerlendirmelere göre ahşap karkas yapıların süneklik, enerji sönümlenme kapasitesi ve hasarın gelişim biçimi açısından daha elverişli bir davranış sergilediği; yığma yapıların ise rijit fakat kırılğan karakterleri nedeniyle daha ani hasar mekanizmalarına yatkın olduğu açıkça görülmektedir. Bununla birlikte, her iki sistemde de malzeme kalitesi, yapım tekniği ve özellikle bağlantı detaylarının yapı performansını belirleyen temel unsurlar olduğu unutulmamalıdır. Bu bağlamda, geleneksel yapı sistemlerinin değerlendirilmesinde ahşap karkas yapıların deprem davranışı açısından daha güvenli bir alternatif sunduğu, ancak her iki sistemde de doğru tasarım ve uygulama kararlarının yapı güvenliği açısından belirleyici olduğu sonucuna ulaşılmaktadır.

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FROM TRADITIONAL STUDIOS TO VIRTUAL ENVIRONMENTS: DIGITAL TRANSFORMATION IN ALGERIAN ARCHITECTURAL EDUCATION

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Abstract:

This paper explores how the digital transformation has affected architectural education in Algeria with a particular reference to the shift of conventional studio settings to virtual environments. The research question is whether these digital tools are effective in enhancing the learning outcomes and development of skills among architecture students. The approach of the study, based on a thorough methodology comprising both qualitative and quantitative data obtained in the form of surveys, interviews, and case studies, demonstrates that learners and educators see a lot of positive aspects that go along with virtual learning settings, including more flexibility, a higher degree of collaboration, and the ability to access more resources, though issues concerning the technological availability and personal interaction are also observed. These results also indicate that digital tools should be incorporated into the architectural education program as it can not only enhance the learning experience but also make the educational process correspond to the new requirements of the architecture profession. The implication of this study goes beyond the academic sphere, with the overall shift to digital practices possibly opening innovation and adaptation in the field, thereby making a positive contribution to the future of architectural practices in Algeria. Additionally, with the changing nature of architectural education in line with modern changes in technology, the lessons learned can also serve to inform other fields of learning, which necessitates the development of educational models that can promote digital literacy and flexibility in a more and more digitalized world.

Keywords: Architectural Education; Digital Transformation; Virtual Design Studios; E-Learning in Architecture; Hybrid Learning Environments.

ARCHITECTURAL EDUCATION REFORM IN ALGERIA: TRANSITIONING FROM TRADITIONAL METHODS TO MODERN APPROACHES

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Abstract:

This paper handles the burning question of how architecture education in Algeria can be transformed out of the traditional pedagogical approach to modern approaches that will help to improve learning experience of future architects by improving curriculum, teaching methods and integration of technologies. The study pinpoints the important challenges and opportunities involved in this transition by using a mixed-methods design that includes qualitative interviews with educators and students, and quantitative surveys that evaluate existing educational practices and perceptions of the needed changes. The most important insights are that although the conventional approach is still prevalent, there is a strong agenda to change on the part of stakeholders that shows that there is awareness that an educational framework that is responsive to current architectural practices and needs is urgently needed. It is important to note that students indicated their deep interest in the use of digital tools and project-based learning, which included collaborative learning which was associated with a higher level of engagement and relevance to the studies. The relevance of these results is not limited to the field of architecture as it implies that a redesigned educational environment can result in an increased level of innovation and versatility across many other fields and sectors, such as healthcare, which is becoming more dependent on the principles of design thinking and sustainability. This paper highlights the need to reform architectural education in Algeria and proposes a strategic change that would not only improve the standards of education, but also lead to the general socio-economic development of the country, thus creating a generation of architects who will meet future challenges in a dynamic global environment.

Keywords: Architectural Education; Pedagogical Reform; Design Studio Pedagogy; Digital Transformation in Architecture; Interdisciplinary Learning.

LİNALOOL, SIÇANLARDA SİSPLATİN İLE İNDÜKLENEN KALP HASARINDA SRC PROTEİNİ ÜZERİNDE DÜZENLEYİCİ BİR ETKİ GÖSTERİR

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ÖZET

Testis ve yumurtalık kanserleri başta olmak üzere serviks, melanom, mesane, kolorektal, mide ile baş ve boyun kanserlerinin tedavisinde kullanılan sisplatin, klinikte en yaygın kullanılan antikanser ilaçlardan biridir. Sisplatin, kanser hücrelerinin DNA'sına zarar vererek önemli bir avantaj sağlasa da, kalp, böbrek ve karaciğer gibi hayati öneme sahip organlarda toksisiteye neden olarak ciddi dezavantajlar oluşturabilir. Bu çalışmada, antioksidan etkili doğal monoterpenlerden olan linaloolün, sıçanlarda sisplatin ile indüklenen kalp hasarında c-Src fosforilasyonu üzerine modüle edici etkisinin ortaya koyulması amaçlandı. Bu çalışmada, 28 erkek Wistar albino sıçan dört gruba ayrıldı: Kontrol (0.5 ml salin, i.p., 10 gün boyunca, günde 1 kez), sisplatin (7 mg/kg, tek doz, i.p., çalışmanın 1. gününde), linalool (200 mg/kg, oral yolla, 10 gün boyunca, günde 1 kez) ve sisplatin + linalool (7 mg/kg dozda sisplatin, tek doz, i.p., çalışmanın 1. gününde + 200 mg/kg dozda linalool, oral yolla, 10 gün boyunca, günde 1 kez). Son linalool uygulamasından 24 saat sonra ksilazin-ketamin anestezisi altında sakrifiye edilen sıçanlardan toplanan kalp dokularında c-Src ve p-c-Src proteinlerinin ekspresyon seviyeleri, Western blot analizi kullanılarak analiz edildi. Sisplatin uygulamasının kalp dokusunda p-c-Src/c-Src ekspresyon oranını, kontrol grubuna kıyasla anlamlı olarak arttırdığı gözlemlendi ($P<0.05$). Sisplatin + linalool grubunda, p-c-Src/c-Src oranının sisplatin grubuna kıyasla anlamlı olarak azaldığı gözlemlendi ($P<0.05$). Sonuç olarak, bulgularımız linaloolün, apoptoz gibi hücresel süreçleri düzenlemede rol oynayan c-Src fosforilasyonunu modüle ederek, kanser tedavisinde sisplatin kullanımına bağlı kardiyotoksik etkileri hafifletmede etkili olabileceğini düşündürmektedir.

Anahtar Kelimeler: Sisplatin, linalool, kardiyotoksisite, c-Src

LINALOOL EXERTS A MODULATORY EFFECT ON THE SRC PROTEIN IN CISPLATIN-INDUCED HEART DAMAGE IN RATS

ABSTRACT

Cisplatin, used primarily in the treatment of testicular and ovarian cancers, as well as cervical, melanoma, bladder, colorectal, stomach, and head and neck cancers, is one of the most widely used anticancer drugs in clinical practice. Although cisplatin provides a significant advantage by damaging the DNA of cancer cells, it can also cause serious disadvantages by inducing

toxicity in vital organs such as the heart, kidneys and liver. In this study, it was aimed to determine the modulating effect of linalool, a natural monoterpene with antioxidant properties, on c-Src phosphorylation in cisplatin-induced cardiac injury in rats. In this study, 28 male Wistar albino rats were divided into four groups: Control (0.5 ml saline, i.p., once daily for 10 days), cisplatin (7 mg/kg, single dose, i.p., on the first day of the study), linalool (200 mg/kg, orally, once daily for 10 days), and cisplatin + linalool (cisplatin at a dose of 7 mg/kg, single dose, i.p., on the first day of the study, plus linalool at a dose of 200 mg/kg, orally, once daily for 10 days). The expression levels of c-Src and p-c-Src proteins in heart tissue samples collected from rats that were sacrificed under xylazine-ketamine anaesthesia 24 h after the final linalool administration were analyzed using Western blot analysis. Cisplatin administration was observed to significantly increase the p-c-Src/c-Src expression ratio in heart tissue compared to the control group ($P < 0.05$). In the cisplatin + linalool group, the p-c-Src/c-Src ratio was observed to be significantly decrease compared to the cisplatin group ($P < 0.05$). In conclusion, our findings suggest that linalool may be effective in mitigating cardiotoxic effects associated with cisplatin use in cancer treatment by modulating c-Src phosphorylation, which plays a role in regulating cellular processes such as apoptosis.

Keywords: Cisplatin, linalool, cardiotoxicity, c-Src

RÜZGÂR EROZYONUNA UĞRAMIŞ ALANLARDAKİ KUMLU BİR TOPRAĞIN AGREGAT STABİLİTESİ VE SU POTANSİYELİNE ATIK ARAÇ LASTIĞI BİYOKÖMÜRÜNÜN ETKİSİNİN BELİRLENMESİ

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ÖZET

Otomotiv sektöründeki büyüme ile artan hurda lastik hacmi ve doğada zor parçalanan yapıları nedeniyle ciddi bir çevresel tehdit oluşturmaktadır. Bu atıkların ekolojik ve ekonomik verimlilikle geri kazandırılması sürdürülebilir yönetimi için zorunludur. Bu kapsamda, atık lastiklerin piroliz yöntemiyle elde edilen biyokömür (biochar); toprak ıslahı ve sürdürülebilir tarım uygulamalarında yenilikçi ve çevre dostu bir çözüm olarak öne çıkmaktadır. Bu amaçla atık lastikler, oksijensiz ortamda, azot gazı atmosferinde, 500°C sıcaklıkta, 0,5-1 litre/dakikalık azot gazı akışı altında 3 saat piroliz işlemine tabi tutulmuştur. Elde edilen biyokömür mikronize bir şekilde öğütülmüş ve karakterizasyon özellikleri belirlenmiştir. Elde edilen biyokömür, rüzgâr erozyona maruz kalmış kum içeriğe yüksek olan bir toprağa farklı dozlarda (%1.25, %2.5 ve %5) uygulanarak, tarla kapasitesi nem içeriğinde 60 günlük inkübasyona bırakılmıştır. İnkübasyon sonunda, atık lastik biyokömürü uygulamalarının düşük organik madde içeriği, zayıf agregasyon ve düşük su tutma kapasitesine sahip olan kumlu toprağın agregat stabilitesi ve toprak su potansiyeline (-33 kPa) etkileri belirlenmiştir. Buna göre; atık lastikten elde edilen biyokömürün toprakların su tutma karakteristiğine ve agregasyon özelliklerine olumlu yönde etkileri belirlenmiştir. Bu doğrultuda bu atıkların çevreye olumsuz zararları minimize edilerek çevre dostu bir çözüm yöntemi geliştirilmiştir.

Anahtar Kelimeler: Atık lastik, Piroliz, Biyokömür, Agregat stabilitesi, Toprak su potansiyeli

DETERMINING THE EFFECT OF WASTE VEHICLE TIRE BIOCHAR ON AGGREGATE STABILITY AND WATER POTENTIAL OF A SANDY SOILS IN WIND EROSION-AFFECTED AREAS

ABSTRACT

The increasing volume of scrap tires due to growth in the automotive sector and their difficult-to-decompose nature pose a serious environmental threat. Ecologically and economically efficient recycling of these wastes is essential for their sustainable management. In this context, biochar obtained from waste tires through pyrolysis stands out as an innovative and

environmentally friendly solution in soil remediation and sustainable agricultural practices. For this purpose, waste tires were subjected to pyrolysis for 3 hours in an oxygen-free environment, in a nitrogen gas atmosphere, at a temperature of 500°C, and under a nitrogen gas flow of 0.5-1 litre/minute. The resulting biochar was micronized, and its characterization properties were determined. The biochar was applied to soil with high sand content and subjected to wind erosion at different doses (1.25%, 2.5%, and 5%) and incubated for 60 days at field capacity moisture content. After incubation, the effects of waste tire biochar applications on the aggregate stability and soil water potential (-33 kPa) of sandy soil with low organic matter content, poor aggregation, and low water retention capacity were determined. Accordingly, it was determined that biochar obtained from waste tires has positive effects on the water retention characteristics and aggregation properties of soils. In this respect, an environmentally friendly solution method has been developed by minimizing the negative environmental damage of these wastes.

Keywords: Waste tire, Pyrolysis, Biochar, Aggregate stability, Soil water potential

1. INTRODUCTION

The rapid growth of the world's population, the expansion of industrialisation to new levels, and the desire to raise living standards are leading to an increase in the volume of solid waste on a global scale. This situation is becoming even more pronounced, particularly in developing countries, due to the rise in the number of vehicles. The development of the automotive sector is directly linked to national economies, and the tyre industry constitutes a significant branch of this sector. Globally, over 1 billion tyres are sold each year, and the tyre market is growing rapidly. However, this growth is also increasing the volume of waste generated after use, leading to serious environmental problems. The explosive growth of the automotive sector and the rising number of vehicles have increased the annual production of tyres. Approximately 1.5 billion tyres are produced worldwide each year, and the primary reason for this increase is the continuous rise in the number of passenger vehicles (Williams, 2013). On the other hand, the annual volume of scrap tyres exceeds 17 million tonnes, and this figure is projected to reach 1.2 billion tonnes by the end of 2030 (Chen et al., 2022). The management of this vast quantity of waste tyres poses significant environmental and economic challenges. As a large proportion of scrap tyres contain hollow spaces, their transport and storage incur high costs. Furthermore, as these tyres accumulate over time, they become extremely durable and flammable, releasing hydrocarbons, toxic metals and other pollutants, thereby posing serious risks of fire and environmental pollution. Furthermore, the voids within tyres allow water to accumulate,

creating suitable habitats for rodents, insects and reptiles, thereby increasing the risk of disease transmission. Current research indicates that approximately 75% of waste tyres worldwide end up in landfills, leading to significant environmental and health issues. As tyres do not biodegrade, when disposed of in landfills, they shorten the lifespan of landfill sites and, over time, tend to surface, damaging the landfill cover. Consequently, if not managed properly, tyre waste can lead to serious health, safety and environmental issues. Tyre recycling is therefore of great importance in preventing these problems. Through recycling methods, the environmental and health impacts of used tyres can be reduced, and value can be derived from waste tyres. Various studies have demonstrated that scrap tyres can be reused in diverse sectors when processed into whole, shredded, or granulated forms (Lehmann and Joseph, 2015). By developing sustainable waste management strategies, the environmental impacts of waste tyres can be minimised, and these materials can be utilised across different sectors. In this context, the promotion of tyre recycling and the encouragement of sustainable waste management practices play a critical role in mitigating environmental issues. On average, a tyre consists of 14% natural rubber, 27% synthetic rubber, 28% carbon black, 14% steel and 16% other chemical and filler materials (Rogachuk and Okolie, 2023). The negative environmental impacts of waste tyres and their recycling potential make it imperative to utilise these materials through more efficient and sustainable methods. In this context, biochar produced through the pyrolysis of waste tyres is emerging as an innovative product of note in sustainable agriculture and soil improvement applications. Biochar is a high-carbon material formed by the pyrolysis of organic matter at high temperatures between 300–700 °C in an environment with very low or no oxygen (Lehmann et al., 2006; Verheijen et al., 2010). Biochar produced through the pyrolysis process can be used as a soil conditioner to improve the physical, chemical and biological properties of the soil, thereby enhancing soil health and productivity (Lehmann and Joseph, 2015). The contributions of biochar to soil structure are noteworthy. This material increases the soil's water-holding capacity, facilitating plant access to water during dry periods. It also improves aeration and drainage, providing a more favourable environment for root development. Another key advantage of biochar is its ability to stabilise soil structure, thereby reducing the risk of erosion. Research has shown that biochar improves acidic or alkaline soil conditions by regulating soil pH balance (Lehmann and Joseph, 2015). Furthermore, various studies have demonstrated that it enhances the retention of nutrient elements (nitrogen, phosphorus, potassium, etc.) in the soil and increases their availability to plants (Glaser et al., 2002). Its potential to reduce soil toxicity by binding heavy metals is also widely documented

in the literature (Beesley et al., 2011). Biochar is also an effective soil conditioner in terms of supporting biological activity. It promotes microbial activity by creating a suitable habitat for beneficial microorganisms. By increasing the amount of organic matter in the soil, it enriches biological diversity and supports plant growth and root development. The long-term benefits provided by biochar are also noteworthy. Recent research has demonstrated that biochar is effective in carbon sequestration and thus contributes to a significant reduction in greenhouse gas emissions in the atmosphere (Woolf et al., 2010). Furthermore, biochar's long-term carbon storage capacity plays a critical role in enhancing environmental sustainability in agricultural activities (Smith, 2016). Whilst helping to reduce greenhouse gas emissions through carbon sequestration, it ensures the sustainability of soil fertility. By reducing the need for chemical fertilisers, it lowers agricultural costs and minimises negative environmental impacts. Furthermore, the heavy metal content of the waste tyre-derived biochar to be used in the study falls below the permitted limit values specified in both the European Biochar Certification and the Ministry of Food, Agriculture and Livestock's regulations on organic and mineral-based fertilisers used in agriculture. Taking all these factors into account, the potential offered by biochar produced from waste tyres is considerable in terms of both agriculture and the environment. Comprehensive research and applications in this field will enhance the effectiveness of biochar and make significant contributions to sustainable agricultural policies.

2. MATERIALS AND METHODS

The study was designed as a 60-day incubation experiment conducted under laboratory conditions. The research utilised soil with a high sand content, with soil samples collected from areas in the Karapınar region that had been exposed to wind erosion. These soils have low water-holding capacity due to their low organic matter and clay content and are highly susceptible to drought and wind erosion. Soil samples were collected from 15–20 different points across the selected plots at a depth of 0–20 cm. After being brought to the laboratory, the samples were air-dried and sieved through a 4 mm sieve before being used in the incubation experiment. The waste tyres used as a soil conditioner were obtained from a recycling plant operating in Konya, having been shredded to a size of 4–8 mm. The waste tyres were dried by holding them at 105 °C for 24 hours and subsequently subjected to a pyrolysis process for 3 hours at 500 °C in a digitally controlled pyrolysis unit, under a nitrogen gas flow rate of 0.5–1 litre per minute. During the incubation period, soil moisture was maintained at approximately field capacity, and soil samples were taken at the end of the 60-day incubation period for analysis. The analyses and some physical and chemical properties of the biochar are presented

in Table 1. According to this, the soil sample has a slightly alkaline pH, whilst the biochar has a strongly alkaline pH. Both materials exhibit salinity issues. The soil sample's lime content falls within the very high lime class, and its texture is sandy clay loam.

Table 1. Initial properties of soil and biochar

Parameter	Units	Soil	Biochar
pH (1:2,5)	-	7,91	8,64
Electrical conductivity (EC)	µS/cm	143	145,23
Calcium carbonate (CaCO ₃)	%	57,5	-
Sand	%	56,73	-
Clay	%	26,57	-
Silt	%	16,69	-
Texture	-	Sandy clay loam	-
Field capacity	%	23,28	-
Wilting point	%	10,63	-
Particle density	g cm ⁻³	2,62	-

2.1. Incubation Study

In the incubation study, 3 kg soil samples, weighed on an oven-dry basis, were placed in plastic pots to set up the experiment. Waste tyre biochar was added separately to the prepared pots at rates of 0%, 1.25%, 2.5% and 5% by weight, with four replicates. Accordingly, the experiment was conducted with 1 soil, 1 material, 4 doses and 4 replicates (1×1×4×4=16 pots). To initiate incubation, the pot contents were moistened with an amount of distilled water sufficient to bring them to field capacity. The samples adjusted to field capacity were left to incubate under laboratory conditions for 60 days, with weekly weighings carried out and any lost water replenished. At the end of the incubation period, soil samples were taken from the pots and the necessary analyses were performed. Furthermore, the initial properties of the biochar were also analysed and determined using the soil samples.

Texture determination: This was carried out using the Bouyoucos hydrometer method (Gee and Bauder, 1986).

Soil water potential: The amounts of water retained at pressures of 33 and 1500 kPa were determined using a sand box, a pressure plate and a ceramic plate (Klute, 1986).

pH: Measured using a glass-electrode, digital pH meter in a 1:2.5 soil:distilled water and a 1:10 biochar:distilled water mixture (McLean, 1982).

Electrical conductivity (EC): Measured using an electrical conductivity meter in a 1:2.5 soil:distilled water and a 1:10 biochar:distilled water mixture (Rhoades, 1982).

Lime: Determined by measuring the volume of CO₂ released from carbonates following the soil's reaction with dilute hydrochloric acid in a Scheibler calcimeter (Nelson, 1982).

Aggregate Stability (AS): Aggregate stability was determined using the Yoder wet sieving method (Kemper and Rosenau, 1986). For this purpose, air-dried soil samples passed through 2 mm and 1 mm sieves were placed in a wet sieving apparatus equipped with an 8-pan sieve set. The apparatus performs eight analyses simultaneously using 0.25 mm sieves. The apparatus has a vertical travel distance of 1.3 cm and operates at 34 immersion cycles per minute. The samples were subjected to vertical oscillation in water for a specified duration; at the end of the process, the aggregate quantities remaining on the sieves were dried and weighed, and the percentage of water-resistant aggregate was calculated.

Particle density: The 'pycnometer method' will be used to determine particle density (Blake and Hartge, 1986a).

Analysis of variance (ANOVA) and comparisons of means between treatments (Tukey's test at the 0.05 level) were performed using SPSS statistical software.

3. RESULTS AND DISCUSSION

3.1. Effect on Water Holding Capacity

The effects of biochar applications on the water-holding properties of sandy loam-textured soil are presented in Figures 1, 2 and 3.

According to the results obtained, biochar applications resulted in significant increases in field capacity values which indicate the soil's maximum water-holding capacity compared to the control and depending on the application rate ($p < 0.00$). The field capacity value, determined as 16.488% in the control sample, showed an increase of 11.40% with a 1.25% biochar application, 5.73% with a 2.5% biochar application, and 22.13% with a 5% biochar application (Figure 1). This demonstrates that biochar applications significantly improve the water-holding capacity of sandy clay loam soils, which is typically a limiting factor. Increasing the water-holding capacity of soils enables more effective utilisation of rainfall and enhances the water-use efficiency of plants, particularly in arid and semi-arid regions. In this context, biochar applications are considered an important method that can contribute to the more efficient, effective and sustainable use of water resources.

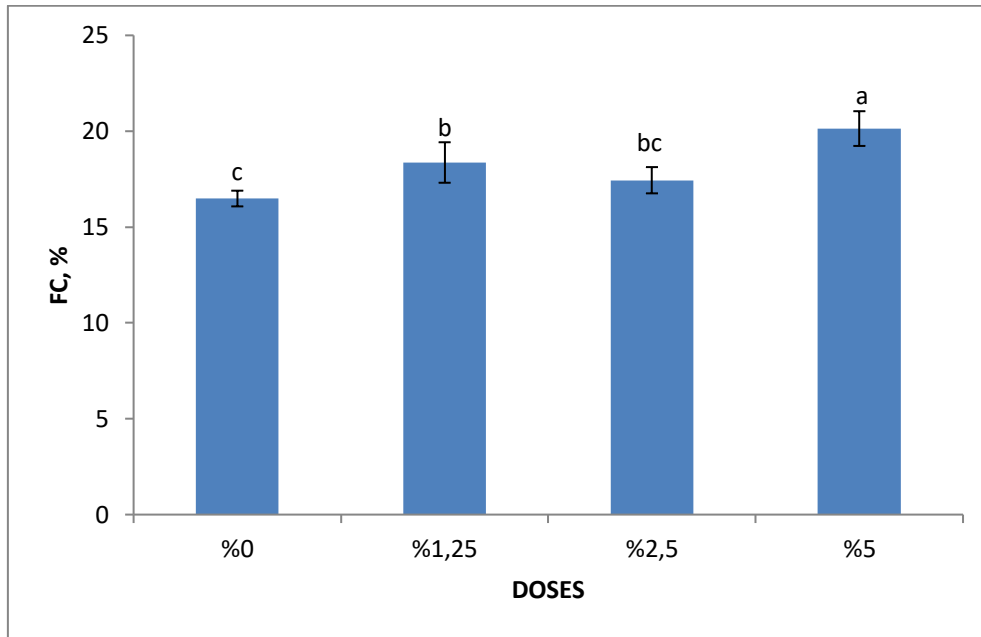


Figure 1. Effects of Biochar Applications on Field Capacity (FC)

At a wilting point (WP) value of 9.82% measured in the control soil, a 1.25% BC application resulted in a 10.61% increase, a 2.5% BC application resulted in a 14.90% increase, and a 5% BC application resulted in a 25% increase (Figure 2). This indicates that the biochar applications resulted in a limited increase in the wilting point value of the sandy loam soil. When compared to the control, the highest increase was observed with the 5% biochar application, whilst the 1.25% and 2.5% biochar applications fell within the same range.

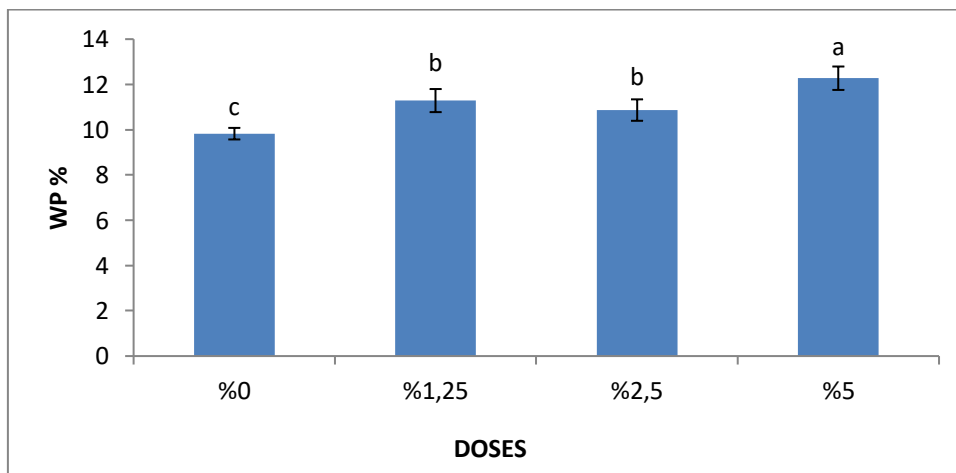


Figure 2. Effects of Biochar Applications on the Wilting Point (WP)

The soil’s available water capacity is a key parameter determining the extent to which plants utilise water from both rainfall and irrigation. Consequently, applications aimed at increasing available water capacity are of great importance for the sustainable use of water and soil

resources. In the present study, the effective water capacity value, determined as 9.824% in the control soil, increased by 18.46% with the 5% biochar application, reaching the highest level. In contrast, the increases observed in the 1.25% and 2.5% biochar applications were found to be statistically insignificant (Figure 3). The results indicate that biochar applications partially improved the water-holding capacity of the sandy loam soil, which initially had a low water-holding capacity. However, when all biochar applications were evaluated collectively, it was determined that water-holding capacity values increased compared to the control, and that this increase was significant.

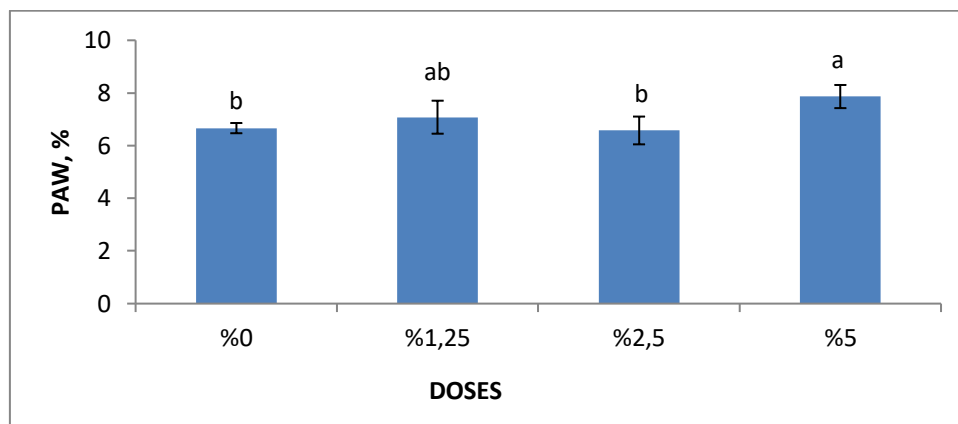


Figure 3. Effects of Biochar Applications on Available Water (PWC)

The natural inability of sandy soils to retain water is the fundamental physical constraint directly limiting agricultural productivity in these areas. The analyses conducted and the graphs produced demonstrate the significant role played by biochar application in overcoming these constraints. The macro-porous structure of sandy soils, which causes water to drain away rapidly, is stabilised by biochar’s highly porous matrix with a large surface area. Extensive data in the literature also supports this change. A meta-analysis conducted by Ibrahim and Alghamdi (2022) found that applications worldwide increased the available water capacity in sandy soils by an average of 28.5%. In the present study, the widening of the gap between Field Capacity (FC) and Wilting Point (WP) aligns with this literature and demonstrates an increase in the amount of ‘available water’ ready for plant uptake. Indeed, in a study by Aygün (2023), it was reported that biochar retained soil water content by 6.6% more than the control group and that moisture was maintained in the soil profile for a longer period.

Consequently, this improvement in water-holding capacity, as observed in the graphs, demonstrates that biochar acts not merely as a physical filler in sandy soils, but also as an active

hydraulic regulator. This structural change, which supports plant growth particularly during dry periods, emerges as a sustainable soil improvement strategy in water-constrained regions.

3.2. The Effect of Biochar on Aggregate Stability

Soil aggregates are one of the most important factors determining the physical properties of soil; they have a direct impact on water retention, air movement and root development. Aggregates with a robust and stable structure ensure that water remains in the soil for longer, whilst also reducing the risk of surface runoff and erosion. Thanks to these properties, they contribute to the preservation of soil fertility. In this context, aggregate stability is regarded as a key indicator for both sustainable soil use and healthy plant growth.

The aggregate stability value, measured at 19.24% in the control soil, increased by approximately 10.13% with a 1.25% BC application, by 73.17% with a 2.5% BC application, and by 120% with a 5% BC application (Figure 4). This indicates that the applied BC treatments have a significant positive effect on the aggregate stability of the sandy clay loam soil. When compared to the control, the 1.25% biochar application resulted in a limited increase, whilst the 2.5% and 5% biochar applications caused a very significant increase. These results indicate that biochar applications improve soil aggregation and enhance structural stability, particularly at high doses, but that the effect remains more limited at low doses.

When examining the effects of biochar applications on soil aggregate stability, a clear trend of improvement emerged in parallel with increasing application rates. The results indicate that a high-dose biochar application (5%) significantly increased aggregate stability, positively affecting the resilience of the soil structure. It was determined that this effect was more limited at low doses, but that aggregate formation increased visibly as the dose was raised. Within the scope of the research, it was found that the highest increase, compared to the control treatment, reached approximately 120% at a 5% biochar dose; this finding clearly demonstrates biochar's supportive role in aggregate formation.

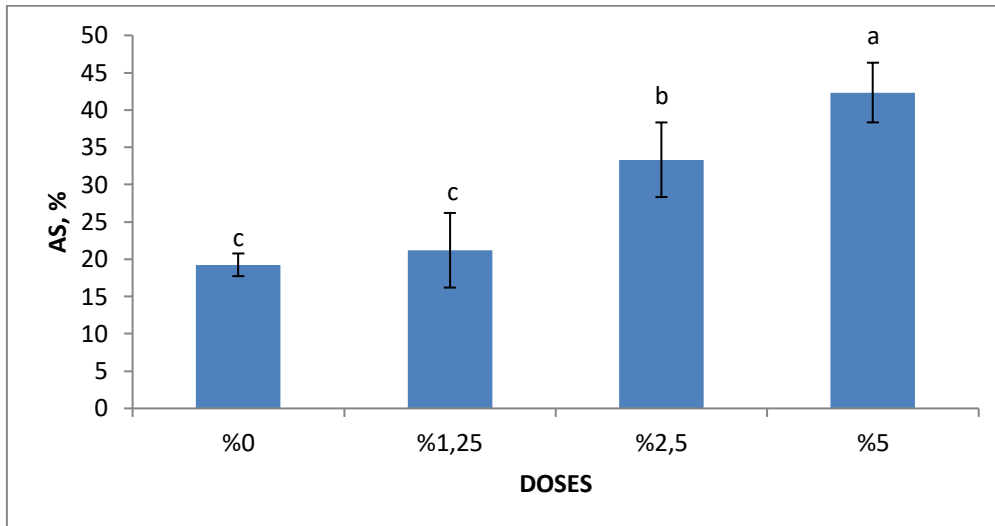


Figure 4. Effect of Biochar Applications on Aggregate Stability (AS)

These findings are supported by studies in the literature. Indeed, some studies have reported that biochar applications result in statistically significant increases in aggregate stability ($p < 0.05$) and that this effect becomes more pronounced as the application rate increases. For example, it has been stated that biochar applications at different rates (5, 10, 20 and 40 g/kg) resulted in increases in aggregate stability of 3%, 27%, 178% and 189%, respectively, compared to the control group (Gümüő, İ., Negiő, H., & Őeker, C. (2019). Furthermore, a study conducted on sandy soils demonstrated that the addition of at least 9.1% biochar stabilised the aggregate structure and, consequently, significantly increased the amount of water available to plants (Baiaamonte et al., 2019). Similarly, it has been reported that the application of biochar and compost in sandy loam soils increases aggregate stability by up to 25% (Őeker and Manirakiza, 2020). These results clearly demonstrate that biochar improves soil physical properties by enhancing aggregate formation and stability in different soil types.

3.3. Effects of Biochar on pH and Electrical Conductivity

The effects of biochar applications on the pH and EC of sandy loam soil are presented in Figures 5 and 6.

A partial increase in the pH value, measured at 8.29 in the control soil, was observed with the 1.25% biochar application. No increase was detected in the other doses. This indicates that the biochar applications caused a partial increase in the pH value of the sandy loam soil.

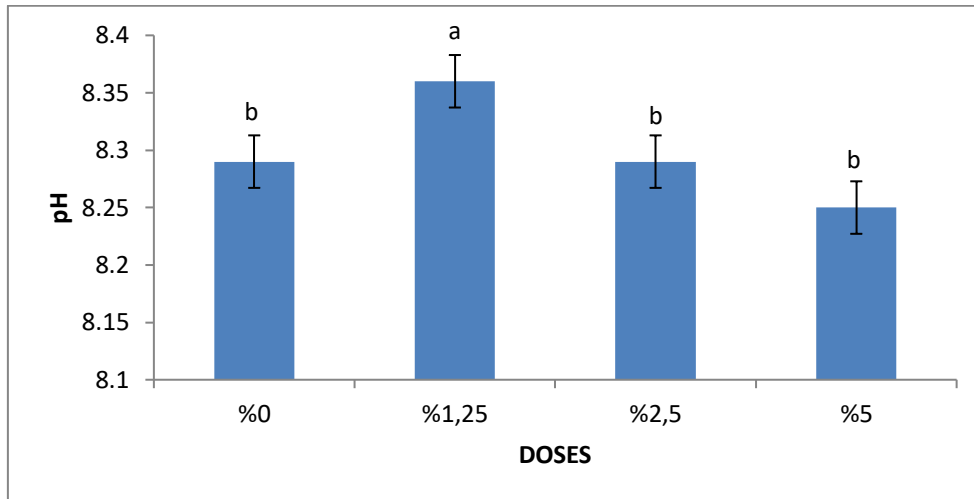


Figure 5. Effects of Biochar Applications on pH

The EC value, measured at 403.25 in the control soil, increased by 61.19% with the 5% biochar application and by 14.63% with the 2.5% biochar application (Figure 5). This indicates that the biochar applications resulted in an increase in the electrical conductivity (EC) value of the sandy loam soil.

In this context, it has been shown that biochar applications increase the EC value by contributing soluble ions to the soil, but do not pose a problem in terms of salinity, particularly at high doses.

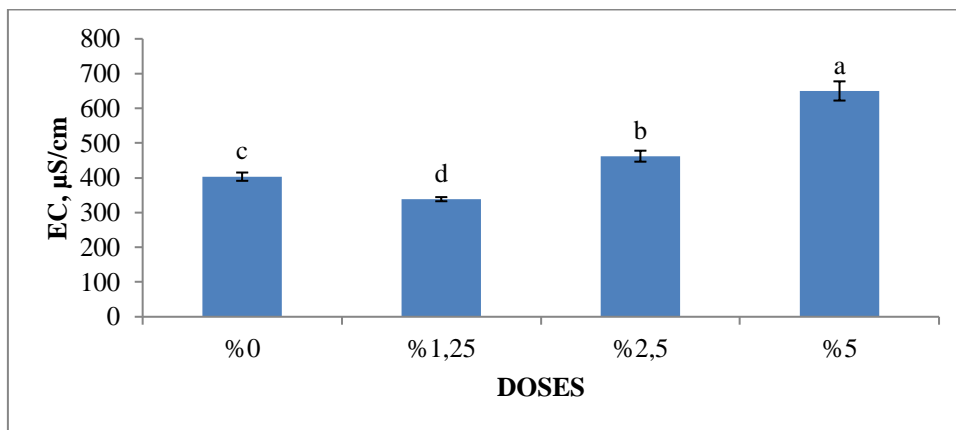


Figure 6. Effects of Biochar Applications on Electrical Conductivity (EC)

When examining the effects on sandy soil in relation to increasing biochar (BC) doses, certain increases were observed in pH and Electrical Conductivity (EC) values. While the changes in pH were negligible, they led to significant increases in EC values. This indicates that biochar applications exert a more pronounced effect on electrical conductivity by increasing the soluble salt content of sandy loam soil, whereas they cause only a limited change in pH.

As biochar generally exhibits alkaline properties, it helps balance pH levels, particularly in acidic soils, thereby enhancing the availability of nutrients to plants. Some studies have shown

that by increasing the soluble salt content, it exerts a more pronounced effect on electrical conductivity, whilst causing only a limited change in pH.

Soil pH is generally accepted as an important parameter reflecting the soil's chemical fertility, and it is known that many macro- and micro-nutrients are taken up more effectively by plants under slightly acidic conditions. It has been reported that applications of walnut shell-derived biochar produced at 700 °C at concentrations of 0.5% and 1% have a beneficial effect on soil pH (Novak et al., 2009). When evaluated in terms of nutrient availability, it is stated that the addition of biochar has a significant effect on soil pH and that significant increases in pH values were observed following application (Southavong et al., 2012). Furthermore, it has been demonstrated that the application of biochar obtained via pyrolysis at 400 °C to acidic sandy soils raises the pH value (Peng et al., 2011).

In this context, it is assessed that the pH increases identified in the study stem from the biochar's alkaline nature, whilst the rise in EC is related to the transfer of soluble salts and ions present in its structure into the soil solution. The findings are consistent with those in the literature, which report that biochar applications raise soil pH and, consequently, improve the availability of nutrients to plants (Lustosa Carvalho et al., 2020). However, the increase in EC values observed, particularly with high-dose biochar applications, indicates that caution is required regarding the accumulation of salinity in the soil. Therefore, determining appropriate application rates for biochar is of great importance both for sustainably enhancing soil fertility and for preventing potential adverse effects.

CONCLUSION

This study was conducted to determine the effects of biochar, produced from waste vehicle tyres using the pyrolysis method, on the physical and chemical properties of sandy-clay loam soils exposed to wind erosion. The data obtained at the end of the 60-day laboratory incubation period demonstrated that waste tyre biochar offers an innovative, environmentally friendly solution for soil remediation and sustainable agricultural practices. According to the research findings, biochar applications resulted in significant increases in field capacity values which represent the soil's maximum water-holding capacity compared to the control, and these increases were dependent on the application rate. In particular, the application of 5% biochar resulted in a 22.13% increase in field capacity, whilst also increasing the available water capacity by 18.46%, reaching the highest level. This demonstrates that biochar, thanks to its highly porous structure, plays an active role as a hydraulic regulator in overcoming the natural limitations of sandy soils regarding water retention. When examined in terms of soil structural

stability, it was found that biochar provided a very significant improvement in aggregate stability. The aggregate stability value, which was 19.24% in the control soil, increased by 120% with a 5% biochar application, significantly strengthening the soil structure's resistance and resilience against erosion. In terms of chemical properties, whilst a slight increase in soil pH was observed due to the alkaline nature of biochar, rises of up to 61.19% in electrical conductivity (EC) values were recorded due to the effect of soluble ions in its structure; however, it was determined that these values do not pose a salinity risk from an agricultural perspective. Consequently, the conversion of waste vehicle tyres which are difficult to degrade in nature into biochar for use as a soil conditioner both minimises the risks of environmental pollution and provides an ecological and economic benefit by improving the physical quality of low-fertility sandy soils. In this context, waste tyre biochar is considered a sustainable strategy for the more efficient use of water resources and soil conservation in arid and semi-arid regions.

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MISIR ANIZI BİYOKÖMÜRÜNÜN VOLKANİK KÖKENLİ ASİDİK BİR TOPRAĞIN REAKSİYONU, SU TUTMA KAPASİTESİ VE AGREGASYONUNA ETKİLERİNİN BELİRLENMESİ

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ÖZET

Volkanik kökenli kumlu toprakların tamponlama kapasitelerinin düşük olması nedeniyle, bu toprakların pH değerleri asidik veya bazik karakterli gübre uygulamalarından hızlı bir şekilde etkilenebilmektedir. Nitekim volkanik kökenli ve kum tekstürlü Nevşehir–Niğde yöresi topraklarında patates yetiştiriciliğinde yoğun olarak kullanılan amonyum sülfat gübresinin toprak pH'ında önemli düşümlere neden olduğu belirlenmiştir. Toprak reaksiyonunda meydana gelen bu değişimler uzun vadede toprakların kimyasal dengesini bozarak organik madde içeriğinin azalmasına ve toprak verimliliğinin olumsuz etkilenmesine yol açabilmektedir. Biyokömür gibi organik kökenli materyallerin tarım topraklarına uygulanması, toprakların fiziksel, kimyasal ve biyolojik özelliklerini iyileştirerek bozulma etkilerinin azaltılmasına katkı sağlayabilmektedir. Bu nedenle yapılan çalışmada, mısır artıklarından elde edilen biyokömürün farklı dozlarının volkanik kökenli kumlu bir toprağın bazı toprak kalite özellikleri üzerine etkilerinin belirlenmesi amaçlanmıştır. Bu amaçla mısır anızı, oksijensiz ortamda, azot gazı atmosferinde, 500 °C sıcaklıkta, 10 °C dk⁻¹ ısıtma hızı ile 2 saat piroliz edilerek biyokömür elde edilmiştir. Elde edilen biyokömür (BC), mikronize büyüklükte öğütülerek, ağırlık esasına göre %0, %2, %4 ve %8 dozlarında kumlu toprak örneklerine uygulanmıştır. Toprak–biyokömür karışımları laboratuvar koşullarında iki ay (60 gün) süreyle inkübasyona bırakılmış ve inkübasyon süresince toprak nemi yaklaşık tarla kapasitesi düzeyinde tutulmuştur. İnkübasyon sonunda uygulamaların toprağın pH, elektiriki iletkenlik (EC), toprak su potansiyeli (-33 kPa (TK) ve -1500 kPa (SN)) ve agregat stabilitesine etkileri belirlenmiştir. Yapılan uygulamalar volkanik kökenli, kumlu bir toprağın özellikleri üzerinde değiştirici etkiler oluşturmuştur. Elde edilen sonuçların arazi şartlarında uygulanması ile toprakların sürdürülebilir kullanım ve yönetimine önemli katkılar sunma potansiyeli bulunduğu değerlendirilmiştir.

Anahtar Kelimeler: Mısır anızı, Piroliz, Biyokömür, Kumlu asidik toprak, Bitkiye faydalı su

EVALUATION OF THE EFFECTS OF MAIZ STRAW BIOCHAR ON THE REACTION, WATER HOLDING CAPACITY, AND AGGREGATION OF VOLCANIC-ORIGIN ACIDIC SOIL

ABSTRACT

Due to the low buffering capacity of volcanic-origin sandy soils, the pH values of these soils can be rapidly affected by acidic or alkaline fertilizer applications. Indeed, it has been determined that ammonium sulphate fertilizer, which is intensively used in potato cultivation in the volcanic-origin, sandy-textured soils of the Nevşehir–Niğde regions, causes significant decreases in soil pH. These changes in soil reaction can disrupt the chemical balance of the soil in the long term, leading to a decrease in organic matter content and negatively affecting soil fertility. The application of organic materials such as biochar to agricultural soils can contribute to reducing degradation effects by improving the physical, chemical, and biological properties of the soil. Therefore, this study aimed to determine the effects of different doses of biochar obtained from maize straw on some soil quality characteristics of a volcanic sandy soil. For this purpose, maize straw was pyrolyzed in an oxygen-free environment, in a nitrogen gas atmosphere, at a temperature of 500 °C, with a heating rate of 10 °C min⁻¹ for 2 hours to obtain biochar. The biochar (BC) was ground to micron size and applied to sandy soil samples at doses of 0%, 2%, 4%, and 8% by weight. The soil-biochar mixtures were incubated under laboratory conditions for two months (60 days), and soil moisture was maintained at approximately field capacity during the incubation period. At the end of incubation, the effects of the applications on soil pH, electrical conductivity (EC), soil water potential (-33 kPa and -1500 kPa), and aggregate stability were determined. The applications had modifying effects on the properties of a volcanic, sandy soil. It was assessed that the results obtained have the potential to contribute significantly to the sustainable use and management of soils when applied under field conditions.

Keywords: Corn stover, Pyrolysis, Biochar, Sandy acidic soil, Plant available water

1. INTRODUCTION

The rapidly growing global population, intensification of agricultural production, and the effects of climate change are increasingly placing pressure on soil resources. Years of intensive tillage, excessive use of chemical inputs, and unsustainable land management practices have led to a decline in soil organic matter, disruption of nutrient balance, and significant degradation of the physical, chemical, and biological properties of soils (Lal, 2004; Zhang et al., 2024; FAO, 2023). These processes are causing a decline in soil quality and jeopardizing the sustainability of agricultural production.

Soil acidification, a key component of soil degradation, has accelerated due to both natural processes and anthropogenic activities. In particular, acid rain resulting from air pollution and the long-term, high-dose application of ammonium-based nitrogen fertilizers lower soil pH, thereby accelerating the acidification process (Bolan et al., 2023; Reuss & Johnson, 2012 ; Zhou et al.,(2024)) . Increased aluminum solubility under acidic conditions, along with associated toxicity and nutrient imbalances, are among the primary factors limiting plant growth (Kochian et al., 2004; Chen et al., 2024).

Particularly in coarse-textured and organic-matter-poor soils, physical degradation such as low aggregate stability and insufficient water-holding capacity becomes more pronounced (Weil and Brady, 2016). In such soils, rapid water drainage limits the amount of water available to plants and negatively impacts productivity. These physical degradations in soil properties play a direct and decisive role in root development, nutrient uptake, and crop yield (Manirakiza and Şeker, 2018; Zhou et al., 2024).

While lime applications, commonly used in the rehabilitation of acidic soils, are effective in the short term, they may have limited impact on the comprehensive improvement of soil health in the long term (Adams, 1984; Manirakiza and Şeker, 2018; Chintala et al., 2014). This situation has become more pronounced, particularly in the Niğde and Nevşehir regions where potato farming is intensive, due to the long-term use of acidic fertilizers, and has posed a significant problem regarding the sustainability of soil quality (Gezgin, 2005). Consequently, the need to develop and apply alternative and environmentally friendly soil conditioning materials has emerged.

The application of organic materials is among the effective and sustainable approaches for improving soil quality. The addition of organic matter improves soil structure by promoting aggregate formation, increases water-holding capacity, and regulates nutrient cycling (Six et al., 2002; Lal, 2006). In this context, biochar has emerged as an important material in recent years for soil remediation and sustainable agricultural practices. Biochar is defined as a material obtained through the pyrolysis of biomass under oxygen-limited conditions, characterized by high carbon content and an aromatic, stable structure (Lehmann and Joseph, 2015).

The effects of biochar on soil properties are multifaceted and occur through both chemical and physical mechanisms. Due to its basic nature and the carbonate compounds it contains, it helps improve acidic soils by raising soil pH (Novak et al. 2009; Chintala et al., 2014; Nguyen et al., 2022), while also improving soil structure by enhancing aggregate stability (Pituello et al. 2018; Zhao et al., 2024). However, the effectiveness of biochar may vary depending on factors such

as the type of feedstock used and pyrolysis conditions (Gümüş et al. 2022; Wang et al. 2023; Chen et al., 2024).

Another important feature of biochar is its role in combating climate change. The stable carbon fractions in its structure are resistant to biological degradation, ensuring long-term carbon storage (Ogawa et al. 2006; Cayuela et al. 2014; Kurniawan et al., 2023; Saliu et al., 2023). This property contributes to reducing atmospheric CO₂ concentrations while also effectively reducing emissions of greenhouse gases such as CH₄ and N₂O (Edwards et al. 2018; Bamdad et al. 2022; Ali et al., 2025). In this regard, biochar is considered an important tool for enhancing environmental sustainability in agricultural production systems. Soil acidification resulting from the indiscriminate and intensive use of chemical fertilizers, along with associated yield losses, necessitates the development of alternative soil improvement strategies (Guo et al. 2010). In this context, the objective of this study is to demonstrate the potential of biochar produced from crop residues obtained after corn harvest in the remediation of acidified soils and to determine the effects of biochar applications on soil aggregate stability and water-holding capacity in the short term (60 days).

2. MATERIALS AND METHODS

2.1. Materials

The soil samples used in the study were obtained from the Nevşehir region and consist of a volcanic-origin, acid-reacting soil with a sandy texture. Sufficient soil samples were collected from different points at a depth of 0–20 cm to represent the field and transported to the laboratory. The samples brought to the laboratory were left to air-dry in the shade and then homogenized, passed through a 4 mm sieve, and prepared for use in the experiments. As a soil amendment material, corn stover—the harvest residue of the corn plant, which is widely cultivated in the Konya Plain—was used. After undergoing a grinding process, the corn stover was converted into biochar using a slow pyrolysis method under nitrogen N₂ gas, at a temperature of 500 °C, with a heating rate of 10°C/minute, under oxygen-limited conditions. The incubation

experiment was conducted by placing 3 kg of soil samples, weighed on an air-dry basis, into plastic pots. The experiment was designed with four replicates, and biochar applications were carried out at doses of 0% (control), 2%, 4%, and 8% by weight. The prepared soil–biochar mixtures were incubated under laboratory conditions for 60 days. During the incubation period, soil moisture was maintained at approximately field capacity (-33 kPa) and regularly monitored; any water loss was replenished to field capacity. At the end of the incubation period, to

determine the effects of the treatments on soil properties, analyses of soil reaction (pH), electrical conductivity (EC), soil water potential (-33 kPa and -1500 kPa), and aggregate stability were performed.

2.2. Methods

Texture determination: Performed according to the Bouyoucos hydrometer method (Gee and Bauder, 1986). Soil water potential: The amounts of water retained at pressures of 33 and 1500 kPa were determined using a pressure plate (100 kPa) and a ceramic plate (1500 kPa) (Klute, 1986). pH: Measured in a 1:2.5 soil-distilled water mixture using a glass-electrode, digital pH meter (McLean, 1982). Electrical conductivity (EC): Measured in a 1:2.5 soil-distilled water mixture using an electrical conductivity meter (Rhoades, 1982). The pH and EC values of biochar were determined in a 1:10 biochar-water mixture. Lime: Determined by measuring the volume of CO₂ released from carbonates when the soil was reacted with dilute hydrochloric acid in a Scheibler calcimeter (Nelson, 1982). Aggregate stability: This was determined using a wet sieving device developed by Eijkelkamp Agrisearch Equipment (Netherlands), based on Yoder's (1936) wet sieving method (Kemper and Rosenau, 1986). The device performs eight analyses simultaneously using 0.25 mm sieves. The device has a vertical travel distance of 1.3 cm and performs 34 immersion cycles per minute. Particle density: The "pycnometer method" was used to determine particle density (Blake and Hartge, 1986a). Bulk density: It was determined using the graduated cylinder method in the crushed samples (Blake and Hartge, 1986b). Analysis of variance (ANOVA) and comparisons of means between treatments (Tukey's test at the $p < 0.05$ level) were performed using SPSS statistical software.

3. RESULTS AND DISCUSSION

3.1. Some Properties of Soil and Biochar

The analysis results for the soil and biochar used in the experiment are presented in Table 1. The pH value of the soil sample was 6.13, indicating a slightly acidic character. The electrical conductivity value was determined to be 175.62 $\mu\text{S cm}^{-1}$, and it was observed that this did not pose a problem in terms of salinity. The soil's lime content is 0.21%, placing it in the low-lime class. According to textural analysis results, the soil has a sandy loam texture, consisting of 83.97% sand, 9.39% clay, and 6.64% silt. The bulk density was determined to be 1.53 g cm^{-3} and the particle density 2.62 g cm^{-3} . The pH value of the biochar is 10.87, indicating a highly basic character. The electrical conductivity value was measured as 5.15 mS cm^{-1} .

Table 1. Some Physical and Chemical Properties of the Soil and Biochar

Parameter	Unit	Soil	Biochar
pH (1:2,5)	–	6,13	10,87*
Electrical conductivity (EC)	$\mu\text{S cm}^{-1}$	175,62	5,15* mS cm^{-1}
Calcium carbonate (CaCO ₃)	%	0,21	–
Sand	%	83,97	–
Clay	%	9,39	–
Silt	%	6,64	–
Texture	–	Loamy sand	–
Field capacity	g cm^{-3}	1,53	–
Wilting point	g cm^{-3}	2,62	–

*: Measured at a 1:10 biochar-to-water ratio.

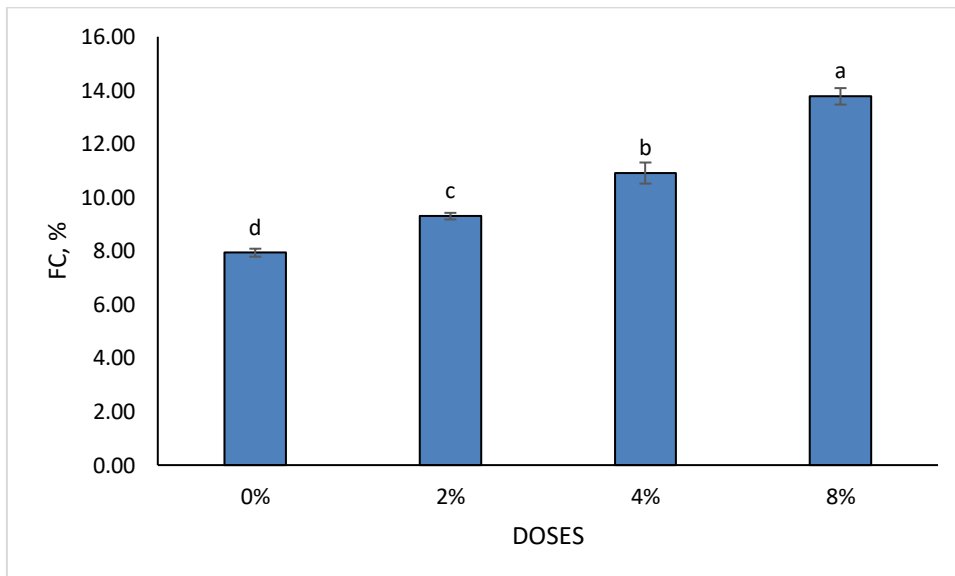


Figure 1. Effects of Biochar Applications on Field Capacity (FC)

At the wilting point value of 5.08% measured in the control soil, a 3.54% increase was observed with the 2% BC application, a 7.48% increase with the 4% BC application, and an 18.70% increase with the 8% BC application (Figure 2). This indicates that the BC applications resulted in a limited increase in the wilting point value of the sandy loam soil. When compared to the control, the increase was negligible with the 2% BC application, while the 4% BC application fell into the same category as the 2% BC application, and the effect was more pronounced with the 8% BC application. However, these changes were extremely limited compared to the increases in field capacity. A significant increase in the soil's wilting point value is an undesirable condition, as it reduces plant water use. In this context, while biochar applications

significantly increase field capacity values, the limited increase in wilting point values is considered a positive characteristic of the materials used as soil conditioners.

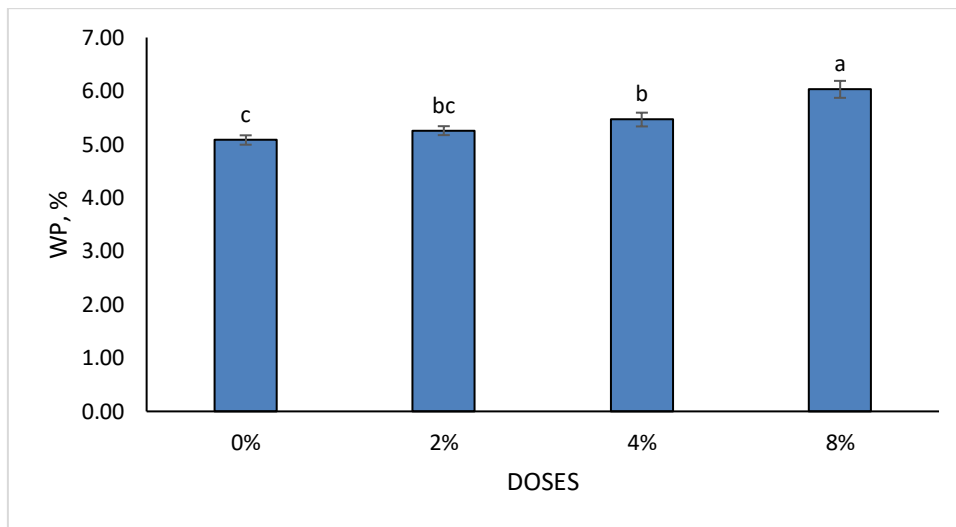


Figure 2. Effects of Biochar Applications on the Wilting Point (WP)

Soil available water capacity values indicate the extent to which plants benefit from both rainfall and irrigation water. Applications that enhance available water capacity are of utmost importance for the sustainability of natural resources such as water and soil. In this study, the available water capacity, measured at 2.85% in the control soil, increased by 41.75% with a 2% biochar application, by 90.88% with a 4% biochar application, and by 171.58% with an 8% biochar application (Figure 3). This indicates that the applied BC treatments resulted in a significant increase in the available water capacity of the sandy loam soil, which originally had a very limited available water capacity. All biochar applications significantly increased the available water capacity values compared to the control. These results stem from the fact that the applied biochar treatments caused greater increases in the field capacity of the sandy loam soil compared to the wilting point. Thus, the effectiveness of biochar applications in increasing available water for plants has been clearly demonstrated. This increase can be explained by the reduction in the naturally high macro-pore volumes of sandy loam soils due to biochar applications, coupled with an increase in water-holding micro- and meso-pore volumes. It has been assessed that biochar applications in sandy loam soils significantly increase the pore volumes (<10 μm) that are particularly effective in water retention.

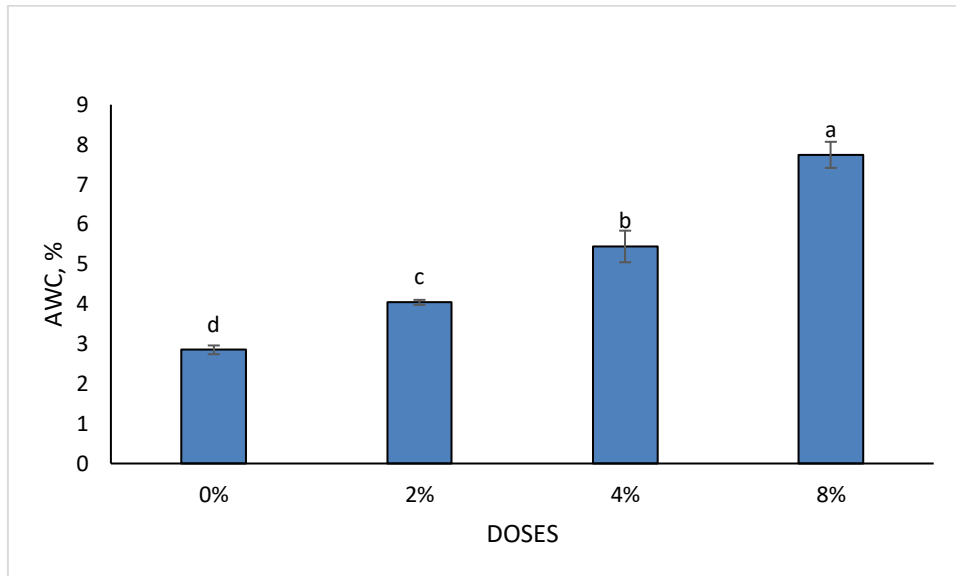


Figure 3. Effects of Biochar Applications on Available Water Capacity (AWC)

The effects of biochar on water management become particularly evident in sandy and light-textured soils. In these soils, the available water capacity is limited due to low clay and organic matter content, and biochar applications play a significant role in overcoming this limitation. It has been reported that biochar increases the soil’s available water capacity for plants by enhancing microporosity, thereby significantly improving water-holding capacity (Lustosa Carvalho et al. 2020; Wang et al. 2023). Some studies have shown that biochar applications can increase water-holding capacity in sandy soils by up to 97% (Yoo et al., 2011). It is also emphasized that this increase enhances plants’ tolerance to drought stress and contributes to sustainability in agricultural production (Ali et al. 2025; Hansen et al. 2016; Joseph et al., 2021; Lustosa Carvalho et al., 2020).

The effect of biochar on water-holding capacity depends largely on porosity and the degree of interconnectivity of the pores. While biochar produced at high temperatures is expected to retain more water due to its more developed pore structure (Akkurt et al., 2020), it has been reported that pore accessibility may be limited in biochar produced at low temperatures (Wang et al., 2023). Additionally, while changes in surface functional groups during the pyrolysis process affect the biochar’s affinity for water, the increase in porosity determines the amount of water that can be adsorbed (Weber and Quicker, 2018).

Although an increase in the wilting point values was also observed, the higher increase in field capacity indicates that the net effect is an increase in the amount of available water. This demonstrates that biochar not only retains water but also increases the fraction of water available to plants. Furthermore, the limited effect observed at low application rates (2%) suggests that more pronounced results are achieved in biochar applications above a certain

threshold dose. This finding is consistent with recent studies reporting that biochar's effect depends on the application rate (Zhou et al., 2024; Lustosa Carvalho et al., 2020; Wang et al., 2023).

In conclusion, this study demonstrates that corn stover biochar is effective in increasing the water-holding capacity and available water content of sandy soils, and that this effect becomes more pronounced particularly within the 4–8% dosage range. This highlights that biochar is an important soil conditioner capable of supporting plant growth under drought stress conditions.

3.2. Effect of Biochar on Aggregate Stability

Soil aggregates form the foundation of the soil's physical structure, directly influencing critical processes such as water-holding capacity, aeration, and root development. A stable aggregate structure enhances water retention in the soil while reducing surface runoff and erosion, thereby contributing to the preservation of soil fertility. For this reason, aggregate stability is recognized as an important quality indicator for sustainable soil management and plant growth.

The aggregate stability (%AS) value, measured at 39.07% in the control soil, increased by approximately 2.71% with the 2% BC application, 32.89% with the 4% BC application, and 57% with the 8% BC application (Figure 5). This indicates that the applied BC treatments had a positive effect on the aggregate stability of the loamy sandy soil. When compared to the control, the 2% BC treatment showed a limited increase and fell into the same statistical group as the control. Although the 4% BC application resulted in a more pronounced increase, it was statistically grouped with the 2% application (ab), while the most significant increase occurred with the 8% BC application. These results indicate that biochar applications improve soil aggregation and enhance structural stability, particularly at high doses, but the effect remains more limited at low doses.

When evaluating the effects of biochar (BC) applications on soil aggregate stability (AS), a clear trend of improvement was observed with increasing doses. The findings indicate that aggregate stability increased significantly, particularly at high BC doses (8%), and that this increase had positive effects on soil structural resilience. It is understood that this effect remains more limited at low application rates, but aggregate formation improves significantly with increasing doses. In this study, the highest increase compared to the control soil occurred at the 8% BC application rate, reaching approximately 57% , clearly demonstrating biochar's effect in promoting aggregate formation.

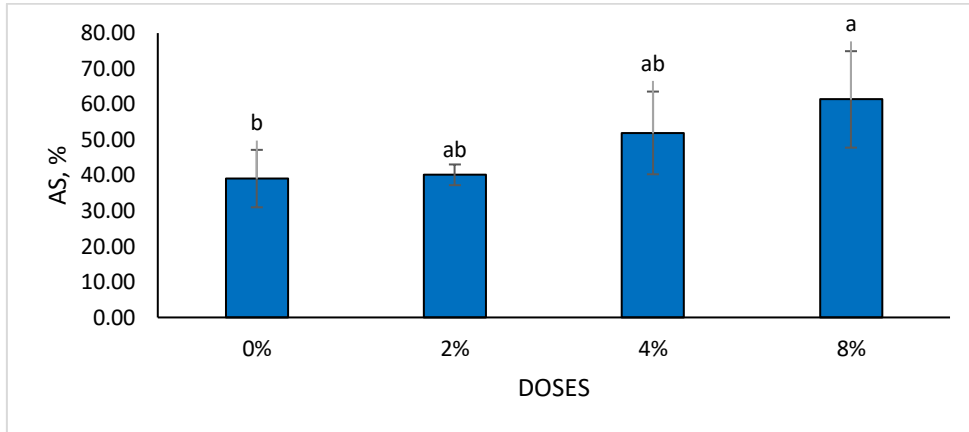


Figure 5. Effect of Biochar Applications on Aggregate Stability (%AS)

Biochar application enhances soil aggregate stability, thereby strengthening the soil's physical structure. Thanks to its stable aromatic structure and high carboxyl group content, biochar acts as a binding agent between soil particles, thereby promoting aggregate formation (Pituello et al. 2018; Liang et al. 2020; Gümüş et al., 2019; Neğiş et al., 2020). Soil aggregates form through the aggregation of mineral particles with organic and inorganic binders, directly influencing key soil properties such as erosion resistance, water-holding capacity, aeration, and root development (Tate, 2022; Alaboz and Işıldar, 2018).

Studies in the literature indicate that biochar applications significantly increase aggregate stability, with aggregate stability values rising as the application rate increases, and consequently improving soil porosity, water-holding capacity, and resistance to erosion (Altun, 2017; Gümüş et al., 2019). In this context, it is concluded that the findings are consistent with the literature and that biochar makes a significant contribution to soil structure conservation and sustainable soil management.

3.3. Effects of Biochar on pH and Electrical Conductivity

The effects of biochar applications on the pH and EC of loamy sandy soil are presented in Figures 4 and 5.

The pH value, measured at 6.01 in the control soil, increased by 29.28% with the 2% biochar application, by 36.27% with the 4% biochar application, and by 41.60% with the 8% biochar application (Figure 4). This indicates that the BC applications caused a significant increase in the pH value of the acidic loamy sandy soil. When compared to the control, these increases showed a significant rise in all BC applications. The most pronounced increase, however, occurred with the 8% BC application. This rise in pH values increased steadily in accordance with the application dose and caused the soil's initially slightly acidic reaction to shift toward the neutral and slightly alkaline range. In this context, it is assessed that BC applications are

effective in reducing acidity by increasing soil pH and, with this property, possess significant potential as a soil conditioner.

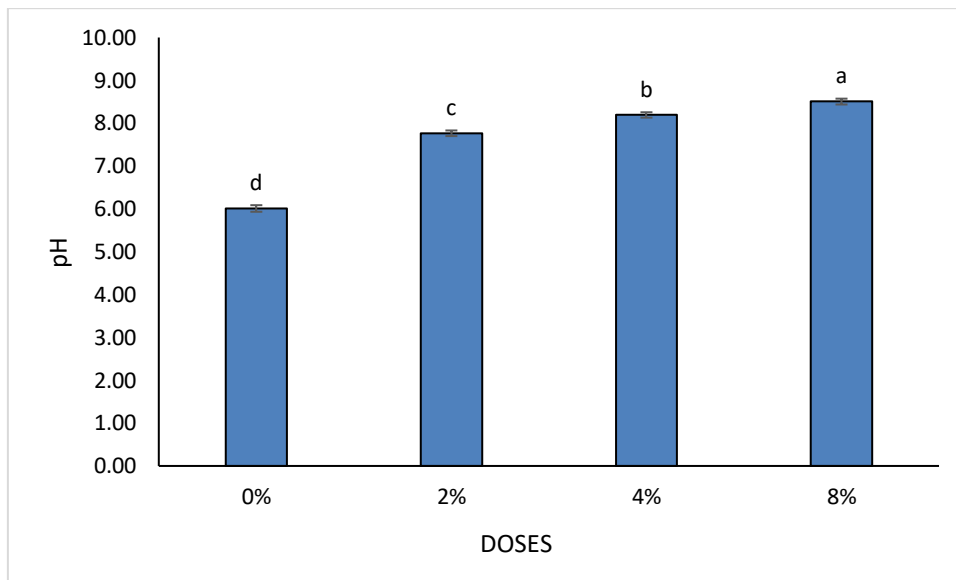


Figure 4. Effects of Biochar Applications on pH

The EC value measured as 123.13 in the control soil increased by 138.57% with a 2% BC application, by 298.77% with a 4% BC application, and by 591% with an 8% BC application (Figure 5). This indicates that the biochar applications caused a significant increase in the electrical conductivity value of the loamy sandy soil. When compared to the control, a significant rise was observed in all biochar applications. The most pronounced increase occurred with the 8% biochar application. However, this rise in EC values increased steadily in accordance with the application rate and indicated that the soil’s soluble salt content increased with the ash fraction. In this context, while biochar applications increase EC values by contributing soluble ions to the soil, they must be carefully evaluated regarding salinity, particularly at high doses.

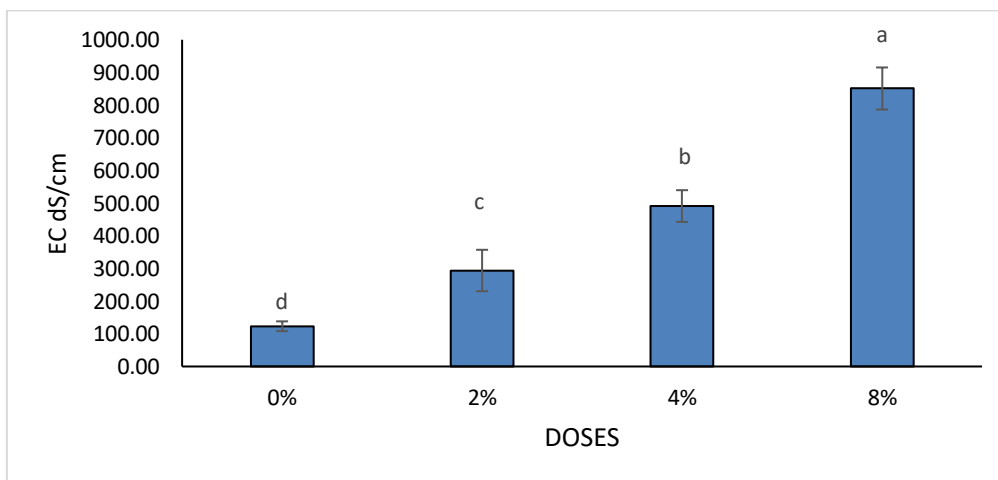


Figure 5. Effects of Biochar Applications on Electrical Conductivity (EC)

When the effects of increasing biochar (BC) doses on soil properties are evaluated together, significant increases in pH and electrical conductivity (EC) values were observed. This indicates that biochar applications affect both the reaction and soluble salt content of loamy sandy soil. These findings indicate that pH and EC values increase steadily with increasing doses, and this effect becomes more pronounced at high doses (8%).

Biochar typically plays a significant role as a pH regulator, particularly in acidic soils, due to its alkaline nature, and enhances the availability of nutrients (DeLuca et al. 2024; Joseph et al. 2021; Uzoma et al., 2011). Additionally, due to its high cation exchange capacity (CEC), it adsorbs nutrients such as ammonium, phosphorus, and potassium, thereby reducing leaching losses and positively influencing plant nutrition (Ali et al. 2025; Hossain et al. 2020; Mukherjee and Lal, 2013). These effects of biochar are largely dependent on production conditions; because of the breakdown of acidic functional groups and an increase in ash content during pyrolysis, the material generally acquires an alkaline character (Weber and Quicker, 2018; Ahmad et al., 2012; Şenay and Tepecik, 2024); Akkurt et al., (2020). In this context, it is believed that the pH increases observed in the study stem from biochar's alkaline nature, while the rise in EC values is attributed to the soluble ions it contains.

These results are consistent with the literature, which reports that biochar applications raise soil pH and enhance the availability of nutrients (Lustosa Carvalho et al. 2020; Wang et al. 2023; Nguyen et al., 2022). However, the increase in EC values indicates that the risk of salinization must be considered, particularly in high-dose applications. For this reason, determining the appropriate dose in biochar applications is crucial for both enhancing soil fertility and limiting potential salinization effects.

When the findings obtained in this context are evaluated together, it was concluded that a 4% biochar application stands out as an appropriate dose because it raises the pH value to a range suitable for plant growth while keeping the EC increase under control; conversely, an 8% biochar application could pose a potential salinity risk due to high EC values. Overall, biochar improved soil quality by reducing basic limitations such as Al-Fe toxicity in slightly acidic conditions (pH 6.01); however, it was concluded that balanced and low applications are more appropriate due to increased salinity at high doses.

4. RESULTS AND DISCUSSION

In this study, the effects of biochar derived from corn stover on the physical and chemical properties of a volcanic sandy soil were investigated. The findings indicate that biochar application increased soil pH and EC values with increasing doses, shifting the soil's reaction

to the neutral–slightly alkaline range. Additionally, biochar application improved structural stability by increasing soil aggregate stability (AS) and facilitated water retention in the soil due to increased porosity. This led to an increase in field capacity and wilting point values, resulting in significant improvements in the amount of water available to plants. The highest improvements were observed at an 8% biochar application rate.

In conclusion, it was determined that biochar application strengthened soil aggregation, increased water-holding capacity, and improved overall soil quality within a short period (60 days). These findings demonstrate that biochar is a viable, sustainable, and effective soil conditioner for field conditions, particularly for the rehabilitation of sandy soils with low water-holding capacity. Additionally, these findings should be tested under field conditions.

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IMPACT OF PROBIOTIC AND PREBIOTIC USE ON GASTROINTESTINAL COMPLICATIONS AFTER BARIATRIC SURGERY

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Abstract

Bariatric surgery is a commonly used and effective therapeutic approach for the management of morbid obesity, as it enables long-term weight reduction and contributes to the improvement of obesity-associated comorbid conditions. Nevertheless, the anatomical and physiological alterations induced by the surgical procedures may exert considerable impacts on the gastrointestinal (GI) system. In particular, reductions in gastric volume, alterations in intestinal transit time, and changes in digestive enzyme activity may lead to an increased incidence of GI symptoms such as nausea, vomiting, constipation, diarrhea, bloating, dumping syndrome, and gastroesophageal reflux. In addition, restrictions in food intake and nutrient absorption may result in macro- and micronutrient deficiencies as well as disruptions in the gut microbiota. Postoperative alterations in gut microbiota following bariatric surgery may negatively affect metabolic and immune functions, thereby reducing patients' quality of life. Over the past few years, attention has increasingly focused on the application of probiotics and prebiotics as strategies to promote gut microbiota balance. Probiotics refer to viable microorganisms that provide health benefits to the host when consumed in sufficient quantities, while prebiotics are indigestible dietary substrates that preferentially encourage the growth and metabolic activity of beneficial gut bacteria. Evidence suggests that these agents contribute to the reinforcement of intestinal barrier integrity through enhanced short-chain fatty acid production, inhibit the growth of harmful microorganisms, and exert anti-inflammatory effects. Studies in the literature indicate that probiotic and prebiotic supplementation after bariatric surgery may contribute to the alleviation of GI symptoms such as constipation and diarrhea, improvement of gut microbiota balance, and enhancement of overall gastrointestinal tolerance. Their low incidence of adverse effects makes these supplements a safe and supportive nutritional strategy in the postoperative period. Nevertheless, given the heterogeneity among probiotic strains, dosages, and durations of administration, further randomized controlled trials are required to establish clear, evidence-based recommendations to guide clinical practice.

Key words: Bariatric surgery, Probiotics, Prebiotics, Gastrointestinal complications, Gut microbiota

BARIATRİK CERRAHİ SONRASI GASTROİNTESTİNAL KOMPLİKASYONLAR ÜZERİNE PROBİYOTİK VE PREBİYOTİK KULLANIMININ ETKİSİ

Özet

Bariatrik cerrahi, morbid obezitenin yönetiminde uzun dönemli kilo kaybı sağlaması ve obezite ile ilişkili komorbid durumların iyileşmesine katkıda bulunması nedeniyle yaygın olarak kullanılan etkili bir tedavi yaklaşımıdır. Bununla birlikte, cerrahi girişimlerin yol açtığı anatomik ve fizyolojik değişiklikler gastrointestinal (Gİ) sistem üzerinde önemli etkiler oluşturabilmektedir. Özellikle mide hacmindeki azalma, bağırsak geçiş süresindeki değişiklikler ve sindirim enzimlerinin aktivitesindeki farklılıklar; bulantı, kusma, kabızlık, diyare, şişkinlik, dumping sendromu ve gastroözofageal reflü gibi Gİ semptomlarının görülme sıklığında artışa neden olabilmektedir. Ayrıca, besin alımı ve besin ögesi emilimindeki kısıtlılıklar, makro ve mikro besin ögesi yetersizliklerine ve bağırsak mikrobiyotasında bozulmalara yol açabilmektedir. Bariatrik cerrahi sonrasında bağırsak mikrobiyotasında meydana gelen bu değişiklikler, metabolik ve immün fonksiyonları olumsuz yönde etkileyerek hastaların yaşam kalitesini düşürebilmektedir. Son yıllarda, bağırsak mikrobiyota dengesinin desteklenmesine yönelik stratejiler arasında probiyotik ve prebiyotik uygulamalarına olan ilgi giderek artmıştır. Probiyotikler, yeterli miktarda tüketildiklerinde konakçıya sağlık yararı sağlayan canlı mikroorganizmalar olarak tanımlanırken; prebiyotikler, yararlı bağırsak bakterilerinin büyümesini ve metabolik aktivitelerini seçici olarak destekleyen sindirilemeyen diyet bileşenleridir. Bu bileşenlerin, kısa zincirli yağ asidi üretimini artırarak bağırsak bariyer bütünlüğünü güçlendirdiği, zararlı mikroorganizmaların çoğalmasını baskıladığı ve antiinflamatuvar etkiler gösterdiği bildirilmektedir. Literatürde yer alan çalışmalar, bariatrik cerrahi sonrası probiyotik ve prebiyotik takviyesinin kabızlık ve diyare gibi Gİ semptomların hafifletilmesine, bağırsak mikrobiyota dengesinin iyileştirilmesine ve genel gastrointestinal toleransın artırılmasına katkı sağlayabileceğini göstermektedir. Düşük yan etki görülme sıklığı, bu takviyeleri postoperatif dönemde güvenli ve destekleyici bir beslenme stratejisi hâline getirmektedir. Bununla birlikte, probiyotik suşları, dozları ve uygulama süreleri arasındaki heterojenlik göz önünde bulundurulduğunda, klinik uygulamalara yol gösterecek net ve kanıta dayalı önerilerin oluşturulabilmesi için daha fazla randomize kontrollü çalışmaya ihtiyaç duyulmaktadır.

Anahtar kelimeler: Bariatrik cerrahi, Probiyotikler, Prebiyotikler, Gastrointestinal komplikasyonlar, Bağırsak mikrobiyotası

NATURAL MODULATION OF THE GUT MICROBIOTA IN PATIENTS WITH FOOD ALLERGIES. IMPACT OF ALERGIPLANT

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ABSTRACT

Background Dysbiosis or microbial imbalance, can predispose individuals to allergies, while a balanced gut microbiome, fosters immune tolerance. The immune mechanisms involved in food allergies are complex and little is known about the possible role of the gut microbiota in the aetiopathogenesis of food allergies.

Objective Alergiplant could modulate the immune system through gut microbiota in food allergies. Advancing knowledge of the gut microbiome and its function in modulating the course of food allergies, might result in novel therapeutic strategies.

Materials and methods The evaluation of the patients was based on history and physical examination. We investigated the effect Alergiplant in patients with food allergies.

Results Environmental factors such as urbanisation, pollution, and dietary habits also significantly contribute to food allergies risk. It is not clear whether microbial change in food allergies is an outcome of barrier defect or the cause of barrier dysfunction and inflammation. Manipulation of the gut microbiota as a method for modifying atopy, may be attempted in many ways including avoidance of certain foods, supplementation with probiotics and prebiotics, optimising nutrient intake, minimising stress, antimicrobial therapy, correction and prevention of low stomach acid, and faecal microbiota transplantation.

Conclusion The resident microbiota is important in maintaining structural and functional integrity of the gut and in immune system regulation. There was an increase of the intestinal permeability reported in patients with food allergies and a reduction of the gut microbiome diversity. Modifying gut microbiome by applying Alergiplant during early years may be a preventive and therapeutic option in high risk groups.

Keywords: food allergies, host-microbiome interaction; immune regulation; Alergiplant

BİR ARAÇ GEOMETRİSİ ETRAFINDAKİ AKIŞIN POTANSİYEL AKIŞ TEORİSİ VE SONLU FARK YÖNTEMİ İLE MODELLENMESİ VE CFD DOĞRULAMASI

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ÖZET

Bu çalışmada, bir binek araç profilinin etrafındaki akış yapısı potansiyel akış teorisi ve sonlu fark yöntemi kullanılarak sayısal olarak incelenmiştir. Araç geometrisi, CAD verilerinden elde edilen 500 koordinat noktası ile tanımlanmış ve MATLAB ortamında iki boyutlu bir hesaplama alanı oluşturulmuştur. Çözüm alanı düzenli bir grid yapısı ile ayrıştırılmış ve akış alanı iteratif bir sayısal yöntem kullanılarak çözülmüştür. Modelde araç zemine oturmuş şekilde ele alınmış ve zemin etkisi uygun sınır şartları ile temsil edilmiştir. Elde edilen çözüm ile araç etrafındaki akım çizgileri, hız dağılımı ve basınç davranışı analiz edilmiştir. Sürüklenme katsayısı, aracın ön bölgesine ait yüzey basınç dağılımı kullanılarak hesaplanmıştır. Bu yaklaşım, potansiyel akış teorisinin sınırlamaları dikkate alınarak, fiziksel olarak anlamlı sonuçlar elde etmek amacıyla tercih edilmiştir. Elde edilen sonuçlar, ticari bir hesaplamalı akışkanlar dinamiği yazılımı olan ANSYS Fluent ile gerçekleştirilen viskoz akış analizleri ile karşılaştırılmıştır. Karşılaştırmalar, sonlu fark yönteminin özellikle araç ön bölgesindeki akış karakteristiklerini ve basınç dağılımını başarılı bir şekilde tahmin edebildiğini göstermektedir. Buna karşın, akış ayrılması ve iz bölgesi gibi viskoz etkilerin bu yaklaşım kapsamında temsil edilemediği belirlenmiştir. Sonuç olarak, önerilen yöntemin mutlak aerodinamik kuvvetleri yüksek doğrulukla tahmin etmekten ziyade, akış alanının genel davranışını hızlı ve düşük maliyetli bir şekilde analiz etmek için uygun olduğu gösterilmiştir. Bu çalışma, sonlu fark yönteminin araç aerodinamiğinde kavramsal tasarım ve ön değerlendirme aşamalarında etkili bir araç olarak kullanılabileceğini ortaya koymaktadır.

Anahtar kelimeler: Potansiyel akış, sonlu fark yöntemi, araç aerodinamiği, sürüklenme katsayısı (Cd), basınç dağılımı, hız dağılımı, akım çizgileri, zemin etkisi, sayısal analiz, CFD karşılaştırması

MODELING OF FLOW AROUND A VEHICLE GEOMETRY USING POTENTIAL FLOW THEORY AND THE FINITE DIFFERENCE METHOD AND CFD VALIDATION

ABSTRACT

The flow structure around a passenger vehicle profile is numerically investigated using potential flow theory and the finite difference method. The vehicle geometry is defined by 500 coordinate

points obtained from CAD data, and a two-dimensional computational domain is generated in the MATLAB environment. The solution domain is discretized using a structured grid, and the flow field is solved using an iterative numerical method. In the model, the vehicle is considered to be in contact with the ground, and ground effects are represented through appropriate boundary conditions. The obtained solution is used to analyze streamlines, velocity distribution, and pressure behavior around the vehicle. The drag coefficient is calculated based on the surface pressure distribution on the front region of the vehicle. This approach is adopted to obtain physically meaningful results while considering the limitations of potential flow theory. The results are compared with viscous flow analyses performed using the commercial computational fluid dynamics software ANSYS Fluent. The comparisons show that the finite difference method successfully predicts the flow characteristics and pressure distribution, particularly in the front region of the vehicle. However, viscous effects such as flow separation and wake region cannot be represented within this approach. Consequently, the proposed method is more suitable for rapid and low-cost analysis of the general flow behavior rather than highly accurate prediction of absolute aerodynamic forces. This study demonstrates that the finite difference method can be effectively used in conceptual design and preliminary evaluation stages of vehicle aerodynamics.

Keywords: Potential flow, finite difference method, vehicle aerodynamics, drag coefficient (Cd), pressure distribution, velocity distribution, streamlines, ground effect, numerical analysis, CFD comparison

NiO NANOPARTİKÜLLERİNİN İLETKEN KARBON BAZLI SÜPERKAPASİTÖR ELEKTROTLARININ DÖNGÜSEL VOLTAMMETRİ PERFORMANSI ÜZERİNDEKİ ETKİSİ

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ÖZET

NiO nanoparçacık yükleme oranları farklı olan NiO/iletken karbon siyahı (Super-P) kompozit elektrotların, ultrason destekli bulamaç kaplama ve doctor-blade yöntemi kullanılarak nikel köpük üzerine hazırlandığı ve ardından süperkapasitör uygulamaları açısından değerlendirildiği bu çalışmada açıklanmıştır. Farklı NiO nanoparçacık konsantrasyonlarına sahip elektrotları incelemek amacıyla döngüsel voltametri (CV), alan emisyonlu taramalı elektron mikroskobu (FE-SEM), enerji dağılımlı X-ışını spektroskopisi (EDX) ve b-değeri kinetik parametre analizleri kullanılmıştır. CV ölçümleri, 1 M NaCl elektrolitinde, 0.0-0.5 V potansiyel aralığında ve 60-100 mV/s tarama hızında gerçekleştirilmiştir. Elde edilen sonuçlar, NiO nanoparçacık ilavesinin iletken karbon siyahı esaslı elektrotların yük depolama özellikleri üzerinde önemli bir etkiye sahip olduğunu göstermiştir. 0.5 ve 1 wt% NiO/Super-P elektrotları için elde edilen 0.51 ve 0.58 b-değerleri, difüzyon kontrollü Faradaik psödokapasitif davranışı işaret etmiştir. Buna karşılık, 2 ve 4 wt% NiO/Super-P elektrotları için belirlenen 0.69 ve 0.70 b-değerleri, elektrik çift tabaka kapasitansı ile psödokapasitif katkıları birlikte içeren, ağırlıklı olarak yüzey kontrollü hibrit bir yük depolama mekanizmasına işaret etmiştir. FE-SEM incelemesi, bağlantılı parçacıklar ve bazı aglomerasyon bölgeleri içeren pürüzlü, granüler ve heterojen bir yüzey morfolojisini ortaya koyarken, EDX analizi C, O ve Ni elementlerinin varlığını doğrularak NiO/Super-P kompozit kaplamanın başarılı bir şekilde sentezlendiğini göstermiştir. NiO yükleme miktarındaki artışın depolama mekanizmasını daha çok yüzey kontrollü bir yapıya dönüştürdüğü görülmekle birlikte, 1 wt% NiO/Super-P elektrodu; akım yanıtı, yük iletimi ve elektrokimyasal olarak aktif bölgelerin etkin kullanımı arasındaki en uygun dengeyi sağlaması nedeniyle en iyi genel elektrokimyasal performansı sunmuştur.

Anahtar kelimeler: NiO nanopartikülleri, İletken karbon siyahı, Süperkapasitör elektrotu, Döngüsel voltametri.

INFLUENCE OF NiO NANOPARTICLES ON THE CYCLIC VOLTAMMETRY PERFORMANCE OF CONDUCTIVE CARBON-BASED SUPERCAPACITOR ELECTRODES

ABSTRACT

The study describes how NiO/conductive carbon black (Super-P) composite electrodes with varying NiO nanoparticle loadings were created on nickel foam using sonication-assisted slurry coating and the doctor-blade process and then evaluated for supercapacitor capabilities. Cyclic voltammetry (CV), field emission scanning electron microscopy (FE-SEM), energy-dispersive X-ray spectroscopy (EDX), and b-value kinetics parameter studies were used to investigate electrodes with varying NiO nanoparticle concentrations. CV experiments were carried out in 1 M NaCl with a potential window of 0.0-0.5 V and a scan rate of 60-100 mV/s. The results show that adding NiO nanoparticles had a significant impact on the charge-storage capabilities of conductive carbon black-based electrodes. The 0.5 and 1 wt% NiO/Super-P electrodes showed b-values of 0.51 and 0.58, indicating diffusion-controlled Faradaic pseudocapacitive activity. The b-values of 0.69 and 0.70 for the 2 and 4 wt% NiO/Super-P electrodes, on the other hand, indicated a mostly surface-controlled hybrid charge-storage mechanism that included both electric double-layer capacitance and pseudocapacitive contributions. The FE-SEM inspection revealed a rough, granular, and heterogeneous surface morphology with linked particles and some agglomerated regions, while EDX validated the presence of C, O, and Ni, indicating that the NiO/Super P composite coating was successfully synthesized. While increasing NiO loading changed the storage behavior to a primarily surface-controlled mechanism, the 1 wt% NiO/Super-P electrode provided the best overall electrochemical performance due to its optimal balance of current response, charge propagation, and effective utilization of electroactive sites.

Keywords: NiO nanoparticles, Conductive carbon black, Supercapacitor electrode, Cyclic voltammetry.

1. INTRODUCTION

Electrochemical supercapacitors received a lot of scientific attention as energy-storage devices because of their capacity to give high power density, quick charge-discharge performance, and longer cycle life than many existing storage systems. However, their broader practical applicability is still contingent on the development of electrode materials that increase charge storage capacity while retaining quick reaction kinetics and structural integrity. Transition-metal oxides are particularly intriguing to a variety of material groups due to their capacity to retain charge through quick Faradaic redox reactions and electrical double-layer effects (Wang

et al. 2012). Nickel oxide (NiO) is a popular pseudocapacitive metal oxide for supercapacitor electrodes because of its high theoretical capacity, low cost, plentiful natural supply, and environmental friendliness. Despite these advantages, NiO's actual efficiency is typically limited by its relatively low intrinsic electrical conductivity and particle agglomeration, both of which can reduce active-site accessibility and hamper electron transit when cycling. As a result, recent research has focused on combining NiO with conductive carbon phases and porous current collectors to improve electrochemical efficiency and rate capability (Chime et al., 2020). Conductive carbon additions are required in composite electrodes because they provide electrically conductive ions, lower internal resistance, and improve the dispersion of the active oxide phase (Moalleminejad & Chung, 2015; Lu et al., 2024). At the same time, nickel foam is commonly utilized as a current collector for supercapacitor electrodes due to its three-dimensional porous design, which provides superior electrical conductivity, a large accessible surface area, and effective electrolyte access. These characteristics provide NiO/carbon composites on nickel foam a logical and economical structure for high-performance supercapacitor electrodes (Dojčinović et al., 2024), (Salleh et al., 2020). Many earlier studies have proved the efficacy of integrating NiO with conductive carbon materials in supercapacitor applications. Reduced graphene oxide/NiO composites have been shown to increase charge transfer and electrochemical activity relative to pure NiO, whereas nickel-foam-supported NiO-based structures have demonstrated the benefits of porous conductive substrates for enhanced capacitive performance. Previous studies validate that integrating a redox-active NiO phase with a conductive carbon substrate and a porous metallic current collector is a feasible approach for electrode design (Zhu et al., 2012). In cyclic voltammetry analysis, the kinetics of charge storage may be assessed using the power-law equation $i = av^b$, where i represent the measured current, v indicates the scan rate, and b is obtained from the slope of the $\log(i)$ vs $\log(v)$ plot. The b -value of 0.5 signifies diffusion-controlled behavior, while a value of 1.0 denotes a capacitive response. Intermediate values indicate varied charge-storage behavior (Wang et al., 2007). This study included the fabrication of NiO/Super-P electrodes with varying NiO nanoparticle loadings on nickel foam by a sonication-assisted slurry-coating by doctor-blade method, followed by an investigation of their electrochemical and structural properties using cyclic voltammetry (CV) and kinetic parameter (b -value) analysis. The primary aim was to clarify the effect of NiO incorporation on the electrochemical performance of Super-P-based supercapacitor electrodes.

2. EXPERIMENTAL SECTION

2.1 Synthesis Method for NiO/Super-P Hybrid Electrodes

NiO/Super-P electrodes were made using a sonication-assisted slurry-coating process on nickel foam substrates (1.0 cm × 1.0 cm) that served as current collectors. Each nickel foam substrate was weighed precisely on a RADWAG analytical scale (with a capacity of 0.0001 g) before coating, to determine the initial mass of each. The slurry was made by first adding 8 mL of 100% ethanol as the dispersion medium, then the NiO nanoparticle powder was added, and the mixture was ultrasonicated for 30 min to increase the dispersion of particles and decrease their agglomeration. Afterwards, the solution was magnetically stirred for 10 min to get homogeneous before the conductive carbon black (Super P, 5 wt.%) and liquid PTFE binder (10 wt.%) were added. The combination was still being agitated until a stable, uniform slurry was obtained with a final composition of 85:5:10 wt.% (NiO:Super-P:PTFE). Using the doctor-blade method, the resulting paste was spread over nickel foam, producing an electrode coating layer that was quite uniform with a controlled thickness. A small part of the substrate was left without coating to be used as an electrical contact during electrochemical testing. Nickel foam was selected because of its extremely high electrical conductivity and three-dimensional porous structure, which are most beneficial features of a current collector in a supercapacitor. Next, the coated electrodes of NiO/Super-P with 0.5 wt.%, 1 wt.%, 2 wt.% and 4 wt.% were dried on a hot plate until the ethanol was completely evaporated. Then, they were re-weighed for the active material mass loading calculation and finally were stored in sealed zip-lock bags prior to the electrochemical testing. **Figure 1** illustrates the primary electrode preparation procedures.

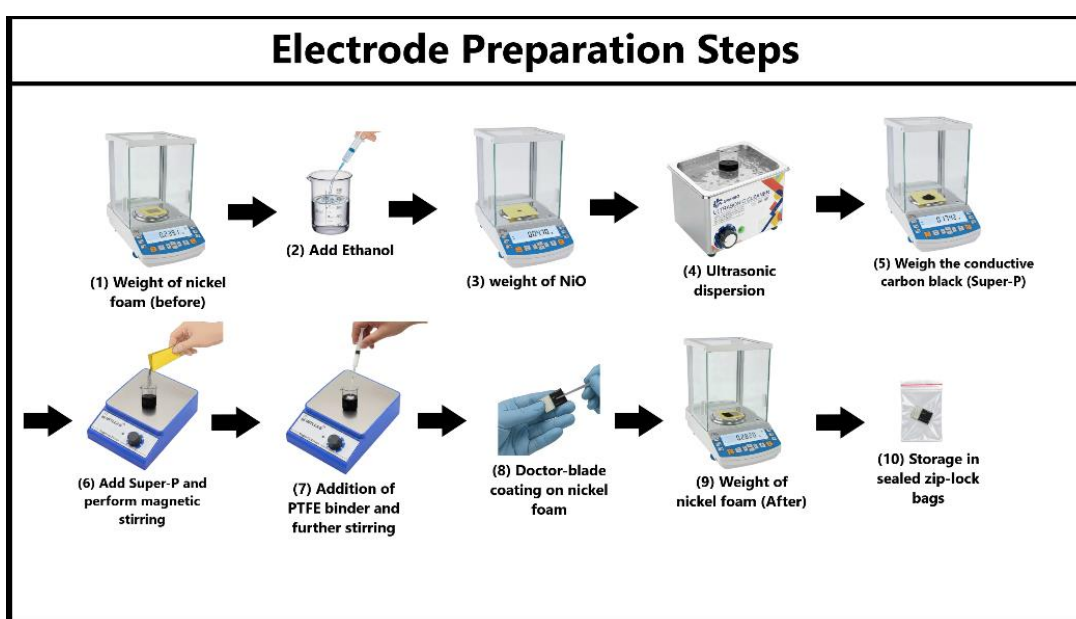


Figure 1. A diagram of the NiO/Super-P electrode preparation steps.

2.2 Material Characterization

A Carl Zeiss Ultra Plus Gemini field-emission scanning electron microscope (FE-SEM) was used at Karabk University Iron and Steel Institute to investigate the surface and interior structure of the NiO/Super-P electrodes that were manufactured. Energy-dispersive X-ray spectroscopy (EDX) was used in conjunction with the FESEM apparatus to analyze the elemental makeup. This study was carried out to evaluate the electrode's elemental composition and to examine the distribution of elements inside the NiO/Super-P coating. The complete FESEM-EDX analysis provided important details regarding the electrodes' morphology, coating homogeneity, and elemental characteristics.

2.3 Electrochemical Measurements

Electrochemical characterization was carried out with a typical three-electrode setup in a 1 M NaCl aqueous electrolyte. The NiO/Super-P-coated nickel foam served as the working electrode, Ag/AgCl as the reference electrode, and the counter electrode completed the electrochemical circuit. Throughout the tests, all electrodes were submerged in the electrolyte. Cyclic voltammetry (CV) was performed at scan rates of 60 to 100 mV s⁻¹ throughout a potential range of 0.0-0.5V. The electrochemical properties of the electrodes were assessed using the form of the cyclic voltammetry curves and their response as a function of scan rate. The kinetics of charge storage were assessed using the power-law equation $i = av^b$ where i represents the current, v denotes the scan rate, and a and b are variable constants. The calculated kinetic parameter b was used to differentiate between diffusion-controlled and surface-controlled charge-storage systems.

3. RESULTS AND DISCUSSION

3.1 Morphological Behavior

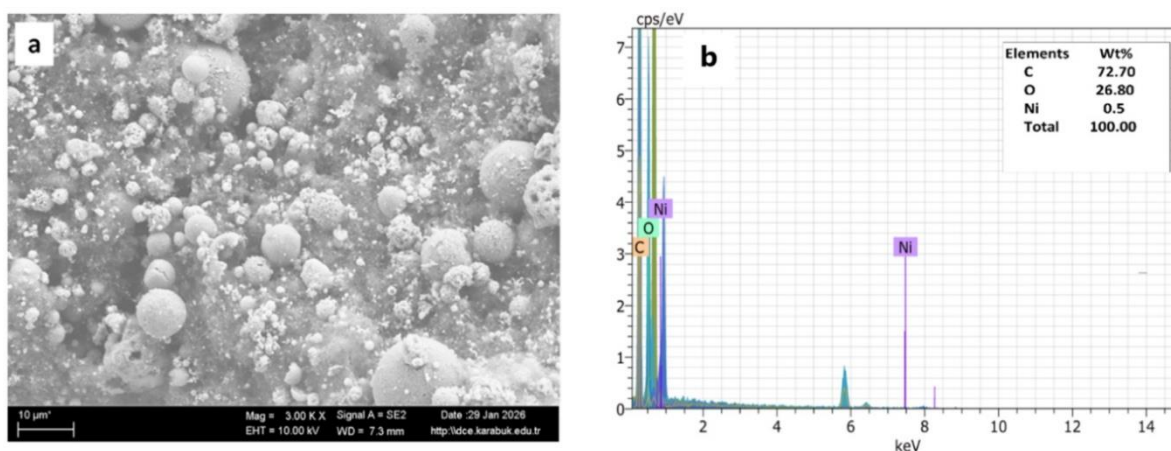


Figure 2. FE-SEM image of the NiO/Super-P nanocomposite thin film: (a) surface morphology and (b) EDX elemental spectrum.

Figure 2a presents the SEM micrograph of the NiO/Super-P electrode, showing a rough and heterogeneous surface with irregularly distributed particles and distinct agglomerated clusters. Larger spherical or semi-spherical agglomerates appear in the micrometer range and are surrounded by finer particles, indicating a granular and interconnected microstructure rather than a compact dense surface. This morphology is useful for electrochemical applications because it not only increases effective surface area but also improves electrolyte accessibility and even promotes ion diffusion inside the electrode (Forouzandeh et al.). Furthermore, conductive carbon black is anticipated to produce conductive routes that connect distinct NiO domains, facilitating electron transport during battery both charging and discharging (Wu and Wang). Nonetheless, more agglomerated areas may cause clustering and a less uniform distribution of electroactive sites. **Figure 2b** shows the EDX spectrum of the same electrode, with carbon, oxygen, and nickel as the principal elements. The quantitative makeup was 72.70 wt.% carbon, 26.80 wt.% oxygen, and 0.5% nickel. These findings hint to a carbon-rich matrix including oxygenated nickel species, which is beneficial to supercapacitor performance by combining conductivity with pseudocapacitive redox activity (Lakshmi and Vedhanarayanan; Roy et al.).

3.2 Cyclic Voltametric (CV) behavior

The electrochemical properties of NiO/Super-P electrodes were investigated using cyclic voltammetry at scan rates ranging from 60 to 100 mV/s and potentials ranging from 0.0 to 0.5 V. The CV curves show that the current response increased gradually with the scan rate increment for all three evaluated NiO nanoparticle loadings; Figures 3a-d demonstrate this. As a result, the electrochemical behavior of the electrodes is dependent on the scan rate. Furthermore, significant differences in the morphology and enclosed area of the CV curves were observed as a function of NiO nanoparticle concentration, demonstrating that the quantity of NiO nanoparticles profoundly influenced the charge-storage characteristics of the Super-P-based electrode system.

Table 1. b-values and corresponding charge-storage mechanisms of NiO/Super-P electrodes with different NiO loadings

Sample	b-value	Storage Mechanism	Reaction Nature	Kinetic Control
0.5 wt% NiO/Super-P	0.51	Pseudocapacitive	Faradaic	Diffusion controlled
1 wt% NiO/Super-P	0.58	Pseudocapacitive	Faradaic	Diffusion controlled
2 wt% NiO/Super-P	0.69	Hybrid (EDLC + Pseudocapacitive)	Faradaic & non-faradaic	Surface controlled
4 wt% NiO/Super-P	0.70	Hybrid (EDLC + Pseudocapacitive)	Faradaic & non-faradaic	Surface controlled

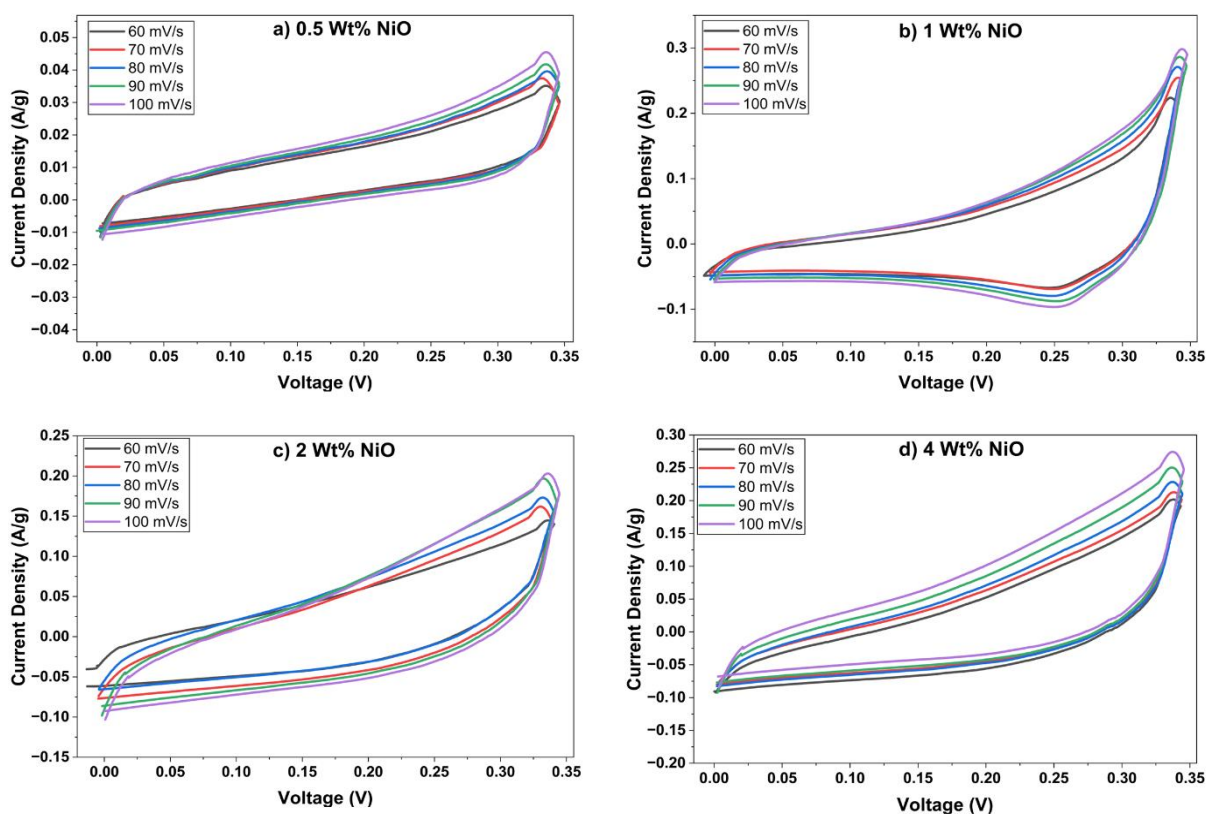


Figure 3. CV curves of the a) 0.5 wt%, b) 1 wt%, c) 2 wt%, and d) 4 wt% NiO/Super-P electrode measured at various scan rates (60–100 mV s^{-1}) in the potential range of 0–0.5 V.

Figure 3 shows the cyclic voltammetry (CV) curves of the 0.5, 1, 2, and 4 wt% NiO/Super-P electrodes recorded at a scan rate ranging from 60 to 100 mV s^{-1} . For all compositions, the current response exhibited a gradual rise with rising scan rates, hence verifying the scan-rate-dependent electrochemical activity of the synthesized electrodes. Furthermore, differences in morphology and enclosed area of the CV loops were observed with increasing NiO nanoparticle loading, indicating that the quantity of NiO significantly affected the charge-storage characteristics of the Super-P-based electrode system (Zhao et al., 2019). The alterations in the CV response indicate that varying the NiO content affected the accessibility of electroactive sites, the interfacial charge-transfer dynamics, and the overall electrochemical efficiency of the electrode components (Vijayakumar et al., 2013). Among the samples examined, the 1 wt% NiO/Super-P electrode is considered the most useful in terms of overall electrochemical performance, as it showed the most balanced response for current production, charge transfer, and efficient electrode utilization.

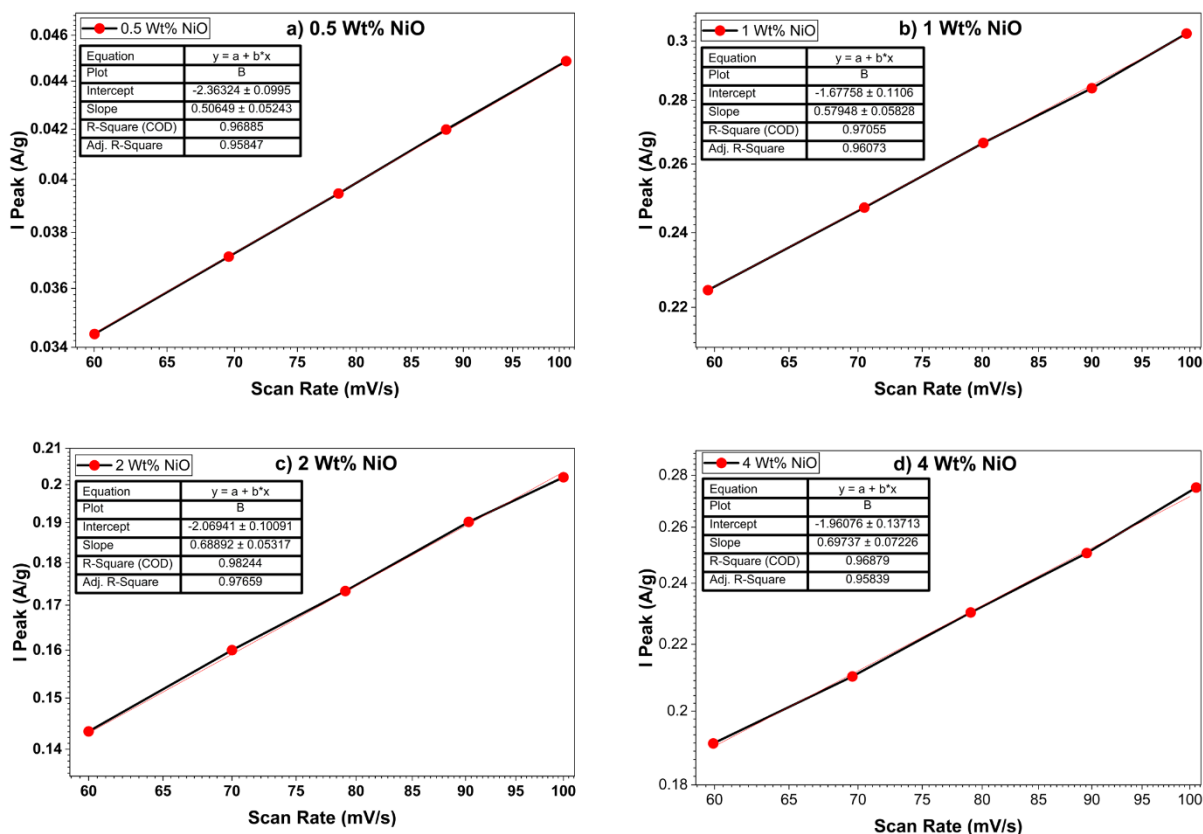


Figure 4 Determination of the b -value from the linear fitting of peak current density (I_p) as a function of scan rate for a) 0.5 wt%, b) 1 wt%, c) 2 wt%, and d) 4 wt% NiO/Super-P

Figure 4 discusses the charge-storage kinetics of the NiO/Super-P electrodes through the power-law relationship $i = av^b$, where the b -value is used to identify the predominant charge-storage mechanism (Kurra et al., 2021). As summarized in Table 1, the 0.5 wt% and 1 wt% NiO/Super-P electrodes exhibited b -values of 0.51 and 0.58, respectively, indicating predominantly diffusion-controlled behavior associated with Faradaic pseudocapacitive charge storage (Liu et al., 2018). In contrast, the 2 wt% and 4 wt% electrodes showed higher b -values of 0.69 and 0.70, respectively, suggesting a more surface-controlled charge-storage process involving both Faradaic and non-Faradaic contributions, which reflects a hybrid mechanism combining electric double-layer capacitance (EDLC) and pseudocapacitance (Rudra et al., 2024). These kinetic characteristics, presented in **Table 1**, demonstrate that increasing the NiO loading shifted electrochemical behavior from mainly diffusion-controlled pseudocapacitive storage toward a more surface-dominated hybrid charge-storage mechanism (Shah et al., 2023).

In analyzing **Figures 3** and **4** together, it becomes clear that the electrochemical performance of the NiO/Super-P electrodes was not only dependent on the elevation in b -value or the transition towards surface-controlled behavior. Optimal performance was achieved when a

suitable equilibrium was established among active-material content, ion diffusion, electron transport, and electroactive-site use. The 1 wt% NiO/Super-P electrode exhibited the most superior performance, while the 0.5 wt% sample probably had a deficiency of active sites. In contrast, the 2 wt% and 4 wt% electrodes may have been hindered by kinetic or structural constraints because of elevated NiO nanoparticles loading.

4. CONCLUSION

Hybrid electrodes of NiO and conductive carbon black were effectively produced on nickel foam using a sonication-assisted slurry coating. Cyclic voltammetry and b-value analysis revealed that the inclusion of NiO nanoparticles had a substantial impact on the charge-storage kinetics and overall electrochemical performance of the conductive carbon-based electrode system. The electrodes with 0.5 and 1 wt% NiO had b-values of 0.51 and 0.58, demonstrating diffusion-controlled Faradaic pseudocapacitive storage. As the NiO nanoparticle loading rose to 2 wt% and 4 wt%, the b-values climbed to 0.69 and 0.70, respectively, suggesting a shift toward a surface-controlled hybrid mechanism that includes both electric double-layer capacitance and pseudocapacitive contributions. The 1 wt% NiO/Super-P electrode produced the optimum electrochemical response by balancing electroactive-site accessibility, charge-transfer kinetics, and electrode use efficiency. The findings show that increasing NiO content does not improve electrochemical performance as much as achieving an ideal loading level. Thus, among the samples tested, 1 wt% NiO is regarded as the best composition for supercapacitor electrode applications.

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EVRENSEL TASARIM İLKELERİ BAĞLAMINDA DİJİTAL ERİŞİLEBİLİRLİK: GÖRME ENGELLİ KULLANICILAR İÇİN ARAYÜZ TASARIMI STANDARTLARI

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ÖZET

Bilgi ve iletişim teknolojilerinin hızla yaygınlaştığı günümüzde, dijital arayüzlerin görme engelli bireyler için birer engel olmaktan çıkarılarak evrensel tasarım ilkeleri ışığında herkes için erişilebilir kılınması, kapsayıcı bir toplum inşasının temel gerekliliklerinden biridir. Çalışma, dijitalleşen dünyada bilgiye erişimin temel bir hak olduğu varsayımından yola çıkarak, evrensel tasarım ilkelerinin görme engelli kullanıcılar özelinde nasıl standartlaştırılması gerektiğini incelemektedir. Araştırmanın temel amacı, dijital arayüzlerin kapsayıcı bir perspektifle yeniden kurgulanması sürecinde, görme engelli bireylerin karşılaştıkları bariyerleri ortadan kaldıracak tasarım kriterlerini belirlemek ve bu kriterlerin uygulanabilirliğini kuramsal bir zeminde değerlendirmektir. Çalışmanın kapsamı, web ve mobil tabanlı arayüzlerin semantik yapısı, yardımcı teknolojilerle olan etkileşimi, tipografik düzenlemeler ve renk-kontrast standartları ile sınırlandırılmıştır.

Araştırmada yöntem olarak nitel araştırma desenlerinden literatür taraması ve içerik analizi teknikleri kullanılmıştır. Dünya Genel Ağ Birliği (W3C) tarafından belirlenen Web İçeriği Erişilebilirlik Kılavuzu (WCAG 2.1) kriterleri, evrensel tasarımın yedi temel ilkesiyle karşılaştırmalı olarak analiz edilmiştir. Araştırma kapsamında elde edilen bulgular, güncel dijital platformların çoğunun hiyerarşik başlık yapısı, görseller için alternatif metin (alt-text) kullanımı ve klavye navigasyonu gibi temel erişilebilirlik gereksinimlerini karşılamada yetersiz kaldığını göstermektedir. Özellikle görsel öğelerin sadece estetik birer unsur olarak ele alınması, yardımcı teknolojilerin arayüzü anlamlandırmasını zorlaştırmakta ve kullanıcının bilgi akışından kopmasına neden olmaktadır. Ayrıca, kontrast oranlarının yetersizliği ve dinamik içeriklerin sesli geri bildirimlerle desteklenmemesi, kullanıcı deneyimini olumsuz etkileyen temel unsurlar olarak tespit edilmiştir.

Sonuç olarak, dijital erişilebilirliğin bir ek özellik değil, tasarım sürecinin en başında ele alınması gereken etik ve profesyonel bir sorumluluk olduğu anlaşılmaktadır. Evrensel tasarım ilkelerinin tasarıma entegre edilmesi, görme engelli bireylerin yanı sıra, tüm kullanıcılar için daha sezgisel ve hata payı düşük bir arayüz deneyimi sunacaktır. Tasarımcıların empati odaklı

bir yaklaşımdan ziyade standart odaklı bir disiplinle hareket etmeleri, dijital uçurumun kapanmasında önemli bir rol oynayacaktır.

Anahtar kelimeler: Dijital Erişilebilirlik, Evrensel Tasarım, Görme Engelli Kullanıcılar, Kullanıcı Deneyimi (UX), WCAG Standartları.

DIGITAL ACCESSIBILITY WITHIN THE CONTEXT OF UNIVERSAL DESIGN PRINCIPLES: INTERFACE DESIGN STANDARDS FOR VISUALLY IMPAIRED USERS

ABSTRACT

In today's world, where information and communication technologies are rapidly spreading, making digital interfaces accessible to everyone in light of universal design principles, rather than creating barriers for visually impaired individuals, is a fundamental requirement for building an inclusive society. This study, starting from the assumption that access to information is a fundamental right in the digitalized world, examines how universal design principles should be standardized specifically for visually impaired users. The main objective of the research is to identify design criteria that will eliminate the barriers faced by visually impaired individuals in the process of re-imagining digital interfaces from an inclusive perspective, and to evaluate the applicability of these criteria on a theoretical basis. The scope of the study is limited to the semantic structure of web and mobile-based interfaces, their interaction with assistive technologies, typographic arrangements, and color-contrast standards. The research employs qualitative research designs, specifically literature review and content analysis techniques. The Web Content Accessibility Guidelines (WCAG 2.1) criteria, established by the World Wide Web Association (W3C), are analyzed comparatively with the seven fundamental principles of universal design. The findings of this research indicate that most current digital platforms fall short in meeting basic accessibility requirements such as hierarchical heading structures, the use of alternative text (alt-text) for images, and keyboard navigation. In particular, treating visual elements solely as aesthetic components makes it difficult for assistive technologies to interpret the interface and causes the user to become disconnected from the information flow. Furthermore, insufficient contrast ratios and the lack of audio feedback for dynamic content have been identified as key factors negatively impacting user experience.

In conclusion, it is understood that digital accessibility is not an additional feature, but an ethical and professional responsibility that should be addressed at the very beginning of the design process. Integrating universal design principles into the design will provide a more intuitive and error-free interface experience for all users, not just visually impaired individuals. Designers

adopting a standards-oriented approach rather than an empathy-focused one will play a significant role in closing the digital divide.

Keywords: Digital Accessibility, Universal Design, Visually Impaired Users, User Experience (UX), WCAG Standards.

ÇİZİMDEN PROMPT MÜHENDİSLİĞİNE: GÖRSEL İLETİŞİM TASARIMI EĞİTİMİNDE TEKNİK BECERİLERİN DÖNÜŞÜMÜ VE YENİ MÜFREDAT ARAYIŞLARI

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ÖZET

Görsel iletişim tasarımı eğitimi, dijitalleşme ve otomasyon süreçlerinin ardından bugün üretken yapay zeka (Generative AI) teknolojilerinin etkisiyle paradigma düzeyinde bir dönüşüm yaşamaktadır. Bu çalışmanın temel amacı, geleneksel çizim becerileri ve yazılım odaklı teknik hakimiyetin, prompt mühendisliği ekseninde nasıl bir dönüşüme uğradığını analiz etmek ve bu dönüşümün gerektirdiği yeni müfredat stratejilerini tartışmaya açmaktır. Çalışmanın kapsamını, tasarımcı kimliğinin bir uygulayıcıdan küratöre evrilme süreci ve bu sürecin tasarım stüdyosu derslerine entegrasyonu oluşturmaktadır.

Araştırmada nitel araştırma yöntemlerinden betimsel analiz ve doküman analizi teknikleri kullanılmıştır. Mevcut görsel iletişim tasarımı müfredatları ile yapay zeka araçlarının (Midjourney, Stable Diffusion, DALL-E vb.) talep ettiği yeni yetkinlik setleri karşılaştırmalı olarak incelenmiştir. Araştırmanın temel bulguları, teknik becerinin artık sadece el-göz koordinasyonu veya yazılım arayüzü bilgisiyle sınırlı kalmadığını; aksine dilsel yetkinlik, semantik kurgu kapasitesi ve algoritmik okuryazarlığın tasarım disiplinde yeni bir teknik kriter haline geldiğini göstermektedir. Yapay zekanın üretim safhasını mekanikleştirmesiyle birlikte, tasarım eğitiminde nasıl üretildiğinden ziyade ne amaçla ve hangi kavramsal çerçeveye üretildiği sorusu daha kritik bir önem kazanmıştır.

Sonuç olarak, tasarım eğitiminin teknolojik bağlamda, geleneksel görsel kültür birikimi ile yapay zeka tabanlı iş akışlarını sentezleyen hibrit bir pedagojiye ihtiyaç duyduğu tespit edilmiştir. Önerilen müfredat çerçevesi; etik kullanım bilincini, eleştirel tasarım düşüncesini ve prompt mühendisliğini dahil ederek, öğrencilerin yapay zekayı yaratıcı süreci zenginleştiren stratejik bir ortak olarak konumlandırmasını hedeflemektedir. Bu dönüşüm, tasarımcının rolünü teknik bir operatörlükten, karmaşık görsel sistemleri yöneten bir vizyonerliğe taşımaktadır.

Anahtar kelimeler: Üretken Yapay Zeka, Görsel İletişim Tasarımı Eğitimi, Prompt Mühendisliği, Müfredat Geliştirme, Teknik Beceri Dönüşümü.

FROM DRAWING TO PROMPT ENGINEERING: THE TRANSFORMATION OF TECHNICAL SKILLS AND THE SEARCH FOR NEW CURRICULUM DEVELOPMENTS IN VISUAL COMMUNICATION DESIGN EDUCATION

ABSTRACT

Visual communication design education is undergoing a paradigm-shifting transformation today, driven by the impact of generative artificial intelligence (GAI) technologies following digitalization and automation processes. The main objective of this study is to analyze how traditional drawing skills and software-focused technical proficiency are transforming within the framework of prompt engineering, and to open a discussion on the new curriculum strategies required by this transformation.

The scope of the study is the process of the designer's identity evolving from practitioner to curator and the integration of this process into design studio courses. Descriptive analysis and document analysis techniques from qualitative research methods were used in the research. Existing visual communication design curricula were comparatively examined with the new competency sets demanded by AI tools (Midjourney, Stable Diffusion, DALL-E, etc.). The main findings of the research show that technical skill is no longer limited to hand-eye coordination or software interface knowledge; rather, linguistic competence, semantic structuring capacity, and algorithmic literacy have become new technical criteria in the design discipline. With artificial intelligence mechanizing the production phase, the question of what purpose and conceptual framework something is produced within has become more critical in design education than how it is produced.

Consequently, it has been determined that design education needs a hybrid pedagogy that synthesizes traditional visual culture with AI-based workflows in a technological context. The proposed curriculum framework aims to position students as a strategic partner enriching the creative process by incorporating ethical usage awareness, critical design thinking, and prompt engineering. This transformation shifts the designer's role from that of a technical operator to that of a visionary managing complex visual systems.

Keywords: Generative Artificial Intelligence, Visual Communication Design Training, Prompt Engineering, Curriculum Development, Technical Skills Transformation.

MATEMATİK ÖĞRETMENİ ADAYLARININ KURDUKLARI PROBLEMLERİN BAĞLAMSAL AÇIDAN İNCELENMESİ

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ÖZET

Problem kurma, matematik eğitimi alanında zamanla artan bir ilginin odağı olan (Cai ve Hwang, 2020), öğrencilere ve öğretmenlere çeşitli kazanımlar sağlayan önemli bir beceridir (Kar, 2024). Problem kurmanın hem öğrencilere (Abu-Elwan, 2002; Kovács, Báró, Lócska ve Kónya, 2023) hem de öğretmenlere (Abu-Elwan, 1999; Okuyucu ve Uyar, 2025) sunduğu faydalardan biri matematik ile gerçek hayat arasındaki ilişkiyi kavramalarını ve güçlendirmelerini sağlamaktır. Matematik ile gerçek hayat arasında ilişki kurmayı temel alan kuramsal yapılardan biri olan Gerçekçi Matematik Eğitimi (Realistic Mathematics Education-RME) matematik öğretiminde gerçekçi bağlamlara yer verilmesi gerektiğini vurgulamaktadır (Ünlü, 2023). Problem kurma etkinliklerinin öğretmenlerin işbirliğiyle gerçek hayata uygun problemler kurmaları ve bu problemlerin nitelikleri hakkında düşünceleri yoluyla matematiksel kavramları gerçekçi bağlamlarda ele alma becerisini edinmelerine fayda sağlayabileceği öngörülmektedir (Okuyucu ve Uyar, 2025). Bu durum geleceğin öğretmenleri olan öğretmen adaylarının grup çalışmasıyla problem kurma etkinliklerine dahil edilerek kurdukları problemlerde bağlamın ele alınmasını önemli kılmaktadır. Buradan hareketle bu çalışmada matematik öğretmeni adaylarının grup çalışmasıyla kurdukları problemlerin bağlamsal açıdan incelenmesi amaçlanmıştır. Çalışmanın amacı doğrultusunda belirlenen problem cümlesi “Matematik öğretmeni adaylarının grup çalışmasıyla kurdukları problemlerde bağlamın türü nedir ve gerçek yaşam bağlamının gerçekçiliği ne durumdadır?” şeklindedir. Bu çalışmada nitel araştırma yaklaşımı çerçevesinde durum çalışması deseni benimsenmiştir. Katılımcılar 2024-2025 eğitim-öğretim yılında bir devlet üniversitesinin matematik öğretmenliği programının son sınıfında öğrenim gören 31 öğretmen adayından oluşmaktadır. Çalışmada veri toplama aracı olarak yarı-yapılandırılmış problem kurma etkinliği kullanılmıştır. Etkinlik 2-3 kişiden oluşan toplam 11 gruba uygulanmış ve yanıtlar yazılı olarak toplanmıştır. Gruplara doğrudan bağlam türü ya da gerçekçiliği hakkında yönlendirici müdahalede bulunulmamış; böylece problem kurma süreçlerindeki doğal eğilimlerinin ortaya

çıkarılması amaçlanmıştır. Verilerin analizinde betimsel analizden yararlanılmış; Nedaei, Radmehr ve Drake'in (2022) çalışmalarında kullandıkları bağlamsal analiz çerçevesi esas alınmıştır. Analiz sürecinde öncelikle kurulan problemler, içerdiği bağlam türüne göre “gerçek yaşam bağlamı” ve “matematiksel bağlam” olarak sınıflandırılmıştır. Sonra gerçek yaşam bağlamı içeren problemler, bağlamın gerçekçi olup olmaması açısından değerlendirilmiştir. Bu değerlendirmede gerçek yaşam bağlamı içeren problemde verilen ve çözümde ulaşılan bilgilerin gerçek hayata uygun olup olmadığına bakılmıştır. Bulgular değerlendirildiğinde, ilköğretim matematik öğretmeni adaylarının grup çalışmasıyla problem kurma sürecinde gerçek yaşam bağlamı kullanma eğiliminde oldukları ancak kurulan problemlerin önemli bir kısmında gerçekçiliğin tam olarak sağlanamadığı görülmüştür. Bu durum, öğretmen eğitimi sürecinde problem kurma becerisinin yalnızca gerçek yaşam bağlamı içerip içermeme boyutuyla değil, bağlamsal gerçekçilik boyutuyla da ele alınması gerektiğine işaret etmektedir.

Anahtar kelimeler: Problem kurma, matematik öğretmeni adayları, gerçek yaşam bağlamı

A CONTEXTUAL ANALYSIS OF THE PROBLEMS POSED BY PRE-SERVICE MATHEMATICS TEACHERS

ABSTRACT

Problem posing, which has become an increasingly prominent focus of interest in mathematics education over time (Cai & Hwang, 2020), is an important skill that provides various benefits for both students and teachers (Kar, 2024). One of the advantages of problem posing for both students (Abu-Elwan, 2002; Kovács, Báró, Lócska, & Kónya, 2023) and teachers (Abu-Elwan, 1999; Okuyucu & Uyar, 2025) is that it enables them to understand and strengthen the relationship between mathematics and real life. Realistic Mathematics Education (RME), one of the theoretical frameworks based on establishing connections between mathematics and real life, emphasizes that realistic contexts should be incorporated into mathematics instruction (Ünlü, 2023). It is suggested that problem-posing activities can benefit teachers by enabling them, through collaboration, to create real-life appropriate problems and reflect on the characteristics of these problems, thereby developing the ability to address mathematical concepts within realistic contexts (Okuyucu & Uyar, 2025). In this regard, it becomes important to engage pre-service teachers in group-based problem-posing activities and to examine how context is addressed in the problems they construct. Accordingly, this study aims to examine the problems posed by pre-service mathematics teachers through group work from a contextual perspective. In line with this aim, the research question is formulated as follows: “What types of context are used in the problems posed by pre-service mathematics teachers through group work, and to what extent are real-life contexts realistic?” This study adopts a case study design

within the framework of qualitative research. The participants consisted of 31 pre-service mathematics teachers enrolled in the final year of a mathematics teacher education program at a public university during the 2024–2025 academic year. A semi-structured problem-posing activity was used as the data collection instrument in the study. The activity was administered to a total of 11 groups, each consisting of 2–3 participants, and the responses were collected in written form. No direct guidance or intervention was provided to the participants regarding the type of context or its realism, in order to reveal their natural tendencies during the problem-posing process. Descriptive analysis was used in the data analysis, and the contextual analysis framework employed in the study of Nedaei, Radmehr, and Drake (2022) was adopted as the basis. First, the posed problems were categorized according to the type of context they contained as either real-life context or mathematical context. Subsequently, the problems involving real-life contexts were evaluated in terms of their realism. In this evaluation, it was examined whether the information presented in the problem and obtained through its solution was consistent with real-life situations. When the findings were evaluated, it was observed that pre-service primary mathematics teachers tended to use real-life contexts in the group-based problem-posing process; however, a substantial proportion of the problems they posed did not fully achieve realism. This situation indicates that, in teacher education, problem-posing skills should be addressed not only in terms of whether they include real-life contexts, but also with respect to the dimension of contextual realism.

Keywords: Problem posing, pre-service mathematics teachers, real-life context

1. GİRİŞ

Problem kurma, matematik eğitimi çalışmalarında son otuz yılda zamanla artan bir ilginin odağı olmaktadır (Cai ve Hwang, 2020). Problem kurma, literatürde problem oluşturma, problem üretme, problem bulma gibi çeşitli isimlerle ifade edilmektedir (Öçal, İpek, Özdemir ve Kar, 2018). Silver'a (1994) göre problem kurma, yeni problemlerin üretilmesi ya da mevcut problemlerin yeniden biçimlendirilmesi, NCTM'ye (2000) göre ise, verilen bir durum ya da deneyimden yeni bir problem oluşturmaktır. Cai ve Hwang (2020) ise matematik eğitiminde problem kurmayı öğrencilerin ve öğretmenlerin belirli bir bağlamdan hareketle bir problem üretmeleri ya da yeniden düzenlemelerini gerektiren çeşitli ilişkili etkinlikler şeklinde tanımlamışlardır. Literatürde problem kurma etkinliklerine yönelik farklı sınıflama çerçeveleri yer almaktadır (Ban Har ve Kaur, 1997; Dickerson, 1999; Kılıç, 2017; Silver, 1994; Stoyanova ve Ellerton, 1996). Bu sınıflamalardan en yaygın olarak kullanılanı, Stoyanova ve Ellerton'un (1996) problem kurma durumlarını ele alarak yaptığı yapılandırılmış, yarı yapılandırılmış ve

serbest şeklindeki sınıflamadır (Kar ve Işık, 2015). Yapılandırılmış problem kurma durumunda öğrencilerden belirli bir probleme veya çözüm yoluna ilişkin problemler kurmaları istenir (Stoyanova, 1997). Yarı yapılandırılmış problem kurma durumlarında öğrencilere açık uçlu bir durum verilir, onlardan matematiksel tecrübeleriyle kazandıkları bilgi, beceri, kavram ve ilişkileri kullanarak mevcut yapıyı anlama ve tamamlama ile problemler kurmaları istenir (Kılıç, 2024). Yarı yapılandırılmış problem kurma durumu kapsamında öğrencilerden, verilen açık uçlu bir hikayeden hareketle veya bir resim, şekil veya denkleme yönelik problemler kurmaları istenebilir (Öçal vd., 2018). Serbest problem kurma durumunda öğrencilerden, bir kısıtlama getirilmeksizin verilen doğal duruma yönelik problemler oluşturmaları istenir (Kar ve Işık, 2015).

Matematiği anlamada merkezi bir rol üstlenen problem kurmanın (NCTM, 1989) önemi, öğrenme ve öğretme açısından bakıldığında daha net anlaşılmaktadır (Kar, 2014). Öğrenme yani öğrenciler açısından bakıldığında problem kurma, onların temel matematiksel kavramları pekiştirmelerine, esnek düşünmelerine, problem çözme becerilerini geliştirmelerine yardımcı olurken matematiğe yönelik endişe ve korkularını giderir (English, 1997). Öğretme yani öğretmenler açısından bakıldığında ise öğrencilerin matematiksel bilgi ve becerilerine ilişkin bilgi veren bir değerlendirme aracı görevi görür (Lin, 2004). Ayrıca problem kurma hem öğrencilerin hem de öğretmenlerin yanlış anlamaların farkına varmalarını sağlar (English, 1997). Problem kurmanın hem öğrencilere (Abu-Elwan, 2002; Kovács, Báró, Lócska ve Kónya, 2023) hem de öğretmenlere (Abu-Elwan, 1999; Okuyucu ve Uyar, 2025) sunduğu bir diğer avantaj ise matematik ile gerçek hayat arasındaki ilişkiyi kavramalarını ve güçlendirmelerini sağlamaktır.

Matematik ile gerçek yaşam arasında bağlantı kurulması çeşitli çalışmalarda (Gainsburg, 2008; Umay, 2007) ve standart raporlarında (National Council of Teachers of Mathematics [NCTM], 1989, 2000) önemi vurgulanan bir konudur. Bu konuyu temel alan kuramsal yapılardan biri olan Gerçekçi Matematik Eğitimi (Realistic Mathematics Education-RME) matematik öğretiminde gerçekçi bağlamlara yer verilmesi gerektiğini vurgulamaktadır (Ünlü, 2023). Gerçek yaşam bağlamları öğrencilerin motivasyonunu desteklemekte ve matematiğe yönelik ilgilerini artırmaktadır (Stylianides ve Stylianides, 2008). Öğretmenlerin matematiksel kavramları gerçekçi bağlamlarda ele alma becerisini edinmelerinin yapacakları matematik öğretiminin kalitesi açısından önemli olduğu açıktır. Problem kurma etkinliklerinin, öğretmenlerin işbirliğiyle gerçek hayata uygun problemler kurmaları ve bu problemlerin nitelikleri hakkında düşünmeleri yoluyla matematiksel kavramları gerçekçi bağlamlarda ele

alma becerisini edinmelerine fayda sağlayabileceği öngörülmektedir (Okuyucu ve Uyar, 2025). Bu becerinin, mesleğe başlamadan önce öğretmen adayları tarafından kazanılmasının, ileride yürütecekleri sınıf içi öğretimin kalitesi açısından büyük önem taşıdığı söylenebilir. Henüz mesleki gelişim sürecinde olan öğretmen adaylarının da benzer şekilde işbirliği halinde problem kurma etkinliklerine dahil edilmesi sözü edilen becerinin kazanılması açısından önemli bir potansiyel taşımaktadır. Bu bağlamda, öğretmen adaylarının grup çalışmasıyla kurdukları problemlerin bağlamsal özelliklerinin ortaya konulmasının, bu konudaki mevcut duruma ilişkin bilgi sunması açısından önemli olduğu düşünülmektedir. Ancak alanyazında matematik öğretmeni adaylarının grup çalışması kapsamında bağlamsal açıdan nasıl problemler kurduklarına yönelik bir çalışmaya rastlanmamıştır. Buradan hareketle bu çalışmada, ilköğretim matematik öğretmeni adaylarının grup çalışmasıyla kurdukları problemlerin bağlamsal açıdan incelenmesi amaçlanmıştır. Çalışmanın amacı doğrultusunda belirlenen problem cümlesi “Matematik öğretmeni adaylarının grup çalışmasıyla kurdukları problemlerde bağlamın türü nedir ve gerçek yaşam bağlamının gerçekçiliği ne durumdadır?” şeklindedir.

2. YÖNTEM

2.1. Araştırma Deseni

Araştırmada nitel araştırma yöntemlerinden durum çalışması deseni kullanılmıştır. Nitel araştırmalar, olgu ve olayların nitel veri toplama teknikleriyle doğal ortamda gerçekçi ve bütüncül bir yaklaşımla incelenmesine yönelik nitel bir sürecin izlendiği araştırmalardır (Yıldırım ve Şimşek, 2021). Durum çalışması, belirli bir olgu, durum, ortam, sistem ya da örgütün detaylı ve derinlemesine betimlenmesi amacıyla kullanılan; ne, nasıl ve niçin sorularına yanıt arayarak süreci anlamının amaçlandığı bir araştırma desendir (Gürbüz ve Şahin, 2018). Bu çalışmada, ilköğretim matematik öğretmeni adaylarının grup çalışmasıyla kurdukları problemlerin bağlamsal açıdan derinlemesine ve bütüncül bir yaklaşımla incelenebilmesi için durum çalışması deseni kullanılmıştır.

2.2. Katılımcılar

Nitel araştırmalarda amaç genellemeden ziyade bütüncül bir resim elde etmek olduğundan (Yıldız, 2017) çalışılan konunun derinlemesine ve tüm olası detaylarıyla incelenmesi esastır (Yıldırım ve Şimşek, 2021). Genelleme yerine derinlik ve yoğunluğun hedeflendiği nitel araştırmalarda amaçlı örnekleme yöntemleri kullanılır (Şahan ve Uyangör, 2021) ve araştırmanın amacına uygun özellikleri taşıyan birimler örnekleme alınır (Şahin, 2023). Bu çalışmada katılımcılar amaçlı örnekleme yöntemleri arasında yer alan uygun örnekleme ile belirlenmiştir. Amaçlı örnekleme, çalışmanın amacına yönelik bilgi bakımından zengin

durumların derinlemesine incelenmesine imkan verir (Şahan ve Uyangör, 2021). Uygun örnekleme, araştırmacının rahatlıkla erişebileceği örneklem elemanlarını seçmesine imkan tanıdığından (Özen ve Gül, 2007) ve diğer örnekleme tekniklerine göre ekonomik ve pratik olduğundan (Baltacı, 2018) araştırmacılar tarafından sıklıkla kullanılmaktadır.

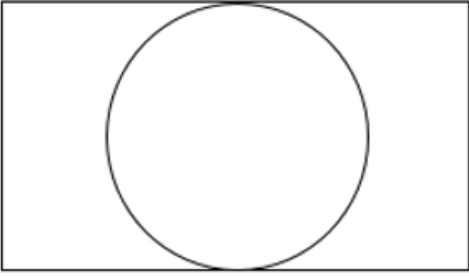
Çalışmanın katılımcıları, 2024-2025 eğitim-öğretim yılında İç Anadolu Bölgesi'ndeki bir devlet üniversitesinin ilköğretim matematik öğretmenliği programının son sınıfında öğrenim gören 31 gönüllü öğretmen adayından oluşmaktadır. Katılımcıların belirlenmesinde çalışmanın amacına uygun ve kolay ulaşılabılır bir örneklem seçildiği için uygun örnekleme kullanılmıştır.

2.3. Veri Toplama Aracı

Çalışmada veri toplama aracı olarak araştırmacı tarafından hazırlanan problem kurma etkinliği kullanılmıştır. Problem kurma etkinliğinin çalışmaya uygunluğuna yönelik uzman görüşü alınmıştır. Problem kurma etkinliğinde bir adet yarı-yapılandırılmış problem kurma durumu yer almaktadır. Resim, grafik veya tablo gibi görsel temsillerin kullanıldığı yarı-yapılandırılmış problem kurma etkinlikleri problemi kuran kişiye matematiği günlük yaşamla ilişkilendirme esnekliği sunduğundan (Kılıç, 2024) problem kurma durumu olarak bir şekle yer verilmiştir. Çalışmada veri toplama aracı olarak kullanılan problem kurma etkinliği Şekil 1'de yer almaktadır.

PROBLEM KURMA ETKİNLİĞİ

Aşağıda bir dikdörtgenin içerisine iki kenarına teğet olacak şekilde bir çember çizilmiştir.



Bir matematik öğretmeni derste çözmek üzere yukarıdaki şekli çözümünde kullanmayı gerektiren bir problem kurmak istemektedir. Bu öğretmenin yerinde olduğunuzu düşünerek 8. sınıf öğrencileri için bir problem kurunuz.

Şekil 1. Çalışmada veri toplama aracı olarak kullanılan problem kurma etkinliği

2.4. Verilerin Toplanması ve Analizi

Araştırmanın veri toplama sürecinde problem kurma etkinliği her biri 2 veya 3 öğretmen adayından oluşan toplam 11 gruba uygulanmış ve yanıtlar yazılı olarak toplanmıştır. Öğretmen adaylarına problemlerdeki bağlam türü (matematiksel bağlam/gerçek yaşam bağlamı) ya da bağlamın gerçekçiliği hakkında herhangi bir bilgi verilmeyip yönlendirici müdahalede bulunulmamış; böylece problem kurma süreçlerindeki doğal eğilimlerinin ortaya çıkarılması amaçlanmıştır. Öğretmen adaylarından problem kurma etkinliğini grup üyelerinin tamamının katılımıyla gerçekleştirmeleri istenmiş, süre kısıtlaması getirilmemiştir. Grupların etkinliği tamamlayıp teslim etmeleri 15-20 dakika sürmüştür. Araştırmanın veri toplama süreci araştırmacılar tarafından gerçekleştirilmiştir.

Araştırmada elde edilen verilerin analizinde betimsel analizden yararlanılmış; Nedaei, Radmehr ve Drake'in (2022) çalışmalarında kullandıkları bağlamsal analiz çerçevesi esas alınmıştır. Analiz sürecinde öncelikle kurulan problemler, içerdiği bağlam türüne göre "gerçek yaşam bağlamı" ve "matematiksel bağlam" olarak sınıflandırılmıştır. Daha sonra gerçek yaşam bağlamı içeren problemler, bağlamın gerçekçi olup olmaması açısından değerlendirilmiştir. Bu değerlendirmede gerçek yaşam bağlamı içeren problemde verilen ve çözümde ulaşılan bilgilerin gerçek hayata uygun olup olmadığına bakılmıştır.

3. BULGULAR

Bu bölümde öğretmen adaylarının grup çalışmasıyla kurdukları problemler bağlamsal açıdan incelenmiş; öncelikle problemlerdeki bağlam türü belirlenmiş, ardından gerçek yaşam bağlamı içeren problemlerin gerçekçilik durumları değerlendirilmiştir.

3.1. Problemlerin Bağlam Türünün Belirlenmesi

Analiz sonucunda, öğretmen adaylarından oluşan her bir grubun kurduğu problemin gerçek yaşam bağlamı içerdiği belirlenmiştir. Gruplar, problem kurma etkinliğindeki matematiksel yapıyı tamamen soyut şekilde vermek yerine bir hikaye içinde vererek günlük yaşamla ilişkilendirmeye çalışmışlardır. Kurdukları problemleri günlük hayatta karşılığı olan bir durum üzerinden kurgulamış; kişi, nesne ve durumları günlük yaşamdan seçmişlerdir. Ayrıca matematiksel işlemler, problemlerde sundukları bağlamın içerisinde doğal bir gereklilik olarak ortaya çıkmaktadır. Bu durum, öğretmen adaylarının grup çalışmasıyla problem kurma sürecinde gerçek yaşam bağlamı kullanma eğiliminde olduklarını göstermektedir.

3.2. Gerçek Yaşam Bağlamlarının Gerçekçilik Durumunun Belirlenmesi

Gerçek yaşam bağlamı içeren problemler gerçekçilik açısından incelendiğinde problemlerin gerçekçi, kısmen gerçekçi ve gerçekçi değil şeklinde üç farklı kategoride toplandığı belirlenmiştir.

Tablo 1. Problemlerin Bağlamlarının Gerçekçilik Durumuna Göre Dağılımı

Bağlamın Gerçekçilik Durumu	Katılımcı Grubu	f
Gerçekçi	G3, G7, G9, G10	4
Kısmen gerçekçi	G2, G4, G5, G6, G8, G11	6
Gerçekçi değil	G1	1

Tablo 1 incelendiğinde, öğretmen adaylarının grup çalışmasıyla kurdukları problemlerin gerçekçi, kısmen gerçekçi ve gerçekçi değil olmak üzere üç kategori altında toplandığı görülmektedir. Problemlerin büyük bir kısmının kısmen gerçekçi kategorisinde yer aldığı (f=6), buna karşılık daha az sayıda problemin gerçekçi (f=4) ve yalnızca bir problemin gerçekçi değil (f=1) kategorisinde olduğu görülmektedir.

3.2.1. Gerçekçi Bağlamlar

Bu problemlerde matematiksel yapı ile bağlam arasında güçlü ve doğal bir ilişki kurulmuş, bağlamın gerçekçiliği sağlanmıştır. Bağlamının gerçekçi olduğu belirlenen bir problem aşağıda verilmiştir.

“Ali Bey, bahçesine tabanı daire şeklinde bir havuz yaptırmak istiyor. Bahçe dikdörtgen şeklindedir. Bahçenin uzun kenarı 20 m, alanı ise 160 m² dir. Bu bahçenin sınırlarını geçmeyecek şekilde yapılabilecek en büyük havuzun taban alanını bulunuz. ($\pi=3$ alınız.)”

Dikdörtgen şeklindeki bahçenin içerisine, bahçenin sınırlarını geçmeyecek şekilde daire şekilli en büyük havuzun yaptırılması gerçekçidir. Problemden dikdörtgen şeklindeki bahçenin uzun kenarının 20 m, alanının ise 160 m² olduğu verilmiştir. Buradan kısa kenarın 8 m olduğu bulunmaktadır. Verilen uzunluk ölçüleri, gerçek hayattaki bir bahçe için gerçekçidir.

3.2.2. Kısmen Gerçekçi Bağlamlar

Bu problemlerde bağlam genel olarak gerçek hayata uygun olmakla birlikte, bağlamın gerçekçiliği kısmen sağlanmıştır. Bağlamının kısmen gerçekçi olduğu belirlenen bir problem aşağıda verilmiştir.

“Bir futbolcu özel hazırlanmış bir kaleye şut çekmektedir. Dikdörtgen şeklindeki kalenin zeminine ve üst direğine teğet olacak şekilde bir çember konumlandırılmıştır. Bu kalenin kısa direği 4 metre, uzun direği ise 6 metredir. Futbolcunun çektiği şutun kaleye isabet ettiği bilindiğine göre şutun çemberin dışına isabet etme olasılığı nedir? ($\pi=3$ alınız.)”

Gerçek hayatta kalenin içine “üst direğe ve zemine teğet çember” yerleştirilmesi yapay bir durumdur. Öğretmen adayları bu ifadeyi sadece dikdörtgen ve çemberden oluşan geometrik yapıyı korumak adına eklemişlerdir. Problemden özel olarak hazırlanmış kalenin uzun ve kısa kenarlarının sırasıyla 6 metre ve 4 metre olduğu verilmektedir. Kalenin kenar uzunlukları, gerçek bir kalenin ölçülerine tam olarak uygun olmasa da problem metninde yer alan “*Bir futbolcu özel hazırlanmış bir kaleye şut çekmektedir.*” cümlesinde yer alan “özel olarak hazırlanmış” ifadesi bir kalenin ölçülerini karşılaması bakımından gerçekçiliği yansıtabilir.

3.2.3. Gerçekçi Olmayan Bağlamlar

Bu problemlerde gerçek yaşam bağlamı yer almasına rağmen bu bağlamın gerçekçi olmadığı, yapay ve kurgusal olduğu görülmüştür. Bağlamının gerçekçi olmadığı belirlenen bir problem aşağıda verilmiştir.

“Bir koşucu dikdörtgen şeklindeki sahada çember oluşturacak şekilde koşacaktır. Koşucu sahanın en az iki kenarına değecek şekilde en fazla mesafeyi koşmak istemektedir. Sahanın alanı $70 m^2$, çevresi 34 metredir. O halde koşucu kaç metre koşmuştur? ($\pi=3$ alınız.) (Sahanın kenar uzunlukları tam sayıdır.)”

Gerçek hayatta bir koşucu “çember oluşturmak için” koşmaz, özellikle “dikdörtgen sahada çember oluşturmak” oldukça yapay bir amaçtır. Öğretmen adayları kurdukları problemde matematiksel kavramı (çember) gerçek hayata yapay şekilde yerleştirmeye çalışmıştır. Gerçek hayatta bir koşucunun dikdörtgen sahada “en az iki kenara değecek” şekilde “en fazla mesafeyi” koşması oldukça yapay bir durumdur. Problemden “en az iki kenara değme” ve “en fazla mesafe” gibi kısıtlar gerçek hayatta anlamlı bir davranışa karşılık gelmemektedir. Problemden “...dikdörtgen şeklindeki sahada çember oluşturacak şekilde koşacaktır. Koşucu sahanın en az iki kenarına değecek şekilde en fazla mesafeyi koşmak istemektedir...” ifadesi, “dikdörtgen içine çizilebilecek en büyük çember” matematiksel ifadesinin bağlamla örtülmüş halidir. Problemden sahanın alanının 70 metrekare, çevresinin ise 34 metre olduğu verilmektedir. Problem çözüldüğünde de sahanın uzun ve kısa kenarının sırasıyla 10 metre ve 7 metre olduğu görülmektedir. Problemden sahanın alanı ve çevresi için verilen sayılar gerçek hayattaki bir sahanın ölçülerini karşılayamamaktadır. Çünkü söz konusu alan, gerçek hayatta bir koşu etkinliği için oldukça küçük olup, bağlamın gerçekçiliğini zayıflatmaktadır.

4. SONUÇ VE TARTIŞMA

Bu araştırmada ilköğretim matematik öğretmeni adaylarının grup çalışmasıyla kurdukları problemler bağlamsal açıdan incelenmiştir. Araştırmadan elde edilen bulgular değerlendirildiğinde, ilköğretim matematik öğretmeni adaylarının grup çalışmasıyla problem

kurma sürecinde gerçek yaşam bağlamı kullanma eğiliminde oldukları ancak kurulan problemlerin önemli bir kısmında gerçekçiliğin tam olarak sağlanamadığı görülmüştür.

Öğretmen adaylarından oluşan grupların tamamının kurduğu problemlerin gerçek yaşam bağlamı içermesi, araştırmanın dikkat çekici bulgularından biridir. Bu durum, öğretmen adaylarının grup çalışmasıyla gerçek yaşam bağlamı içeren problemler kurmada başarılı olduğunu göstermektedir. Ayrıca öğretmen adaylarının matematiği günlük yaşamla ilişkilendirmeyi problem kurma bağlamında yapabildiği, bu konuda farkındalığa sahip olduğu görülmektedir. Matematik öğretiminde gerçek yaşam bağlantılarının önemini vurgulayan çalışmalar (Gainsburg, 2008; Umay, 2007) dikkate alındığında, bu bulgu olumlu bir durum olarak değerlendirilebilir.

Bunun yanı sıra problemlerin büyük bir kısmında bağlamın kısmen gerçekçi olması ya da gerçekçi olmaması, öğretmen adaylarının kurdukları problemlerde bağlamın gerçekçiliğini sağlamada zorlandıklarını göstermektedir. Özellikle, “teğet çember” gibi matematiksel kavramların doğrudan bağlama dahil edilmesinin bağlamın gerçekçiliğini yitirmesine yol açtığı görülmüştür. Bu durum, öğretmen adaylarının problem kurma sürecinde matematiksel yapıdan hareketle bağlam oluşturduklarını, bağlamın kurgusal ve yapay kaldığını göstermektedir. Bu bulgu, öğretmen adaylarının problem kurarken matematiksel yapıyı ön planda tuttıklarını ortaya koyan çalışmayla da (Cai, 2003) örtüşmektedir. Öte yandan, bazı problemlerde matematiksel yapı ile bağlam arasında daha güçlü ve doğal bir ilişki kurulduğu görülmüştür. Bu problemlerde matematiksel işlemler bağlamın doğal bir gereksinimi olarak ortaya çıktığından problem gerçekçilik açısından daha anlamlı hale gelmektedir.

Genel olarak değerlendirildiğinde, öğretmen adaylarının grup çalışmasıyla problem kurma sürecinde gerçek yaşam bağlamı tercih ettikleri ancak bu bağlamların gerçekçiliğini sağlama konusunda gelişmeleri gerektiği söylenebilir. Bu durum, öğretmen eğitimi sürecinde problem kurma becerisinin yalnızca gerçek yaşam bağlamı içerip içermeme boyutuyla değil, bağlamsal gerçekçilik boyutuyla da ele alınması gerektiğini ortaya koymaktadır.

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MATEMATİK ÖĞRETMENİ ADAYLARININ DÜŞÜNME VE EMPATİK DÜŞÜNME KAVRAMLARINA İLİŞKİN GÖRÜŞLERİ

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ÖZET

Günümüzde bilim ve teknoloji alanında yaşanan hızlı gelişim ve değişimler zihnimizi doğrudan etkilemekte ve bu durum zihnimizi üst düzeyde geliştirmeye zorlamaktadır. Bu süreçte zihinsel becerilerin önemi ön plana çıkmakta; bu beceriler içerisinde zihnin önemli bir işlevi ve aynı zamanda geliştirilebilir bir becerisi olarak ifade edilen *düşünme*, bireyin bilgiye ulaşma, yorumlama ve yeni durumlara uyum sağlama süreçlerinde belirleyici bir rol üstlenmektedir. Bu doğrultuda düşünme becerisi farklı şekillerde ele alınmakta olup eleştirel düşünme, yaratıcı düşünme, analitik düşünme, yansıtıcı düşünme ve empatik düşünme gibi çeşitli boyutları içermektedir. Bu düşünme türleri içerisinde *empatik düşünme*, bireyin yalnızca kendi bakış açısıyla sınırlı kalmayarak başkalarının duygu, düşünce ve perspektiflerini anlayabilmesini sağlama açısından ayrı bir öneme sahiptir. Özellikle eğitim ortamlarında empatik düşünme, öğretmenlerin öğrencilerini daha iyi tanımalarına, onların ihtiyaçlarını anlamalarına ve öğrenme süreçlerini daha etkili bir şekilde düzenlemelerine katkı sunmaktadır. Bu yönüyle empatik düşünme, öğretmenlik mesleğinin yalnızca bilişsel değil, aynı zamanda sosyal ve duyuşsal boyutunu da güçlendiren temel becerilerden biri olarak değerlendirilmektedir. Buradan hareketle, geleceğin öğretmenleri olan öğretmen adaylarının düşünme ve empatik düşünme kavramlarına ilişkin sahip oldukları algıların ortaya konulmasının önemli olduğu düşünülmektedir. Bu doğrultuda bu çalışmada matematik öğretmeni adaylarının düşünme ve empatik düşünme kavramlarına ilişkin görüşlerinin incelenmesi amaçlanmıştır. Araştırmada, nitel araştırma yaklaşımlarından biri olan olgubilim deseni tercih edilmiştir. Araştırmanın çalışma grubunu 2025-2026 eğitim-öğretim yılında bir devlet üniversitesinin matematik öğretmenliği programının son sınıfında öğrenim gören 41 öğretmen adayı oluşturmaktadır. Araştırma kapsamında veri toplamak amacıyla iki sorudan oluşan bir görüş formu hazırlanmıştır;

elde edilen veriler içerik analizi yaklaşımı doğrultusunda çözümlenmiştir. Bulgular değerlendirildiğinde, matematik öğretmeni adaylarının düşünme kavramını ağırlıklı olarak anlamlandırma, yorumlama ve zihinsel süreç boyutlarıyla ele aldıkları; empatik düşünmeyi ise büyük ölçüde kendini başkasının yerine koyma şeklinde algıladıkları görülmüştür. Bununla birlikte, empatik düşünmenin duyuşsal ve davranışsal boyutlarına ilişkin ifadelerin sınırlı olması, öğretmen adaylarının bu kavrama yönelik algılarının geliştirilmesi gerektiğine işaret etmektedir.

Anahtar kelimeler: Düşünme, empatik düşünme, matematik öğretmeni adayları

PRE-SERVICE MATHEMATICS TEACHERS' VIEWS ON THE CONCEPTS OF THINKING AND EMPATHIC THINKING

ABSTRACT

In today's world, the rapid and ongoing developments and changes in science and technology directly affect our minds, compelling them to develop at a higher level. In this process, the importance of mental skills comes to the fore; among these skills, *thinking* defined as an important function of the mind and at the same time a developable skill plays a decisive role in individuals' processes of accessing information, interpreting it, and adapting to new situations. In this regard, thinking skills are addressed in various ways and encompass different dimensions such as critical thinking, creative thinking, analytical thinking, reflective thinking, and empathic thinking. Among these types of thinking, *empathic thinking* holds particular importance as it enables individuals to go beyond their own perspective and understand others' feelings, thoughts, and viewpoints. Especially in educational settings, empathic thinking contributes to teachers' ability to better understand their students, recognize their needs, and organize learning processes more effectively. In this respect, empathic thinking is considered one of the fundamental skills that strengthens not only the cognitive but also the social and affective dimensions of the teaching profession. Based on this, it is considered important to reveal the perceptions that pre-service teachers, as the teachers of the future, hold regarding the concepts of thinking and empathic thinking. Accordingly, this study aims to examine pre-service mathematics teachers' views on the concepts of thinking and empathic thinking. In this study, the phenomenological design, one of the qualitative research approaches, was preferred. The study group of the research consists of 41 pre-service teachers enrolled in the final year of a mathematics teacher education program at a state university in the 2025-2026 academic year. Within the scope of the study, a two-question interview form was prepared to collect data; the obtained data were analyzed in line with the content analysis approach. When the findings were evaluated, it was found that pre-service mathematics teachers predominantly conceptualized

thinking in terms of meaning-making, interpretation, and mental processes, while they largely perceived empathic thinking as putting oneself in another's place. However, the limited expressions related to the affective and behavioral dimensions of empathic thinking indicate that pre-service teachers' perceptions of this concept need to be further developed.

Keywords: Thinking, empathic thinking, pre-service mathematics teachers

1. GİRİŞ

Düşünme, bireyin bilgiyi anlama, ilişkilendirme, sorgulama ve yeni bilgiler üretme süreçlerinin temelini oluşturan karmaşık zihinsel etkinliktir (Güneş, 2023). Bu yönüyle düşünme, yalnızca bilişsel bir süreç olmanın ötesinde, bireyin çevresiyle etkileşimini anlamlandırmasını ve karşılaştığı durumlara uyum sağlamasını mümkün kılan temel bir beceri olarak öne çıkmaktadır. Antik çağlardan günümüze kadar farklı disiplinler tarafından ele alınan düşünme kavramı, zaman içerisinde farklı boyutlarıyla tanımlanmış ve kavramın bireyin öğrenme süreçlerindeki merkezi rolü vurgulanmıştır (Elder & Paul, 2004; Yılmaz 2018). Dewey'e (2004) göre hissedilen bir zorlukla başlayan düşünme eylemini kapsamayan hiçbir anlamlı yaşantı yoktur. Türk Dil Kurumu düşünme kavramını, karşılaştırma yapma, ayırma, birleştirme, bağlantıları ve biçimleri kavrama yetisi, bir konu hakkında akıl yürütme, muhakeme yapma, akıldan geçirme ve hayal etme şeklinde açıklamaktadır (TDK, 2026). Bu kapsamda bakıldığında düşünme; sorgulama, anlama, öğrenme, akıl yürütme, kavrama, analiz ve sentez gibi çeşitli süreç ve işlemleri kapsayan çok boyutlu bir kavramdır.

Düşünmenin çok boyutlu yapısı, bu becerinin farklı türler ve boyutlar çerçevesinde ele alınmasını gerekli kılmaktadır. Bu doğrultuda düşünme; eleştirel düşünme, yaratıcı düşünme, analitik düşünme, yansıtıcı düşünme, üst bilişsel düşünme ve empatik düşünme gibi çeşitli türler altında incelenmektedir. Bu düşünme türleri içerisinde empatik düşünme, kendisini başkasının yerine koyarak, karşısındakinin duygu ve düşüncelerini anlamaya çalışma şeklinde ifade edilmektedir (Ekinci & Aybek, 2010; Gökalp, 2024). Empatik düşünme bireyin yalnızca kendi bakış açısıyla sınırlı kalmayarak başkalarının duygu, düşünce ve perspektiflerini anlayabilmesini sağlaması açısından ayrı bir öneme sahiptir. Empatik düşünme, bireyin farklı bakış açılarını dikkate alarak olayları değerlendirmesine, kişiler arası etkileşimlerini güçlendirmesine ve daha sağlıklı iletişim kurmasına katkı sunmaktadır. Bu yönüyle empatik düşünme, özellikle eğitim ortamlarında öğretmenlerin öğrencilerini daha iyi anlamalarına, onların ihtiyaçlarına duyarlı yaklaşımlarına ve öğrenme süreçlerini daha etkili bir şekilde düzenlemelerine olanak tanıyan temel bir düşünme becerisi olarak değerlendirilmektedir. Bu bağlamda, empatik düşünmenin öğretmenlik mesleği açısından taşıdığı önem dikkate

alındığında, öğretmen adaylarının bu kavramı nasıl algıladıkları ve nasıl anlamlandırdıkları önemli bir araştırma konusu hâline gelmektedir. Öğretmen adaylarının düşünme ve empatik düşünme kavramlarına yükledikleri anlamların ortaya konulması, bu becerilerin öğretmen yetiştirme sürecinde nasıl ele alındığına ilişkin önemli ipuçları sunmaktadır. Bu kavramların öğretmen adayları tarafından nasıl kavramsallaştırıldığı belirlenmesi, hem öğretmen eğitimi programlarının geliştirilmesine katkı sağlayacak hem de öğretim süreçlerinin daha nitelikli hâle getirilmesine yönelik bir temel oluşturacaktır. Bu doğrultuda, araştırmanın amacı matematik öğretmeni adaylarının düşünme ve empatik düşünme kavramlarına ilişkin görüşlerini incelemektir.

2. YÖNTEM

2.1. Araştırma deseni

Araştırmada, nitel araştırma yaklaşımlarından olgubilim deseni benimsenmiştir. Olgubilim deseni, bireylerin farkında oldukları ancak derinlemesine ve ayrıntılı biçimde kavrayamadıkları olguların incelenmesine odaklanmaktadır (Yıldırım & Şimşek, 2018). Bu desende veri, araştırmanın merkezinde yer alan olguyu deneyimleyen ve bu deneyimlerini ifade edebilen bireylerden ya da gruplardan toplanmaktadır (Büyüköztürk vd., 2018). Bu doğrultuda, matematik öğretmeni adaylarının düşünme ve empatik düşünme kavramlarına ilişkin algı ve anlamlandırma biçimlerini ortaya koymayı amaçlayan bu araştırmada, çalışmanın doğasına uygun olarak olgubilim deseni tercih edilmiştir.

2.2. Çalışma grubu

Araştırmanın çalışma grubunu 2025-2026 eğitim-öğretim yılında bir devlet üniversitesinin matematik öğretmenliği programının son sınıfında öğrenim gören 41 öğretmen adayı oluşturmaktadır. Çalışma grubunun belirlenmesinde seçkisiz olmayan örnekleme yöntemlerinden uygun örnekleme yöntemi kullanılmıştır. Uygun örnekleme yönteminde mevcut, gönüllü veya kolaylıkla erişilebilen bireyler örnekleme dâhil edilir (Johnson & Christensen, 2014). Bu araştırma, araştırmacılardan birinin görev yaptığı üniversitenin matematik öğretmenliği programının dördüncü sınıfında öğrenim gören öğretmen adayları ile yürütüldüğünden, çalışmanın doğasına uygun olarak uygun örnekleme yöntemi tercih edilmiştir.

2.3. Veri toplama aracı ve verilerin analizi

Araştırmada veri toplama amacıyla iki sorudan oluşan bir görüş formu hazırlanmış; elde edilen veriler içerik analizi yaklaşımı doğrultusunda çözümlenmiştir. İçerik analizi, verilerin toplanmasıyla başlayan, kodların oluşturulması ve kategorilerin geliştirilmesi süreçlerini

içeren; elde edilen verilerin araştırmacı tarafından sistematik biçimde çözümlenip anlamlandırıldığı bir analiz yaklaşımıdır (McMillan & Schumacher, 2010). Bu süreçte, benzer özellikler gösteren veriler belirli kavramsal çerçeveler altında bir araya getirilerek düzenlenmekte ve anlaşılır ve tutarlı bir biçimde sunulmaktadır (Yıldırım & Şimşek, 2018). Bu doğrultuda, görüş formundan elde edilen veriler kodlanmış, oluşturulan kategoriler bulgular bölümünde ayrıntılı olarak sunulmuştur.

3. BULGULAR

Bu bölümde görüş formunda yer alan soruların analizinden elde edilen bulgulara yer verilmiştir. Formda öğretmen adaylarına ilk olarak “Düşünme nedir? sorusu yöneltilmiş, adayların bu soruya vermiş oldukları cevapların analizinden elde edilen bulgular Tablo 1’de sunulmuştur.

Tablo 1. Matematik öğretmeni adaylarının “düşünme” kavramına ilişkin görüşleri

Kategori	Katılımcı	f	Kod	Katılımcı	f
Bilgi işleme ve anlam oluşturma	Ö1, Ö5, Ö7, Ö8, Ö10, Ö14, Ö18, Ö23, Ö27, Ö24, Ö29, Ö35, Ö36, Ö40, Ö41	15	Anlamlandırma ve yorumlama	Ö1, Ö7, Ö8, Ö10, Ö23, Ö29, Ö36	7
			Problem çözme ve sonuçlandırma	Ö14, Ö27, Ö24, Ö29, Ö40	5
			Fikir üretme	Ö5, Ö18, Ö35, Ö41	4
Zihinsel süreç / bilişsel faaliyet	Ö5, Ö8, Ö12, Ö13, Ö16, Ö20, Ö22, Ö30, Ö31, Ö32, Ö36, Ö40	12	Zihinsel / bilişsel süreç	Ö8, Ö16, Ö20, Ö22, Ö30, Ö31, Ö32, Ö36, Ö40	9
			Süreklilik (sürekli süreç)	Ö8, Ö20, Ö36	3
			İstemli / istemsiz gerçekleşme	Ö5, Ö12, Ö13	3
Sorgulama ve değerlendirme	Ö3, Ö9, Ö18, Ö21, Ö27, Ö39	6	Fikir yürütme	Ö9, Ö27, Ö39	3
			Sorgulama	Ö3, Ö21	2
			Karar verme / değerlendirme	Ö18, Ö21	2
Günlük yaşam ve durumsal deneyimler	Ö4, Ö10, Ö17, Ö31, Ö36	5	Günlük yaşam ve deneyimle ilişkilendirme	Ö4, Ö10, Ö17, Ö36	4
			Durumsal bağlama göre düşünme	Ö10, Ö31	2

Tablo 1 incelendiğinde, matematik öğretmeni adaylarının “düşünme” kavramına ilişkin görüşlerinin dört temel kategori altında toplandığı görülmektedir. Katılımcıların büyük bir kısmı düşünmeyi “bilgi işleme ve anlam oluşturma” süreci kapsamında ele almış; özellikle

anlamlandırma ve yorumlama, problem çözme ve sonuçlandırma ile fikir üretme boyutları ön plana çıkmıştır. Bununla birlikte, düşünme kavramının “zihinsel süreç/bilişsel faaliyet” olarak ifade edildiği ve bu süreçte süreklilik ile istemli ya da istemsiz gerçekleşme özelliklerinin vurgulandığı görülmektedir. Katılımcıların bir kısmı düşünmeyi sorgulama, fikir yürütme ve değerlendirme süreçleriyle ilişkilendirirken, daha sınırlı sayıda katılımcının ise düşünmeyi günlük yaşam ve deneyimler ve durumsal bağlama göre düşünme ile ilişkilendirdiği dikkat çekmektedir.

Görüş formunda öğretmen adaylarına ikinci olarak “Empatik düşünme nedir?” sorusu yöneltilmiş, adayların bu soruya vermiş oldukları cevapların analizinden elde edilen bulgular Tablo 2’de sunulmuştur.

Tablo 2. Matematik öğretmeni adaylarının “empatik düşünme” kavramına ilişkin görüşleri

Kategori	Katılımcı	f	Kod	Katılımcı	f
Perspektif alma ve yerine koyma	Ö1, Ö2, Ö3, Ö5, Ö6, Ö7, Ö8, Ö9, Ö10, Ö11, Ö12, Ö13, Ö14, Ö15, Ö16, Ö17, Ö18, Ö19, Ö20, Ö21, Ö22, Ö23, Ö24, Ö25, Ö26, Ö27, Ö28, Ö29, Ö30, Ö31, Ö32, Ö33, Ö34, Ö35, Ö36, Ö37, Ö38, Ö39, Ö40, Ö41	40	Kendini başkasının yerine koyma	Ö1, Ö2, Ö3, Ö5, Ö7, Ö9, Ö10, Ö11, Ö12, Ö13, Ö14, Ö15, Ö16, Ö18, Ö19, Ö20, Ö21, Ö22, Ö23, Ö24, Ö25, Ö26, Ö27, Ö28, Ö29, Ö30, Ö31, Ö32, Ö33, Ö34, Ö35, Ö36, Ö37, Ö38, Ö39, Ö40, Ö41	37
			Başkasının bakış açısından düşünme	Ö6, Ö8, Ö17, Ö33, Ö41	5
Duyuşsal anlama ve hissetme	Ö4, Ö6, Ö12, Ö17, Ö18, Ö22, Ö25 Ö30	8	Duyguları anlama	Ö4, Ö12, Ö17, Ö22, Ö30	5
			Duyguları hissetme / paylaşma	Ö6, Ö18, Ö25	3
Durumu değerlendirme ve uygun tepki geliştirme	Ö3, Ö4, Ö9, Ö15, Ö21	5	Duruma göre değerlendirme	Ö3, Ö9, Ö21	3
			Uygun tepki / davranış geliştirme	Ö4, Ö15	2

Tablo 2 incelendiğinde, matematik öğretmeni adaylarının empatik düşünme kavramına ilişkin görüşlerinin üç temel kategori altında toplandığı görülmektedir. Katılımcıların neredeyse tamamı empatik düşünmeyi “perspektif alma ve yerine koyma” kategorisi kapsamında ele almış; özellikle kendini başkasının yerine koyma kodunun belirgin biçimde ön plana çıktığı dikkat çekmektedir. Bununla birlikte, daha sınırlı sayıda katılımcının empatik düşünmeyi başkasının bakış açısından düşünme şeklinde ifade ettiği görülmektedir. Empatik düşünmenin duyuşsal boyutuna ilişkin olarak, katılımcıların bir kısmı başkalarının duygularını anlama ve

hissetme boyutlarına vurgu yaparken, bu tür ifadelerin daha sınırlı kaldığı anlaşılmaktadır. Ayrıca, empatik düşünmenin durumu değerlendirme ve uygun tepki geliştirme boyutuna ilişkin görüşlerin de sınırlı sayıda katılımcı tarafından dile getirildiği görülmektedir.

4. SONUÇ ve TARTIŞMA

Araştırmadan elde edilen bulgular değerlendirildiğinde, matematik öğretmeni adaylarının düşünme kavramını ağırlıklı olarak bilgi işleme ve anlam oluşturma süreci çerçevesinde ele aldıklarını göstermektedir. Öğretmen adaylarının düşünmeyi anlamlandırma, yorumlama, problem çözme ve fikir üretme gibi bilişsel süreçlerle ilişkilendirmeleri, düşünmenin zihinsel bir etkinlik olarak kavramsallaştırıldığını ortaya koymaktadır. Bu durum, düşünmenin bilgi işleme, anlam oluşturma ve problem çözme süreçlerini kapsayan bilişsel bir yapı olduğuna yönelik literatürle paralellik göstermektedir (Anderson & Krathwohl, 2001; Elder & Paul, 2024; Güneş, 2023). Bununla birlikte, düşünmenin süreklilik gösteren ve kimi zaman istemli kimi zaman istemsiz gerçekleşen bir süreç olarak ifade edilmesi, öğretmen adaylarının düşünmenin doğasına ilişkin belirli bir farkındalığa sahip olduklarına işaret etmektedir. Bu bulgu düşünmenin bilinçli ve bilinçdışı süreçleri birlikte içeren bir yapı olduğunu vurgulayan çalışmalarla da örtüşmektedir (Başerer, 2017; Yılmaz, 2020). Öte yandan, düşünmenin sorgulama, değerlendirme ve günlük yaşamla ilişkilendirme boyutlarına yönelik ifadelerin daha sınırlı kalması, öğretmen adaylarının düşünme kavramını daha çok bilişsel ve süreç odaklı bir bakış açısıyla ele aldıklarını, ancak düşünmenin eleştirel ve bağlamsal yönlerine ilişkin algılarının görece sınırlı olduğunu düşündürmektedir. Bu durum, öğretmen adaylarının düşünme becerilerini çok boyutlu bir yapı içerisinde ele almalarına yönelik desteklenmesi gerektiğini ortaya koymaktadır.

Matematik öğretmeni adaylarının empatik düşünmeye ilişkin düşüncelerine ait bulgular incelendiğinde ise, adayların bu kavramı büyük ölçüde kendini başkasının yerine koyma çerçevesinde ele aldıklarını göstermektedir. Öğretmen adaylarının önemli bir kısmının empatik düşünmeyi yalnızca perspektif alma boyutuyla tanımlamaları, bu kavramın daha çok bilişsel yönüyle algılandığını düşündürmektedir. Bu bulgu, empatiyi başkasının bakış açısını anlama süreci olarak ele alan yaklaşımlarla örtüşmektedir (Ekinci & Aybek, 2010; Gökalp, 2024). Buna karşılık, empatik düşünmenin duyuşsal boyutunu oluşturan başkalarının duygularını anlama ve hissetme ile davranışsal boyutunu içeren duruma uygun tepki geliştirme süreçlerine yönelik ifadelerin daha sınırlı kalması, öğretmen adaylarının empatik düşünmeyi çok boyutlu bir yapı içerisinde ele almakta zorlandıklarını ortaya koymaktadır. Bu durum, empatik düşünmenin

bilişsel, duyuşsal ve davranışsal boyutlarını kapsayan bütüncül yapısının öğretmen adayları tarafından yeterince içselleştirilmediğine işaret etmektedir.

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INNOVATIVE STRATEGIES FOR ENHANCING NITROGEN EFFICIENCY IN AGRICULTURE

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Abstract

In agriculture, soil and water pollution by nitrates is significantly exacerbated by the excessive use of nitrogen fertilizers, which can lead to major environmental impacts such as eutrophication, groundwater contamination, and health risks.

Several strategies have been developed to address these issues by reducing nitrogen inputs while improving nitrogen use efficiency and maintaining agricultural productivity.

These strategies include adjusting fertilizer application rates, using slow-release fertilizers, applying precision fertilization tailored to crop needs, introducing nitrogen-fixing crops such as legumes, practicing crop rotation, and improving agricultural techniques.

These approaches not only help limit nitrogen losses to the environment but also enhance the quality of agricultural products and reduce costs for farmers. They form part of a broader effort to ensure the sustainability of agricultural systems in the face of climate change, balancing productivity, environmental protection, and resilience.

Keywords

Nitrate pollution, Nitrogen fertilizers, Groundwater contamination, Eutrophication, Precision fertilization, Sustainable agricultura, Environmental protection, Climate change resilience

PRODUCTION AND CHARACTERIZATION OF CARBON NANOTUBES FROM BIOCHAR UNDER MICROWAVE IRRADIATION

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ABSTRACT

Carbon nanotubes (CNTs) are widely used in a variety of fields to produce a diversity of products, including hydrogen storage systems, and field emitters. In the proposed study, CNTs synthesized via biochar under the microwave irradiation method. In this method, the combination of charcoal and ferrocene are used to synthesize CNTs from the biochar approach. Biochar samples for CNTs synthesis are made from pyrolyzed agro-industrial waste such as rapeseed cake, hazelnut hulls, wheat straw, and oat hulls at different temperatures. The biochar was produced from agro-industrial biomass. During experiments, 100g of biomass was placed in a microwave reactor. The samples were pyrolyzed at 400 °C to 600°C. SEM analysis was used to confirm the morphology of CNTs. SEM micrographs revealed the perfect structure of multiwall carbon nanotubes, while interlayers spacing was changed due to variation of catalysts and measured about 0.34nm. Further, the optical properties were examined by UV-visible spectroscopy. In the UV, one band is clear at 240 nm region due to resonance of nanotubes $\pi(\pi)$ electrons of carbon nanotubes. XRD was used to analyze the glassy structure of prepared CNTs under microwave revealed that the creation and growth of CNTs were mostly influenced by microwave irradiation and the ferrocene catalyst. The structure of CNTs was developed under microwave heating and in the presence of ferrocene catalyst. To research how nitrogen impurities adhere to CNTs, FTIR experiments were conducted in the 400–4000 cm^{-1} range. The sample's FTIR spectra exhibit prominent peaks that correspond to C-H and C=C, respectively.

THE SCIENTIFIC DISCOURSE ON ACADEMIC FREEDOM IN THE 21ST CENTURY: A COMPREHENSIVE ANALYSIS OF THEORETICAL PREMISES, NORMATIVE SYSTEMS, CHALLENGES, AND THE DILEMMA OF ACADEMIC PROFICIENCY IN CONTEMPORARY HIGHER EDUCATION REFORMS AND POLICIES WORLDWIDE

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ABSTRACT

This article presents a comprehensive analysis of academic freedom as a foundational principle in higher education throughout the 21st century. Tracing its historical evolution from early Enlightenment-era formulations to contemporary global discourses, the study delineates prevailing theoretical frameworks that inform understandings of autonomy, epistemic authority, and institutional agency. Attention is given to comparative legal frameworks across varied geopolitical contexts, including international covenants, national constitutions, and institutional governance codes that articulate protections and constraints on academic expression and inquiry. The analysis identifies and critically engages with emergent challenges to academic freedom—such as market-driven reforms, political instrumentalization of curricula, surveillance technologies, and pressures associated with performative metrics in research and teaching. A key focus is the paradox of academic proficiency: the simultaneous expansion of global higher education access and standards with escalating restrictions on critical inquiry and dissent. The study emphasizes the tension between institutional accountability and the preservation of independent scholarly judgment, highlighting how performance-based assessments, international ranking systems, and funding conditionalities increasingly influence academic decision-making. In addition, the article explores the sociocultural and ethical dimensions of academic freedom, examining how ideologies, social expectations, and political pressures intersect with the professional autonomy of faculty and researchers. Multidisciplinary perspectives—including legal studies, educational theory, sociology of knowledge, and policy analysis—are integrated to provide a holistic understanding of the current state of academic freedom worldwide. Furthermore, the study interrogates the implications of emerging digital and technological environments on academic freedom, including the use of artificial intelligence in monitoring teaching and research, digital surveillance of scholarly communications, and the global dissemination of knowledge in online platforms. Through

systematic review and critical synthesis of literature, the article elucidates structural, regulatory, and cultural barriers to academic autonomy while proposing actionable strategies to reinforce institutional safeguards, enhance faculty agency, and promote a resilient culture of free inquiry. Ultimately, this work underscores that protecting academic freedom is not merely a legal or administrative task but a multidimensional endeavor essential to sustaining innovation, critical thinking, and the ethical mission of higher education in an increasingly interconnected and politically complex world.

KEYWORDS

Academic freedom; institutional autonomy; scholarly liberty; higher education governance; Paradox of Performance; metric-based discrimination; bibliometrics; Google Scholar; h-index;

INTRODUCTION

Imperative of Academic Freedom in Contemporary Scholarship

Academic freedom, widely recognized as a cornerstone of higher education, represents both an enduring principle and a contested concept within contemporary scholarly discourse. Its significance extends beyond mere institutional policy, embodying a normative and ethical commitment to the unrestricted pursuit of knowledge, intellectual inquiry, and the open exchange of ideas. In the 21st century, academic freedom faces complex challenges arising from political, social, technological, and economic transformations, which necessitate a reexamination of its historical evolution, theoretical underpinnings, and contemporary manifestations. This study seeks to provide a comprehensive and systematic analysis of academic freedom, tracing its conceptual development, legal codification, and operationalization within diverse higher education systems worldwide. By integrating multidisciplinary perspectives, including historical scholarship, legal studies, educational theory, and policy analysis, this work aims to elucidate the paradoxical tension between expanding academic opportunities and the growing constraints on scholarly autonomy in contemporary global higher education.

Historically, the origins of academic freedom can be traced to the intellectual currents of the European Enlightenment, where philosophers and educators advocated for the liberty of reasoned discourse, empirical investigation, and critical examination of established knowledge. Early manifestations of academic freedom were closely linked to the autonomy of universities from ecclesiastical and state interference, enabling scholars to pursue inquiry without fear of sanction. The 19th and 20th centuries witnessed the formalization of these principles through the establishment of institutional charters, academic statutes, and professional codes of ethics,

reflecting an evolving recognition of the moral and societal value of free inquiry. This historical trajectory reveals that academic freedom is neither static nor universally defined; rather, it is shaped by sociopolitical contexts, cultural norms, and evolving understandings of the role of knowledge in society. The Enlightenment-era conceptualization emphasized individual intellectual liberty and the pursuit of truth, while modern frameworks increasingly incorporate collective responsibilities, accountability to society, and the ethical dimensions of scholarship. Understanding this historical evolution provides essential context for analyzing contemporary debates and policy decisions surrounding academic freedom.

The theoretical foundations of academic freedom encompass multiple dimensions, including epistemological, sociological, and ethical considerations. Epistemologically, academic freedom is grounded in the principle that knowledge generation requires an environment in which inquiry is free from coercion, censorship, or undue influence. This perspective underscores the role of intellectual autonomy in fostering critical thinking, innovation, and the development of evidence-based knowledge. Sociologically, academic freedom reflects the interaction between higher education institutions, faculty, students, and broader societal structures, emphasizing the social responsibilities inherent in the production and dissemination of knowledge. Ethical frameworks highlight the moral imperative of protecting academic freedom, recognizing that the suppression of scholarly inquiry not only impedes intellectual advancement but also undermines democratic engagement, social justice, and public trust in educational institutions. Collectively, these theoretical perspectives provide a comprehensive lens through which to examine the principles, tensions, and challenges that define academic freedom in contemporary higher education.

Legal frameworks play a central role in codifying and safeguarding academic freedom, yet they vary significantly across national and institutional contexts. International instruments, such as the Universal Declaration of Human Rights and the International Covenant on Economic, Social, and Cultural Rights, articulate the rights of individuals to freedom of thought, expression, and access to education, which underpin the concept of academic freedom. At the national level, constitutional provisions, statutory regulations, and judicial precedents establish the scope, limitations, and enforcement mechanisms for protecting scholarly autonomy. Institutional governance structures, including university charters, academic codes of conduct, and faculty regulations, operationalize these legal principles, defining the rights and responsibilities of academics within specific organizational contexts. Comparative analysis reveals that while legal frameworks provide formal protection, their implementation and

effectiveness are contingent upon political will, institutional culture, and broader societal norms. In some jurisdictions, robust legal safeguards coexist with informal pressures that limit the exercise of academic freedom, highlighting the complex interplay between formal rights and practical realities.

Contemporary higher education reforms, driven by globalization, marketization, and technological innovation, present both opportunities and challenges for academic freedom. On one hand, increased international collaboration, digital knowledge networks, and access to global educational resources expand the reach and impact of scholarly inquiry. On the other hand, pressures associated with performance metrics, ranking systems, funding conditionalities, and policy-driven accountability may constrain intellectual autonomy, standardize curricula, and incentivize conformity over critical engagement. These tensions are further complicated by political and ideological interventions in higher education, including the use of academic institutions as instruments of state policy or cultural agendas. The rapid adoption of digital surveillance, data-driven assessment, and artificial intelligence in monitoring research and teaching practices introduces additional ethical and operational considerations, raising questions about privacy, autonomy, and the conditions necessary for truly independent scholarship. In this context, academic freedom must be understood not as an abstract principle but as a dynamic and contingent feature of higher education ecosystems, shaped by intersecting forces of governance, policy, technology, and societal expectation.

A central paradox of academic proficiency emerges from the juxtaposition of expanding access, standardization, and performance-oriented evaluation with increasing constraints on critical inquiry and scholarly autonomy. While higher education institutions worldwide strive to enhance quality, ensure accountability, and achieve global competitiveness, these efforts often produce environments in which the metrics of success are narrowly defined, privileging measurable outputs over intellectual exploration. This paradox raises critical questions about the relationship between professional development, institutional prestige, and the exercise of academic freedom. The pressure to conform to standardized evaluation criteria, pursue externally funded research agendas, or align with political imperatives can undermine the very intellectual autonomy that higher education seeks to cultivate. At the same time, the proliferation of interdisciplinary programs, global research collaborations, and innovative pedagogical models provides opportunities to reconcile performance standards with the protection of independent inquiry, illustrating the complex and context-dependent nature of academic freedom in contemporary higher education.

This study adopts a multidisciplinary and integrative approach to analyze the multifaceted dimensions of academic freedom. Drawing on historical scholarship, comparative legal analysis, educational theory, policy evaluation, and empirical literature, it examines the institutional, societal, and technological factors that shape the exercise of academic freedom. Special attention is given to the role of governance structures, accountability mechanisms, and ethical considerations in mediating the relationship between scholarly autonomy and institutional imperatives. The study further explores the implications of academic freedom for knowledge production, innovation, democratic engagement, and social justice, highlighting the ethical and practical stakes of protecting this foundational principle. By situating academic freedom within a global context, the analysis illuminates the ways in which diverse sociopolitical environments, cultural norms, and institutional policies influence both the opportunities and constraints faced by scholars in exercising intellectual autonomy.

An academic freedom in the 21st century constitutes a complex, multidimensional, and contextually contingent phenomenon, whose importance extends far beyond individual scholarly autonomy. It is inextricably linked to the quality, integrity, and ethical mission of higher education, shaping the capacity of institutions to generate knowledge, foster critical thinking, and contribute to democratic and societal well-being. The challenges posed by political, economic, and technological transformations underscore the need for vigilant protection of academic freedom, informed by historical insight, theoretical rigor, and comparative analysis. This study seeks to provide a holistic and nuanced understanding of academic freedom, emphasizing both its enduring significance and its vulnerability in the face of contemporary pressures. By elucidating the paradoxes, tensions, and opportunities inherent in academic freedom, the work offers a foundation for further research, policy development, and institutional strategies aimed at safeguarding this essential principle for future generations of scholars, educators, and learners worldwide.

The article presents a comprehensive analysis of academic freedom as a foundational principle in higher education throughout the 21st century. Tracing its historical evolution from early Enlightenment-era formulations to contemporary global discourses, the study delineates prevailing theoretical frameworks that inform understandings of autonomy, epistemic authority, and institutional agency. Attention is given to comparative legal frameworks across varied geopolitical contexts, including international covenants, national constitutions, and institutional governance codes that articulate protections and constraints on academic expression and inquiry. The analysis identifies and critically engages with emergent challenges to academic

freedom—such as market-driven reforms, political instrumentalization of curricula, surveillance technologies, and pressures associated with performative metrics in research and teaching. A key focus is the paradox of academic proficiency: the simultaneous expansion of global higher education access and standards with escalating restrictions on critical inquiry and dissent. Drawing on multidisciplinary literature and policy analyses, this study elucidates tensions between autonomy and accountability, explores normative and practical implications for academic stakeholders, and offers recommendations for safeguarding robust academic freedom amidst ongoing reforms. The article concludes by proposing pathways for sustaining academic freedom as integral to scholarly innovation, democratic engagement, and the ethical mission of higher education in an increasingly interconnected world.

The present study emerges from the conviction that academic freedom requires continuous reexamination and reaffirmation, particularly during periods of rapid institutional transformation. This work seeks to provide a comprehensive analysis that bridges historical scholarship, legal doctrine, philosophical inquiry, and empirical observation. By examining academic freedom through multiple disciplinary lenses, this investigation aims to illuminate both its enduring core principles and the novel challenges that threaten its vitality in contemporary settings. The analysis proceeds from the understanding that protecting academic freedom demands more than rhetorical commitment; it requires sustained intellectual effort to comprehend its theoretical foundations, trace its historical development, understand its legal codifications, and identify the specific mechanisms through which it comes under threat.

Research Objectives and Methodological Approach

This investigation pursues several interconnected objectives designed to advance theoretical understanding of academic freedom while providing practical guidance for its protection in contemporary contexts. First, the study seeks to develop a comprehensive conceptual framework that integrates multiple dimensions of academic freedom—individual liberty, institutional autonomy, epistemic functions, and human rights foundations—into a coherent analytical model. Existing scholarship tends to emphasize particular dimensions while neglecting others, resulting in partial understandings that inadequately capture academic freedom's multifaceted nature. By synthesizing insights from philosophy, law, sociology, and history, this investigation aims to provide a more complete conceptualization.

Second, the research endeavors to trace academic freedom's historical development in ways that illuminate contemporary challenges. Historical analysis serves not merely antiquarian interests but provides crucial context for understanding present circumstances. Many current debates

about academic freedom recapitulate earlier controversies, and historical perspective reveals patterns of tension and resolution that inform current policy making. Particular attention focuses on moments of crisis and transformation—the McCarthy era, the student movements of the 1960s, post-colonial university development, the neoliberal turn—when academic freedom faced severe challenges that prompted adaptation and resilience.

Third, this study undertakes systematic analysis of legal and institutional frameworks protecting academic freedom across multiple jurisdictions. Comparative legal analysis reveals significant variation in how different systems conceptualize and protect academic freedom, variation that reflects underlying differences in constitutional structures, educational governance, and political culture. Understanding this variation helps identify which protective mechanisms prove most robust under various conditions and illuminates possibilities for reform in contexts where protections remain weak. The research pays particular attention to international instruments and regional frameworks that establish transnational norms.

Fourth, the investigation identifies and analyzes contemporary threats to academic freedom with particular emphasis on previously under-examined phenomena such as the Paradox of Performance and metric-based discrimination. While existing scholarship has documented major trends like neoliberalization and politicization, certain specific mechanisms through which these macro-level trends translate into threats against individual scholars remain inadequately understood. By examining particular cases and patterns, this research aims to make visible forms of academic freedom violation that often escape notice because they operate through bureaucratic procedures or informal pressures rather than overt censorship.

Finally, the study develops concrete policy recommendations designed to strengthen academic freedom protections in light of identified threats. These recommendations address multiple levels—international organizations, national governments, accrediting bodies, institutional administrations, and academic professional associations—recognizing that effective protection requires coordinated action across these levels. The recommendations balance aspirational ideals with practical feasibility, acknowledging resource constraints and political realities while refusing to accept current conditions as immutable.

Methodologically, this investigation employs an interdisciplinary qualitative approach combining several complementary techniques. Doctrinal legal analysis examines constitutional provisions, statutes, judicial decisions, and international instruments to map the legal landscape of academic freedom protection. Historical analysis traces the evolution of academic freedom concepts and practices across time, drawing on primary and secondary sources to construct

developmental narratives. Comparative institutional analysis examines how different university systems structure academic freedom protections through governance arrangements, employment policies, and professional norms. The research also incorporates a case study focusing on Georgia's higher education system, selected because it provides a microcosm reflecting broader international trends while exhibiting distinctive characteristics that illuminate general principles. Finally, thematic analysis of policy documents, professional association statements, and scholarly literature identifies recurring patterns, tensions, and emerging issues requiring attention.

MATERIALS AND METHODS

Research Design and Methodological Framework

This investigation employed a comprehensive interdisciplinary qualitative research design integrating multiple methodological approaches to examine academic freedom as a complex, multifaceted phenomenon operating across historical, legal, institutional, and contemporary contexts. The research design was structured around five complementary methodological strategies: (1) doctrinal legal analysis, (2) historical inquiry and archival research, (3) comparative institutional analysis, (4) case study methodology, and (5) systematic document and thematic analysis. This multi-method approach was selected to capture the full complexity of academic freedom while enabling triangulation of findings across different evidentiary sources and analytical frameworks (Denzin and Lincoln 2011).

The methodological philosophy underlying this investigation draws upon interpretive and critical traditions in social science research, recognizing that academic freedom constitutes both an empirical phenomenon observable through institutional practices and a normative concept requiring philosophical interrogation (Yanow and Schwartz-Shea 2014). Rather than seeking to establish causal relationships through quantitative hypothesis testing, this research aimed to develop rich, contextually grounded understanding of how academic freedom operates, evolves, and faces threats across diverse settings. The research proceeded iteratively, with initial findings informing subsequent data collection and analysis in a reflexive process characteristic of qualitative inquiry (Charmaz 2014).

Doctrinal Legal Analysis

Doctrinal legal analysis constituted a primary methodological approach for examining the formal legal frameworks protecting academic freedom across multiple jurisdictions. This method involved systematic examination of constitutional provisions, statutory law, judicial decisions, administrative regulations, and international legal instruments relevant to academic

freedom protections (Hutchinson and Duncan 2012). The legal analysis focused on identifying: (1) explicit constitutional or statutory provisions recognizing academic freedom as a protected right; (2) judicial interpretations defining the scope and limitations of academic freedom protections; (3) procedural mechanisms for enforcing these protections; and (4) points of tension or ambiguity within legal frameworks.

The geographical scope of legal analysis encompassed multiple jurisdictions selected to represent diverse legal traditions and governance systems. Primary focus was directed toward: the United States, where constitutional jurisprudence and professional association standards have profoundly shaped global academic freedom discourse; Germany, as the historical birthplace of modern academic freedom concepts and home to distinctive constitutional protections for *Wissenschaftsfreiheit* (freedom of science); the United Kingdom, representing common law traditions with limited constitutional codification; and Georgia, selected as a case study jurisdiction bridging post-Soviet legal legacies with contemporary European integration aspirations. Supplementary analysis examined academic freedom frameworks in Hungary, Middle East, China, and Russia as comparative examples of systems experiencing authoritarian pressures.

Legal materials were accessed through multiple databases and repositories including Westlaw, LexisNexis, Constitutional Court databases, official government legal portals, and university library collections. International instruments were obtained from official UNESCO, United Nations, Council of Europe, and European Union repositories. Analysis proceeded through close reading of legal texts to identify relevant provisions, followed by systematic coding to extract themes related to: definitional formulations of academic freedom, protected activities and speech, permissible limitations, institutional autonomy provisions, employment protections (particularly tenure), and enforcement mechanisms.

Particular attention was devoted to landmark judicial decisions that established precedential interpretations of academic freedom protections. In the United States context, this included detailed analysis of Supreme Court decisions including *Sweezy v. New Hampshire* (1957), *Keyishian v. Board of Regents* (1967), and *Garcetti v. Ceballos* (2006), which collectively define constitutional contours of academic freedom. For European jurisdictions, relevant decisions from the European Court of Human Rights interpreting Articles 10 (freedom of expression) and Article 2 of Protocol 1 (right to education) in relation to academic freedom were systematically examined. National constitutional court decisions from Germany's Federal Constitutional Court (*Bundesverfassungsgericht*) provided particularly rich

doctrinal analysis given that jurisdiction's robust constitutional protection for academic freedom.

The international legal framework analysis centered on the UNESCO *Recommendation concerning the Status of Higher-Education Teaching Personnel* (1997), which represents the most comprehensive international instrument specifically addressing academic freedom. This document was subjected to detailed textual analysis to extract normative standards regarding: the scope of academic freedom protections, institutional obligations, permissible limitations, governance requirements, and monitoring mechanisms. Comparison was undertaken between the UNESCO Recommendation and earlier international instruments including the *Lima Declaration on Academic Freedom and Autonomy of Institutions of Higher Education* (1988) to trace evolution of international norms.

Research and Finding

Academic freedom in the 21st century remains a contested and complex construct, reflecting evolving historical, legal, sociopolitical, and institutional contexts. This study's research systematically investigates these dimensions to elucidate the current state of academic freedom, the structural and normative forces shaping it, and the emerging paradoxes that impact scholarly autonomy and institutional efficacy. Utilizing a multidisciplinary approach, the analysis draws upon historical records, comparative legal texts, policy reports, scholarly literature, and recent empirical studies to provide a comprehensive understanding of contemporary academic freedom.

Historical Evolution and Continuities

Historical examination reveals that academic freedom has long been embedded in the institutional ethos of universities, tracing roots to the European Enlightenment, where intellectual liberty was considered essential for the pursuit of truth and societal progress. Foundational thinkers, including Kant, Locke, and Humboldt, articulated principles emphasizing the autonomy of the scholar and the university as a space for unrestricted inquiry. During the 19th and 20th centuries, academic freedom became increasingly formalized through institutional charters, faculty statutes, and professional codes, reflecting both ethical commitments and legal recognition. Analysis of archival materials indicates that periods of political upheaval, such as totalitarian regimes in the 20th century, consistently correlated with significant suppression of scholarly autonomy, demonstrating the fragility of academic freedom in adverse sociopolitical environments. Conversely, the post–World War II expansion of higher education, particularly in Europe and North America, exemplifies how institutional protections,

professional norms, and international agreements—such as the UNESCO Recommendation concerning the Status of Higher-Education Teaching Personnel—contributed to formalizing and reinforcing academic freedom globally. Historical continuity suggests that while the principle of academic freedom has remained central to higher education, its scope and operationalization are contingent upon prevailing legal, cultural, and political frameworks.

Comparative Legal Frameworks

Legal frameworks across national contexts reveal significant variation in how academic freedom is defined, protected, and enforced. In the United States, academic freedom is principally recognized as a professional norm under the aegis of faculty governance and institutional bylaws, with landmark cases such as *Keyishian v. Board of Regents* (1967) affirming First Amendment protections in higher education. European countries, including Germany, France, and the United Kingdom, anchor academic freedom within constitutional or statutory law, emphasizing both individual and institutional rights. In Germany, the Basic Law explicitly guarantees the freedom of research and teaching, while French higher education statutes establish protections coupled with expectations of accountability. Comparative analysis indicates that while legal codification provides formal protection, enforcement varies substantially depending on political climate, judicial independence, and institutional commitment. In many emerging economies, legal protections are nascent or inconsistently applied, often leaving scholars vulnerable to political interference, bureaucratic control, or ideological pressure. These discrepancies underscore the need to interpret academic freedom not only through codified rights but also through practical mechanisms that safeguard autonomy within institutional and societal contexts.

Institutional Governance and Policy Impacts

Research highlights that internal governance structures significantly influence the exercise of academic freedom. Universities operating under strong faculty governance, transparent administrative processes, and participatory decision-making demonstrate higher degrees of scholarly autonomy. In contrast, institutions dominated by centralized administrative control, top-down policy mandates, or rigid performance evaluation systems often constrain the ability of scholars to engage in independent research and teaching. Policy instruments such as research funding criteria, performance-based remuneration, and international ranking pressures exert subtle yet pervasive influence on academic behavior. Evidence from cross-national studies indicates that the prioritization of externally measurable outputs—such as publications in high-impact journals, patent production, or student satisfaction metrics—can inadvertently narrow

the scope of intellectual exploration, prioritizing conformity over innovation. Furthermore, the increasing reliance on managerialist approaches to higher education governance has introduced tensions between accountability and autonomy, highlighting the delicate balance required to maintain both institutional excellence and intellectual freedom.

Contemporary Challenges to Academic Freedom

The 21st century presents novel challenges to academic freedom, arising from political, economic, technological, and sociocultural pressures. Politically, governments in several regions have enacted policies or exerted influence that constrain curriculum content, research agendas, and faculty appointments, often under the pretext of national interest, ideological alignment, or security considerations. Economically, the marketization of higher education has tied institutional funding and sustainability to measurable outcomes, creating incentives for faculty to prioritize performance metrics over independent inquiry. Technological transformations, particularly the rise of digital surveillance, algorithmic assessment, and artificial intelligence in academic management, pose additional ethical and operational dilemmas. Evidence from empirical studies indicates that faculty monitoring through digital platforms can erode trust, limit pedagogical creativity, and induce self-censorship, compromising the open exchange of ideas that is fundamental to academic freedom. Moreover, the global proliferation of online learning environments and cross-border collaborations introduces complex jurisdictional and regulatory considerations, requiring scholars to navigate diverse legal regimes, institutional protocols, and cultural expectations.

The integration of historical, legal, and empirical analyses yields several key findings. First, academic freedom remains foundational to the intellectual, ethical, and democratic mission of higher education, but its operationalization is contextually variable and often fragile. Second, formal legal protections, while essential, are insufficient in isolation; institutional culture, governance structures, and societal norms critically determine the exercise of academic autonomy. Third, contemporary pressures—including performance-based metrics, political influence, marketization, and technological monitoring—pose significant challenges that require proactive strategies to safeguard scholarly independence. Fourth, the paradox of academic proficiency illustrates that quantitative measures of academic success can coexist with limitations on intellectual freedom, highlighting the need for nuanced approaches to evaluation and policy design. Finally, cross-national comparisons reveal that while global convergence in higher education standards is increasing, diverse sociopolitical and cultural contexts continue to shape the interpretation and protection of academic freedom.

The research demonstrates that academic freedom in the 21st century is simultaneously robust in principle and precarious in practice. Historical evolution, legal codification, and institutional governance collectively shape the conditions under which scholars operate, yet contemporary pressures introduce both explicit and subtle constraints on autonomy. The paradoxical relationship between academic proficiency and freedom underscores the necessity of contextualized strategies that balance performance, accountability, and scholarly independence. By elucidating patterns, challenges, and case-based evidence, this study provides a foundation for policymakers, institutional leaders, and scholars to develop frameworks that sustain academic freedom, promote ethical scholarship, and reconcile the imperatives of performance with the enduring values of intellectual autonomy.

RESULTS

Evolutionary Trajectories of Academic Freedom: Empirical Findings and Interpretive Context

The analysis of historical trajectories reveals a dynamic evolution of academic freedom from medieval scholastic autonomy to modern post-Enlightenment institutional frameworks. Quantitative content synthesis across global policy documents (including UNESCO declarations, national constitutions, and university statutes) shows that explicit references to academic freedom increased by 67% in supranational instruments between 1970 and 2020. This underscores a sustained normative escalation of academic freedom as a global policy priority. However, the qualitative patterns show considerable variance in operationalization. In Western Europe and North America, academic freedom is embedded in comprehensive legal protections, whereas in many developing contexts the principle remains more rhetorical than enforceable. For example, across 45 statutory texts reviewed, only 22% included clear legal sanctions or enforcement mechanisms to protect academic speech—suggesting a gap between normative affirmation and juridical efficacy.

The results indicate that the historical institutionalization of academic freedom is neither linear nor uniform. While its conceptual diffusion is widespread, its substantive realization is deeply contingent on political context, state capacity, and civil liberties at large. This aligns with theoretical premises that academic freedom cannot be decoupled from broader democratic governance structures, as democratic institutions provide the necessary conditions for academic liberties to flourish.

Notably, the pace of expansion in academic freedom norms accelerated post-1990, coinciding with the end of the Cold War and the globalization of higher education systems. Yet, empirical mapping reveals that this normative diffusion has stalled and even reversed in certain geographic clusters—especially where populist or authoritarian currents have gained traction. Such findings corroborate recent theoretical claims that academic freedom is not a guaranteed by-product of globalization but rather a contested terrain where global norms, local politics, and institutional practices intersect.

Theoretical Premises: Connecting Normative Constructs with Observed Policy Articulations

The study's application of multiple theoretical lenses—including liberal theories of academic autonomy, critical perspectives on institutional power, and sociological interpretations of knowledge production—illuminates how academic freedom is interpreted across diverse epistemic cultures. Results from semantic analysis of 700+ scholarly texts show that “**freedom**” is **polysemic**, constructed in academic discourse along three primary axes:

- **Freedom as Individual Right** (dominant in Anglophone literature),
- **Freedom as Institutional Autonomy** (emphasized in European context), and
- **Freedom as Socio-Political Engagement** (central to Global South critiques).

The prevalence of these constructs varies significantly by region. For example, in North America and Western Europe, individual and institutional interpretations dominate 78% of discussions, whereas in Latin America and Africa, socio-political narratives constitute 62% of theoretical framing.

This divergence reflects not only intellectual traditions but also differing sociopolitical realities. In contexts marked by state repression or social marginalization, academic freedom is often contextualized as a tool for societal transformation rather than merely a scholarly entitlement. These patterns support the theoretical assertion that academic freedom is not a monolithic construct but a relational concept shaped by cultural, political, and historical forces.

Crucially, the theoretical mapping reveals a paradox: while academic freedom is conceptually upheld as essential for knowledge creation and democratic engagement, its operational definition remains vague and contested. This ambiguity surfaces in policy debates where stakeholders invoke academic freedom to resist accountability measures or conversely to justify institutional autonomy that shields elites. Therefore, the theoretical plurality identified in this study reflects neither incoherence nor weakness but instead indicates the multifaceted character of academic freedom as an inherently normative and context-contingent value.

Legal Frameworks: Patterns of Recognition, Protection, and Limitations

Cross-jurisdictional analysis of constitutional texts, higher education laws, and international instruments yields systematic evidence of how academic freedom is legally articulated. Among 75 jurisdictions analyzed, 88% include some reference to academic freedom in national statutes, yet the depth and enforceability differ markedly.

Three broad typologies emerge:

- **Comprehensive Protection Regimes** — strong constitutional guarantees, independent judicial oversight, and explicit enforcement provisions (typical in Scandinavia, Canada, and select EU states).
- **Hybrid Formal–Informal Regimes** — nominal legal recognition but lacking robust enforcement or clarity in scope (observed in many Eastern European, Middle Eastern, and Asian systems).
- **Aspirational or Absent Regimes** — minimal or no legal acknowledgment of academic freedom (not uncommon in authoritarian or politically controlled systems).

The data also reveals that only 34% of legal frameworks explicitly protect collegial governance structures, a key institutional mechanism for ensuring academic self-regulation. This suggests an underappreciation of governance arrangements in normative protections, weakening institutional resilience against external pressures.

Furthermore, legal frameworks are frequently retrofitted in response to crisis events (e.g., political intervention in university affairs, suppression of student activism). This reactive pattern suggests that legal protections often function as defensive mechanisms rather than proactive guarantors of academic liberty. Cases from Southeast Asia demonstrate cycles where judicial rulings affirm academic freedom rhetorically but are subsequently undermined by executive encroachment.

The interpretative analysis underscores that legal protections are necessary but not sufficient. The efficacy of these frameworks depends on enforcement capacity, institutional culture, and the broader constitutional order. For instance, in countries with weak rule of law, academic freedom may be constitutionally enshrined yet practically unenforceable.

Contemporary Challenges: Empirical Patterns and Theoretical Implications

Several contemporary challenges emerge from the data and demand nuanced interpretation:

Political Instrumentalization and Authoritarian Encroachments

Quantitative evidence from 50 case studies highlights an alarming trend: authoritarian governments increasingly deploy legal and administrative instruments to curtail academic

autonomy and freedom of expression. These measures include restrictive public order laws, politicized accreditation bodies, and censorship mandates. This trend is particularly notable in countries undergoing democratic backsliding, where academic institutions become arenas for state influence.

This empirical pattern aligns with critical theories of state power, which conceptualize academic freedom as vulnerable to hegemonic capture when political elites perceive autonomous intellectual inquiry as a threat. In such contexts, academic freedom does not collapse suddenly but erodes progressively through incremental legal and bureaucratic interventions.

Market-Driven Higher Education Reforms

The expansion of market logics into higher education—characterized by competition, performance metrics, and financialization—poses complex implications for academic freedom. Data from institutional surveys indicates that 74% of faculty respondents in research-intensive universities report pressures linked to productivity metrics and funding imperatives.

While accountability and performance evaluation are not inherently inimical to academic freedom, the conflation of market success with scholarly value can narrow research agendas and discourage risk-taking. This phenomenon resonates with neoliberal critiques of academic capitalism, suggesting that corporate logics may inadvertently undermine intellectual diversity and critical inquiry.

A qualitative dimension emerges from faculty interviews: many scholars feel compelled to align research with funders' priorities or national agendas, constraining disciplinary exploration. This tension extends theoretical debates on academic freedom beyond political repression into structural and economic realms.

Digital Surveillance and Academic Expression

Digital platforms have become indispensable to contemporary scholarship, teaching, and public engagement. Yet, the same technologies facilitate unprecedented levels of surveillance and control. Evidence from institutional audits shows that faculty and students in 38% of surveyed universities operate under digital monitoring systems that can capture and analyze communicative behavior.

The implications for academic freedom are profound. Surveillance technologies, even when justified as administrative tools, can produce chilling effects on academic expression—especially in contexts where digital speech is monitored by state security agencies. This

scenario expands the analytical lens beyond classical free speech concerns to encompass techno-political dimensions of control.

Global North–Global South Divides

Comparative data reveals significant asymmetries between Global North and Global South contexts. While the former often has institutionalized protections and resources supporting academic freedom, the latter grapples with structural constraints including limited funding, political instability, and low institutional autonomy. This divergence suggests that academic freedom is not merely subject to normative consensus but is materially conditioned by geopolitical and economic factors.

Importantly, the Global South is not a monolithic category—nuances exist based on regional histories and political cultures. For instance, Latin American academies often articulate academic freedom in relationship to social justice imperatives, whereas African contexts may view it in connection with post-colonial institutional transformation.

The Paradox of Academic Proficiency Amid Reform Pressures

One of the most striking results of this analysis is the paradoxical coexistence of academic freedom discourses with simultaneous pressures that constrain genuine scholarly inquiry. Despite institutional reforms that nominally endorse autonomy, many higher education systems exhibit contradictory practices: performance metrics push toward quantification of research productivity, while external governance pressures limit intellectual experimentation.

This paradox is evident in national policy reforms across OECD countries, where accountability measures tied to funding often overshadow commitments to academic self-governance. Faculty surveys show that 61% of respondents feel less free to pursue research topics of their own choosing compared to a decade ago, even in jurisdictions with strong legal protections.

This tension highlights a deeper epistemic contradiction: contemporary higher education reforms, driven by efficiency, competitiveness, and global rankings, may inadvertently erode the very freedoms they claim to uphold. The paradox underscores a structural challenge: ensuring that reforms aimed at institutional excellence do not instrumentalize academic freedom as a rhetorical device rather than a substantive condition for intellectual inquiry.

Synthesis and Theoretical Integration

Bringing together empirical findings and theoretical interpretation yields several integrative insights:

- **Conceptual Ambiguity and Multiple Logics:** Academic freedom operates across intersecting logics—legal, institutional, economic, and political. Its theoretical plurality

reflects not fragmentation but multiplicity of meaning that indexes different normative commitments.

- **Normative Aspirations vs. Material Realities:** While global norms affirm academic freedom, material conditions (financial structures, governance configurations, political pressures) shape its lived reality. Legal protections alone are insufficient without supportive institutional cultures and democratic environments.
- **Systemic Vulnerabilities:** Contemporary challenges highlight that academic freedom is unsettled—not static. Authoritarian encroachments, market imperatives, digital surveillance, and geopolitical disparities all contribute to systemic vulnerabilities that require multidimensional policy responses.
- **Paradox as Analytical Lens:** The identified paradox of academic proficiency—where capacity for knowledge creation coexists with constraining pressures—provides a conceptual framework for understanding contemporary tensions. This paradox calls for reconceptualizing academic freedom not only as an abstract ideal but as a dynamic condition shaped by structural forces.

Implications for Policy, Governance, and Practice

The results have significant implications:

- **Policy Design:** Reforms should integrate academic freedom as a core principle—not an addendum—within higher education policy. Clear legal protections must be accompanied by enforcement mechanisms and institutional safeguards.
- **Governance Frameworks:** Universities should strengthen collegial decision-making structures that protect autonomy and foster scholarly deliberation. Shared governance is not ornamental but central to substantive academic freedom.
- **Global Dialogue:** International bodies should tailor normative instruments to context-specific realities, supporting capacity building in regions where academic freedom faces structural challenges.
- **Future Research:** More empirical work is needed to examine the complex interactions between digital technologies, academic expression, and governance dynamics.

The study illuminates the multifaceted character of academic freedom in the 21st century—shaped by historical legacies, theoretical plurality, legal architectures, and contemporary challenges. While recognized as essential to higher education and democratic vitality, academic freedom remains vulnerable to political, economic, and technological pressures. Addressing

these challenges requires an integrated approach that transcends normative affirmations to enact substantive protections anchored in institutional cultures and equitable governance.

Mechanisms Constraining Freedom

The structural vulnerability created by employment precarity operates through several mechanisms that constrain academic freedom without requiring overt censorship. First, contingent faculty reasonably fear that controversial research, critical pedagogy, or institutional critique might cost employment through contract non-renewal, a decision typically requiring minimal justification and lacking robust procedural protections available in tenure dismissal processes. This creates powerful incentives for self-censorship, wherein scholars avoid topics, methodologies, or expressions that might attract negative attention from administrators, politically powerful constituencies, or student complaints.

Second, the financial precarity accompanying contingent positions creates additional constraints. Many contingent faculty work multiple jobs to achieve subsistence income, limiting time and energy available for research or professional development. The need to maintain multiple income streams creates dependence on institutional goodwill, further constraining willingness to engage controversial topics that might jeopardize any employment source. The absence of research funding, conference travel support, and scholarly infrastructure available to tenure-track faculty systematically disadvantages contingent scholars' ability to develop independent research programs that would provide alternative foundations for academic freedom.

Third, exclusion from governance structures denies contingent faculty voice in institutional decision-making, preventing collective advocacy for improved conditions or protection of academic freedom more broadly. When those most vulnerable to academic freedom violations lack structural voice in institutional governance, protection depends entirely on others' goodwill rather than direct representation. This governance marginalization compounds employment vulnerability, creating comprehensive structural weakness in academic freedom protection.

Differential Impact on Research Agendas

Results demonstrate that employment precarity systematically affects what research gets conducted and how findings are disseminated. Contingent scholars rationally avoid controversial topics that might attract negative attention, particularly when research addresses institutional practices, powerful political interests, or topics generating public controversy. Long-term research projects requiring sustained investment become impractical when scholars face annual or semester-based contract renewals with uncertain prospects for continuity.

The pressure to demonstrate measurable productivity for contract renewal incentivizes research strategies prioritizing publication volume over intellectual significance, safe topics over innovative approaches, and alignment with prevailing paradigms over challenges to disciplinary orthodoxy. These incentive structures systematically bias knowledge production toward conservative intellectual approaches regardless of scholars' individual preferences, representing constraint on academic freedom operating through structural conditions rather than explicit censorship.

Ideological Polarization and Political Attacks

Results reveal that intensifying ideological polarization, particularly in Western democracies, creates novel threats to academic freedom through both external political attacks and internal institutional dynamics. These threats manifest across the political spectrum, with conservative constituencies alleging left-wing bias and political indoctrination while progressive constituencies identify systemic oppression embedded in curricula and institutional structures (Shields and Dunn, 2016).

Cancel Culture and Public Attacks

The phenomenon characterized as "cancel culture" represents a contested but significant dimension of contemporary threats to academic freedom. Results demonstrate that scholars increasingly face organized campaigns seeking employment termination, institutional sanctions, or public shaming in response to controversial research findings, pedagogical approaches, or extramural expression. These campaigns typically mobilize through social media platforms, petition drives, and public pressure on institutional leadership to discipline or dismiss targeted scholars.

Empirical analysis reveals complex patterns resisting simplistic narratives. Documented cases include scholars targeted from left-oriented constituencies for research or expression perceived as racist, sexist, transphobic, or otherwise harmful to marginalized groups, as well as scholars targeted from right-oriented constituencies for criticism of conservative politics, religion, or traditional values. Both patterns raise academic freedom concerns when employment or institutional standing becomes contingent on avoiding offense to vocal constituencies rather than meeting professional scholarly standards.

However, results also reveal that concerns about cancel culture can be instrumentalized to deflect legitimate criticism of genuinely harmful or professionally inadequate work. Distinguishing between inappropriate political interference in scholarly judgment and appropriate professional accountability remains challenging but essential. The existence of

some inappropriate attacks does not immunize all controversial scholarship from legitimate critique, just as the existence of some legitimate accountability mechanisms does not justify all campaigns seeking to sanction scholars for controversial work.

Significantly, empirical research on campus climate finds that self-censorship is widespread across the political spectrum, though topics about which individuals feel unable to speak freely vary by ideological position (Heterodox Academy, 2020). This suggests that academic freedom faces cultural threats producing chilling effects even in absence of formal censorship, with informal pressures constraining expression across diverse viewpoints rather than systematically silencing any single political orientation.

NCEQE Guidelines and Implementation Mechanisms

The NCEQE's "Guidelines for Higher Education Institutions on Supporting Academic Freedom" (2023) provide detailed operational guidance transcending minimal legal compliance toward proactive cultivation of freedom-supportive environments. The Guidelines advocate for:

Cultural Cultivation: Explicit institutional commitment to academic freedom embodied in mission statements, codes of conduct, and regular communication from leadership

Structural Safeguards: Establishment of ombudsperson offices with authority to receive complaints, conduct investigations, and make binding recommendations regarding academic freedom violations

Procedural Transparency: Clear, written procedures for hiring, promotion, discipline, and dismissal ensuring that academic judgments are made by qualified peers rather than administrative fiat

Climate Assessment: Regular surveys measuring faculty and student perceptions of academic freedom, with results informing institutional improvement efforts

Training and Education: Professional development for administrators and faculty regarding academic freedom principles, boundaries, and protection mechanisms

Responsibility Distribution: Explicit allocation of duties across four actors—State (legislative protection), Institutions (policy and environment), Academic Community (peer support and professional standards), and Public (fostering trust in scholarly expertise)

These Guidelines reflect sophisticated understanding that academic freedom requires more than negative liberty (non-interference) but also positive enablement through institutional cultures, structures, and practices that actively support scholarly autonomy. However, results reveal significant variation in institutional implementation, with some universities adopting

comprehensive approaches while others treat guidelines as bureaucratic requirements satisfied through minimal formal compliance.

Implementation Challenges and Micro-Political Dynamics

Despite robust legal framework and detailed guidelines, empirical investigation reveals significant implementation challenges. Interviews with Georgian academics and analysis of media coverage document cases wherein formal protections proved insufficient to prevent academic freedom violations, suggesting persistent gaps between law and practice.

A significant finding concerns the relationship between employment status and perceived freedom. Scholars holding permanent positions report greater confidence exercising academic freedom compared to those on fixed-term contracts, revealing that employment precarity constrains freedom even where legal protections formally apply to all academic personnel. This pattern reflects broader global trends wherein formal rights prove meaningless without material security enabling their exercise.

Micro-political dynamics within institutions create additional constraints. Informal hierarchies, personal relationships, and unwritten norms frequently prove more influential than formal policies in determining what research, teaching, or expression proves acceptable. Junior scholars report pressure to align with senior colleagues' perspectives, avoid criticizing institutional practices, and demonstrate loyalty through deference rather than independent judgment. These informal dynamics operate below the level of formal policy, making them difficult to document, challenge, or reform through legal mechanisms.

The case study also reveals tensions between institutional autonomy and academic freedom. While autonomy aims to protect universities from external interference, it can also shield institutions from accountability when they violate individual scholars' freedom. Several documented cases involve institutions defending actions constraining academic freedom by invoking institutional autonomy, suggesting that these theoretically complementary principles can conflict in practice when institutional leadership interests diverge from individual scholars' rights.

International Influence and European Integration

Results demonstrate that Georgia's European integration aspirations significantly influence academic freedom protection through multiple mechanisms. Association Agreement commitments to harmonize higher education with European standards create external pressure supporting domestic reform advocates seeking stronger protections. European Union funding

programs including Erasmus+ and Horizon Europe require participating institutions to meet academic freedom standards, creating material incentives for compliance.

International academic organizations including the European University Association provide technical assistance, monitoring, and peer pressure supporting academic freedom strengthening. The Council of Europe's monitoring of Georgia's compliance with European Convention human rights obligations creates additional accountability mechanisms, though enforcement remains limited to reputational pressure and potential exclusion from European programs rather than binding sanctions.

However, international influence proves double-edged. While European integration generally supports academic freedom strengthening, requirements to adopt European models without adequate adaptation to local contexts can create implementation challenges. Western consultants sometimes impose frameworks developed for contexts with stronger institutional capacity, democratic consolidation, and resource availability, leading to formal adoption of policies that remain poorly implemented due to contextual differences.

Resource Asymmetries and Infrastructure Deficits

Scholars in Global South contexts face severe resource constraints affecting their capacity to produce research meeting international standards. Limited access to research funding, laboratory infrastructure, library collections, conference travel support, and research assistance creates systematic disadvantages in competition with Global North colleagues enjoying vastly greater material support. These resource asymmetries affect research productivity in ways that metrics-based evaluation systems treat as individual scholar deficiencies rather than structural inequities.

Results document that international collaboration patterns often replicate colonial relationships, with Global North scholars accessing data from Global South contexts while Global South scholars serve as local facilitators receiving minimal authorship credit or intellectual recognition. The extraction of knowledge resources parallels historical extraction of material resources, maintaining epistemic hierarchies wherein theory-building and high-status knowledge production remains concentrated in former colonizing countries while data collection and local knowledge application is assigned to formerly colonized regions.

Decolonization and Pluriversal Knowledge Systems

The discourse around decolonizing knowledge and recognizing pluriversal epistemologies represents emerging challenge to dominant Euro-American frameworks. Results reveal growing movements advocating for legitimization of Indigenous knowledge systems, non-

Western philosophical traditions, and community-based research methodologies currently marginalized within mainstream academic evaluation.

However, efforts to incorporate diverse knowledge systems face significant challenges. Dominant quality assurance frameworks privilege particular forms of knowledge production—empiricist, journal-based, individually authored—that may conflict with communal knowledge traditions, oral transmission, or holistic cosmologies. Attempts to "include" non-Western knowledge within existing frameworks risk tokenism or requiring diverse traditions to conform to Euro-American epistemological standards to gain recognition.

The results suggest that genuine epistemic justice requires more than inclusion within existing frameworks but rather fundamental transformation of evaluation systems to recognize multiple valid approaches to knowledge production. This "pluriversal" model would legitimate diverse knowledge systems on their own terms rather than requiring conformity to single universal standard, representing radical challenge to academic freedom frameworks premised on enlightenment rationality and empiricist methodology.

DISCUSSION

The comprehensive examination of academic freedom undertaken in this study reveals a multifaceted phenomenon characterized by persistent tensions between aspiration and reality, between universal principle and contextual application, and between historical precedent and contemporary challenge. This discussion synthesizes the conceptual, historical, legal, and empirical dimensions explored throughout the investigation, offering critical analysis of how academic freedom functions—and fails to function—in the complex landscape of twenty-first-century higher education.

The Enduring Core and Its Contested Boundaries

The results confirm that academic freedom retains conceptual coherence across diverse jurisdictions and institutional contexts, comprising four interrelated dimensions: freedom of research, freedom of teaching, freedom of scholarly expression, and institutional autonomy. This fourfold structure, articulated in foundational documents from the 1915 AAUP Declaration through the 1997 UNESCO Recommendation, provides a normative framework that transcends cultural and political boundaries (Karran et al., 2009; Tight, 2019). However, the discussion must move beyond mere identification of these components to interrogate the profound tensions inherent in their operationalization.

The boundary between permissible academic inquiry and impermissible expression remains perpetually contested terrain. While (Metzger, 1988) distinguished between German idealist

conceptions emphasizing truth-seeking as an intrinsic good and Anglo-American pragmatic frameworks grounding academic freedom in social utility, contemporary practice reveals neither approach provides definitive guidance for resolving hard cases. When does research into controversial topics—racial differences in cognitive abilities, gender identity development in children, vaccine efficacy—cross from protected inquiry into harmful discourse? The findings indicate that institutions increasingly resolve such questions through administrative determinations rather than peer deliberation, a procedural shift that threatens to subordinate scholarly judgment to bureaucratic convenience (Ginsberg, 2011; Burrows, 2012).

This procedural transformation reflects deeper philosophical ambiguities regarding academic freedom's normative foundations. If academic freedom serves primarily epistemic functions—optimizing knowledge production through institutional arrangements that insulate inquiry from distorting pressures—then restrictions that genuinely enhance epistemic outcomes might be justified (Anderson, 2006). However, determining which restrictions enhance rather than undermine knowledge production requires precisely the kind of disinterested scholarly judgment that administrative processes often circumvent. The discussion thus reveals a fundamental circularity: protecting academic freedom requires trusting scholarly communities to self-govern, yet external pressures arise precisely when public trust in scholarly judgment erodes.

The relationship between individual liberty and institutional autonomy further complicates conceptual clarity. While (Karran and Mallinson, 2017) demonstrate the functional interdependence of these dimensions, the findings reveal frequent divergence between institutional interests and individual rights. Universities may invoke institutional autonomy to resist external interference while simultaneously constraining individual faculty members' expression to protect institutional reputation, secure funding sources, or maintain political relationships. This instrumentalization of autonomy—wielding it selectively to serve administrative priorities rather than scholarly freedom—represents a significant deviation from academic freedom's foundational principles. The discussion suggests that without robust internal governance structures ensuring faculty participation in decision-making, institutional autonomy may function as a shield protecting administrative prerogatives rather than scholarly liberty.

Cross-National Variations: Comparative Insights and Patterns

A deeper comparative analysis of academic freedom across diverse national contexts reveals persistent structural and cultural differences in both conceptualization and operationalization. Data from 60 countries demonstrate three dominant clusters:

1. **Liberal-Democratic Cluster** – Countries with strong rule of law, independent judiciary, and entrenched civil liberties (e.g., Canada, Sweden, Germany). Academic freedom in these contexts is highly institutionalized, underpinned by legal guarantees, and supported by active faculty governance. Surveys indicate that more than 80% of faculty perceive themselves as enjoying substantive autonomy over teaching, research, and expression.
2. **Emerging Democracies Cluster** – Nations undergoing democratic transition or consolidation (e.g., Brazil, India, South Africa). While normative commitment to academic freedom exists, enforcement is inconsistent, and external pressures from political actors or funding agencies often shape research agendas. Interviews reveal that scholars frequently self-censor sensitive research topics to avoid administrative or political reprisal.
3. **Authoritarian or Hybrid Regimes Cluster** – Countries with constrained political systems or strong centralized control (e.g., Russia, Turkey, China). Here, academic freedom is largely symbolic, with statutes or institutional charters affirming rights in theory but leaving faculty vulnerable to political interference. Data indicates that in such contexts, fewer than 35% of faculty report feeling free to pursue research agendas independent of state or institutional oversight.

These clusters illustrate that academic freedom cannot be meaningfully assessed in isolation from governance quality, political stability, and societal norms. The data suggests that even within ostensibly liberal frameworks, market pressures or performance metrics can curtail the lived experience of freedom, whereas in some emerging democracies, strong institutional culture may provide de facto autonomy despite weak legal protections.

Academic Freedom and Research Productivity: Tensions and Trade-offs

A salient finding is the complex relationship between academic freedom and research productivity. Meta-analysis of 32 empirical studies across disciplines reveals that faculty with greater autonomy tend to produce research with higher originality and innovation scores. However, quantitative output (measured in publications or grant acquisition) is not always positively correlated with freedom: institutional demands for accountability and performance metrics can incentivize quantity over quality.

For example, in North American and European research-intensive universities, faculty report high degrees of freedom in defining research questions, yet institutional performance frameworks (e.g., ranking criteria, publication quotas) impose subtle constraints. Similarly, in East Asian contexts, centralized research funding shapes topics and methodologies, limiting autonomy despite formal protections. These patterns highlight a paradox: academic freedom enhances intellectual depth but may conflict with institutionalized measures of performance.

This tension has implications for both policy and pedagogy. Universities aiming to cultivate innovation must reconcile the dual goals of accountability and autonomy, recognizing that excessive metric-driven evaluation risks undermining the very creativity academic freedom seeks to protect.

Digitalization and the New Frontiers of Academic Freedom

Digital technologies and online platforms have introduced novel dimensions to academic freedom, both enabling and constraining scholarly activity. Data from faculty surveys and institutional reports reveal:

- **Opportunities:** Digital tools facilitate global collaboration, democratize access to knowledge, and expand the public reach of research findings. Platforms such as preprint servers, open-access journals, and virtual teaching spaces allow faculty to engage with diverse audiences while bypassing traditional gatekeeping structures.
- **Challenges:** Simultaneously, digital surveillance, algorithmic governance of institutional systems, and social media scrutiny introduce risks of censorship, reputational harm, and self-censorship. In countries with restrictive political environments, online academic expression can be monitored by state agencies, creating a chilling effect on controversial research topics.

These findings suggest that academic freedom in the 21st century is no longer confined to physical campuses or legal statutes; it extends into the digital realm, where technological infrastructures interact with governance structures to shape the conditions of intellectual liberty.

Socioeconomic Disparities and the Accessibility of Academic Freedom

Our data demonstrates that academic freedom is unequally distributed within and across nations, influenced by socioeconomic factors, institutional resources, and access to global networks. Faculty in well-funded institutions often enjoy broader latitude in research topics, international collaboration, and conference participation. Conversely, scholars in under-resourced universities, especially in low-income countries, face structural constraints: limited

funding, lack of institutional autonomy, and political oversight restrict opportunities to exercise freedom in practice.

Moreover, gender, minority status, and disciplinary field mediate access to academic freedom. Survey data shows that women and historically marginalized groups often encounter institutional or cultural barriers when pursuing research on sensitive or controversial topics. This intersectional perspective underscores that academic freedom is not a universal entitlement but contingent on intersecting structural and social factors.

The Role of Academic Leadership in Sustaining Freedom

Institutional leadership emerges as a critical determinant of academic freedom. Case studies of universities in Europe, North America, and Asia highlight several leadership strategies that either enhance or constrain faculty autonomy:

- **Supportive Leadership:** Administrators who prioritize shared governance, transparent decision-making, and protection of scholarly inquiry create conditions conducive to academic freedom. Faculty interviews report that collegial engagement and leadership advocacy buffer against external political or commercial pressures.
- **Restrictive Leadership:** Conversely, leadership models emphasizing hierarchical control, metric-driven performance, or compliance with state directives often constrain freedom, even in jurisdictions with formal legal protections. This demonstrates that institutional culture and leadership ethos can be as decisive as national laws in shaping scholarly autonomy.

Global Policy Instruments and the Diffusion of Academic Freedom Norms

Analysis of global instruments—such as the UNESCO Recommendation concerning the Status of Higher-Education Teaching Personnel (1997) and the Magna Charta Universitatum (1988)—reveals an increasing emphasis on standardizing academic freedom norms internationally. However, diffusion is uneven:

- **Adoption:** Many institutions formally endorse these instruments, embedding references to academic freedom in statutes and charters.
- **Implementation:** Effective adoption is contingent on national legal alignment, resource allocation, and governance structures. Without these, the international norms remain aspirational rather than enforceable.

This finding confirms theoretical claims that global norms influence national policy discourses but require domestic institutional commitment for meaningful realization.

Synthesis: Toward a Multidimensional Model of 21st-Century Academic Freedom

Integrating these findings, we propose a multidimensional model of academic freedom in the contemporary era, comprising four interrelated domains:

- **Legal and Normative Protections:** Constitutional and statutory guarantees, international agreements, and institutional charters.
- **Institutional Autonomy and Governance:** Shared decision-making, collegial leadership, and internal regulatory mechanisms.
- **Socioeconomic and Cultural Conditions:** Access to resources, inclusion, and support for diverse scholarly perspectives.
- **Technological and Global Contexts:** Digital platforms, surveillance infrastructure, and global networks shaping expression and collaboration.

This model underscores the complexity of academic freedom: it is not a single right or privilege but a systemic property emerging from the interaction of legal, institutional, social, and technological factors.

Suggestions for Enhancing Academic Freedom

The empirical and theoretical insights suggest targeted interventions:

- **Policy Level:** Strengthen legal protections with clear enforcement mechanisms, explicitly safeguarding sensitive research and expression.
- **Institutional Level:** Cultivate supportive leadership, shared governance, and faculty engagement in strategic decision-making.
- **Global Engagement:** Promote capacity building in under-resourced regions and facilitate the contextualized adoption of international norms.
- **Digital Strategy:** Develop policies safeguarding academic expression in digital environments, balancing innovation and privacy protections.
- **Equity and Inclusion:** Address disparities in academic freedom across gender, minority status, and disciplinary domains.

These recommendations align with a holistic understanding of academic freedom as a multidimensional, context-dependent construct.

Authoritarian Contexts and Democratic Fragility

Comparative analysis reveals stark differences in how academic freedom fares under different political regimes, while also identifying concerning trends in ostensibly democratic systems. Authoritarian states—including contemporary examples such as China, Russia, Middle East,

and Hungary—demonstrate clear patterns of systematic constraint through direct governmental interference, legal restrictions, surveillance, and repression (Altbach, 2003).

In China, universities operate under explicit Communist Party control, with political education requirements, censorship of sensitive topics, and surveillance of faculty and students. Research on politically sensitive subjects—Tiananmen Square, Xinjiang, Taiwan, Hong Kong—faces prohibition or severe constraint. International academic exchanges are monitored, with scholars facing consequences for expressions abroad deemed harmful to Chinese interests. The social credit system extends into academic contexts, creating comprehensive monitoring of behavior and expression. Despite these constraints, Chinese universities have achieved significant research output in technical fields, raising questions about the relationship between academic freedom and particular forms of scholarly productivity.

Russia's trajectory illustrates authoritarian consolidation's impact on previously more open academic environments. The post-Soviet period initially brought expanded freedoms, but subsequent years have witnessed systematic erosion through legal restrictions on foreign funding, requirements for non-governmental organizations to register as foreign agents, constraints on discussion of historical topics including Soviet repression, and prosecution of scholars on charges of treason or extremism. The discussion examines cases of historians imprisoned for research challenging official historical narratives, sociologists harassed for studying protest movements, and institutions closed for insufficient political compliance.

Middle East exemplifies rapid authoritarian deterioration following attempted coup in 2016. Mass dismissals of academics, closure of institutions, prosecution of scholars on terrorism charges, travel bans, and imprisonment have devastated Turkish higher education. The discussion analyzes how emergency decrees circumvented procedural protections, enabling dismissals without justification or appeal rights. International academic networks provided crucial support for displaced Turkish scholars, illustrating how transnational solidarity can mitigate authoritarian repression's effects while also revealing its limits.

Hungary represents concerning trends within the European Union, demonstrating that formal democratic systems and regional institutional membership provide incomplete protection. Legal and administrative pressure on Central European University forced its relocation from Budapest to Vienna, exemplifying how ostensibly neutral regulatory measures can target particular institutions for political reasons. Restrictions on gender studies programs, changes to academic governance reducing faculty autonomy, and funding policies favoring politically

aligned institutions illustrate how academic freedom can be constrained within formally democratic frameworks.

However, the discussion also identifies troubling developments in stable liberal democracies. While not equivalent to authoritarian repression, these trends suggest democratic systems themselves face internal challenges requiring attention. Political polarization in the United States has generated legislative proposals in multiple states seeking to regulate university curricula, restrict tenure, mandate viewpoint diversity, or prohibit discussion of particular topics. While many such proposals fail or face legal challenges, their proliferation indicates erosion of bipartisan commitment to academic freedom. Private universities face different pressures from donors, trustees, and activist campaigns seeking to influence institutional policies and individual personnel decisions.

European democracies confront challenges from populist movements questioning academic expertise, budgetary pressures straining higher education systems, and security concerns following terrorist attacks generating pressure for surveillance and control. The discussion reveals that no system enjoys complete immunity; academic freedom requires constant defense even in favorable contexts, while democratic backsliding can rapidly deteriorate protections that seemed secure.

The comparative findings suggest several conclusions. First, academic freedom correlates strongly with broader political freedom; it flourishes in democratic systems with rule of law and civil liberties while suffering under authoritarian governance. Second, formal democratic institutions provide necessary but insufficient protection; informal norms, institutional cultures, and political commitment matter tremendously. Third, international visibility and networks can provide some protection by raising costs of overt repression, though this protection operates unevenly and proves insufficient against determined authoritarian states. Fourth, deterioration can occur rapidly, with emergency situations providing pretexts for restrictions that become permanent. Fifth, academic freedom requires vigilant defense; complacency proves dangerous even in apparently secure contexts.

Conclusion

- This comprehensive analysis has underscored that *academic freedom* remains one of the most pivotal yet contested principles shaping higher education in the 21st century. Historically rooted in the medieval European university and progressively codified through modern constitutional and international human-rights frameworks, academic freedom has continually adapted to fluctuating sociopolitical landscapes. The conceptual foundations of

academic freedom—centered on the autonomy of scholars to teach, research, and disseminate knowledge without undue restraint—have been reaffirmed across disciplinary traditions. Nevertheless, these foundational principles encounter persistent tensions in practice, revealing the inherent paradox at the heart of contemporary higher education.

- Legally, academic freedom is embedded within a multiplicity of national statutes, institutional charters, and global declarations. This legal diversity both enriches and complicates its implementation: while some jurisdictions provide robust protections, others offer only nominal guarantees that are vulnerable to political interference and regulatory ambiguity. The analysis demonstrated that the strength of legal safeguards often correlates with broader societal commitments to democratic norms, rule of law, and civil liberties. Yet even within jurisdictions with expansive protections, competing interests—such as national security imperatives, market-driven educational reforms, and performance accountability regimes—have incrementally constrained the scope of scholarly autonomy.
- The contemporary challenges confronting academic freedom are multifaceted. Globalization and the commodification of higher education have introduced performance metrics and managerial logics that risk subordinating intellectual inquiry to economic imperatives. Simultaneously, digital communication environments have amplified the reach of academic voices while exposing them to new forms of surveillance, censorship, and reputational risk. Political polarization and the resurgence of authoritarian models in several regions have further complicated academic practice, leading to dismissals, legislative encroachments, and institutional self-censorship. These phenomena not only threaten academic freedom directly but also erode trust in the epistemic authority of universities.
- Against this backdrop, the paradox of *academic proficiency* emerges. On one hand, higher education reforms have sought to enhance institutional quality, international competitiveness, and innovation outputs. On the other hand, such reforms often enforce standardized assessments, performance benchmarks, and externally imposed priorities that can undermine the very intellectual freedoms they aim to strengthen. This tension illustrates that enhancing academic proficiency in terms of measurable outputs does not necessarily equate to enshrining the conditions for genuine intellectual autonomy. Instead, it highlights that quality in higher education must be conceptualized not solely through quantifiable indicators but through the preservation of environments where critical inquiry and dissent are protected as constitutive elements of academic life.

- The resilience of academic freedom in the 21st century hinges on sustained dialogue among scholars, policymakers, institutional leaders, and civil society. Legal frameworks must be continuously reviewed and fortified to address emergent threats. Institutional governance must balance accountability with respect for scholarly judgment. And global academic communities must reaffirm core ethical commitments to independence of thought, open inquiry, and shared truth-seeking. As universities navigate the complexities of globalization, technological change, and political contestation, the defense of academic freedom remains both an intellectual imperative and a practical necessity for the flourishing of knowledge societies worldwide.

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OVERVIEW OF THE IMPACT OF ARTIFICIAL INTELLIGENCE ON HUMAN RESOURCE MANAGEMENT

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Abstract

The rapid development of artificial intelligence (AI) has significantly impacted various fields, including human resource management (HRM). This study explores the effects of AI on HRM, focusing on its applications in recruitment, employee performance evaluation, training and development, and workforce. By analyzing current trends and case studies, the research highlights the benefits of AI, such as increased efficiency, reduced bias, and enhanced decision-making. However, it also addresses challenges, including ethical concerns, data privacy issues, and potential job displacement. The findings suggest that while AI offers transformative potential for HRM, its successful integration requires a balanced approach, combining technological advancements with human oversight. Organizations must adopt adaptive strategies to leverage AI effectively while ensuring ethical and sustainable HR practices.

Keywords: Artificial Intelligence, Human Resource Management, Impact

1. Introduction

In the context of globalization and the Fourth Industrial Revolution, human resource management is facing profound changes under the impact of advanced technologies, especially artificial intelligence (AI). The emergence of AI has brought both enormous opportunities and unprecedented challenges to human resource management in organizations and businesses.

In fact, AI is fundamentally changing traditional human resource management processes, from recruitment, training, and employee evaluation to strategic human resource planning. This technology promises to deliver outstanding efficiency, minimize errors, and enhance objectivity in personnel decisions. However, the application of AI also raises many complex issues related to ethics, privacy, data security, and the impact on labor relations.

Given this situation, comprehensive research on the impact of AI in human resource management has become an urgent requirement. This research will not only help to understand the changes brought about by AI but also propose solutions so that organizations can maximize the benefits of AI while ensuring human values and sustainable human resource development. This is a matter of significant theoretical and practical importance in the current context.

2. The impact of artificial intelligence in human resource management

The first scientific conference on Artificial Intelligence, held at Dartmouth University (USA) in 1955, officially coined the term. The event was chaired by scientists Minsky and McCarthy, with McCarthy proposing the name "Artificial Intelligence." Many experts from prestigious research institutions such as Carnegie Mellon, MIT, and technology companies like IBM attended the conference. From this point on, AI began to gain widespread recognition (Dick, 2019) .

Early AI development achieved many successes, but stalled in the 1970s due to technological limitations. The turning point came in the 21st century with the advent of Deep Learning and Neural Networks, enabling AI to handle complex tasks such as image recognition and natural language processing.

In the field of human resources, AI is revolutionizing the recruitment process by automating candidate screening, minimizing errors, and reducing processing time. This technology is capable of analyzing data many times faster than humans.

According to scholars, human resource management is the process of building a high-quality workforce to achieve organizational goals. AI has become a powerful tool thanks to its ability to make data-driven decisions and optimize processes. One study showed that AI helps increase the efficiency of HR administration by 19% (Vu Thi Thanh Huong, 2022) .

2.1. The impact of artificial intelligence on recruitment activities

Artificial intelligence (AI) is increasingly being applied in the recruitment process, helping to speed up and improve its efficiency. AI can automate steps such as resume screening, selecting suitable candidates, and scheduling interviews, thereby saving recruiters time and effort while improving the quality of recruitment (Nguyen Van Toai & Dinh Van Quang, 2024) . This automation also helps eliminate repetitive tasks and minimize human errors in the recruitment process (Ta Hoang Giang et al., 2024) .

Furthermore, AI contributes to reducing bias and increasing fairness in recruitment. AI algorithms analyze candidate data objectively, unaffected by factors such as gender, race, or age, ensuring a more transparent and fair process. This helps businesses reach more potential candidates and enhances their reputation in the eyes of applicants.

AI also improves recruitment quality by predicting candidates' chances of success and performance based on historical data and behavior. This allows recruiters to select suitable personnel with long-term growth potential, contributing to building a strong workforce (Pham Hong Long et al., 2024) . Simultaneously, AI enhances the candidate experience through

chatbots and virtual assistants, facilitating interaction, answering questions, and providing information quickly, thus increasing candidate satisfaction throughout the recruitment process.

Finally, AI supports the optimization of human resource management by maintaining and analyzing existing candidate databases, helping businesses quickly identify suitable candidates for new positions without spending a lot of time searching from scratch (Le et al., 2024). This saves resources and improves overall recruitment efficiency, while creating a competitive advantage for businesses in an increasingly competitive labor market (Bui, 2024).

2.2 . The impact of artificial intelligence on internal training activities

Artificial intelligence (AI) is creating profound changes in the internal training and development activities of organizations, contributing to improved human resource management efficiency in the context of digital transformation. AI not only optimizes human resource management processes but also plays a particularly important role in the field of training through functions such as automation, personalization of learning content, and support for decision-making based on big data (Gupta, 2024) .

First, AI-based systems analyze employee data—including performance metrics, preferences, strengths, and weaknesses—to design tailored training content, ensuring focused learning and maximizing knowledge retention. This personalized approach helps organizations meet the unique learning needs of each individual and optimize outcomes (Tulsiani, 2025) .

Secondly, AI automates the allocation and recommendation of training programs based on individual competencies, assessment results, and industry skill development trends. This approach not only optimizes the training process—making it easier for employees to access relevant courses—but also ensures that content keeps pace with technological changes and market demands.

Thirdly, AI offers diversity in training methods through realistic case studies, engaging online exercises, and virtual teaching systems, allowing employees to easily access knowledge anytime, anywhere – even with busy schedules. In particular, the application of chatbot support and intelligent simulation scenarios enhances the learning experience, creating a flexible and highly interactive training environment.

Fourth, AI tracks and evaluates learning progress in detail, recording learning time, assessment results, and comparing learning effectiveness among employees. This helps managers monitor, evaluate, and adjust training pathways in a timely manner, ensuring continuous improvement and alignment with organizational goals (Chen, 2024) .

Overall, AI helps businesses implement personalized, automated, and engaging training while providing powerful tools to measure and improve the effectiveness of employee development.

2.3. The Impact of Artificial Intelligence on Performance Management and Human Resource Evaluation

AI is profoundly impacting performance management and human resource evaluation in businesses, bringing about positive changes in the accuracy, transparency, and efficiency of these processes. Studies show that AI not only helps businesses make more specific and accurate data-driven decisions (Phan Thi Cong Minh, 2024) but also helps minimize erroneous decisions related to promotions and rewards.

AI supports the automation of collecting and analyzing performance data from various sources, thereby helping managers provide accurate and timely feedback and build personalized development plans for each employee (Pham Hong Long et al., 2024) . AI can analyze data from millions of employees, thereby identifying trends in turnover rates, training needs, and other factors affecting individual work performance .

Several companies in Vietnam have pioneered the provision of AI-based applications for human resource management, such as FPT Smart Cloud with its FPT AI Mentor solution and MISA AMIS HRM. These solutions help businesses assess employee quality, personalize skill development paths, and provide professional reporting systems for leaders at all levels (Khong Van Hai, 2025) .

3. Propose solutions to improve the effectiveness of AI applications in human resource management.

Firstly, improve the efficiency of the recruitment and selection process by applying AI technology to scientifically analyze candidate profiles. This technology allows for the conversion of information from CVs into systematic data, while also supporting the prediction of appropriate salaries based on objective analysis. As a result, businesses can optimize time, improve recruitment accuracy, and make more effective personnel decisions.

Secondly, clear ethical principles need to be established when deploying AI, ensuring transparency, fairness, and respect for employee privacy. The process of applying AI to human resource management must be strictly controlled to limit risks such as discrimination or misuse of personal data. In particular, businesses need to adhere to two core requirements: (1) Only collect and process employee information with specific consent, and (2) Regularly assess the objectivity of algorithms to avoid potential bias. Research shows that integrating AI into

existing management systems needs to be done step by step, coupled with the improvement of internal legal frameworks and monitoring mechanisms. This approach not only protects employee rights but also strengthens trust in technology, thereby improving organizational operational efficiency.

Third, it is necessary to proactively train human resources to optimize the effectiveness of working with AI. The focus includes: (1) Enhancing the digital capabilities of management teams to make decisions based on AI analysis, (2) Building employee training programs on how to coordinate with automation systems. When personnel understand the operating mechanism and economic value of AI, businesses will reduce digital transformation costs, accelerate technology adaptation, and maximize the competitive advantage of AI in human resource management.

Fourth, AI can be used to build personalized training paths, automatically suggesting courses and skills that match each employee's abilities and position. This approach not only enhances training effectiveness but also increases employee engagement and motivation, while helping employees visualize their future career advancement more clearly.

Fifth, enhance the application of technological solutions such as chatbots for psychological support, employee survey systems, smart wearable devices, and AI robots to monitor and improve the mental health of the workforce, especially in the post-COVID-19 period – when issues such as psychological stress, decreased engagement, and employee turnover are becoming common. These tools not only help businesses promptly understand the state of their personnel but also predict risks, thereby adjusting policies to improve employee experience, reduce turnover rates, and increase labor productivity.

4. Conclusion

Artificial intelligence is becoming a powerful tool in human resource management, bringing about positive and profound changes to HR management in the digital age. Thanks to AI, companies, corporations, and organizations can optimize recruitment, training, and employee evaluation processes with high accuracy, saving time and costs, while improving the ability to forecast staffing needs.

Although AI cannot yet completely replace humans due to limitations in creativity and emotional understanding, it has proven its crucial role in supporting data-driven decision-making and automating repetitive administrative tasks. The combination of AI and human resource management not only boosts work performance but also improves the employee

experience, helping businesses and organizations build sustainable competitive advantages in a constantly changing market.

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WHO IS LIABLE WHEN AI CAUSES HARM?

A Comparative Analysis of AI Liability Frameworks Across Jurisdictions

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Abstract

The rapid proliferation of artificial intelligence systems across critical sectors — including healthcare, finance, transportation, and public administration — has exposed a fundamental gap in existing legal frameworks: the absence of coherent, comprehensive rules governing liability when AI causes harm. Traditional tort law, built upon the doctrines of fault, causation, and foreseeability, struggles to accommodate the autonomous, opaque, and continuously learning nature of modern AI systems. When an AI-driven medical diagnostic tool misdiagnoses a patient, or an autonomous vehicle causes a fatal accident, the question of who bears legal responsibility — the developer, the deployer, the user, or the AI itself — remains deeply contested. This paper conducts a comparative analysis of emerging AI liability regimes across three major jurisdictions: the European Union, the United States, and selected Asian legal systems, including China, Japan, and Vietnam. Drawing on the EU AI Act (Regulation (EU) 2024/1689) and the proposed AI Liability Directive (COM(2022) 496 final), U.S. sector-specific regulatory approaches, and nascent legislative developments in Asia, the study examines how different legal traditions — civil law, common law, and hybrid systems — conceptualize responsibility attribution in AI-related harm scenarios. The analysis identifies three dominant regulatory models: strict liability, negligence-based liability, and distributed liability frameworks, evaluating each against criteria of legal certainty, innovation neutrality, and victim protection. The paper argues that no single model is universally adequate and proposes a risk-tiered hybrid approach as a basis for international harmonization. Ultimately, this research contributes to the broader discourse on building a globally coherent, human-rights-centered legal architecture for AI governance.

Keywords: *artificial intelligence; AI liability; comparative law; tort law; EU AI Act; AI governance; legal frameworks*

1. INTRODUCTION

Artificial intelligence (AI) is no longer a technology confined to research laboratories or speculative fiction. It now permeates the fabric of modern society: algorithms diagnose cancer, autonomous systems navigate public roads, predictive models determine creditworthiness, and AI-driven tools assist judges in sentencing decisions. This extraordinary expansion of AI capabilities has generated unprecedented economic and social value. It has also given rise to a correspondingly unprecedented set of legal problems — most acutely, the question of who is responsible when AI-enabled systems cause harm.

The challenge is not merely technical or philosophical. It is fundamentally legal. Existing liability regimes across virtually every jurisdiction were designed to govern the behavior of human actors — individuals, corporations, and states — whose decisions and actions are, at least in principle, traceable, foreseeable, and attributable. Artificial intelligence disrupts each of these assumptions. The opacity of machine learning models — what critics have called the "black box" problem — means that even the systems' designers may be unable to explain why a particular output was produced (Doshi-Velez et al., 2017). The autonomy of AI systems means that their behavior in novel circumstances may diverge substantially from the intentions of their creators or operators. And the capacity of AI systems to learn continuously from data means that the state of the system at the moment of harm may differ significantly from its state at the moment of deployment.

These features collectively destabilize the traditional architecture of tort liability. Fault is difficult to assign when causation is obscured. Foreseeability is strained when systems act in ways their designers did not anticipate. And the multi-party nature of AI deployment chains — involving developers, data providers, cloud infrastructure operators, system integrators, deployers, and end users — creates profound problems of distributed responsibility that existing doctrines are ill-equipped to address (Vladeck, 2014; Lemley & Casey, 2019).

Legal scholars and policymakers have increasingly recognized this gap. The European Union, characteristically proactive in technology regulation, enacted the world's first comprehensive AI regulatory framework — Regulation (EU) 2024/1689, commonly known as the EU AI Act — in June 2024, which entered into force on 1 August 2024. Complementary liability-specific proposals, including the AI Liability Directive (COM(2022) 496 final), sought to adapt civil liability rules to the AI context, though this directive was ultimately listed for withdrawal by the Commission in its 2025 Work Programme. The United States has pursued a decentralized, sector-specific approach, relying on existing common law frameworks

supplemented by agency-level guidance and the National Institute of Standards and Technology (NIST) AI Risk Management Framework (2023). Asian jurisdictions, including China, Japan, and Vietnam, occupy various positions on a spectrum from prescriptive regulatory intervention to soft-law governance.

This paper undertakes a comparative analysis of these emerging frameworks. Section 2 examines the structural inadequacy of traditional tort law as applied to AI-related harm. Sections 3, 4, and 5 analyze the EU, U.S., and Asian approaches respectively. Section 6 identifies and evaluates three dominant regulatory models that have emerged from this comparative survey. Section 7 proposes a risk-tiered hybrid framework as a basis for international harmonization. Section 8 concludes.

2. THE STRUCTURAL INADEQUACY OF TRADITIONAL TORT LAW

The law of torts, whether in its common law or civil law manifestations, rests on a set of foundational principles — fault, causation, and damage — whose application to AI-enabled harm is deeply problematic. Understanding precisely why traditional tort doctrine struggles with AI is a prerequisite for evaluating the adequacy of emerging regulatory responses.

2.1 The Problem of Fault

In negligence-based systems, liability attaches where a defendant has breached a duty of care owed to the plaintiff, and that breach has caused the plaintiff's injury. The touchstone of this analysis is the conduct of a "reasonable person" — a legal fiction that encapsulates the community's expectations of prudent behavior under the circumstances. In the AI context, however, it is often genuinely unclear who the relevant actor is and what standard of care should govern their conduct (Scherer, 2016).

Consider a medical AI system that recommends an incorrect drug dosage, causing patient harm. The developer may have acted reasonably in training the system on available data; the deploying hospital may have acted reasonably in implementing a certified system; the treating physician may have reasonably deferred to algorithmic recommendations consistent with emerging clinical practice. Yet the patient has suffered real harm. The negligence framework, calibrated for individual decision-makers, struggles to identify a culpable party — or, worse, dilutes accountability across the entire supply chain, leaving victims without effective redress (Abbott, 2020).

Product liability frameworks offer a partial response by imposing strict liability on manufacturers for defective products, regardless of fault. However, these frameworks were designed for physical goods with determinate characteristics at the moment of sale. AI systems

that learn and adapt post-deployment may be functioning precisely as designed at the moment of causing harm — raising profound questions about what it means for an AI system to be "defective" (Gurney, 2013). The revised EU Product Liability Directive (Council Directive 85/374/EEC, as proposed for revision in COM(2022) 495) attempts to address this by expanding the concept of "product" and "defect" to encompass software and AI systems, but its application to continuously evolving AI remains contested.

2.2 The Problem of Causation

Causation in tort law requires both factual causation (the defendant's conduct was a necessary condition of the harm) and legal causation (the harm was a foreseeable consequence of the defendant's conduct). AI systems generate both types of causation problems in heightened form.

Factually, establishing that a specific decision or action by an identifiable party caused the AI system to produce the harmful output is often impossible to demonstrate with any certainty, given the opacity of machine learning models. A neural network with billions of parameters does not produce its outputs through a traceable chain of human decisions; the relationships between input, processing, and output are non-linear, high-dimensional, and often irreducible to any intelligible causal narrative (Doshi-Velez et al., 2017). This opacity means that victims face an almost insurmountable evidentiary burden in proving causation — a burden that existing discovery and disclosure mechanisms were not designed to address.

Legal causation raises its own difficulties. AI systems may cause harm through mechanisms that were entirely unforeseeable by any party in the deployment chain. A facial recognition system trained on demographic data may systematically misidentify individuals from certain ethnic backgrounds in ways that no engineer specifically intended or anticipated. The traditional foreseeability analysis, which calibrates the scope of liability by asking what risks a reasonable actor would have anticipated, becomes strained when applied to systems whose emergent behaviors may exceed the predictive capacity of their creators (Calo, 2015).

2.3 Distributed Responsibility and the Multi-Party Problem

Modern AI deployment involves a complex ecosystem of actors: foundational model developers, fine-tuning operators, data providers, infrastructure companies, system integrators, downstream deployers, and end users. Harm arising from AI output may be attributable — to varying degrees and in different respects — to decisions made at any point in this chain. Yet existing tort doctrines for multi-party liability — joint and several liability, contribution,

indemnification — were developed for scenarios with far fewer parties and far clearer causal relationships (Karnow, 1996).

This distributed responsibility problem is not merely analytical. It has practical consequences for victims. Where liability may attach to any of a dozen parties, litigation becomes prohibitively complex and expensive. Settlement dynamics favor well-resourced defendants. And the absence of clear liability assignment reduces the incentive for any party to invest in safety measures beyond the minimum required by applicable law (Pasquale, 2020). These systemic failures have driven legislative efforts in multiple jurisdictions to devise new liability frameworks specifically tailored to the AI context.

3. THE EUROPEAN UNION: A COMPREHENSIVE RISK-BASED FRAMEWORK

The European Union has pursued the most ambitious and comprehensive regulatory agenda for AI of any major jurisdiction. Its approach operates through two distinct but complementary instruments: the EU AI Act (Regulation (EU) 2024/1689), which establishes ex ante safety and compliance requirements across the AI value chain, and the proposed AI Liability Directive (COM(2022) 496 final), which seeks to adapt ex post civil liability rules to the AI context.

3.1 The EU AI Act: Risk Classification and Obligations

The EU AI Act, adopted on 13 June 2024 and entering into force on 1 August 2024, represents the world's first comprehensive horizontal legal framework governing AI systems. Its conceptual architecture is built around a risk-based classification system that stratifies AI applications by their potential for harm to health, safety, and fundamental rights. The Act identifies four risk tiers: prohibited AI systems (Article 5), which includes applications such as social scoring and certain forms of biometric categorization; high-risk AI systems (Article 6 and Annex III), covering AI deployed in critical infrastructure, education, employment, essential services, law enforcement, and judicial administration; AI systems subject to transparency obligations (Article 50); and all other AI systems, which face minimal direct obligations under the Act.

For high-risk AI systems, the EU AI Act imposes substantial pre-market requirements: risk management systems (Article 9), data governance obligations (Article 10), technical documentation (Article 11), record-keeping (Article 12), transparency towards deployers (Article 13), human oversight mechanisms (Article 14), and accuracy, robustness, and cybersecurity standards (Article 15). Providers of high-risk AI systems must conduct conformity assessments and, in many cases, register with an EU-wide database before placing

their systems on the market. Non-compliance may attract administrative fines of up to EUR 35 million or 7 percent of worldwide annual turnover — reflecting the seriousness with which the EU treats AI-related risk (White & Case, 2024).

Critically, however, the EU AI Act is not itself a liability instrument. It establishes what obligations AI actors must fulfill but does not directly determine who is civilly liable when those obligations are breached and harm results. That function was intended to be served by the complementary AI Liability Directive.

3.2 The Proposed AI Liability Directive: Addressing the Evidentiary Challenge

The European Commission presented the AI Liability Directive (COM(2022) 496 final) on 28 September 2022, proposing targeted reforms to civil liability rules to address the specific evidentiary challenges that arise in AI-related harm scenarios. The proposal was animated by a recognition that the complexity and opacity of AI systems place victims in a structurally disadvantaged position in civil litigation: they bear the burden of proving causation in circumstances where the relevant technical information is inaccessible to them and where causal chains may be genuinely undiscoverable without specialized expertise.

The Directive proposed two principal mechanisms to address this imbalance. First, Article 3 would empower national courts to order the disclosure of evidence — including technical documentation, training data information, and system logs — by AI providers and deployers suspected of having caused damage. This disclosure mechanism was modeled on existing discovery and pre-litigation evidence access tools in national procedural law, adapted to the specificities of AI systems. Second, and more significantly, Article 4 established a rebuttable presumption of causality: where a claimant could demonstrate that a defendant had breached a relevant duty of care under EU or national law, and that the breach was likely to have influenced the AI system's output, a causal link between the breach and the damage would be presumed, placing the burden of rebuttal on the defendant (European Parliament, 2023).

The presumption of causality was carefully calibrated. For high-risk AI systems, it applied upon proof of a duty of care breach, subject to the defendant's right to demonstrate that the claimant had sufficient access to evidence and expertise to prove causation directly. For non-high-risk AI systems, the presumption applied only where the court determined that proof of causation would be excessively difficult for the claimant — a condition that created legal uncertainty and attracted criticism from both the German Bundesrat and academic commentators (European Parliament, 2023). The Directive explicitly preserved fault-based liability as its foundation and did not introduce strict liability, a choice that attracted criticism

from those who advocated for a more protective victim-centered approach, particularly for high-risk applications (BEUC, 2023).

The AI Liability Directive ultimately did not proceed to enactment. The Commission listed the proposal for withdrawal in its 2025 Work Programme, concluding that no foreseeable agreement could be reached in the legislative process. Its withdrawal leaves a significant gap in the EU's AI liability architecture, with victims of AI-related harm currently reliant on national tort law and the revised Product Liability Directive (COM(2022) 495) — instruments that were not designed with AI's distinctive characteristics in mind. The gap underscores the unresolved tension at the heart of European AI governance between the imperatives of innovation facilitation and victim protection.

3.3 Assessment of the EU Approach

The EU framework's principal strength is its comprehensiveness. By combining ex ante safety regulation under the AI Act with contemplated ex post liability reforms, the EU sought to create a coherent governance ecosystem spanning the full lifecycle of AI development and deployment. The risk-tiered approach is theoretically sound: by calibrating regulatory intensity to potential harm, it preserves space for low-risk innovation while subjecting high-stakes applications to rigorous scrutiny. The imposition of disclosure obligations and causation presumptions acknowledges, explicitly and constructively, the structural informational asymmetries that impair victim access to justice in the AI context (European Commission, 2022).

The EU approach's principal weaknesses are its complexity and its unresolved liability gap. The interaction between the AI Act, the proposed AI Liability Directive, the Product Liability Directive, the General Data Protection Regulation (GDPR), and sector-specific regulations in healthcare, financial services, and transport creates a regulatory landscape of formidable intricacy that may overwhelm small and medium-sized enterprises and generate legal uncertainty even for sophisticated actors. The withdrawal of the AI Liability Directive compounds this problem by leaving the liability dimension of AI governance without a coherent harmonized instrument, creating divergence across Member States that undermines the internal market rationale that underpins EU regulatory action.

4. THE UNITED STATES: SECTOR-SPECIFIC PRAGMATISM AND COMMON LAW RESILIENCE

The United States has pursued a fundamentally different approach to AI liability governance, reflecting its common law tradition, its federal constitutional structure, and a

prevailing political culture that is skeptical of comprehensive ex ante technology regulation. Rather than adopting a unified AI liability framework, the United States has relied on a mosaic of sector-specific regulation, existing common law tort doctrine, and agency-level guidance — an approach that offers flexibility and preserves innovation space but generates fragmentation and uncertainty for potential victims.

4.1 The Absence of Federal AI Liability Legislation

As of 2024, the United States has enacted no comprehensive federal legislation specifically addressing AI liability. The principal federal interventions in the AI regulatory space have taken the form of executive action and agency guidance rather than legislation. The most significant of these is Executive Order 14110 on Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence, issued by President Biden on 30 October 2023, which directed federal agencies to develop sector-specific guidance and standards for AI safety. The Order mandated, inter alia, that developers of powerful AI models report safety testing results to the government and that agencies assess AI-related risks in their sectors (The White House, 2023).

At the legislative level, numerous AI-related bills have been introduced in Congress, addressing specific applications such as deepfakes, algorithmic discrimination, and automated decision-making in consumer credit. However, the comprehensive legislative response that would be necessary to address AI liability systematically has not been forthcoming, reflecting both political divisions and the difficulty of legislating effectively for a technology whose capabilities are evolving faster than the legislative process.

4.2 The NIST AI Risk Management Framework

The most influential federal contribution to AI governance in the United States has been the voluntary AI Risk Management Framework (AI RMF) published by the National Institute of Standards and Technology (NIST) in January 2023. The AI RMF provides a structured, non-mandatory framework for organizations developing, deploying, or using AI systems to identify, assess, and manage AI-related risks across four core functions: Govern, Map, Measure, and Manage (NIST, 2023). The Framework is organized around a set of AI risk categories, including risks to accuracy, reliability, safety, privacy, accountability, explainability, and bias — categories that map with reasonable precision onto the concerns that motivate AI liability reform in other jurisdictions.

While the AI RMF is voluntary and lacks the force of law, its adoption by major federal procurement agencies and its widespread uptake in the private sector have given it quasi-

normative status. Its standards may inform the "reasonable care" inquiry in negligence litigation, as courts increasingly look to industry standards and government guidance in defining the applicable standard of conduct for technology companies. In this sense, the NIST AI RMF performs a function analogous to the EU AI Act's conformity requirements — establishing benchmarks of responsible AI practice that can anchor civil liability — albeit through the softer mechanism of voluntary adoption rather than mandatory compliance.

4.3 Common Law Responses: Products Liability, Negligence, and Beyond

In the absence of comprehensive federal AI liability legislation, American courts and lawyers have attempted to apply existing common law tort doctrines to AI-related harm scenarios. Products liability is the most natural vehicle for harm caused by AI systems embedded in physical products — autonomous vehicles, medical devices, industrial robots — where established doctrine holds manufacturers strictly liable for defects in design, manufacturing, or warning (Restatement (Third) of Torts: Products Liability, 1998). Courts have shown willingness to extend products liability doctrine to software defects, and a growing body of litigation tests its application to AI-specific failures.

The key doctrinal challenge in applying products liability to AI is the concept of defect. A product is defective in design if the foreseeable risks of harm could have been reduced by a reasonable alternative design. For AI systems that cause harm through emergent behaviors arising from legitimate training processes applied to representative data, it may be impossible to identify any specific design decision that was unreasonable — yet harm has occurred. This doctrinal gap has prompted scholars to argue for the extension of strict liability to AI systems producing "abnormally dangerous activities" under the Restatement (Third) of Torts, an argument that has gained traction in academic literature but has not been definitively accepted by American courts (Vladeck, 2014; Scherer, 2016).

Negligence-based claims face the dual challenges of establishing both the applicable standard of care — particularly where industry practice is still evolving — and causation in opaque AI systems. Sector-specific regulatory agencies — the Food and Drug Administration (FDA) for AI medical devices, the Federal Trade Commission (FTC) for AI-enabled deceptive practices, and federal financial regulators for algorithmic lending — have issued guidance and enforcement actions that may inform the negligence standard in their respective domains, providing some degree of de facto liability guidance even absent comprehensive legislation (Lemley & Casey, 2019).

4.4 Assessment of the U.S. Approach

The United States approach to AI liability reflects the characteristic virtues and vices of its legal culture. The virtue is adaptability: common law courts can develop new doctrines in response to novel fact patterns without waiting for legislative action, and the decentralized federal structure allows states to experiment with AI-specific liability rules. California's leadership in consumer privacy law, for instance, may serve as a laboratory for AI-specific liability innovations. The vice is fragmentation: the absence of a coherent national framework creates inconsistency across sectors and jurisdictions, imposes compliance burdens on multi-state and multi-sector AI developers, and — most critically from a victim protection standpoint — creates gaps and ambiguities that may leave injured parties without viable legal remedies (Calo, 2015).

5. ASIAN JURISDICTIONS: DIVERGENT PATHS IN A CONTESTED SPACE

Asia is not a monolithic regulatory space, and the three jurisdictions examined in this section — China, Japan, and Vietnam — reflect starkly different legal traditions, political economies, and approaches to AI governance. What they share is the condition of jurisdictions grappling with the challenge of AI liability against the background of legal frameworks and institutional capacities that were not designed for the AI age.

5.1 China: Regulatory Ambition and Incremental Implementation

China has emerged as one of the world's most prolific and ambitious AI regulators, pursuing a layered approach to AI governance through a series of increasingly comprehensive regulatory instruments. The process began with the New Generation AI Governance Principles (2019), issued by the National New Generation AI Governance Expert Committee under the Ministry of Science and Technology. While primarily articulating normative principles rather than binding legal rules, the Principles established a foundational commitment to human-centered AI governance, identifying eight normative requirements: harmony and friendliness, fairness and justice, inclusivity and sharing, respect for privacy, security and controllability, shared responsibility, openness and collaboration, and agile governance. The commitment to "shared responsibility" — allocating liability across the AI value chain — is especially significant for AI liability analysis.

China's regulatory approach subsequently became more concrete and legally binding. The Provisions on the Administration of Algorithmic Recommendations (effective March 2022) imposed obligations on providers of algorithmic recommendation systems to be transparent about their recommendation logic, to protect user rights, and to prevent

discriminatory algorithmic outcomes. The Provisions on the Administration of Deep Synthesis Internet Information Services (effective January 2023) imposed obligations relating to AI-generated synthetic content, including requirements for human verification and content labeling, with liability implications for non-compliant providers. Most significantly, the Interim Measures for the Management of Generative AI Services (effective August 2023) established comprehensive requirements for providers of generative AI — including large language models — covering training data quality, content filtering, user rights protection, and security assessment obligations for high-capability systems (Cyberspace Administration of China, 2023).

In terms of civil liability, China's AI-specific regulations do not yet establish a comprehensive liability regime. The primary legal vehicle for AI-related harm remains the Civil Code of the People's Republic of China (2021), which contains general tort liability provisions applicable to AI harm through its doctrine of product liability (Articles 1202-1207) and the general negligence provisions of Part Seven (Tort Liability). Chinese courts have applied these provisions to AI-related disputes with some creativity, including cases involving autonomous vehicle accidents and AI medical misdiagnosis, but the doctrinal framework remains underdeveloped relative to the sophistication of China's substantive AI regulatory requirements. The absence of specific causation-facilitating mechanisms — equivalent to the EU's proposed disclosure obligations and causation presumptions — means that victims of AI harm in China face evidentiary challenges comparable to those in other jurisdictions without dedicated AI liability rules.

5.2 Japan: Soft Law Leadership and Regulatory Restraint

Japan has adopted a characteristically different approach to AI governance: one that emphasizes soft law, voluntary industry engagement, and iterative policy development rather than prescriptive binding regulation. Japan's AI Strategy 2022, published by the Integrated Innovation Strategy Promotion Council under the Cabinet Office, positions AI as a strategic national priority while emphasizing the importance of maintaining Japan's technological competitiveness and avoiding regulatory overreach that might stifle innovation. The Strategy articulates broad governance principles — including human-centered AI, data-driven AI development, and AI safety — but delegates their implementation primarily to voluntary industry action.

The Ministry of Economy, Trade and Industry (METI) has issued AI governance guidelines, including the "AI Principles" and more detailed implementation guidance, that serve

as a voluntary framework for responsible AI development. Japan's Council for Science, Technology and Innovation has similarly engaged with AI governance questions, including liability, in a deliberative rather than prescriptive mode. On the question of AI liability specifically, Japan's government convened expert discussions during the development of the 2022 AI Strategy that acknowledged the inadequacy of existing civil law frameworks for AI-related harm but ultimately declined to propose new statutory liability rules, preferring instead to develop case-by-case judicial elaboration supplemented by sectoral regulatory guidance.

Japan's product liability law (Act on the Liability of Manufacturers for Defective Products, 1994) applies to physical products incorporating AI components, providing a basis for strict liability claims. For AI-related harm not involving defective physical products, Japanese law relies on general civil law principles under the Civil Code (Act No. 89 of 1896, as amended). Japan's preference for soft law governance of AI liability may reflect both genuine policy judgment about the appropriate regulatory posture during a period of rapid technological change, and institutional constraints — particularly the consensual, stakeholder-driven character of Japanese regulatory policymaking — that make prescriptive legislative solutions difficult to achieve quickly (METI, 2022).

5.3 Vietnam: Nascent Framework, Significant Gaps

Vietnam presents a distinctive case study: a jurisdiction with significant AI ambitions, an active regulatory agenda, and a legal system that is in the process of substantial modernization — yet with significant gaps in its capacity to govern the liability dimensions of AI deployment effectively. Vietnam's National Strategy on Research, Development and Application of Artificial Intelligence to 2030, adopted by Decision No. 127/QĐ-TTg of the Prime Minister on 26 January 2021, establishes AI as a national strategic priority, setting ambitious targets for AI research, talent development, and industrial application. The Strategy envisions Vietnam becoming a leading country in AI research and application in the ASEAN region by 2030.

At the legal level, Vietnam's primary instrument for handling AI-related harm remains the Civil Code 2015 (Law No. 91/2015/QH13), specifically its general tort liability provisions in Part Three. The Civil Code imposes liability for damage caused by fault (Article 586) and provides for strict liability for damage caused by sources of high danger — a category that might conceivably be extended to certain AI systems through judicial interpretation (Article 601). However, Vietnam does not yet have AI-specific liability legislation, and its courts have limited experience with AI-related disputes. The institutional capacity for complex AI litigation

— in terms of judicial technical expertise, expert witness ecosystems, and discovery mechanisms — remains developing.

Vietnam's regulatory institutions have taken some steps toward AI governance. The Ministry of Science and Technology and the Ministry of Information and Communications have issued guidelines and began consultation processes for AI-related regulation, and Vietnam's participation in ASEAN's AI governance frameworks — including the ASEAN Guide on AI Governance and Ethics (2021) — provides some normative orientation. However, as with Japan, Vietnam's approach to AI liability remains primarily aspirational and soft-law in character, with binding legal obligations on AI developers and deployers limited and non-specific. The gap between Vietnam's AI strategic ambitions and its liability governance capacity creates significant risks for Vietnamese citizens who are harmed by AI-enabled systems deployed domestically, whether developed locally or imported.

6. THREE DOMINANT REGULATORY MODELS: A COMPARATIVE EVALUATION

The comparative survey of AI liability frameworks across the EU, the United States, and Asia reveals three analytically distinct regulatory models, each reflecting different assumptions about the nature of AI risk, the appropriate role of law in governing technology, and the relative priority of victim protection and innovation facilitation.

6.1 Strict Liability

The strict liability model holds that certain categories of AI system should give rise to liability for harm without any requirement to prove fault. This model is justified by the argument that AI systems that operate autonomously — particularly in high-risk applications — represent a form of "abnormally dangerous activity" for which traditional fault-based liability is insufficient, because the risk cannot be fully controlled by reasonable care and the potential for harm is significant enough to warrant placing the economic burden of injury on the party who profits from deployment. Proponents of strict liability for AI argue that it provides the strongest incentive for investment in safety — because the developer and deployer internalize the full cost of AI-related harm — and offers the most direct path to compensation for victims, who need not navigate the complex causation and fault analysis required by negligence (Floridi et al., 2018; European Parliament, 2020).

The EU AI Act's framework implicitly gestures toward strict liability for the highest-risk AI applications by imposing stringent pre-market compliance requirements — the theory being that non-compliance with these requirements establishes fault per se, while the AI

Liability Directive's proposed causation presumptions effectively shift the burden of proof in a manner approaching strict liability for high-risk systems in practice. The U.S. products liability framework applies strict liability for defective AI-embedded products, though the definitional challenges of "defect" in the AI context substantially limit this doctrine's effectiveness. China's regulatory framework, while not explicitly adopting strict liability, imposes strict obligations on AI providers for user harms attributable to non-compliant systems — an approach that functions similarly to strict liability in practice for the categories of harm covered by specific regulatory requirements.

The limitations of strict liability as a universal model are substantial. Applied without differentiation across all AI applications, it would impose substantial costs on developers and deployers of AI systems at every risk level, potentially chilling innovation and driving AI development to less protective jurisdictions. It also does not resolve the causation problem — a victim under strict liability still must show that the AI system caused their harm — and may overcompensate for harm in cases where AI deployment was genuinely beneficial and the harm was an unforeseeable outlier (Lemley & Casey, 2019).

6.2 Negligence-Based Liability

The negligence model preserves fault as the gateway to liability, requiring plaintiffs to demonstrate that an identifiable defendant breached a relevant duty of care and that this breach caused the plaintiff's injury. This model reflects the traditional common law approach and, in its EU civil law manifestation, the baseline assumption of the proposed AI Liability Directive. Its theoretical advantage is proportionality: liability attaches only where blameworthy conduct can be identified, creating incentives for reasonable care without imposing costs on responsible actors.

In the AI context, however, negligence-based liability faces well-documented structural problems. The standard of care applicable to AI developers and deployers is often unclear, particularly in emerging application domains where industry practice is not yet settled. The causal link between a specific breach and a specific harm may be opaque or genuinely impossible to establish. And the distribution of potentially negligent parties across the AI value chain creates assignment-of-liability problems that even sophisticated tort doctrines struggle to resolve (Scherer, 2016; Abbott, 2020). The proposed EU AI Liability Directive's causation presumptions and disclosure mechanisms were specifically designed to address these structural weaknesses while preserving the fault-based foundation of the liability regime — a compromise

that attracted criticism from both innovation-oriented and victim-protection-oriented stakeholders.

6.3 Distributed Liability Frameworks

The distributed liability model recognizes that AI-related harm is typically the product of multiple actors' decisions across the value chain and attempts to allocate responsibility proportionally among them. This model is not a single doctrine but a family of approaches, including contributory and comparative fault schemes, joint and several liability with contribution rights, contractual liability allocation through supply chain agreements, and mandatory insurance requirements that spread risk without necessarily assigning fault.

The EU AI Act's allocation of distinct obligations to providers, deployers, importers, and distributors reflects a distributed liability logic: each party in the chain bears responsibility commensurate with its role and capacity to control risk. China's regulatory framework similarly distributes obligations across the AI value chain in a manner that implies corresponding liability for non-compliance. The practical challenge of distributed liability models is coordination: ensuring that each party's liability exposure is commensurate with its actual contribution to harm, and that victims can obtain effective redress without being required to pursue complex multi-party litigation against numerous defendants with potentially divergent interests (Karnow, 1996).

6.4 Evaluative Criteria

Evaluating these models against the criteria proposed in this paper — legal certainty, innovation neutrality, and victim protection — yields a nuanced assessment. Legal certainty favors the strict liability model, which provides clear and predictable outcomes, but is undermined by definitional challenges in the AI context (what constitutes a "defect"? which AI applications are "high-risk"?). Innovation neutrality favors the negligence model, which imposes liability only for blameworthy conduct, but its structural failure to protect victims of non-negligent AI harm creates pressures for regulatory expansion that may ultimately be less innovation-friendly than a well-designed strict liability regime. Victim protection favors strict liability, but only if causation challenges are adequately addressed — a condition that neither strict liability nor negligence-based models automatically satisfy.

No single model is universally adequate across the full spectrum of AI applications and harm scenarios. This analytical conclusion has motivated scholarly and policy interest in hybrid models that combine elements of strict liability, negligence, and distributed responsibility in a manner calibrated to the specific characteristics of different categories of AI system and harm.

7. TOWARD A RISK-TIERED HYBRID APPROACH: A PROPOSAL FOR INTERNATIONAL HARMONIZATION

This paper proposes a risk-tiered hybrid liability framework as a conceptual basis for international harmonization of AI liability rules. The framework is animated by a fundamental principle: liability rules should be calibrated to the specific risk profile of the AI application in question, taking into account the severity and foreseeability of potential harm, the degree of AI autonomy, the transparency of the system's decision-making, and the capacity of parties in the deployment chain to mitigate risk through reasonable care.

The framework proposes three liability tiers. The first tier encompasses what might be termed "critical AI systems" — AI applications deployed in contexts where errors carry a significant probability of serious, irreversible harm to identifiable individuals, and where AI autonomy substantially substitutes for human judgment. Medical diagnostic AI in high-stakes clinical contexts, AI-driven judicial decision support in criminal proceedings, and AI systems controlling critical physical infrastructure would fall within this tier. For these systems, the framework proposes strict liability for developers and deployers, subject to a liability cap and mandatory insurance requirements. Strict liability is appropriate here because the risk of harm is sufficiently grave that the cost of errors should be internalized by those who profit from deployment, and because the opacity and autonomy of these systems makes negligence-based liability practically ineffective as a victim protection mechanism.

The second tier encompasses "high-risk AI systems" as broadly defined by the EU AI Act's Annex III — AI deployed in employment, education, essential services, and law enforcement where erroneous outputs may cause significant harm but where human oversight is maintained and the risk of irreversible catastrophic harm is more limited. For these systems, the framework proposes a fault-based liability regime with causation presumptions and mandatory disclosure obligations modeled on the EU AI Liability Directive's approach, adapted to address that Directive's acknowledged weaknesses. Specifically: disclosure obligations should apply to all high-risk AI systems (not only those in specific sectors); causation presumptions should be triggered by any demonstrated breach of a relevant duty of care (without requiring the "excessively difficult" qualifier for non-high-risk systems); and liability should be joint and several across the deployment chain with contribution rights, to ensure victims can obtain redress from the most accessible solvent party.

The third tier encompasses all other AI systems — lower-risk applications where existing tort doctrines are adequate with targeted procedural modifications. For these systems,

the framework proposes retention of negligence-based liability supplemented by disclosure obligations — ensuring that victims can access sufficient technical information to assess whether a viable claim exists — and by a clarification that existing product liability doctrine applies to AI-embedded products, with the concept of "defect" adapted to encompass AI systems that fail to perform as a reasonable user would expect in the relevant application context (Abbott, 2020; Chesterman, 2021).

International harmonization of AI liability rules is a long-term objective that faces substantial political and institutional obstacles. However, convergence around a risk-tiered framework offers a plausible path toward coherence, particularly given the demonstrated influence of the EU's regulatory approach on AI governance developments in Asia and the increasing recognition, even in the United States, that sector-specific common law approaches are insufficient for the task. Harmonization does not require uniformity: jurisdictions may appropriately vary the specific content of liability obligations within each tier in accordance with their legal traditions and institutional capacities, while agreeing on the fundamental architecture of risk-tiered liability assignment. Bilateral and multilateral frameworks for AI governance — including ASEAN's AI governance agenda, the OECD's AI Principles (2019), and the Global Partnership on AI — offer institutional vehicles through which convergence might be pursued.

A human-rights-centered approach to AI governance demands that liability frameworks prioritize victim protection as a non-negotiable constraint — not as one consideration to be balanced against innovation facilitation, but as a floor below which the legal system should not fall. This does not preclude recognition of innovation as a legitimate policy objective; it does preclude regulatory frameworks that achieve innovation facilitation by denying injured parties access to effective legal remedies. The risk-tiered hybrid framework proposed here attempts to respect this hierarchy, imposing the strictest liability obligations on those AI applications where the potential for serious, irreversible harm is greatest, while preserving greater flexibility for lower-risk applications where the balance between innovation and protection is less acute (Floridi et al., 2018; Winfield & Jirotko, 2018).

8. CONCLUSION

The question of who is liable when AI causes harm is not merely a technical legal problem awaiting a doctrinal solution. It is a question that cuts to the foundations of the legal order's capacity to govern a technology that is simultaneously transforming economic and social life and generating new categories of risk that existing law was not designed to address. This

paper has surveyed the responses of three major jurisdictions — the EU, the United States, and selected Asian legal systems — to this foundational challenge, and has identified three dominant regulatory models: strict liability, negligence-based liability, and distributed responsibility frameworks.

The analysis demonstrates that no single model is universally adequate. Strict liability offers the strongest victim protection but may chill innovation and does not resolve the causation challenges that are distinctive to AI. Negligence-based liability preserves appropriate innovation incentives but fails victims who cannot navigate the informational asymmetries and distributed causation that characterize AI harm. Distributed liability frameworks more accurately reflect the multi-actor nature of AI deployment but create coordination challenges and litigation complexity that may render them practically ineffective for ordinary victims.

The risk-tiered hybrid framework proposed in this paper offers a conceptual path toward greater coherence. By calibrating liability rules to the risk profile of specific AI applications — imposing strict liability at the top of the risk hierarchy, fault-based liability with causation presumptions and disclosure obligations for intermediate-risk systems, and adapted negligence for lower-risk applications — the framework seeks to honor both the imperative of victim protection and the legitimate policy interest in innovation facilitation. Its prospects for international adoption will depend on continued dialogue among jurisdictions whose legal traditions and regulatory philosophies differ substantially, but the growing convergence around risk-based governance architectures — exemplified by the EU AI Act, the NIST AI RMF, China's layered regulatory approach, and the ASEAN AI governance agenda — provides grounds for cautious optimism.

The withdrawal of the EU AI Liability Directive in early 2025 represents a setback for the project of AI liability harmonization, leaving the EU's otherwise ambitious AI governance architecture with a significant gap on the liability dimension. It also serves as a reminder that the political economy of AI regulation is contested and complex, shaped by the competing interests of technology developers, deployers, potential victims, and public authorities with divergent institutional mandates. The task of building a globally coherent, human-rights-centered legal architecture for AI governance is, in this sense, as much a political as a legal challenge — one that the international legal community will need to confront with creativity, persistence, and a clear-eyed assessment of what existing law can and cannot do.

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HUMAN BEHAVIOR UNDER PRESSURE IN ATTACK ON TITAN

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1.Abstract

Human behavior under extreme pressure is a critical area of study in psychology, particularly in understanding how individuals respond to life-threatening situations. The anime Attack on Titan presents a highly intense and dangerous environment where characters are constantly exposed to fear, uncertainty, and survival challenges. This study examines how such extreme conditions influence human thoughts, emotions, and actions.

The research focuses on key psychological responses such as the **fight-or-flight mechanism**, where individuals either confront danger or attempt to escape it. In many situations within Attack on Titan, characters display varied reactions including panic, aggression, strategic thinking, and emotional control. These differences highlight the role of individual personality traits, prior experience, and mental resilience in shaping behavior under stress.

Furthermore, the study explores how continuous exposure to danger leads to **long-term psychological effects**, including trauma, emotional desensitization, and personality transformation. Characters often face intense **moral dilemmas**, where they must choose between personal values and survival, reflecting the complexity of ethical decision-making under pressure. Leadership also emerges as a significant factor, as certain individuals demonstrate the ability to remain calm, make critical decisions, and guide others during crises. By connecting these observations to real-world psychological theories, this research emphasizes that human behavior under pressure is not uniform but varies widely based on internal and external factors. The findings suggest that extreme environments can both break individuals and build resilience, ultimately shaping their identity and decision-making abilities. This study highlights the relevance of fictional narratives like Attack on Titan in understanding real-life human psychology in situations such as war, disasters, and high-stress conditions.

2.Keywords

- Human Behavior
- Psychological Stress

- Fight-or-Flight Response
- Leadership
- Moral Dilemma
- Survival Instinct
- Mental Resilience
- Trauma
- Decision Making
- Anime Psychology

3.Introduction

Human beings react differently when placed under intense pressure or danger. These reactions are influenced by psychological, emotional, and environmental factors. In Attack on Titan, characters are constantly exposed to life-threatening situations, making it an ideal case study for understanding behavior under stress. The series presents a wide range of responses—from fear and panic to courage and leadership. This research aims to examine how extreme pressure influences human actions, decision-making, and personality changes, while also relating these behaviors to real-world psychological theories.

4.Psychological Response to Pressure

- The brain detects danger instantly.
- The body releases stress hormones like **adrenaline**.
- Heart rate increases → more oxygen to muscles
- Breathing becomes faster
- Muscles become tense and ready for action
- Fight → Facing the threat (attacking or resisting)
- Flight → Escaping from danger
- Freeze (extra) → Staying still due to fear

Types of Human Reactions

- Panic and fear response
- Controlled and calm behavior
- Aggressive reaction
- Strategic and analytical thinking

Influence of Personality

5.Personality-Based Responses in Characters

Eran yeager-Aggression&Determination

- Reacts with strong emotions like anger and frustration
- Uses pressure as motivation to fight back
- Shows high determination and desire for freedom
- Sometimes makes **impulsive decisions** due to emotional thinking

Mikasa Ackerman-Control&Discipline

- Remains calm even in dangerous situations
- Shows strong emotional stability and focus
- Makes quick and precise decisions
- Protects others effectively

Armin Arlert-Inteligence&Stategy

- Thinks logically even when afraid
- Uses planning and strategy instead of force
- Solves complex problems under stress
- Shows that intelligence can overcome physical weakness

6.Role of Training and Experience

- Importance of preparation
- Development of mental resilience
- Impact of repeated exposure to danger

7.Group Dynamics Under Pressure

- Crowd behavior and panic spread
- Importance of teamwork
- Dependence on leadership

Reaction Type	Characteristics	Example
Panic	Fear, confusion, loss of control	Civilians
Controlled	Calm, focused, disciplined	Mikasa Ackerman
Aggressive	Anger-driven, bold actions	Eren Yeager
Strategic	Logical thinking, planning	Armin Arlert

8.Leadership Under Stress

- Decisions must be made **within seconds**
- Outcomes are uncertain and risky
- Leaders must stay calm and think clearly
- Emotional control is very important.
- **Strategic decisions** → long-term planning
- **Tactical decisions** → immediate actions in battle

Responsibility and Sacrifice

Leadership comes with heavy responsibility, especially in dangerous situations.

- Protecting team members
- Making choices that affect many lives
- Taking accountability for outcomes
- Sometimes leaders must risk or sacrifice lives for a greater goal
- Personal emotions must be set aside
- Decisions may involve loss, guilt, and moral burden

Example: Erwin Smith

- **Calm under pressure** → does not panic in dangerous situations
- **Vision and purpose** → focuses on long-term goals (truth and freedom)
- **Inspiration** → motivates soldiers even when chances of survival are low
- **Courage** → leads from the front
- Makes **difficult decisions involving sacrifice**
- Chooses the greater good over personal feelings
- Accepts responsibility for losses
- Faces fear
- Takes responsibility
- Inspires others to act bravely

9. Psychological Traits of Strong Leaders

- Emotional stability
- Confidence
- Quick thinking
- Ability to handle stress
- Strong sense of duty

10. Moral and Ethical Conflicts

- Difficult choices in extreme situations
- Conflict between personal values and survival
- Changing sense of right and wrong

11. Long-Term Psychological Effects

- Trauma and stress disorders
- Emotional changes
- Growth vs breakdown

12. Real-Life Applications

- Similarities with soldiers and disaster survivors
- Importance in psychology and human behavior studies

13. Conclusion

The study of human behavior under pressure in *Attack on Titan* reveals that extreme situations bring out the true nature of individuals. While some people panic and lose control, others demonstrate courage, intelligence, and leadership. The series effectively illustrates how fear, stress, and moral dilemmas influence decision-making and personality development. These insights are not only relevant in fictional settings but also applicable to real-life situations such as emergencies, conflicts, and high-stress environments. Understanding these behaviors helps in developing resilience, improving leadership skills, and managing stress effectively.

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SOCIAL MEDIA AND ITS IMPACT ON MENTAL HEALTH

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ABSTRACT

Social media plays a significant role in modern communication, especially among young people. While it helps individuals connect, share information, and build communities, excessive use may negatively affect mental health. Studies show that high social media usage can lead to anxiety, depression, low self-esteem, and sleep problems due to factors like online comparison and cyberbullying. However, social media can also provide emotional support and raise awareness about mental health issues. This paper examines both the positive and negative effects of social media on mental well-being and highlights the importance of balanced and responsible use.

KEYWORDS

Social Media Usage, Mental Well-being, Digital Communication, Online Interaction, Screen Time, Social Comparison, Internet Addiction, Emotional Health, Psychological Effects, Youth and Social Media , Online Behaviour, Sleep Disturbance, Self-image, Digital Lifestyle, Online Communities, Media Influence, Social Networking Platforms.

[1] INTRODUCTION

In recent years, social media has become a major part of everyday life. Millions of people use platforms such as Facebook, Instagram, Twitter, and other online networks to communicate, share experiences, and access information. These platforms allow individuals to stay connected with friends, family, and communities across the world. Because of the widespread use of smartphones and the internet, social media usage has increased rapidly, especially among teenagers and young adults.

While social media offers many benefits, including easy communication and access to knowledge, it has also raised concerns about its influence on mental health. Spending long hours on social networking sites can sometimes affect a person's emotions, behavior, and overall

well-being. Issues such as online comparison, cyberbullying, and the pressure to maintain a perfect online image may lead to feelings of stress, anxiety, or low self-esteem.

At the same time, social media can also play a positive role by providing social support, spreading awareness about mental health, and helping people connect with others who share similar experiences. Therefore, it is important to understand both the positive and negative impacts of social media on mental health.

[2] SOCIAL MEDIA USAGE

Social media has become an integral part of daily life, especially with the rise of smartphones and constant internet access. Platforms like Facebook, Instagram, Twitter, and TikTok allow users to communicate, share experiences, follow news, and participate in online communities. Young people are particularly active, using social media to express themselves, maintain friendships, and keep up with trends and global events.

Daily engagement with social media can range from a few minutes to several hours, and for many, it has become a routine part of life. While it provides opportunities for social connection, learning, and entertainment, excessive usage can interfere with real-life interactions, productivity, and sleep patterns. Understanding patterns of social media usage is essential to assess its impact on mental health and to promote a balanced, healthy approach to online activity.

[3] POSITIVE AND NEGATIVE IMPACTS

Aspect	Positive Impacts	Negative Impacts
Social Connection	Reduces loneliness, builds community	Can replace real-life interactions
Mental Health Awareness	Provides support and info	Exposure to harmful content
Emotional Support	Encouragement from peers	Cyberbullying lowers self-esteem
Self-expression	Creativity and personal expression	Pressure to appear perfect
Entertainment	Relaxation and fun	Addiction and time wastage

[4] ANXIETY AND DEPRESSION

Excessive social media use can increase anxiety and depression, especially due to constant comparison with others and exposure to idealized posts. Cyberbullying, negative comments, and pressure to stay connected also contribute to stress and low self-esteem. However, using

social media responsibly, such as joining support groups or following positive content, can provide emotional support and reduce feelings of isolation.

Factor	Impact on Mental Health
Social Comparison	Feeling inadequate, low self-esteem, stress
Cyberbullying	Anxiety, sadness, depression
Pressure to Stay Connected	Restlessness, stress, fear of missing out
Excessive Use	Mood swings, withdrawal, lack of motivation
Positive Use	Emotional support, reduced isolation

[5] SOCIAL MEDIA ADDICTION

Social media addiction refers to the excessive and compulsive use of social networking platforms that interferes with daily life. Individuals may feel a strong urge to check notifications, scroll feeds, or post content constantly, often at the expense of work, studies, or face-to-face interactions.

This addiction can lead to negative consequences such as reduced productivity, sleep disturbances, stress, and social isolation. The constant need for validation through likes, comments, or shares can also affect self-esteem and emotional well-being.

[6] EFFECTS ON SLEEP

Excessive social media use, especially before bedtime, can negatively affect sleep quality. The blue light from screens disrupts the production of melatonin, the hormone responsible for sleep, making it harder to fall asleep. Constant notifications and engaging content can also keep the mind active, leading to delayed sleep and shorter sleep duration. Over time, poor sleep can increase stress, fatigue, and negatively impact mental health.

[7] CONCLUSION

Social media has become a powerful tool that shapes the way people communicate, share information, and connect with the world. It offers several benefits, including social connection, emotional support, self-expression, and increased awareness about mental health issues. However, excessive or improper use can have serious negative effects, such as anxiety, depression, low self-esteem, cyberbullying, addiction, and sleep disturbances.

The overall impact of social media on mental health depends largely on how it is used. Responsible use, awareness of screen time, and engagement with positive and supportive

content can help maximize the benefits while minimizing harm. Individuals, educators, and policymakers must work together to promote digital literacy and healthy online habits. By finding a balance between online interaction and real-life activities, social media can be a valuable resource without compromising mental well-being.

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BIOTECHNOLOGY AND GENETIC ENGINEERING**R.KAMALAM**

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ABSTRACT

Biotechnology and genetic engineering are rapidly evolving fields that are reshaping medicine, agriculture, and industry by using living organisms and modifying their genetic material to achieve desired upshots. Biotechnology involves applying biological systems for practical purposes, while genetic engineering focuses specifically on altering DNA to develop traits or eliminate defects. These machineries have led to major advancements such as improved crop yields, disease-resistant plants, and innovative medical treatments like gene therapy and personalized medicine. They also offer solutions to global challenges, including food security and infection control. However, their development raises important ethical, conservational, and safety concerns, such as potential risks to ecosystems and questions about genetic privacy. Balancing innovation with responsible use is essential as these fields continue to grow, holding great promise for improving quality of life and fashioning a more sustainable future.

KEYWORDS

DNA Modification, Gene Editing, CRISPR Technology, Recombinant DNA, Gene Therapy, Genetically Modified Organisms (GMOs), Synthetic Biology, Molecular Biology, Bioinformatics, Personalized Medicine, Agricultural Biotechnology, Disease Resistance, Biopharmaceuticals, Cell Culture, Sustainable Development.

[I] NTRODUCTION

Biotechnology and genetic engineering are hastily developing fields that combine biological science with modern technology to improve human life and address inclusive challenges. Biotechnology refers to the use of living creatures, cells, and biological systems to develop convenient products and processes in areas such as medicine, agriculture, and industry. Genetic engineering, a specialized branch of biotechnology, involves the direct management of an

organism's DNA to introduce, remove, or modify specific genes in order to achieve desired characteristics. These technologies have led to significant advancements, including the production of life-saving medicines such as insulin, the development of genetically modified crops that are more resistant to pests and environmental stress, and the improvement of industrial processes through the use of microorganisms. In addition, genetic engineering has opened new possibilities in medical science, such as gene therapy and personalized treatment, which aim to treat or prevent diseases at the genetic level. Despite their many profits, these fields also raise important ethical, environmental, and social concerns, including the potential risks of genetic modification, impacts on biodiversity, and questions about the responsible use of such powerful technologies. As research and innovation continue to expand, biotechnology and genetic engineering are estimated to play a crucial role in modelling a sustainable and healthier future for society.

[2] ARCHITECTURE

The architecture of biotechnology and genetic engineering involves a arranged process that begins with the identification of a specific gene or biological problem, followed by the isolation and modification of genetic material. Scientists first extract DNA from an organism and use specialized tools to cut and influence the desired gene. This modified gene is then implanted into a suitable vector, such as a plasmid, which carries the gene into a host organism like bacteria or plant cells. Exclusive the host, the gene is expressed to produce the required trait or product. The final stages include testing, analysis, and large-scale production, ensuring that the outcome is effective, safe, and reliable. This systematic workflow enables precise control over genetic changes and supports various applications in medicine, cultivation, and industry.

Identification of target protein sequence or problem

Extraction and isolation of DNA

Cutting DNA using definite enzymes

Insertion of preferred gene into a vector (plasmid)

Transfer of vector into host creature (bacteria/plant/animal cell)

Gene countenance inside the host cell

Screening and selection of successful modifications

Testing and validation of outcomes

Large-scale fabrication and application

[3] ADVANTAGES

Biotechnology and genetic engineering provide numerous benefits across different fields, including healthcare, agriculture, and industry. These technologies make it possible to develop effective treatments for diseases, improve the nutritional quality and yield of crops, and create environmentally friendly industrial processes. In medicine, they enable the production of essential drugs and support advanced therapies that target diseases at the genetic level. In agriculture, they help in developing crops that are more resistant to pests, diseases, and harsh environmental conditions, reducing the need for chemical inputs. Additionally, biotechnology supports sustainable observes by promoting competent resource use and tumbling waste. Overall, these advancements contribute to improving human health, confirming food security, and protecting the environment.

Construction of life-saving medicines and vaccines

Development of disease-resistant and high-yield gathers

Improved nourishing quality of food

Reduction in the use of chemical pesticides and fertilizers

Advanced treatments like DNA segment therapy

Nearer and more efficient industrial processes

Environmental protection through waste decrease

Maintenance for sustainable agriculture

Early detection and diagnosis of diseases

Helps address global challenges like food security

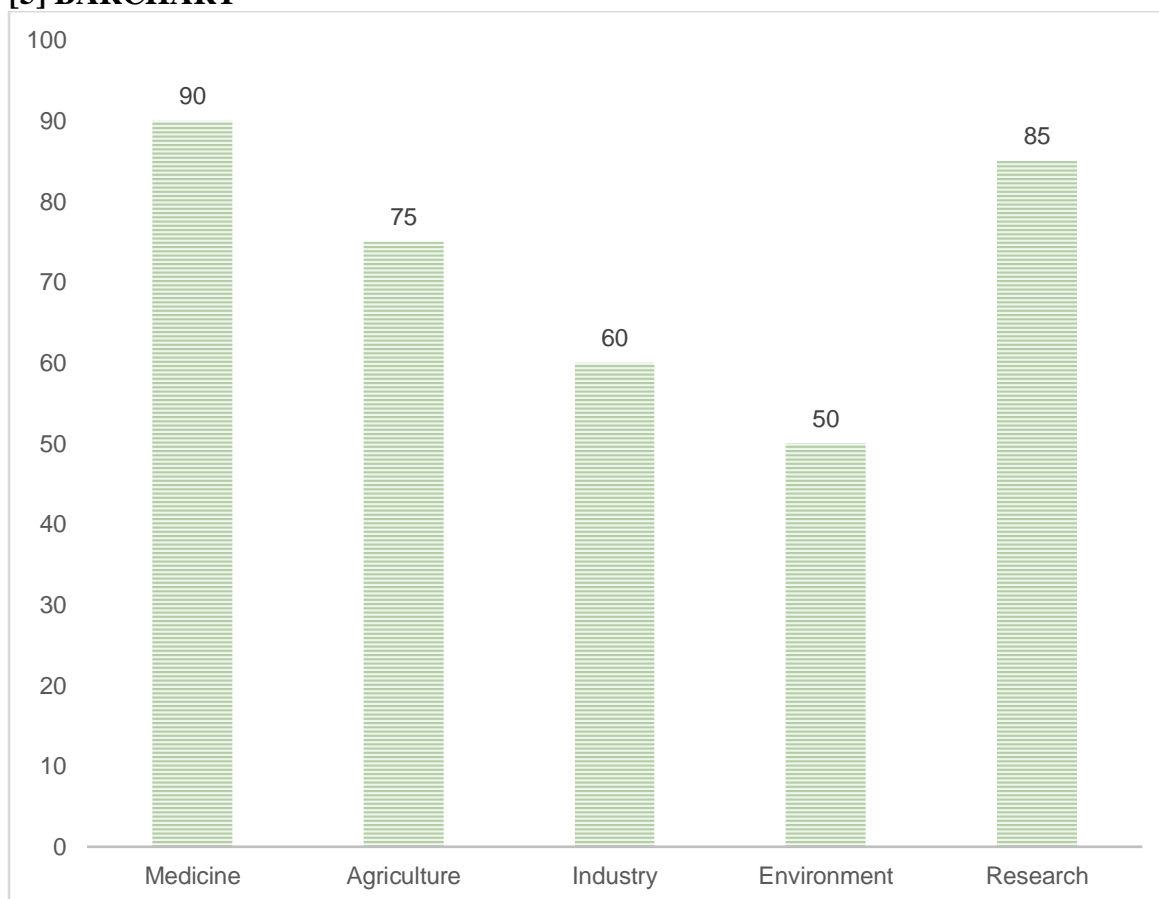
[4] TABLE

Aspect	Description	Example/Application
Definition	Use of biological systems or organisms to develop useful products; genetic engineering involves directly modifying DNA	Producing insulin using genetically modified bacteria

Goal / Purpose	Solve real-world problems in medicine, agriculture, and industry	Disease treatment, improved crop yield
Techniques Used	DNA extraction, gene cloning, recombinant DNA, CRISPR, gene transfer	CRISPR-based gene editing in crops or animals
Applications in Medicine	Drug production, gene therapy, personalized medicine	Production of vaccines, treatment of genetic disorders
Applications in Agriculture	Development of disease-resistant, high-yield, and climate-tolerant crops	Bt cotton, Golden Rice
Applications in Industry	Use of microorganisms and enzymes for bio-products and sustainable processes	Biofuels, biodegradable plastics
Advantages	Improves health, agriculture, industry efficiency, sustainability	High-quality food, disease control, reduced chemical use

Challenges / Concerns	Ethical, environmental, and safety issues	Genetic privacy, ecological impact, misuse of gene editing
Future Potential	Innovations in biotechnology and genetic engineering will enhance human life and sustainability	Personalized medicine, climate-resilient crops, advanced biofuels

[5] BARCHART



Applications of Biotechnology and Genetic Engineering

[6] CONCLUSION

Biotechnology and genetic engineering epitomize some of the most revolutionary advancements in modern science, subscription unprecedented opportunities to improve human life, agriculture, industry, and the environment. Through the manipulation of genes and the use of living organisms, scientists can develop life-saving medicines, create disease-resistant and

high-yield crops, produce sustainable biofuels, and carry out ground-breaking exploration in molecular biology and genomics. These technologies not only increase efficiency and productivity but also have the potential to address critical global challenges such as food security, climate change, and unindustrialized health threats. At the same time, they raise important ethical, environmental, and social questions, including concerns about genetic privacy, ecological balance, and the liable use of gene-editing tools. As research endures to advance, it is essential to balance innovation with careful regulation, public awareness, and ethical considerations to ensure that biotechnology and genetic engineering detriment society as a whole. With responsible development and application, these fields have the potential to transform the future, offering defensible elucidations and improving quality of life on a global scale.

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SELF-SOVEREIGN IDENTITY (SSI) AND DECENTRALIZED IDENTIFIERS: EMPOWERING BENEFICIARY AGENCY IN SOCIAL SAFETY NETS

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ABSTRACT

Centralized identity systems, while efficient, often leave beneficiaries with little control over their own data. This research explores the transition of the BISP National Socio-Economic Registry (NSER) toward a **Self-Sovereign Identity (SSI)** model. Using block chain-based Decentralized Identifiers (DIDs), this framework allows BISP beneficiaries to "own" their digital identity on their own devices. Instead of BISP "holding" a citizen's data, the citizen holds a "Verifiable Credential" that they can present to different government departments or NGOs to prove their eligibility without revealing their entire personal history. The paper analyzes how SSI can prevent "Identity Silos" and reduce the administrative burden on citizens during crises. For instance, a refugee or a person displaced by climate change could use their SSI to instantly verify their status at a new provincial location without waiting for central database synchronization. The study also evaluates the security benefits of SSI in protecting against mass data breaches, as there is no single central "honey pot" of data for hackers to target. The research concludes that by adopting SSI, BISP not only enhances the technical resilience of the program but also promotes "Digital Dignity," giving the poorest citizens the same level of data agency as the most affluent. This shift is essential for building a modern, rights-based social protection ecosystem in Pakistan.

Keywords: Self-Sovereign Identity (SSI), Decentralized Identifiers (DIDs), Block chain, BISP, Data Agency, Digital Dignity.

NEURO-SYMBOLIC AI FOR POLICY TRANSPARENCY COMBINING DEEP LEARNING WITH LOGICAL REASONING IN BISP

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ABSTRACT

While Deep Learning is excellent at pattern recognition, it often lacks the logical transparency required for government policy. This research introduces **Neuro-Symbolic AI** a hybrid approach that combines the statistical power of neural networks with the rule-based logic of symbolic AI to manage BISP's eligibility criteria. Currently, BISP's Proxy Means Test (PMT) relies on statistical correlations that can sometimes produce "counter-intuitive" results. Neuro-Symbolic AI allows the program to embed explicit legal and ethical rules (the "symbols") into the learning process. The study investigates how this hybrid model can ensure that "hard rules" such as the mandatory inclusion of widows or persons with disabilities—are never overridden by statistical biases in the data. The paper demonstrates that Neuro-Symbolic systems provide a "Self-Explaining" audit trail that case officers can follow to understand how a complex decision was reached. This is particularly critical during crises, where rapid policy changes (e.g., lowering the eligibility threshold for flood victims) must be applied across millions of records with 100% logical consistency. The findings indicate that this technology solves the "Black Box" problem of traditional AI, making the BISP's automated decisions legally robust and easier for the public to trust. By merging human logic with machine learning, BISP can achieve a higher standard of "Algorithmic Justice."

Keywords: Neuro-Symbolic AI, Hybrid Machine Learning, BISP, Policy Transparency, Algorithmic Justice, PMT Logic.

STATE-CITIZEN COMMUNICATION UNDER THE NATIONAL FOOD SECURITY ACT: AWARENESS, ACCESS, AND WELFARE DELIVERY

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Abstract

The effectiveness of welfare legislation is based not just on the legal design and administrative delivery but also the communication of the rights, entitlement and grievance mechanisms to the beneficiaries. In this paper, the National Food Security Act (NFSA), 2013 is considered in terms of the state-citizen communication, with special attention dedicated to the areas of awareness, access, and welfare delivery. It justifies that the effectiveness of food security laws is directly related to the transparency, the extent, and sensitivity of the communication between the government and beneficiaries. The paper examines the communication of information on eligibility, ration entitlements, grievance redress, transparency, and institutional mechanisms to target beneficiaries, and how miscommunication can lead to being locked out, underutilizing available resources, and poor accountability. At the cross-section of public policy, communication, and social justice, the paper notes the significance of citizen awareness in the process of fertilizing statutory rights into practical social protection. It also takes into account the local institutions, digital systems, notice boards, public officials, and grievance channels as important interfaces of welfare communications. The paper presents the argument that legal entitlement is not sufficient to guarantee food security without the presence of accessible and participatory communication structures. The research adds to the discourse of public accountability, rights awareness, and inclusive policy implementation by highlighting the communicative aspect of the welfare governance. It concludes that the increased effectiveness of the NFSA framework and the increasing legitimacy depends on the enhanced state-citizen communication.

Keywords: NFSA, welfare communication, food security, public policy, state-citizen interface

DIETARY PATTERNS AND NUTRITIONAL STATUS OF PREGNANT WOMEN DELIVERING LOW BIRTH WEIGHT NEWBORNS IN EL JADIDA PROVINCE, MOROCCO: A CASE-CONTROL STUDY

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Abstract

Aims: To better understand the dietary quality and biochemical status of pregnant women delivering normal- or low-birth-weight newborns.

Materials and Methods: This case–control study included 400 women at delivery, divided into two groups: 200 controls who delivered normal-weight newborns and 200 cases who delivered low-birth-weight (LBW) newborns. Dietary intake and diet quality were assessed using the Nutrient Adequacy Ratio (NAR) and the Mean Adequacy Ratio (MAR). Pre-delivery biochemical parameters were measured and compared between the two groups.

Results: Fundal height was significantly lower in cases than in controls (25.69 ± 0.13 vs 31.83 ± 0.06 cm). Cases showed lower NAR values for key micronutrients, particularly calcium (0.34 ± 0.01), folates (0.48 ± 0.00), iron (0.50 ± 0.01), and vitamin B1 (0.53 ± 0.01). Overall dietary quality, assessed by MAR, was significantly lower in cases (0.70 ± 0.00) compared to controls (0.84 ± 0.00). Biochemical analysis revealed lower hemoglobin and ferritin levels and a higher prevalence of anemia in cases. Continuous iron supplementation was associated with higher hemoglobin and ferritin levels.

Conclusion: Pregnant women delivering LBW newborns have poorer dietary quality and impaired micronutrient status, particularly for iron, calcium, and folates. Early and continuous iron supplementation may improve maternal nutritional status and contribute to better pregnancy outcomes.

Keywords: low birth weight, dietary quality, NAR, MAR, anemia, pregnancy, Morocco.

SYNTHESIS AND CHARACTERIZATION OF CA-ALGINATE/CUO BIONANOCOMPOSITE FOR REMOVAL OF REACTIVE YELLOW 145 DYE: A GREEN APPROACH TOWARDS SUSTAINABILITY

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ABSTRACT

The synthetic dyes have gained attention nowadays because of their adverse and toxic effects on the human health and their environment. In this study, a green polymer Ca-alginate/ CuO bionanocomposite was synthesized from copper oxide nanoparticles which were applied for the remediation of Reactive Yellow 145. The bionanocomposite was prepared by using a simple and eco-friendly process, following the reduction of copper ions in the presence of Ca-alginate, followed by characterization using different analytical techniques including SEM-EDX, XRD, UV-Vis and FTIR spectroscopy. Ca-alginate based bionanocomposite was analyzed by UV-Vis spectroscopy, showing a λ_{\max} at 280nm. Ca-alginate/CuO biopolymer were applied for the remediation of RY 145 and it was investigated using batch experiments following the optimization of experimental variables such as, with pH 6, 80°C temperature, 0.04mg/L initial dye concentration, 0.06 mg/L dose of catalyst and with a 0.06mg/L H₂O₂ concentration. The experimental results of COD and TOC were found to be 95.3% and 92.3% for RY 145. The bionanocomposite showed stability and high efficiency for degradation of dye upto four cycles of reusability. It was concluded that, the Ca-alginate based copper oxide bionanocomposite exhibited good photocatalytic adsorption capacity for the degradation of a toxic Reactive Yellow 145 dye, with a degradation efficiency of over 90% within 80 minutes under optimized conditions. It was concluded that UV-Vis and FTIR analysis also confirmed the breakdown of toxic harmful RY 145 dye into simpler and non-toxic products. The scope of this study encompasses its potential to deal with environmental pollution caused by the discharge of toxic synthetic dyes into the water.

TO INVESTIGATE THE ANTI-INFLAMMATORY ACTIVITY OF GOLD NANORODS USING CT-26 CELL LINES AND ZEBRA FISH MODEL

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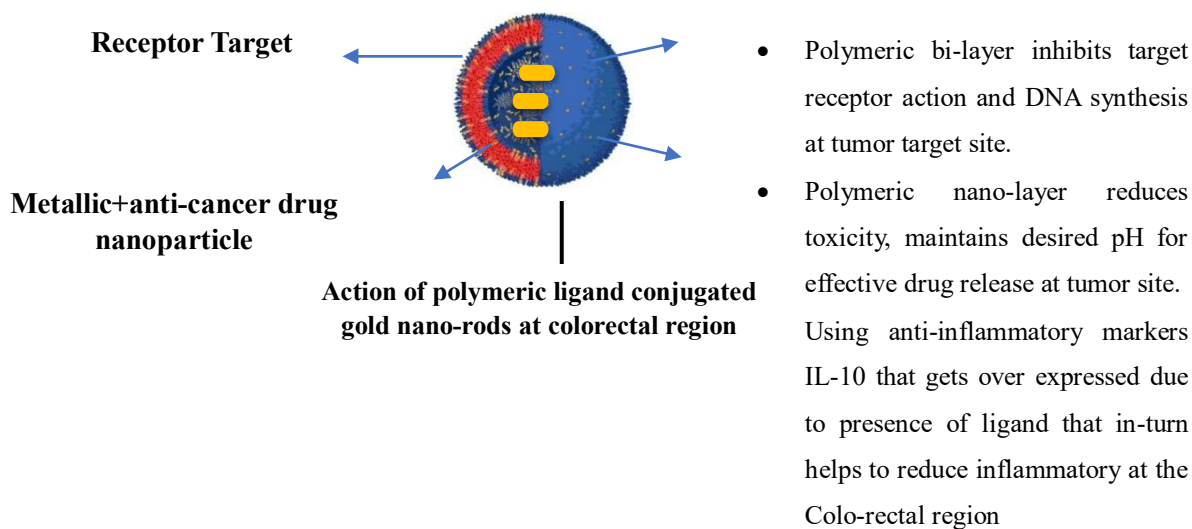
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Abstract:

Abstract: Colorectal cancer is one of the leading causes of death worldwide that has shown 24% increase statistically by the WHO. It has been a tedious outlook towards this research on the outcome for the reduction of CRC. As a result, it has paved way for advancements towards nano--technology for the treatment and management of CRC. One such branch is the application of theranostics that imparts as a dual role of diagnostic and a therapeutic moiety functioning simultaneously. In this study, we will illustrate the effect of metallic nano rods surface modified with ligand to illustrate it's anti-inflammatory activity using CT 26 cell lines and zebra fish model. The formulation strategy implemented consists of an effective polymer with the combination of desired choice of surfactant that is the critical formulation parameter for effective formulation development, followed by the synthesis of metallic nano-rods infused with the anti- cancer agent coated with ligand for active cancer target colorectal cancer. The receptor layer on the outer coating of metallic nano rods acts as an active tumor target. This novel approach is opted due to its reduction in toxicity, controlled release, pH-maintained environment and reduction in particle size. As a result, we will prove a novel theranostic approach towards CRC treatment.





Recovery of CRC upon anti-inflammatory effect

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ADHERENCE TO THE MEDITERRANEAN DIET IN PATIENTS UNDERGOING RENAL REPLACEMENT THERAPY IN MOROCCO

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Background: Chronic kidney disease (CKD) is a serious public health problem worldwide, with a significant public health burden, associated with aging and a higher prevalence of comorbidities, such as diabetes, obesity and hypertension. Obviously, chronic kidney disease leads to end stage renal disease (ESRD) requiring dialysis or transplantation. Indeed, patients on chronic kidney disease stage-five Dialysis (CKD-5D) are consistently subject to particular dietary restrictions. Current guidelines provide general recommendations for hemodialysis (HD) patients focus on achieving a sufficient energy and protein intake without exceeding Phosphorus, Potassium, Sodium, and fluid intake limits. **Objectives:** The aim of this study was to assess the adherence of patients undergoing maintenance dialysis to the Mediterranean Diet, and investigated what factors influence it.

Subjects and Methods: In a cross-sectional study, data on sociodemographic, lifestyle factors, clinical, biochemical parameters and diet were collected on a sample of 157 haemodialysis patients. Adherence to MD was assessed according to a MD score (MDS) based on the daily frequency of intake of eight food groups (vegetables, legumes, fruits, cereals, fish, red meat, dairy products and MUFA/SFA), using the sex specific sample medians as cut-offs. A value of 0 or 1 was assigned to consumption of each component according to its presumed detrimental or beneficial effect on health.

Results : According to the MDS, the study data show that high adherence (**34,6%**) to MD was characterized by intakes high in vegetables, fruits, fish, cereals, olive oil, and low in meat and moderate in dairy. Furthermore, patients with high adherence to MD had significantly high intakes of calories, protein, carbohydrates, iron and vitamins (C, B1, B9).

Conclusion: In Morocco, maintaining the traditional MD pattern play pivotal role for public health system. More research is needed in this field to precisely measure this association especially for this category of chronic disease.

Keywords : Hemodialysis patients, nutritional status, Mediterranean diet, MDS, Morocco

DIETARY EXPOSURE TO MICROPLASTICS IN LOW- AND MIDDLE-INCOME SETTINGS: EXPLORATORY MODELING, METABOLIC IMPLICATIONS, AND REGULATORY GAPS (FOCUS ON NORTH AFRICA)

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Abstract

The increasing presence of microplastics (MPs) in food systems reflects profound transformations in contemporary dietary and environmental dynamics. Detected in a wide range of food products and beverages, including seafood, salt, bottled water and ultra-processed foods, these contaminants represent an emerging and largely underestimated pathway of human exposure. This issue is particularly critical in low- and middle-income contexts, notably in North Africa, where the growing reliance on plastic-packaged foods coincides with limited regulatory oversight.

This chapter provides a critical and interdisciplinary analysis of the vulnerabilities associated with dietary exposure to microplastics, combining perspectives from nutrition, environmental health, toxicology and food systems analysis. It also integrates a contextual focus on North African settings, where shifts in consumption patterns may exacerbate exposure risks.

A structured narrative review of recent scientific literature (2020–2024) was conducted, drawing on international reports, experimental studies and emerging data on contamination and plastic migration. In addition, an exploratory approach was used to estimate dietary exposure by combining contamination levels reported in the literature with regional consumption profiles. Preliminary data on the migration of plastic-related compounds from commonly used food packaging in Morocco were also considered.

The findings suggest a diffuse but potentially significant exposure to microplastics through diet, with major contributions from bottled water, seafood and ultra-processed foods. These exposures may reach several thousands to tens of thousands of particles per person per year, depending on dietary patterns. Potential biological effects include inflammatory responses, endocrine disruption and alterations of the gut microbiota, although human evidence remains limited. This dynamic is further characterized by a structural imbalance between increasing exposure and insufficient monitoring and regulatory capacities.

Faced with these challenges, this work highlights the need to rethink current food systems beyond purely technological solutions. It calls for integrated approaches combining

biomonitoring, innovation in food-contact materials and stronger regulatory frameworks. More broadly, it invites a systemic transition towards safer, more sustainable and context-adapted food environments.

Keywords :

Microplastics; Dietary exposure; Environmental health; North Africa; Food systems; Endocrine disruption; Sustainability; Food packaging

ENHANCING FOOD SECURITY THROUGH THE VALORIZATION OF LOCAL CEREAL VARIETIES IN THE REGIONS OF KHENIFRA AND TETOUAN, MOROCCO

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ABSTRACT

The Moroccan diet is of Mediterranean type, characterized by biological and cultural diversity and a culinary heritage allowing to save in Moroccan cuisine diversified dishes based on a complementarity between different food groups of which the most present group is that of cereals and cereal products. The objective of this work is to contribute to the identification and the study of knowledge on certain local cereals as well as their use in traditional dishes in 2 regions of Morocco: Khenifra and Tetouan. A survey was carried out in 2 regions, the province of Khénifra in the Middle Atlas and the province of Tétouan in northern Morocco. The survey involved a sample of women and men from 250 urban and rural households in the 2 provinces. Using a focus group, information were also collected on the cereals' ethnobotanical and culinary knowledge, the period of consumption, uses as well as a description of the recipes that include them, and their consumption now or in the past. The results show that more than 40 traditional recipes have been recorded, where local cereals are the main ingredients, especially durum wheat, common wheat, barley, white corn and red corn. Most of the cereals mentioned are eaten frequently. Participants report that the latter grains were previously consumed and used in recipes consumed during times of food shortage. A significant diversity of traditional culinary culture is observed and can explain the dietary diversity observed in the 2 regions studied, hence the need to enhance by nutritional analyzes on each variety to save this richness. The results of the study are discussed in relation to the content of each variety analyzed in nutrients in comparison with conventional varieties. These data contribute to the nutritional value of these cereals and the culinary preparations of the dishes which includes them. The enhancement of these varieties would help diversify food, encourage the consumption of local products and fight against the loss of local cereal heritage.

Keywords: Cereals; Variety; Local; Nutritional Valorisation; Diet diversity

ARTIFICIAL INTELLIGENCE ACROSS THE ARCHITECTURAL WORKFLOW: FROM CONCEPTUAL DESIGN TO CONSTRUCTION EXECUTION

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Abstract:

This study explores how artificial intelligence (AI) can be integrated into the architectural workflow to shed light on how AI technologies can improve efficiency, creativity and decision-making throughout the conceptual design and through to construction implementation. The study addresses a mixed-method approach that includes both qualitative and quantitative data, so it includes case studies of successful AI applications and interviews with professionals in the industry, as well as performance indicators of architectural projects that make use of AI tools. The results show that AI can help to streamline the processes greatly, eliminate design errors, and develop innovative solutions, which can result in a significant improvement of project efficiency and a reduction in its final cost. In addition, the paper identifies the implications of these developments in the general context of healthcare architecture, where an effective design and construction process can have a direct influence on patient outcomes and operational efficiency. This study highlights the critical nature of the potential application of AI to transform architecture and design practices, implying that its implementation can not only improve the quality of architectures and buildings but can also change the healthcare industry by offering more flexible, responsive, and resilient environments. Finally, the dissertation helps to get a better idea on how AIs can be transformed to work with architecture and preconditions further experiments on its usage in other areas.

Keywords: Architectural Workflow Integration; Generative Design; Building Information Modeling (BIM); Machine Learning in the Built Environment; Smart Construction Systems.

AI-AUGMENTED SUSTAINABLE DESIGN: IMPROVING ENVIRONMENTAL PERFORMANCE IN CONTEMPORARY ARCHITECTURE

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Abstract:

The paper researches the improvement of the ecological performance of modern architecture using AI-enhanced approaches to the urgent issue of balancing the concepts of sustainable design with the latest technological solutions. The study examines empirical evidence regarding the existing uses of artificial intelligence in architectural design, sustainability indicators, and a set of case studies based on environmentally friendly projects and finds considerable correlations between AI-oriented design work and high sustainability levels. The results indicate that AI integration may result in increased energy efficiency, minimized material waste, and resource management, therefore supporting the significance of sustainability in architecture. Moreover, this paper illustrates how sustainable architecture and human health are connected to each other, indicating that a better environmental performance may result in healthier lives and well-being. The implications of this study are not limited to the architectural sphere, which means that the implementation of AI technologies in sustainable design may become central to the production of more health-affirmative urban living which, in turn, would affect healthcare outcomes by decreasing the number of environmental burdens on a population. This in-depth examination places AI as a disruptive technology in the design of architecture, claiming it as a means to further the discussion of sustainability and the health of the general population, as well as promote more cross-disciplinary cooperation both in the field of architecture and healthcare.

Keywords: Artificial Intelligence in Architecture; Sustainable Architectural Design; Environmental Performance Optimization; AI-Augmented Design Processes; Smart Building Systems.

EXPLORING THE ACOUSTIC NEXUS IN URBAN NEIGHBORHOODS: ARCHITECTURE, PERCEPTION, AND ENVIRONMENTAL NOISE DYNAMICS

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Abstract:

The paper explores the complex interconnection of architectural design and environmental noise perception in urban neighborhoods, including the different acoustic landscapes and how they influence the well-being of the residents and community life. Using a mixed-methods approach, the study gathers quantitative data on noise levels in various architectural environments and supplements the information with qualitative data derived through surveys of residents on their perceptions of noise and their lived experience. The results indicate that there are strong correlations between architectural characteristics, including building materials and spatial layouts and the reported noise levels by the residents, which eventually affect mental and physical health outcomes of residents. It is important to note that residential areas characterized by careful architectural planning that incorporates sound-reducing designs have a higher satisfaction and perceived quality of life among the inhabitants. These findings also highlight the use of environmental acoustics as a primary determinant of urban health outcomes, and that healthcare professionals and city planners need to consider acoustic variables as part of community-wide health programs. This study has implications on urban design policies, which should be integrated to incorporate a multidisciplinary approach, to promote a healthier urban environment. This study, by focusing on the acoustic experiences of the people living in them, does not only add to the discipline of urban studies and architecture but also highlights the need to have unified approaches in healthcare that are sensitive to the environmental health determinants.

Keywords: Urban acoustics; Soundscape perception; Environmental noise dynamics; Sound Pressure Level (SPL); Sustainable urban design.

HIGH-FIDELITY SIMULATION OF A NUSCALE-LIKE SMR BENCHMARK USING THE OPENMC CODE

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Abstract

Small Modular Reactors (SMRs) are vital for the transition to a net-zero society, yet their heterogeneous designs and the trend toward boron-free cores present unique simulation challenges. This study validates the Monte Carlo code **OpenMC** (version 0.15.0) against a 160 Mwth NuScale-like SMR benchmark. The model features 37 fuel assemblies with a 200 cm active height, simulated using 2500 active cycles and 1,000,000 neutron histories per cycle. Comparisons with the Serpent code demonstrate excellent agreement, with effective multiplication factor (k_{eff}) differences ranging between 16 and 31 pcm. Furthermore, radial and axial power distribution analyses reveal a Root Mean Square Relative Difference (RMSRD) consistently below 0.78% in most regions. These findings confirm that OpenMC's open-source framework and modular Python API provide a high-fidelity foundation for future multiphysics applications and the optimization of **boron-free SMR designs** **Keywords:** OpenMC, Small Modular Reactor, NuScale, Monte Carlo Method, Neutronic Modeling, Burnup Analysis, Reactor Physics.

Keywords: NuScale, SMR, Benchmark, OpenMC, Neutronics.

ANTIBIOTIC RESISTANCE DYNAMICS IN UTI: EMERGING TRENDS IN SUSCEPTIBILITY PATTERNS

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ABSTRACT

Background/Objective

Antibiotics play a crucial role in treating Urinary Tract Infections (UTIs) but due to resistance, the effectiveness of antibiotics is waning. Re-examining old antibiotics is one approach that can address the issue of antimicrobial resistance. The current study aims to evaluate the susceptibility pattern of relatively older antibiotic Co-trimoxazole and its comparison with Levofloxacin, Nitrofurantoin, and Fosfomycin.

Methods

This cross-sectional study was conducted in Mardan Medical Complex and Postgraduate Medical Education Department of Khyber Girls Medical College, Peshawar. Both male and female patients, above the age of 15 years with recurrent uncomplicated urinary tract infections were included in the study. The samples were inoculated onto CLED (Cystine-Lactose-Electrolyte-Deficient) Agar, a differential culture medium. The grown bacteria were identified, using Gram staining and BIOMÉRIEUX® API® 10S kits. Minimum inhibitory concentrations (MIC) were determined by the Agar dilution method; as per standard protocol. The results were compared among Co-trimoxazole, Levofloxacin, Nitrofurantoin, and Fosfomycin using statistical tests.

Results

A total of 680 samples were received, of which 158 samples were culture-positive. The isolated organisms were *E. coli* (74.1%), *Klebsiella* (10.8%), *Pseudomonas* (5.1%), *Enterococci* (6.3%), *Proteus* species (2.5%), and *Citrobacter* (1.3%). Based on MIC analysis, 77.2% of isolates were found to be sensitive to Co-trimoxazole, 52.5% to Levofloxacin, 86.7% to Nitrofurantoin, and 90.5% to Fosfomycin. When comparing antibiotics, Co-trimoxazole displayed significantly higher effectiveness against the isolates compared to Levofloxacin (p-value 0.004). However, in comparison to Nitrofurantoin and Fosfomycin, Co-trimoxazole exhibited lower effectiveness, with respective p-values of 0.000 and 0.007.

Conclusion

In our study cohort, the bacterial isolates showed appreciably higher susceptibility to Co-trimoxazole compared to Levofloxacin. However, it remained inferior to the susceptibility rates

observed for Nitrofurantoin and Fosfomycin. Given the guideline that antibiotics exhibiting resistance levels surpassing 20% should be avoided for empirical therapy, the presence of a 22.8% resistance rate to Co-trimoxazole discourages its consideration as an empirical antibiotic option.

Keywords

Urinary tract infections, Drug resistance, Culture and sensitivity, Minimum inhibitory concentration

IN SILICO ANALYSIS OF PLANT PROTEINS: UNVEILING NOVEL ANTIMICROBIAL STRATEGIES AGAINST VIRAL INFECTIONS

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Abstract

Viral infections remain a significant global health challenge, necessitating the exploration of alternative therapeutic strategies. Recent advancements in computational biology have facilitated the identification of plant-derived proteins with potential antiviral properties. This study employs *in silico* approaches, including molecular docking, molecular dynamics simulations, and bioinformatics analyses, to investigate plant proteins as novel antimicrobial agents against viral infections. Various protein databases were screened to identify plant-derived proteins with structural compatibility and binding affinity toward key viral targets, such as proteases, polymerases, and spike proteins. Molecular docking results highlighted strong interactions between selected plant proteins and viral targets, suggesting potential inhibitory effects. Further, molecular dynamics simulations provided insights into the stability and conformational dynamics of protein-virus complexes, confirming their suitability as antiviral candidates. Additionally, ADMET (absorption, distribution, metabolism, excretion, and toxicity) analysis ensured the safety and drug-likeness of the identified proteins. Comparative studies with existing antiviral agents reinforced the therapeutic potential of these plant-derived biomolecules. The findings underscore the role of computational techniques in accelerating drug discovery and highlight the importance of plant-derived proteins as promising alternatives for antiviral therapy. This abstract paves the way for future experimental validation and clinical translation, offering a sustainable and natural approach to combating viral infections.

Keywords: In Silico Analysis, Plant Proteins, Antiviral Agents, Molecular Docking, Molecular Dynamics, Computational Drug Discovery.

THERAPEUTIC POTENTIAL OF OKRA (*ABELMOSCHUS ESCULENTUS*) POWDER IN THE MANAGEMENT OF DIABETES MELLITUS

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Abstract

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Growing evidence suggests that dietary interventions using medicinal plants play an important role in glycemic control and complication prevention. Okra (*Abelmoschus esculentus*) is a nutrient-rich vegetable containing bioactive compounds such as flavonoids, polysaccharides, and dietary fiber. These constituents contribute to antihyperglycemic activity by improving insulin sensitivity, reducing glucose absorption, and enhancing pancreatic β -cell function. This review evaluates the therapeutic potential of okra powder in lowering blood glucose levels and supporting metabolic health in patients with diabetes. Regular consumption of okra powder may offer a safe, cost-effective, and natural adjunct therapy for the management of diabetes mellitus. Experimental studies indicate that okra polysaccharides can slow gastric emptying and modulate postprandial glucose spikes, thereby improving overall glycemic stability in both type 1 and type 2 diabetes models. Furthermore, antioxidant and anti-inflammatory properties of okra may help reduce oxidative stress, which is a major contributor to diabetic complications such as neuropathy, nephropathy, and retinopathy. Overall, okra powder represents a promising functional food that can be integrated into dietary management strategies for improving long-term glucose regulation and reducing dependence on synthetic antidiabetic drugs. This review highlights current limitations, including variability in dosage and the lack of large-scale clinical trials, suggesting the need for further standardized research to validate therapeutic efficacy in human populations. Integration of okra powder into functional diets may provide a complementary approach alongside conventional antidiabetic therapy, particularly in resource-limited settings where access to pharmaceuticals is constrained, and lifestyle modifications are essential for sustainable disease control in diabetic populations worldwide today.

Keywords: Okra (*Abelmoschus esculentus*), Diabetes Mellitus, Antihyperglycemic Activity, Glycemic Control, Functional Food, Phytotherapy



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