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CUMHURİYET 18TH INTERNATIONAL CONFERENCE ON APPLIED SCIENCES

AUGUST 28- 30, 2026
AFYONKARAHİSAR

ISBN : 978-625-8795-43-1

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**CUMHURIYET 18TH INTERNATIONAL CONFERENCE ON APPLIED SCIENCES
AUGUST 28- 30, 2026
AFYONKARAHISAR**

Edited By
ASSOC. PROF. DR. MEHMET FIRAT BARAN

Issued: 25.09.2026
ISBN: 978-625-8795-43-1

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In the conference 11 papers have been presented by Turkish participants and 21 papers by international participants.

Members of the organizing committees of the conference perform their duties with an "official assignment letter"

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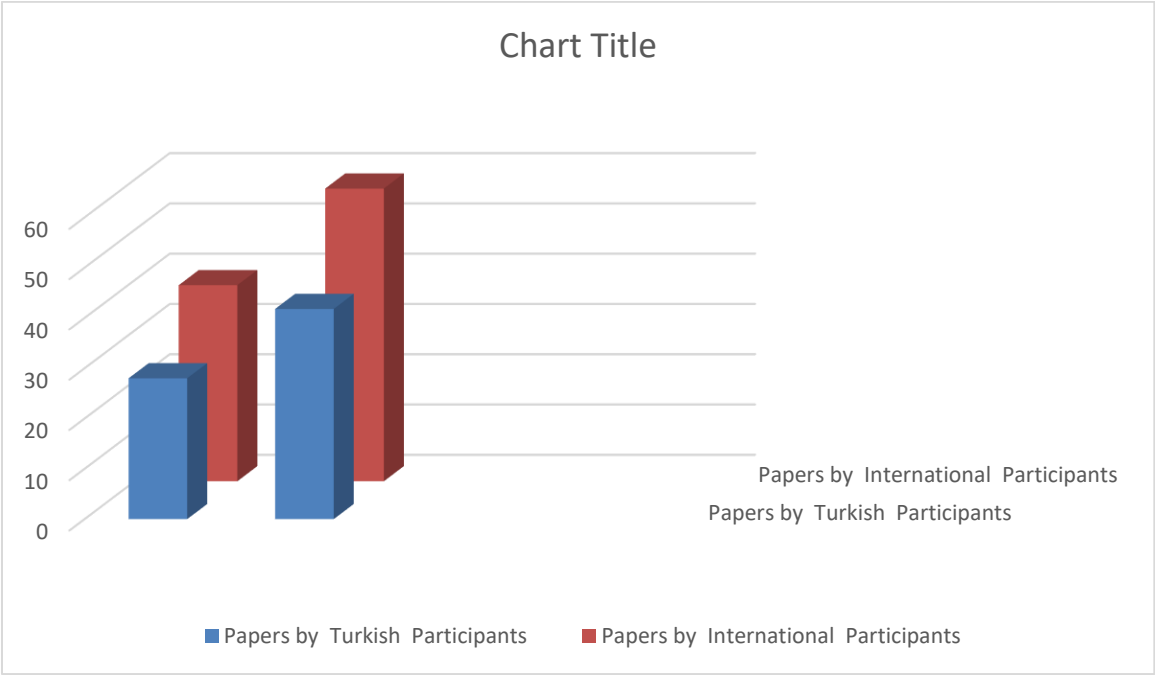
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<i>Papers by Turkish Participants</i>	11	34,38
<i>Papers by International Participants</i> <i>(12 Countries)</i>	21	65,62





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AUGUST 28- 30, 2026 –
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20/09/2026

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**CUMHURİYET 18th INTERNATIONAL CONFERENCE ON SOCIAL SCIENCES
CUMHURİYET 18th INTERNATIONAL CONFERENCE ON APPLIED SCIENCES**

August 28- 30, 2026

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CUMHURİYET 18th INTERNATIONAL CONFERENCE ON SOCIAL SCIENCES			
SESSION - HALL Session 1 – Hall 1	DATE August 29, 2026	TIME Ankara: 11:00 – 13:00	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Dr. Öğr. Üyesi, Uğur ARCAGÖK		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	LATENT IDENTITY PROFILES OF IMMIGRANT STUDENTS IN TÜRKİYE: A PERSON-CENTERED ANALYSIS OF PERCEIVED TEACHER DISCRIMINATION AND DEPRESSIVE SYMPTOMS	Dr. Öğr. Üyesi, Uğur ARCAGÖK
2	İSLAM DÜŞÜNCESİNE GÖRE HİKMET	Öğr. Gör. Dr. Samet Yahya BAL
3	17. YÜZYIL DİNİ DÜŞÜNCE ÇATIŞMALARI BAĞLAMINDA BİR EDEBİ METNİN MİSYONU: CEVÂHİR-İ BEVÂHİR-İ MESNEVÎ'DE ZÂHİR-BÂTIN DENGESİ	Dr. Sait AVCI
4	SİVİL HAVACILIK SEKTÖRÜNDE YER ALAN TERİMLERİN SINIFLANDIRILMASI	Öğr.Gör. Buse ŞAHİN

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON SOCIAL SCIENCES			
SESSION - HALL Session 1 – Hall 2	DATE August 29, 2026	TIME Ankara: 11:00 – 13:00	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Dr. Öğr. Üyesi, Huriye ÇELİKCAN		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	AYAŞ MERKEZ CAMİLERİNDE AHŞAP TAVAN YAPIM TEKNİKLERİ VE SÜSLEME ÖZELLİKLERİ	Hümeyra AKYÜZ Prof. Dr. Lütfiye GÖKTAŞ KAYA
2	ANKARA ALTINDAĞ CAMİLERİNDE KLASİK DÖNEMDEN BATI ÜSLUBA GEÇİŞİ YANSITAN KALEM İŞİ SÜSLEMELER	Saliha ŞEDİT Prof. Dr. Lütfiye GÖKTAŞ KAYA
3	KİŞİSEL OLANIN KÜLTÜR İLE İLİŞKİSİ: OTOETNOGRAFI	Dr. Öğr. Üyesi, Huriye ÇELİKCAN
4	UYGULAMALI MUTFAK EĞİTİMİ VEREN AKADEMİSYENLERİN MENTORLUK DENEYİMLERİ ÜZERİNE FENOMENOLOJİK BİR İNCELEME	Öğr. Gör. Dr., Emrah YILDIZ

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON SOCIAL SCIENCES			
SESSION - HALL Session 1 – Hall 3	DATE August 29, 2026	TIME Ankara: 11:00 – 13:00	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Doç. Dr. Fahrettin Tepealtı		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	SHIFTING OF LOCATION IN TURKISH LABOR MIGRATION: LABOR MIGRATION FROM WESTERN EUROPE TO MIDDLE EAST AND NORTH AFRICA	Mahmut İflazoğlu Doç. Dr. Fahrettin Tepealtı
2	IS THE ALTMAN Z-SCORE MODEL STILL SUCCESSFUL IN PREDICTING CORPORATE BANKRUPTCY IN TODAY’S BUSINESSES?	Asst. Prof. Çağla DEMİR PALİ Asst. Prof. Yasemin ACAR UĞURLU
3	ÜRETİMDE İŞBİRLİKÇİ ROBOT (COBOT) ARAŞTIRMALARININ BİBLİYOMETRİK ANALİZ İLE İNCELENMESİ	Öğr.Gör. Nilgün EROĞLU
4	KOMPÜLSİF SATIN ALMA DAVRANIŞININ “NASILLIĞI” ÜZERİNE BİR VAKA ANALİZİ	Elif SIRAKAYA Dr.Öğr. Üyesi Hakan KARAMAN

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SESSION - HALL	DATE	TIME	ZOOM ID - Passcode
Session 1 – Hall 4	August 29, 2026	Ankara: 11:00 – 13:00	885 7151 8350 - 202224

Head Of Session : Dr.Öğr.Üyesi Beylem ÇELİK

	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	KÜÇÜK VE ORTA BÜYÜKLÜKTEKİ İŞLETMELERDE YAPAY ZEKA RİSK ALGISI	Doktor Öğretim Üyesi, Arafat Salih AYDINER
2	THE IMPACTS OF DIGITAL TRANSFORMATION ON EMPLOYEES IN ORGANIZATIONS	Dr. Cihan KARA
3	THE EFFECTS OF SUSTAINABLE LEADERSHIP ON EMPLOYEE PSYCHOLOGICAL HEALTH AND BURNOUT	Dr. Cihan KARA
4	BİST SÜRDÜRÜLEBİLİRLİK ENDEKSİNDEKİ ŞİRKETLERİN KURUMSAL YÖNETİM VE BAĞIMSIZ DENETİM PROFİLİ: 2020–2024 DÖNEMİNE İLİŞKİN BETİMSSEL BİR İNCELEME	Dr.Öğr.Üyesi Beylem ÇELİK
5	DO DIGITAL BRAND INTEREST AND FINANCIAL MARKET ACTIVITY EXHIBIT EACH OTHER? THE CASE OF TESLA	Res. Asst. Gaye FERAH KORKMAZ Prof. Dr. Selay ILGAZ SÜMER
6	FUTURE OF THE ACCOUNTING PROFESSION IN THE AGE OF DIGITAL TRANSFORMATION: PARADIGM SHIFT, NEW AREAS OF EXPERTISE, AND CONTINUOUS ASSURANCE	Dr. Öğr. Üyesi Berin DİKGÖZ
7	DIGITAL SKILLS AND CROSS-BORDER ONLINE PURCHASING IN EUROPEAN UNION COUNTRIES: A COUNTRY-LEVEL ANALYSIS	Öğr. Gör. Dr. Alaidin KOŞAR Dr. Onur KARAASLAN

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON SOCIAL SCIENCES			
SESSION - HALL Session 1 – Hall 5	DATE August 29, 2026	TIME Ankara: 11:30 – 13:30	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Assis. Prof. Dr. Marko Rajković		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	EQUITABLE ACCESS TO HIGHER EDUCATION IN IRAN: STRATEGIES FOR REDUCING REGIONAL DISPARITIES	Prof. Dr. Yasmin Dastgheib Assis. Prof. Dr. Mohammad Reza Farhadi Fahimeh Bakhshi
2	IMPACT OF DIGITAL LEARNING TOOLS ON STUDENT ENGAGEMENT IN IRANIAN SECONDARY SCHOOLS	Dr. Leila Modarresi Assis. Prof. Dr. Hamed Vaziri
3	INCLUSION POLICIES IN PRIMARY EDUCATION: A CASE STUDY FROM SERBIAN PUBLIC SCHOOLS	Prof. Dr. Luka Stanković Jovana Nikolić Assis. Prof. Dr. Marko Rajković
4	THE EFFECT OF TEACHER PROFESSIONAL DEVELOPMENT PROGRAMS ON LEARNING OUTCOMES IN SERBIA	Assis. Prof. Dr. Ana Petrović Dragan Ilić Zorica Stevanović
5	INNOVATIVE APPROACHES TO CURRICULUM DESIGN IN IRAQI UNIVERSITIES: CHALLENGES AND PROGRESS	Assoc. Prof. Dr. Ahmad Al-Jubouri Assis. Prof. Dr. Sana Hameed Dr. Ali Kareem
6	EDUCATIONAL TECHNOLOGY INTEGRATION IN TEACHER TRAINING COLLEGES IN IRAQ	Prof. Dr. Samir Mahmoud Assis. Prof. Dr. Rana Al-Taie
7	NEW METHODOLOGICAL TRENDS IN ONLINE LEARNING ACROSS RUSSIAN UNIVERSITIES	Prof. Dr. Sergey Ivanov Dr. Ekaterina Sokolova Assis. Prof. Dr. Pavel Kuznetsov

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON SOCIAL SCIENCES			
SESSION - HALL Session 1 – Hall 6	DATE August 29, 2026	TIME Ankara: 11:30 – 13:30	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Assoc. Prof. Dr. Noor Al Harthy		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	THE FOUNDATIONS OF ARMENIAN LOGIC: HISTORICAL ROOTS AND MODERN APPLICATIONS	Prof. Dr. Aram Petrosyan
2	EXPLORING ETHICAL DIMENSIONS IN CONTEMPORARY ARMENIAN POLITICAL PHILOSOPHY	Dr. Lilith Grigoryan Assoc. Prof. Dr. Tigran Hakobyan
3	DEBATES ON MINDFULNESS AND CONSCIOUSNESS: INDIAN PHILOSOPHICAL PERSPECTIVES	Prof. Dr. Ravi Kumar Dr. Sneha Narayan
4	INTERPRETING ADVAITA VEDANTA IN THE CONTEXT OF MODERN SCIENCE	Dr. Priya Nair Assoc. Prof. Dr. Anil Joshi
5	RETHINKING MORAL REALISM THROUGH INDIAN BUDDHIST PHILOSOPHY	Dr. Subhasis Bandyopadhyay Satyam Verma Prof. Dr. Ahmed Al Balushi
6	SOCIAL JUSTICE AND ETHICAL FRAMEWORKS IN CONTEMPORARY OMANI THOUGHT	Assoc. Prof. Dr. Noor Al Harthy
7	PERSPECTIVES ON ISLAMIC PHILOSOPHY: REASON, FAITH, AND MODERNITY	Dr. Waleed Al Shamsi Prof. Dr. Layla Al Mamari

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON SOCIAL SCIENCES			
SESSION - HALL Session 1 – Hall 7	DATE August 29, 2026	TIME Ankara: 11:30 – 13:30	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Dr. Yerbolat Kassenov		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	SOCIAL INTEGRATION OF INTERNAL MIGRANTS IN URBAN KAZAKHSTAN: CHALLENGES AND POLICY RESPONSES	Prof. Dr. Nurzhan Akhmetov Dr. Aigerim Sadykova Assis. Prof. Dr. Dauren Tulepov
2	GENDER ROLES AND FAMILY TRANSFORMATION AMONG YOUNG ADULTS IN KAZAKHSTAN	Assoc. Prof. Dr. Aliya Zhaparova Dr. Yerbolat Kassenov
3	YOUTH ASPIRATIONS AND EDUCATIONAL MOBILITY IN ERITREA: SOCIOLOGICAL INSIGHTS	Dr. Selam Habtemariam Samuel Berhane
4	THE IMPACT OF TRADITIONAL STRUCTURES ON COMMUNITY DEVELOPMENT IN CONTEMPORARY ERITREA	Prof. Dr. Amanuel Tesfay Kibrom Menghisteb
5	SOCIAL CAPITAL AND HEALTH OUTCOMES AMONG OLDER ADULTS IN CAIRO NEIGHBORHOODS	Dr. Noura Fathy Prof. Dr. Hatem Abdelrahman
6	CHANGING MARRIAGE PRACTICES AND THEIR IMPACT ON FAMILY DYNAMICS IN EGYPT	Assoc. Prof. Dr. Ahmed Sorour Dr. Mona Gaber
7	NATIONAL IDENTITY CONSTRUCTION AMONG YOUTH IN POST-SOVIET AZERBAIJAN	Prof. Dr. Elchin Gasimov Dr. Zaur Mammadli
8	MEDIA CONSUMPTION AND VALUES SHIFT IN URBAN AZERBAIJANI SOCIETY	Assoc. Prof. Dr. Leyla Guliyeva Aysel Jafarova

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON SOCIAL SCIENCES			
SESSION - HALL Session 1 – Hall 8	DATE August 29, 2026	TIME Ankara: 11:30 – 13:30	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Prof. Dr. Roya Emami		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	IMPACT OF MONETARY POLICIES ON ECONOMIC GROWTH IN POST-SANCTION IRAN	Prof. Dr. Mehrdad Tavakoli Assis. Prof. Dr. Sara Khosravi Dr. Navid Ghafari
2	TECHNOLOGICAL INNOVATION AND ENTREPRENEURSHIP DEVELOPMENT IN IRANIAN SMES	Prof. Dr. Roya Emami Dr. Parviz Mohammadi Assis. Prof. Dr. Laleh Farhadi
3	GLOBALIZATION AND LABOR MARKET TRANSFORMATION IN SINGAPORE	Prof. Dr. Wei Hoon Tan Assoc. Prof. Dr. Samuel Ong Dr. Jing Li
4	FINANCIAL INCLUSION STRATEGIES AND HOUSEHOLD WELFARE IN SINGAPORE	Assoc. Prof. Dr. Priya Menon Prof. Dr. Adrian Chan Dr. Mei Lin Chia
5	GREEN ECONOMY INITIATIVES AND INDUSTRIAL SUSTAINABILITY IN INDIA	Prof. Dr. Ashish Joshi Dr. Priya Singh

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON SOCIAL SCIENCES			
SESSION - HALL Session 1 – Hall 9	DATE August 29, 2026	TIME Ankara: 11:30 – 13:30	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Dr. Anna Ivanova		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	APPROACHES IN CONTEMPORARY IRANIAN CALLIGRAPHY: TRADITIONAL HERITAGE AND NEW EXPRESSIONS	Prof. Dr. Morteza Farhadi Dr. Parisa Jahanbakhsh Somayeh Shams Assoc. Prof. Dr. Ali Rezaei
2	THE EVOLUTION OF SERBIAN SCULPTURE: MONUMENTALISM AND NATIONAL IDENTITY	Prof. Dr. Marko Milenković Dr. Ivana Stojanović Dragana Ristić
3	DEVELOPING PUBLIC ART INITIATIVES IN THE URBAN LANDSCAPE OF DOHA	Dr. Muna Al-Kuwari Assoc. Prof. Dr. Yusuf Rahman Latifa Al-Jaber
4	CONTEMPORARY CALLIGRAPHIC ART IN QATAR: INTERSECTIONS OF TRADITION AND MODERNITY	Prof. Dr. Ghada Al-Thani Sara Al-Sayed
5	RUSSIAN AVANT-GARDE INFLUENCE ON 21ST CENTURY RUSSIAN PAINTING	Prof. Dr. Vladimir Sokolov Svetlana Volkova Dr. Ekaterina Petrova
6	POST-SOVIET CONTEMPORARY ART MOVEMENTS IN RUSSIA: TRENDS, CHALLENGES, AND GLOBAL DIALOGUE	Dr. Anna Ivanova Assoc. Prof. Dr. Pavel Morozov Nikita Baranov Tatiana Makarova
7	NEW MEDIA INSTALLATION ART AND VIRTUALITY IN SOUTH KOREAN GALLERIES	Prof. Dr. Hyun-Jin Kim Jae-Won Lee

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON SOCIAL SCIENCES

SESSION - HALL Session 2 – Hall 1	DATE August 29, 2026	TIME Ankara: 15:00 – 17:00	ZOOM ID - Passcode 885 7151 8350 - 202224
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Head Of Session : Dr. Öğr. Üyesi Tolgay DURMUŞ

	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	ÖZ-ANLAYIŞ VE DUYGU DÜZENLEME GÜÇLÜKLERİ ARASINDAKİ İLİŞKİLERİN İNCELENMESİ	Merve DİKMEN Dr. Öğr. Üyesi Şule AYDIN YERAL Arş. Gör. Azra Ceren DAĞDELEN
2	MODERN TÜRK TOPLUMLARDA AİLENİN DÖNÜŞÜMÜ: DİJİTALLEŞME, KÜRESELLEŞME VE YENİ ROLLER	Dr. Öğr. Üyesi Tolgay DURMUŞ
3	DİJİTAL BAĞIMLILIK ÇERÇEVESİNDE EBEVEYN-ÇOCUK ETKİLEŞİMİ	Dr. Sahra KIRATLI ACAR
4	KENDİLİKNESNESİ İHTİYAÇLARI İLE YEME BAĞIMLILIĞI ARASINDAKİ İLİŞKİDE ZİHİNSELLEŞTİRMENİN ARACI ROLÜ	Nurbanu Yazlı Dr. Öğr. Üyesi Necmettin Aksoy
5	PEER BULLYİNG EXPERİENCES AND COPİNG STRATEGİES OF UNİVERSİTY STUDENTS	Doç. Dr. Nilgün ÖZTÜRK Öğr. Gör. Ercan ERİNÇ

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON SOCIAL SCIENCES			
SESSION - HALL Session 2 – Hall 2	DATE August 29, 2026	TIME Ankara: 15:00 – 17:00	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Dr. Öğretim Üyesi, Burak KAYA		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	YAPAY ZEKA KAYNAKLI TEKNOSTRESS: GÖRSEL HARİTALAMA TEKNİĞİ İLE BİBLİYOMETRİK ANALİZ	Öğr. Gör., Beyza ÖZDEM Doç. Dr., Canan YILDIRAN
2	SAĞLIK HİZMETLERİNDE DİJİTAL RANDEVU SİSTEMLERİ: MHR'S'NİN ERİŞİM, BEKLEME SÜRELERİ VE HASTA MEMNUNİYETİ AÇISINDAN İNCELENMESİ	Dr., Hicran ÖZDEMİR
3	TÜRK HUKUKUNDA SİGORTACININ SİGORTA ETTİRENE KARŞI AÇTIĞI RÜCU DAVALARI	Dr. Öğr. Üyesi Gökhan GÜNCAN Av. Ödül AKGÜL,
4	AVRUPA KONSEYİ'NİN İDAREYE TAVSİYE ETTİĞİ YASALARA VE HUKUKİ AMACA UYGUNLUK İLKESİ'NİN İNSAN HAKLARI BAĞLAMINDA DEĞERLENDİRİLMESİ	Dr. Öğretim Üyesi, Burak KAYA
5		

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON APPLIED SCIENCES			
SESSION - HALL Session 2 – Hall 3	DATE August 29, 2026	TIME Ankara: 15:00 – 17:00	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Doç. Dr. Özge ÖZTEKİN		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	SERBEST NİLPOTENT NOVİKOVCEBİRLERİNİN MERKEZİ OTOMORFİZMLERİ	Doç. Dr. Özge ÖZTEKİN Yüksek Lisans Öğr. Yusuf ASLAN
2	FIBONACCI HİBRİT VE LUCAS HİBRİT SAYI MATRİSLERİNİN ÖZDEĞER YAPISINDA ALTIN ORAN	Doç. Dr. Özge ÖZTEKİN Doktora Öğr. Mustafa POYRAZ
3	SİBER GÜVENLİK SAVUNMALARINDA MATEMATİK TABANLI YAPAY ZEKA UYGULAMALARI	Dr. Ahmet YILDIRIM
4	YÜKSEK HIZLI VE TEKRARLI DOLU ÇARPMA SINININ KANAT HÜCUM KENARINDA OLUŞTURDUĞU HASARIN DENEYSEL VE SAYISAL ANALİZİ	Lisansüstü Öğrencisi, Musa YİĞİT Doç. Dr. Hacı Abdullah TAŞDEMİR

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON APPLIED SCIENCES

SESSION - HALL	DATE	TIME	ZOOM ID - Passcode
Session 2 – Hall 4	August 29, 2026	Ankara: 15:00 – 17:00	885 7151 8350 - 202224

Head Of Session : Doç. Dr. Gökhan ARSLAN

	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	TECHNOLOGICAL PERFORMANCE OF PLYWOOD PRODUCED FROM HEAT-TREATED BEECH VENEERS	Doç. Dr. Halil İbrahim ŞAHİN
2	ORTA TONAJLI SAVAŞ GEMİLERİNDE GÖREV PROFİLİNE BAĞLI HIZ DAĞILIMLARININ ANA TAHRİK SİSTEMİ PLANLI BAKIMLARINA ETKİSİ	Hakan GÜNGÖR Prof.Dr. Uğur Buğra ÇELEBİ
3	ANALYSIS OF CONSTRUCTION ACTIVITY IN TÜRKİYE USING BUILDING PERMIT DATA: STRUCTURAL BREAKS AND REGIME SHIFTS	Asst. Prof .Dr. Sıtkı Alper ÖZDEMİR
4	EFFECT OF MAXIMUM STRAIN ON THE REPEATED-COMPRESSION RESPONSE OF MSLA-FABRICATED SCHWARZ PRIMITIVE TPMS STRUCTURES	Assistant Professor, Hamdi KULEYİN
5	ABANDONED ARCHITECTURAL HERITAGE IN KAYAKÖY: CLIMATIC VULNERABILITY AND MATERIAL DETERIORATION	Dr. Öğr. Üyesi Ahmet KURNAZ
6	TURKEY’S FOREIGN TRADE STATUS IN THE FISHERIES SECTOR	Doç. Dr. Gökhan ARSLAN
7	ENVIRONMENTAL IMPACT OF FEEDS USED IN FISH FARMING	Doç. Dr. Gökhan ARSLAN

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON APPLIED SCIENCES			
SESSION - HALL Session 2 – Hall 5	DATE August 29, 2026	TIME Ankara: 15:30 – 17:30	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Assoc. Prof. Dr. Suman Sharma		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	SHED SNAKE SKINS: A NATURAL RESOURCE FOR BIOMIMETIC MEMBRANES – ADVANCING PERMEATION STUDIES AND DRUG DELIVERY APPLICATIONS	Emma Grigoryan, Ashot Khachatryan, Karapet Flora Avjyan Savchenko,
2	PRECISION DRUG DELIVERY OF GLIBENCLAMIDE: EXPLORING THE IMPACT OF POLYVINYL PYRROLIDONE AND ETHYL CELLULOSE CONCENTRATION ON RELEASE PROFILES AND KINETICS	Dr. Stepan Arakelova, Assis. Prof. Dr. Lilia Arsenyan
3	INVESTIGATING THE EFFECTS OF AMINOPOLYETHER ON 18F-FDG PROPERTIES AND ITS IMPLICATIONS FOR PET IMAGING APPLICATIONS	Dr. Sunil Kamboj, Dr. Vipin Saini, Lecture GauravBala,
4	ENDOPHYTES AS A NEW SOURCE OF BIOACTIVE COMPOUNDS: ISOLATION AND IDENTIFICATION OF FIBRINOLYTIC PROTEASE-PRODUCING FUNGI FROM HIBISCUS LEAVES	Assoc. Prof. Dr. Suman Sharma
5	FROM CONCEPT TO REALITY: THE DESIGN AND DEVELOPMENT OF A MECHANICAL FORCE GAUGE FOR SQUARE WATERMELON MOLDING	Dr. Bedi Neayti Singh Phd. Candidate Balvinder Thakur,
6	THE ROLE OF EXERCISE IN IMPROVING SEXUAL PERFORMANCE AND SEMEN QUALITY OF SAHIWAL BULLS: A PRACTICAL GUIDE FOR BREEDERS	Assis. Prof. Dr. Rathapon Dr.Sorrachaitawatwong, Nardauma Pouthai
7	INVESTIGATING THE IMPACT OF DIETARY HERBAL SEED SUPPLEMENTATION ON CARCASS CHARACTERISTICS, IMMUNE RESPONSE, AND ANTIOXIDANT STATUS OF BROILER CHICKENS	Sirijit Tipchuwong, Chayanid Asasutjarit

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON APPLIED SCIENCES

SESSION - HALL Session 2 – Hall 6	DATE August 29, 2026	TIME Ankara: 15:30 – 17:30	ZOOM ID - Passcode 885 7151 8350 - 202224
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Head Of Session : Assis. Prof. Dr. R. Rafiemanzelat

	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	EVALUATION OF URBAN LAND DEVELOPMENT DIRECTION IN KABUL CITY, AFGHANISTAN	Ahmad Sharif Ahmadi Yoshitaka Kajita
2	INFLUENCE OF PLACE IDENTITY ON WALKABILITY: A COMPARATIVE STUDY BETWEEN TWO MIXED USED STREETS CHAHARBAGH ST. ISFAHAN, IRAN AND DEREBOYU ST. LEFKOSA, NORTH CYPRUS	Assis. Prof. Dr. R. Rafiemanzelat
3	RENEWED URBAN WATERFRONT: SPATIAL CONDITIONS OF A CONTEMPORARY URBAN SPACE TYPOLOGY	Assis. Prof. Dr. Beate Niemann, Fabian Pramel
4	URBAN ECOLOGICAL INTERACTION: AIR, WATER, LIGHT AND NEW TRANSIT AT THE HUMAN SCALE OF BARCELONA'S SUPERILLES	Philip Speranza
5	PERFORMANCE EVALUATION OF A 'PRIORITY-CONTROLLED' INTERSECTION CONVERTED TO SIGNAL-CONTROLLED INTERSECTION	Prof. Dr. Ezenwa Chinenye Amanamba
6	DISCUSSION ABOUT FREQUENT ADJUSTMENT OF URBAN MASTER PLANNING IN CHINA: A CASE STUDY OF CHANGSHOU DISTRICT, CHONGQING CITY	Sun Ailu Zhao Wanmin
7	HYBRID LIVING: EMERGING OUT OF THE CRISES AND DIVISIONS	Yiorgos Hadjichristou

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON APPLIED SCIENCES			
SESSION - HALL Session 2 – Hall 7	DATE August 29, 2026	TIME Ankara: 15:30 – 17:30	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Doç. Dr. Gökhan ARSLAN		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	IMPACT OF MIDWIFERY-LED CARE ON MATERNAL OUTCOMES IN AZERBAIJANI RURAL COMMUNITIES	Prof. Dr. Leyla Mammadova Mehriban Aliyeva
2	ASSESSING NUTRITIONAL KNOWLEDGE AND PRACTICES AMONG PREGNANT WOMEN IN BAKU	Dr. Gunay Rasulova
3	EFFECTIVENESS OF CONTINUING EDUCATION PROGRAMS IN MIDWIFERY PRACTICE IN FRANCE	Prof. Dr. Claire Dubois Dr. Pierre Martin Amelie Rousseau
4	TRAINING MIDWIVES TO MANAGE OBSTETRIC EMERGENCIES IN RURAL ETHIOPIA: CHALLENGES AND OUTCOMES	Prof. Dr. Alemu Wondimu Dr. Genet Abebe
5	COMMUNITY-BASED ANTENATAL CARE INITIATIVES IN SOUTHERN ETHIOPIA AND IMPACT ON BIRTH OUTCOMES	Dr. Miriam Tadesse Zerihun Mekonnen Assis. Prof. Dr. Kalkidan Endale Prof. Dr. Gebeyehu Bekele
6	MIDWIFERY STUDENTS' ATTITUDES TOWARD EVIDENCE-BASED PRACTICE IN IRANIAN UNIVERSITIES	Dr. Nasrin Ghasemi Assis. Prof. Dr. Marjan Jafari Prof. Dr. Shahla Hassani
7	WOMEN'S EXPERIENCES WITH HOME BIRTH ASSISTED BY MIDWIVES IN URBAN IRAN	Dr. Elham Shams Samira Tavakoli

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON SOCIAL SCIENCES			
SESSION - HALL Session 2 – Hall 8	DATE August 29, 2026	TIME Ankara: 15:30 – 17:30	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Dr. Rasha Al-Haddad		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	INNOVATIVE TEACHING STRATEGIES IN HIGHER EDUCATION	Dr. Ahmed Al-Mutairi Dr. Sara Al-Fahad
2	DIGITAL LEARNING PLATFORMS AND STUDENT ENGAGEMENT	Dr. Leila Mansouri Prof. Dr. Reza Khatami Neda Farhadi
3	CURRICULUM DEVELOPMENT FOR MULTILINGUAL CLASSROOMS	Dr. Rasha Al-Haddad Omar Al-Masri
4	THE ROLE OF TEACHER TRAINING IN IMPROVING EDUCATIONAL OUTCOMES	Dr. Fadi Khalil Dr. Lina Youssef Dr. Samir Nassar
5	EDUCATION FOR SUSTAINABLE DEVELOPMENT: CHALLENGES AND OPPORTUNITIES	Dr. Fatemeh Rahimi Dr. Ali Karimi
6	BLENDED LEARNING APPROACHES IN UNIVERSITY SETTINGS	Amal Hassan Dr. Yasser Ibrahim Prof. Dr. Huda Mahmoud
7		

CUMHURİYET 18th INTERNATIONAL CONFERENCE ON SOCIAL SCIENCES			
SESSION - HALL Session 2 – Hall 9	DATE August 29, 2026	TIME Ankara: 15:30 – 17:30	ZOOM ID - Passcode 885 7151 8350 - 202224

Head Of Session : Dr. Fadwa Salman		
	Bildiri No ve Başlığı / Paper ID and Title	Authors
1	POETIC TRADITIONS AND SYMBOLISM IN PERSIAN LITERATURE	Dr. Reza Mahdavi Niloofer Azimi Farhad Ghanbari
2	LANGUAGE AND IDENTITY IN CONTEMPORARY ARABIC NOVELS	Ahmed Al-Farouqi Layla Hassan
3	ORAL STORYTELLING AND CULTURAL MEMORY IN IRAQI LITERATURE	Samira Al-Khalidi Ali Hussein Dr. Fadwa Salman
4	THEMES OF EXILE AND BELONGING IN PALESTINIAN POETRY	Dr. Rami Barakat Aisha Khalil
5	WOMEN'S VOICES IN CONTEMPORARY SYRIAN FICTION	Nour Haddad Rana Al-Shami Prof. Dr. Bassam Darwish

Contents

FIBONACCI HİBRİT VE LUCAS HİBRİT SAYI MATRİSLERİNİN ÖZDEĞER YAPISINDA ALTIN ORAN.....	1
SERBEST NİLPOTENT NOVİKOVCEBİRLERİNİN MERKEZİ OTOMORFİZMLERİ.....	2
SİBER GÜVENLİK SAVUNMALARINDA MATEMATİK TABANLI YAPAY ZEKA UYGULAMALARI.....	3
TECHNOLOGICAL PERFORMANCE OF PLYWOOD PRODUCED FROM HEAT TREATED BEECH VENEERS ..	19
ORTA TONAJLI SAVAŞ GEMİLERİNDE GÖREV PROFİLİNE BAĞLI HIZ DAĞILIMLARININ ANA TAHRİK SİSTEMİ PLANLI BAKIMLARINA ETKİSİ	31
ANALYSIS OF CONSTRUCTION ACTIVITY IN TÜRKİYE USING BUILDING PERMIT DATA: STRUCTURAL BREAKS AND REGIME SHIFTS	33
EFFECT OF MAXIMUM STRAIN ON THE REPEATED-COMPRESSION RESPONSE OF MSLA-FABRICATED SCHWARZ PRIMITIVE TPMS STRUCTURES.....	49
KAYAKÖY’DE TERK EDİLMİŞ MİMARİ MİRAS: İKLİMSSEL KIRILGANLIK VE MALZEME BOZULMASI	50
ENVIRONMENTAL IMPACT OF FEEDS USED IN FISH FARMING.....	61
TURKEY'S FOREIGN TRADE STATUS IN THE FISHERIES SECTOR.....	66
SHED SNAKE SKINS: A NATURAL RESOURCE FOR BIOMIMETIC MEMBRANES – ADVANCING PERMEATION STUDIES AND DRUG DELIVERY APPLICATIONS.....	72
PRECISION DRUG DELIVERY OF GLIBENCLAMIDE: EXPLORING THE IMPACT OF POLYVINYL PYRROLIDONE AND ETHYL CELLULOSE CONCENTRATION ON RELEASE PROFILES AND KINETICS.....	73
INVESTIGATING THE EFFECTS OF AMINOPOLYETHER ON 18F-FDG PROPERTIES AND ITS IMPLICATIONS FOR PET IMAGING APPLICATIONS.....	74
ENDOPHYTES AS A NEW SOURCE OF BIOACTIVE COMPOUNDS: ISOLATION AND IDENTIFICATION OF FIBRINOLYTIC PROTEASE-PRODUCING FUNGI FROM HIBISCUS LEAVES.....	75
FROM CONCEPT TO REALITY: THE DESIGN AND DEVELOPMENT OF A MECHANICAL FORCE GAUGE FOR SQUARE WATERMELON MOLDING	76
THE ROLE OF EXERCISE IN IMPROVING SEXUAL PERFORMANCE AND SEMEN QUALITY OF SAHIWAL BULLS: A PRACTICAL GUIDE FOR BREEDERS.....	77
INFLUENCE OF PLACE IDENTITY ON WALKABILITY: A COMPARATIVE STUDY BETWEEN TWO MIXED USED STREETS CHAHARBAGH ST. ISFAHAN, IRAN AND DEREBOYU ST. LEFKOSA, NORTH CYPRUS	79
RENEWED URBAN WATERFRONT: SPATIAL CONDITIONS OF A CONTEMPORARY URBAN SPACE TYPOLOGY	80
URBAN ECOLOGICAL INTERACTION: AIR, WATER, LIGHT AND NEW TRANSIT AT THE HUMAN SCALE OF BARCELONA'S SUPERILLES	81
PERFORMANCE EVALUATION OF A 'PRIORITY-CONTROLLED' INTERSECTION CONVERTED TO SIGNAL-CONTROLLED INTERSECTION	82
DISCUSSION ABOUT FREQUENT ADJUSTMENT OF URBAN MASTER PLANNING IN CHINA: A CASE STUDY OF CHANGSHOU DISTRICT, CHONGQING CITY	83
HYBRID LIVING: EMERGING OUT OF THE CRISES AND DIVISIONS.....	84

CUMHURIYET 18th INTERNATIONAL CONFERENCE ON APPLIED SCIENCES
August 28- 30, 2026 – AFYONKARAHISAR
ISBN NR. : 978-625-8795-43-1

IMPACT OF MIDWIFERY-LED CARE ON MATERNAL OUTCOMES IN AZERBAIJANI RURAL COMMUNITIES	85
ASSESSING NUTRITIONAL KNOWLEDGE AND PRACTICES AMONG PREGNANT WOMEN IN BAKU	86
EFFECTIVENESS OF CONTINUING EDUCATION PROGRAMS IN MIDWIFERY PRACTICE IN FRANCE	87
TRAINING MIDWIVES TO MANAGE OBSTETRIC EMERGENCIES IN RURAL ETHIOPIA: CHALLENGES AND OUTCOMES	88
COMMUNITY-BASED ANTENATAL CARE INITIATIVES IN SOUTHERN ETHIOPIA AND IMPACT ON BIRTH OUTCOMES	89
MIDWIFERY STUDENTS' ATTITUDES TOWARD EVIDENCE-BASED PRACTICE IN IRANIAN UNIVERSITIES .	90
WOMEN'S EXPERIENCES WITH HOME BIRTH ASSISTED BY MIDWIVES IN URBAN IRAN	91

**FIBONACCI HİBRİT VE LUCAS HİBRİT SAYI MATRİSLERİNİN ÖZDEĞER
YAPISINDA ALTIN ORAN**

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Özet

Hibrit sayılar, üç sayı sisteminin birleşimi olarak ortaya çıkar: karmaşık, dual ve hiperbolik sayılar. Dolayısıyla, $\mathbb{K}$ ile gösterilen hibrit sayılar kümesi şu şekilde tanımlanır:

$$\mathbb{K} = \{z = a + bi + c\varepsilon + dh : a, b, c, d \in \mathbb{R}\}$$

burada i, ε ve h sırasıyla complex, dual ve dual birimlerdir. Herbir hibrit sayı $z = a + bi + c\varepsilon + dh$, 2×2 tipindeki bir A matrisi ile şu şekilde temsil edilebileceği daha önceki çalışmalarda gösterilmiştir:

$$A = \begin{bmatrix} a + c & b - c + d \\ c - b + d & a - c \end{bmatrix}$$

Bu çalışmada, Fibonacci hibrit sayıları ve Lucas hibrit sayıları olmak üzere iki özel hibrit sayı sınıfına odaklanıyoruz. Bu sayıların bazı cebirsel özelliklerini inceliyor ve matris temsillerine karşılık gelen özdeğerleri araştırıyoruz.

Dahası, Fibonacci hibrit sayılarının ardışık pozitif özdeğerlerinin altın oranda olduğunu göstererek, hibrit sayı teorisi ile klasik Fibonacci analizi arasında ilginç bir bağlantı ortaya koyuyoruz.

Anahtar Kelimeler : Fibonacci hibrit sayıları, Lucas hibrit sayıları, özdeğer, altın oran.

**SERBEST NİLPOTENT NOVİKOVCEBİRLERİNİN MERKEZİ
OTOMORFİZMLERİ**

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ÖZET

Novikov cebirleri ilk olarak hidrodinamik tipteki Hamilton operatörlerinin incelenmesinde ortaya çıkmıştır. Bir $\mathbb{F}$ cismi üzerinde tanımlı N cebiri aşağıdaki özellikleri sağlıyorsa Novikov cebiri olarak adlandırılır:

$$(xy)z - (xz)y = 0, (xy)z - x(yz) = (yx)z - y(xz).$$

N Novikov cebirinin bir θ otomorfizmi her $n \in N$ için $\theta(n) - n \in Z(N)$ koşulunu sağlıyorsa θ otomorfizmine merkezi otomorfizm denir (Burada $Z(N)$, N cebirinin merkezidir).

$N(X)$, $X = \{x_1, x_2, \dots, x_n\}$ kümesi tarafından serbest üretilen Novikov cebiri olmak üzere $N_{n,c} = N(X) / (N(X))^{c+1}$ nilpotentlik sınıfı c olan serbest Novikov cebiridir. Bu çalışmada serbest nilpotent Novikov cebirlerinin merkezi otomorfizmleri incelenmektedir. Öncelikle serbest nilpotent Novikov cebirlerinin merkez yapısı belirlenmekte ardından merkezi otomorfizmlerin karakterizasyonu verilmektedir. Elde edilen sonuçlar merkezi otomorfizm grubunun belirli homomorfizm uzayları ile ilişkili olduğunu göstermektedir. Ayrıca küçük nilpotentlik sınıflarında merkezi otomorfizm gruplarının yapısı açık olarak hesaplanmaktadır.

Anahtar Kelimeler : Novikov cebiri, serbest cebir, nilpotent cebir, merkezi otomorfizmler grubu.

**SİBER GÜVENLİK SAVUNMALARINDA MATEMATİK TABANLI
YAPAY ZEKA UYGULAMALARI**

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ÖZET

Siber saldırıların sayısı ve kompleksliği her geçen gün artmaktadır. Geleneksel yöntemlerin artık siber tehditlerin tespit edilmesi ve önlenmesinde yeterli olamayacağı görüldüğünden yapay zeka çözüm yöntemlerine olan ilgi artmaktadır. Yapay zeka çözümleri hakkında bilgileri güncel literatürde özetleyerek bunlara genel bir bakış açısı gözlemlenmekte ve saldırı tespiti, kötü amaçlı yazılım(trojan) analizi, kimlik avı saldırılarının belirlenmesi, ağ anomali ve izinsiz erişimlerin önlenmesinde yapay zeka yöntemlerinin nasıl işleyebileceğini değerlendirmektedir. Ayrıca üretken yapay zeka, açıklanabilir yapay zeka ve otonom sistemlerin siber güvenlik sistemlerine sağladığı katkılar ile karşılaştıkları güvenlik, gizlilik ve etik sorunlar da tartışılmaktadır. Yapay zeka destekli siber güvenlik sistemlerinin sağladığı avantajlar ve etkinlikleri göz önünde bulundurulduğunda siber güvenlik sistemlerinin kentsel alanlarda korunması, tehditlerin daha hızlı tespit edilmesi, olaylara etkin müdahale edilmesi ve sistemlerin kritik bölgelerde korunması gerekmektedir. Gelecekte daha açıklanabilir, güvenilir ve öğrenme yeteneğine sahip yapay zeka sistemlerinin geliştirilmesi siber güvenlik sistemlerinin daha etkin çalışmasını sağlayacaktır.

Anahtar Kelimeler: Siber Güvenlik, Yapay Zeka, Makine Öğrenmesi, Derin Öğrenme, Ağ Güvenliği.

**YÜKSEK HIZLI VE TEKRARLI DOLU ÇARPMASININ KANAT HÜCUM
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ÖZET

Havacılık sektöründe güvenlik her zaman ön planda tutulmaktadır. Bu kapsamda hava araçlarında dolu çarpması sonucu oluşabilecek hasarların tasarım aşamasında değerlendirilip gerekli önlemlerin alınması son derece önemlidir. Bu çalışma kapsamında kanat hücum kenarına tekrarlı dolu çarpması durumunda yapısal performansın incelenmesi hedeflenmiştir. Kanat hücum kenarı tasarımında kullanılacak olan Alüminyum 7075 T6 malzemesinin sayısal analizlerde doğru bir şekilde temsil edildiğini göstermek adına gaz tabancası test düzeneği yardımıyla 41.7 m/s hızında, 50.8 mm çapında çelik küre atışı gerçekleştirilerek plaka üzerinde oluşan kalıcı deformasyon miktarı ve gerinim değişimi ölçülmüştür. Gerçekleştirilen çelik küre atışı LS-Dyna sonlu elemanlar yazılımıyla modellenerek sayısal analiz ortamında tekrar edilmiştir. Analiz sonucunda plaka üzerinde oluşan kalıcı deformasyon miktarı deneyle uyumlu bir şekilde, %1.06'lık bir hata payı ile hesaplanmıştır. Buz malzeme modelinin doğruluğunu teyit etmek amacıyla farklı hızlarda rijit hedefe buz çarpması deneyleri sayısal analiz ortamında tekrar edilmiştir. Deneylerde ölçülen zamana bağlı kuvvet değerleri sayısal analiz ortamında hesaplanan değerler ile karşılaştırılmış ve sayısal analizlerde çarpma esnasında oluşan kuvvetin iyi bir şekilde tahmin edilebildiği görülmüştür. Malzeme modellerinin doğrulanması çalışmalarının ardından metalik bir kanat hücum kenarı tasarımı gerçekleştirilerek tekli ve çoklu dolu çarpması durumunda oluşan hasar durumu sayısal analizlerle incelenmiştir. Sonuç olarak, tekrarlı atış durumunun daha kritik olduğu ve tasarım aşamasında mutlaka etkisinin incelenmesi gerektiği anlaşılmıştır.

Anahtar Kelimeler : Havacılık Yapıları, Yüksek Hızlı Dolu Çarpması, Kanat Hücum Kenarı, Tekrarlı Dolu Çarpması, Sonlu Elemanlar Analizi.

1. GİRİŞ

Havacılık sektörünün hızla büyümesiyle birlikte uçakların dolu yağışı ile karşılaşması sebebiyle oluşan problemlerde ön plana çıkmıştır. Aletli uçuş tekniklerinin gelişmesi ile birlikte dolu yağışı ve türbülans gibi olumsuz hava koşullarında uçakların faaliyet göstermesi daha olağan bir hal almıştır. Bu durumun bir yansıması olarak yaklaşık otuz saniye kadar görece çok kısa sayılabilecek bir dolu fırtınasında bile uçağın hurdaya çıkartılmasını gerektirecek seviyede hasarlar alması söz konusudur. Daha kötü senaryo ise kontrol yüzeyleri veya motor kaybı neticesinde hava aracının tamamen kaybedilmesi ihtimalidir. Uçağın başta ön yüzey alanında yer alan burun, kanopi, kanat ve kuyruk hücum kenarı bölümleri ile birlikte neredeyse tüm dış yüzeyler dolu riski altındadır [1].

Yabancı cisim hasarı kapsamında değerlendirilen dolu çarpması sebebiyle hava aracı üzerinde oluşacak hasarın öngörülmesi ve tasarımın bu hasarı karşılayabilecek kabiliyette olması büyük önem arz etmektedir. Hava araçları kapsamında çeşitli yapısal parçalara dolu çarpması durumunda oluşabilecek hasarı tahmin etmek için günümüz mühendislik dünyasının en etkili araçlarından olan sonlu elemanlar analizleri ve deneysel çalışmalardan sıkça yararlanılmaktadır. Dolu çarpması ile ilgili gerçekleştirilen çalışmalar incelendiğinde genel olarak çalışmaların dört ana başlık altında yer aldığı görülmektedir.

Araştırmacılar, hesaplamalarda kullanmak adına ilk olarak buz malzemesinin mekanik özelliklerini tespit etmeye odaklanmışlardır. Yüksek deformasyon oranlarında buzun gevrek basma dayanımı, sürtünmeli çatlak kayması ve çatlak etkileşimleri tarafından kontrol edilmektedir [2]. Çevre basıncı koşullarına bağlı olarak şekillenen yarıлма, kayma kırılması ve dökülme gibi hasar modları, çarpışma esnasındaki kırılma mekanizmalarını anlamada kritik rol oynar. Yüksek deformasyon oranlarındaki tek eksenli basma yüklemelerinde buzun dayanımı deformasyon oranına bağlı olarak üstel biçimde artış göstermektedir [3]. Farklı buz tipleri (tatlı su ve deniz buzı) dikey yükleme altında belirgin dayanım farkları sergilemektedir. Darbe anındaki yüksek hızlı parçalanma süreci çatlak ilerlemesinin optik takibini zorlaştırmaktadır. Yüksek hızlı yüklemelerde buz malzemesi ortalama 10 MPa basma dayanımı ve 12 GPa elastisite modülü sergilerken, hedefte oluşan kalıcı deformasyon kristal yapısından ziyade temas geometrisine ve uflanma tipine bağlıdır [4]. Çarpma hızı arttıkça uflanan parça boyutları küçülmekte; düz uçlu geometriler konik veya açılı numunelere göre hedef plakada daha yüksek kalıcı deformasyona yol açmaktadır [4].

Buz malzemesinin mekanik özelliklerinin belirlenmesinin ardından sayısal analiz ortamında dolu çarpması hadisesini modelleme ihtiyacından kaynaklı çeşitli buz malzeme modelleri geliştirilmiştir. Dolu çarpması simülasyonlarında buzun plastik ezilme ve hasar sonrası akışkan benzeri hidrodinamik davranışını içeren elasto-plastik malzeme modelleri deneysel verilerle yüksek uyum sunmaktadır [5]. Buzun gevrek kırılma dinamiğini modellemek adına Mazars elastik hasar modeline çekme-basma modları ile gecikme etkisinin entegre edildiği kullanıcı tanımlı malzeme modelleri de geliştirilmiştir [6].

Geliştirilen malzeme modelleri sayesinde dolu çarpması sonucu oluşacak hasar durumunu sayısal analizlerle yüksek doğrulukta tahmin etmek mümkün hale gelmiştir. Bu kapsamda farklı hava aracı bileşenlerinin dolu dayanımını inceleyen pek çok deneysel ve sayısal çalışma

literatürde çokça yer almaktadır. Uçak kanopisine yönelik saydam panellerin dolu darbesi dayanımı, farklı hız (20-120 m/s) ve mermi çaplarında (20-50 mm) gerçekleştirilen deneysel atışlarla değerlendirilmiştir [7]. Kanat hücum kenarında yer alan Krueger kanatçığında kullanılan CFRP ve köpük çekirdekli sandviç yapıların dolu çarpması altındaki hasar davranışı deneysel testler ve SPH simülasyonlarıyla modellenmiştir [8]. Yüksek hızlı dolu atışlarıyla doğrulanmış bu sayısal yaklaşım, kritik aerodinamik komponentlerin dolu hasar toleransını kupon seviyesi doğrulamalarla öngören maliyet etkin bir yöntem sunmaktadır [8]. Tekrarlı dolu çarpması durumunda oluşan hasarı incelemeyi hedefleyen, havacılık sınıfı CFRP komponentlerde tekrarlı dolu çarpmalarının kümülatif hasar etkisini deneysel ve darbe sonrası basma testleriyle değerlendiren çalışmalarda gerçekleştirilmiştir [9].

Hava aracının görevini başarı ile icra ederek güvenli bir şekilde iniş yapması için kritik öneme sahip kontrol yüzeylerinden olan kanat hücum kenarının dolu hasarına karşı dayanım göstermesi büyük önem teşkil etmektedir. Gerçekleştirilen bu çalışma kapsamında kanat hücum kenarının dolu hasarına karşı yapısal performansı değerlendirilmiştir.

2. DENEYSEL ve SAYISAL ÇALIŞMALAR

Gerçekleştirilen çalışma kapsamında, uçak kanat hücum kenarına tekrarlı dolu çarpması durumunda oluşan hasar deneysel ve sayısal olarak incelenmiştir. Kanat hücum kenarı tasarımında kullanılacak alüminyum alaşım malzemesinin sayısal analizlerde doğru temsil edildiğini teyit etmek amacıyla gaz tabancası test düzeneği yardımıyla düz plakaya çelik küre atışı gerçekleştirilmiştir. Ardından gerçekleştirilen deney koşullarını birebir temsil edecek şekilde sayısal analiz ortamında deney tekrarlanmış ve sonuçlar kıyaslanmıştır. Daha sonra buz malzeme modelini doğrulamak adına açık kaynaklarda yer alan rijit duvara buz çarpması deneyleri sayısal analiz ortamında tekrar edilerek sonuçlar kıyaslanmış ve buz malzeme modelinin doğruluğu gösterilmiştir. Sayısal analiz doğrulama çalışmalarının ardından temsili bir uçak kanat hücum kenarı tasarımı gerçekleştirmiştir. Hücum kenarına tek bir dolu tanesi çarpması durumu ile tekrarlı dolu çarpması durumunda oluşan hasar durumu sayısal analizler yardımıyla incelenmiştir.

2.1. Deney Düzeneği

Test düzeneği gaz tabancası, durdurucu ile birlikte sabot, veri toplama ekipmanı ve test fikstürü olmak üzere dört ana bileşenden oluşmaktadır. Görsel 1 genel sistem yerleşimini ve bağlantı özelliklerini göstermektedir.

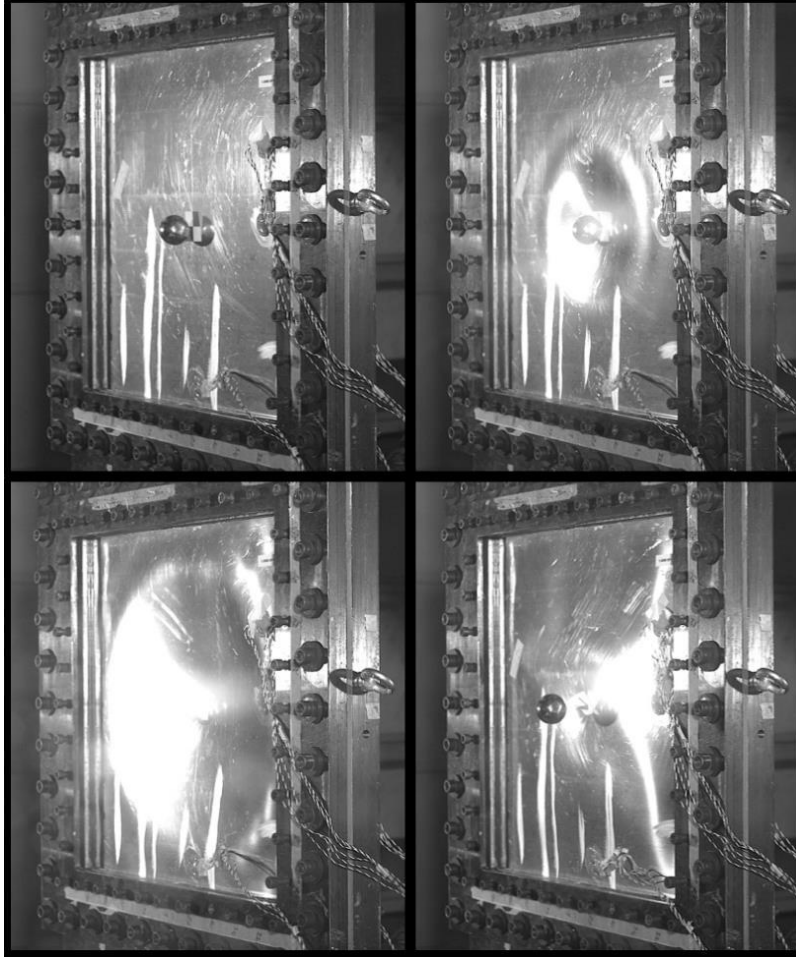


Görsel 1. Test Düzeneği [10]

Gaz tabancasının kontrol ara yüzü aracılığıyla test, sabot içerisindeki mühimmatın fırlatılmasıyla başlatılır. Sabot, basınçlı gaz aracılığıyla namlu boyunca hızlanıp namlu ucunda konumlandırılmış lazer sensörlerden geçerken hız ölçüm cihazını tetikler. Tetiklemenin ardından kayıt işlemini başlatmak için tüm yüksek hızlı kameralar ve veri toplama sistemi eş zamanlı olarak etkinleştirilir. Test süreci boyunca toplanan tüm bilgiler, daha sonra analiz edilmek üzere saklanır.

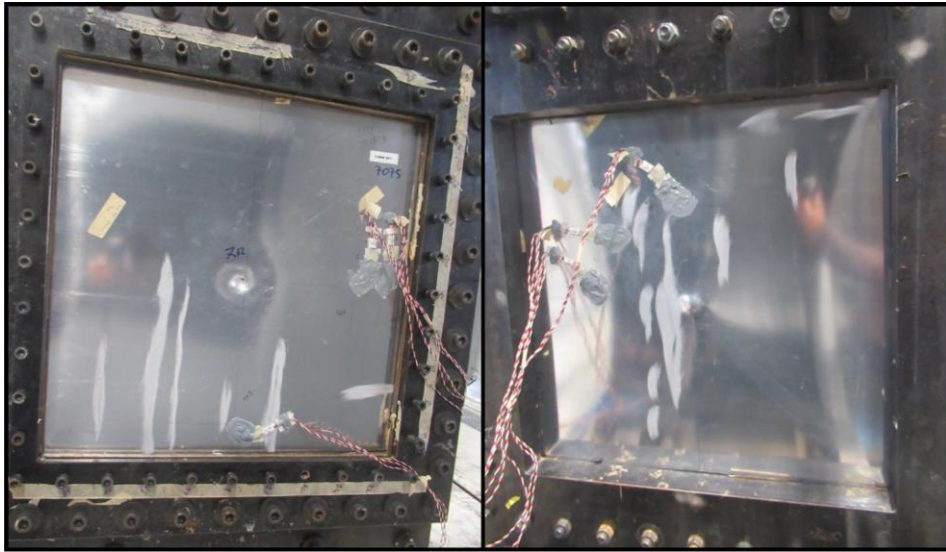
2.2. Çelik Küre Çarpma Test ve Analizi

Alüminyum 7075-T6 plakaların yüksek hızlı çarpma durumunda sergilediği dayanımı incelemek adına gaz tabancası yardımıyla çelik küre atışı gerçekleştirilmiştir. Çelik küre kullanılmasının ardındaki temel gerekçe, deney kapsamında odaklanılan ana olgunun alüminyum plakanın davranışı olmasından kaynaklı analiz ortamında mermiden gelecek belirsizlikleri ortadan kaldırmaktır. Çelik küre hedefe göre çok daha rijit bir davranış sergilemektedir. Bu kapsamda 1.6 mm kalınlığında 700mm X 700mm ölçülerinde alüminyum 7075-T6 plakanın orta noktasına gelecek şekilde 41.7 m/s hızında, 50.8 mm çapında çelik küre atışı gerçekleştirilmiştir. Gerçekleştirilen deney neticesinde çarpma noktasında oluşan kalıcı deformasyon miktarı ölçülmüştür. Plaka ön gerilmeli cıvatalar ile sıkıştırılmak suretiyle test düzeneği tarafından tutulmaktadır. Üç adet yüksek hızlı kamera ile ön, yan ve arka görünüm olacak şekilde görüntü kaydı alınmıştır (Görsel 2). Plaka üzerinde kalıcı deformasyon oluşmuş fakat herhangi bir kopma veya yırtılma gözlemlenmemiştir.



Görsel 2. Hızlı Kamera Görüntüsü

Görsel 2 incelendiğinde çarpma etkisi ile şok dalgasının yayılımı ve plaka sınırına ulaştıktan sonra sönümlendiği net bir şekilde gözlemlenmektedir. Plaka üzerine rozet tipi gerinim ölçerler yerleştirilerek çarpma etkisi ile plaka üzerinde oluşan gerinim değerleri veri toplama cihazı ile kaydedilmiştir. Deney sonucu plaka üzerinde oluşan hasar durumu Görsel 3’te verilmektedir.



Görsel 3. Çelik Küre Çarpması Sonucu Plaka Üzerinde Oluşan Deformasyon

Gerçekleştirilen çelik küre atışı LS-DYNA sonlu elemanlar yazılımı ile analiz ortamında tekrarlanmıştır. Çelik küre malzeme modeli olarak MAT1_Elastic kullanılmıştır. Çelik küre malzeme özellikleri Çizelge 1’de verilmiştir.

Çizelge 1. Çelik Küre Malzeme Özellikleri

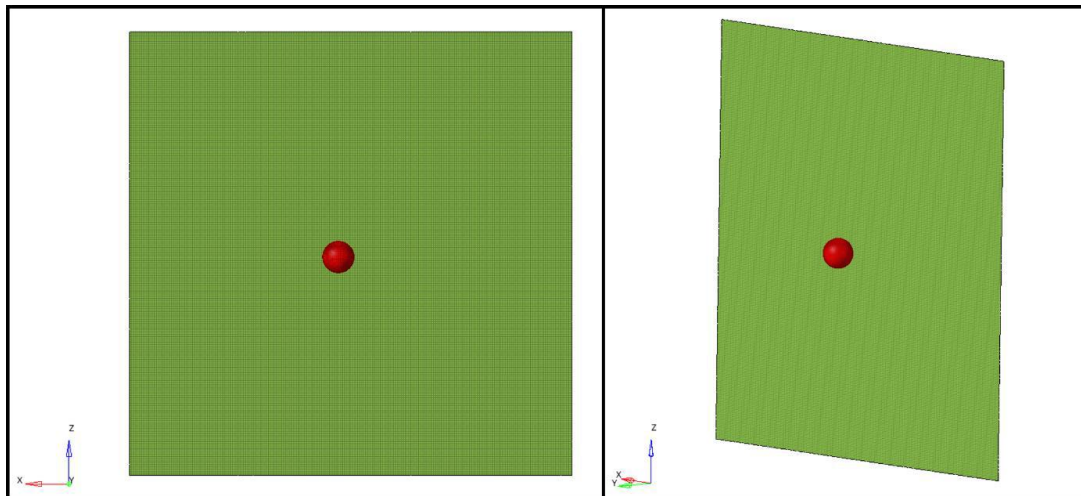
Yoğunluk (ton/mm ³)	8.04 e-09
Elastisite Modülü (MPa)	205000
Poisson Oranı	0.3

Deneyde kullanılan çelik kürenin kütlesi 546,6 gram olup 50.8 mm çapına sahiptir. Analiz ortamında eleman formülasyonu ELFORM 1 olacak şekilde, ortalama ağ boyutu 1 mm olmak üzere 28672 katı eleman ile temsil edilmiştir. Alüminyum plaka malzeme özellikleri ise açık kaynaktan alınmış olup [11] MAT98_Simplified_Johnson_Cook malzeme modeli kullanılmıştır. Alüminyum 7075 T6 için kullanılan Johnson Cook malzeme parametreleri ve elastik malzeme özellikleri Çizelge 2’de verilmiştir.

Çizelge 2. Alüminyum 7075 T6 Malzeme Özellikleri [11]

Yoğunluk (ton/mm ³)	2.7 e-09
Elastisite Modülü (MPa)	71000
Poisson Oranı	0.33
A (MPa)	546
B (MPa)	678
N	0.71
C	0.024
m	1.56

700 mm X 700 mm ölçülerinde 1.6 mm kalınlığındaki plakayı modellemek için 3 mm ağ boyutuna sahip ELFORM 16 formülasyonunda 54289 kabuk eleman kullanılmıştır. Her bir kabuk elemanda 5 adet integrasyon noktası bulunmaktadır. Çelik küre ve alüminyum plakayı içeren sonlu elemanlar modeli Görsel 4’te görülmektedir.

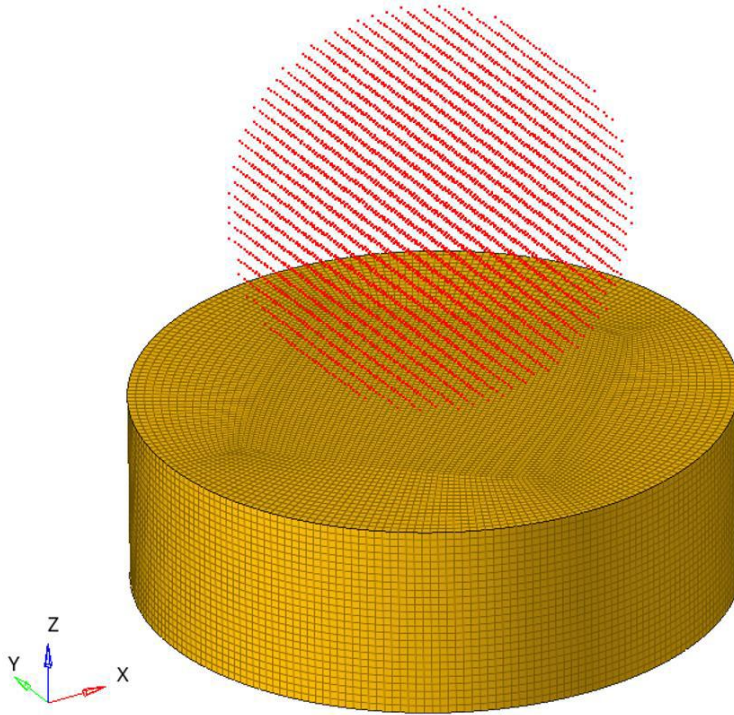


Görsel 4. Sonlu Elemanlar Modelinin Genel Görünümü

Çelik kürenin başlangıç hız ve konumu deney ile özdeş olacak şekilde modellenmiştir. Plaka üzerinde oluşan kalıcı deformasyon miktarı ve gerinim ölçerlerden elde edilen gerinim verileri analiz çıktısı olarak değerlendirilmiştir.

2.3. Buz Malzeme Modelinin Doğrulanması

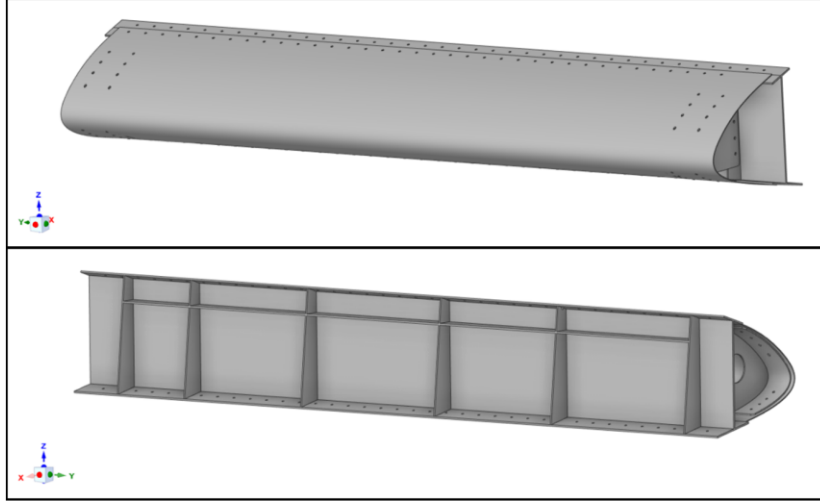
Açık kaynaklardan alınan buz malzeme modelinin doğruluk seviyesini ölçmek ve sayısal analizlerde kullanılacak SPH eleman sayısını belirlemek adına Tipmann'ın gerçekleştirmiş olduğu tez çalışmasında [12] yer alan rijit duvara buz çarpması deneyi LS-DYNA ortamında modellenerek sonuçlar irdelenmiştir. Deney kapsamında, 50.8 mm çapındaki buz küre gaz tabancası yardımıyla kuvvet ölçüm aparatı yerleştirilmiş, rijit kabul edilebilecek silindirik alüminyum plakaya 144.3 m/s hız ile atılmış ve iki gerinim ölçer yardımı ile Wheatstone köprüsü kurularak kuvvet değeri kaydedilmiştir. Buz modellemesi için SPH çözüm tekniği tercih edilmiştir. Ağ bağımsız bir yöntem olmasından kaynaklı yüksek darbe hızları etkisi ile katı elemanlarda yüksek sıkışma nedeniyle görülen negatif hacim hatasının önüne geçmek ve buzun sıvılaşma davranışını iyi temsil etmesi sebebiyle yöntemin uygun olduğuna karar verilmiştir. Buz malzeme modeli olarak MAT_Plasticity_Compression_Tension_EOS kullanılmıştır. Şekil değiştirme hızı hassasiyetli bir malzeme modeli olmasından kaynaklı kullanımı tercih edilmiştir. Kullanılan MAT155 Malzeme özellikleri açık kaynaktan alınmıştır [13]. Çekme yükü altında şekil değiştirme hızından bağımsız olacak şekilde modellenmiştir. 76.2 mm çap ve 25.4 mm kalınlığa sahip alüminyum plaka için malzeme modeli olarak rijit kabulünden dolayı MAT_Elastic kullanılmıştır. Alüminyum plakayı modellemek için 186000 elemandan oluşan ELFORM 1 katı elemanlar kullanılmıştır. Ağ boyutu merkezde sık bir hal alacak şekilde ortalama 1 mm alınmıştır. Sınır koşulu olarak plakanın sabitlendiği alt yüzeyden 6 serbestlik derecesinde kısıtlama verilmiştir. Modele ait genel görünüm Görsel 5'te verilmiştir.



Görsel 5. Sonlu Elemanlar Modeli Genel Görünümü

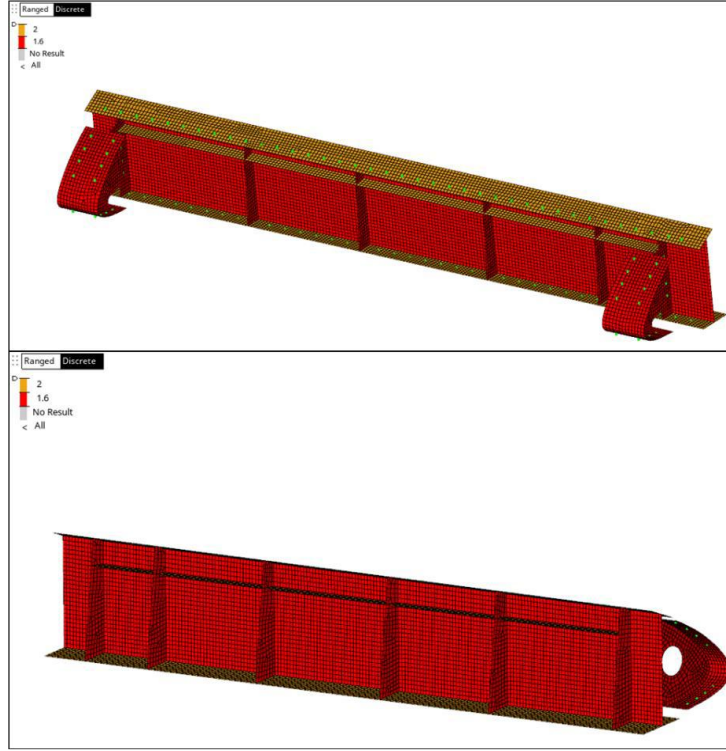
2.4. Kanat Hücüm Kenarı Tasarımı ve Dolu Çarpması Analizi

Çalışma kapsamında çeşitli uçakların hücüm kenarı tasarımları incelenmiş ve bunlardan ilham alınmak suretiyle temsili bir metalik kanat hücüm kenarı tasarımı gerçekleştirilmiştir. Tasarımı tamamlanan hücüm kenarına tekli ve çoklu dolu çarpması durumunda yapısal dayanım incelenmiştir. Hücüm kenarı tasarımı kiriş, kabuk ve 2 adet kanat kaburgası olmak üzere toplamda 4 ana parçanın 116 adet alüminyum perçin ile montajlanmasından oluşmaktadır. Tasarıma ait genel görünüm Görsel 6’da verilmektedir.



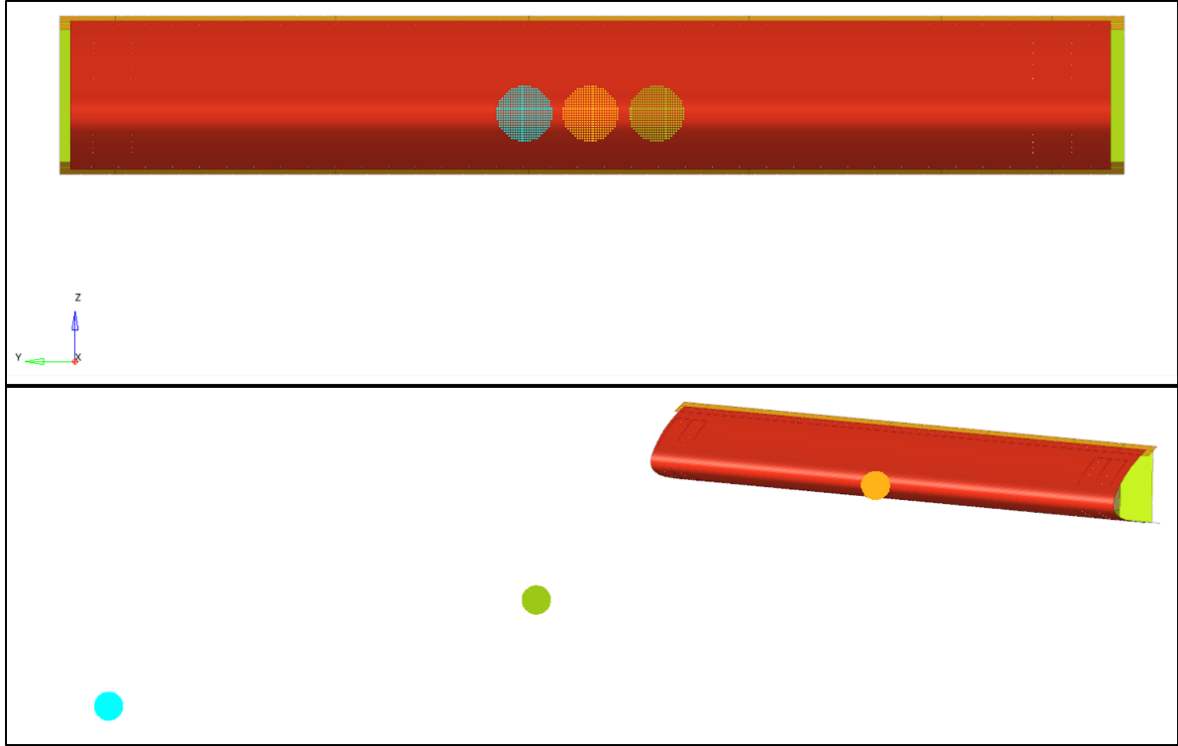
Görsel 6. Kanat Hücüm Kenarı Tasarımı

Hücüm kenarına ait sonlu elemanlar modeli ELFORM 16 formülasyonunda 85462 adet kabuk elemandan oluşmaktadır. Doğrudan çarpma yüzeyini temsil ettiğinden dolayı kabuk ağ boyutu sık tutularak 2 mm olacak şekilde modellenmiştir. Geriye kalan parçaların tamamında ağ boyutu 5 mm olacak şekilde modelleme gerçekleştirilmiştir. Sınır koşulu olarak hücüm kenarının kanata bağlanması için tasarlanan kiriş alt ve üst flanşında yer alan bağlayıcı deliklerinden, tüm serbestlik dereceleri kısıtlanmıştır. Kaburga ve kabuk malzemesi olarak daha önce deneysel çalışmalar ile doğrulanmış Al7075 T6 kullanılmıştır. Alüminyum plaka doğrulama çalışmalarında kullanılan malzeme parametreleri sabit tutulmak suretiyle MAT98 Simplified_Johnson_Cook malzeme modelinden faydalanılmıştır. Kabuk kalınlığı 1.6 mm olacak şekilde tasarım gerçekleştirilmiştir. Hücüm kenarı sonlu elemanlar modeline ait genel görünüm ve kabuk dışında kalan parçaların kalınlık bilgisi Görsel 7’de verilmiştir.



Görsel 7. Hücum Kenarı Sonlu Elemanlar Modeli

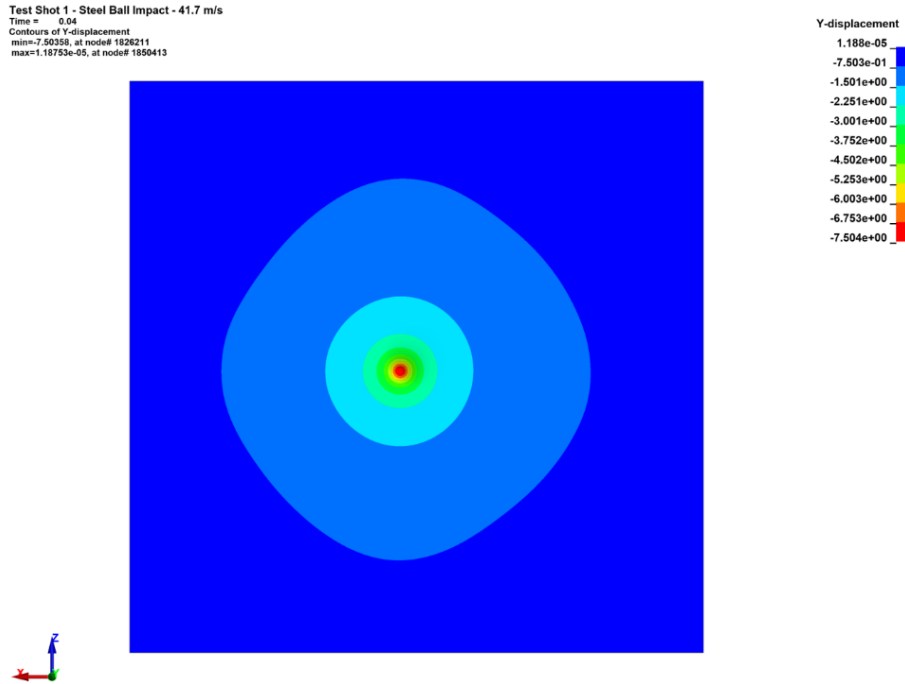
Sonlu elemanlar modeli oluşturulan hücum kenarına iki farklı konfigürasyonda dolu çarpması durumunda oluşan yapısal hasar incelenmiştir. İlk olarak tek bir dolu tanesinin çarpması durumunda oluşan hasar incelenmiş olup ardından üç farklı dolu tanesinin ardışık çarpması durumunda hücum kenarı üzerinde ne gibi bir hasara sebebiyet verdiğini gözlemlemek adına sayısal analizler gerçekleştirilmiştir. Analiz kapsamında 50.8 mm çapında ve 61.8 gram ağırlığındaki her bir buz küresine 150 m/s başlangıç hızı tanımlanmıştır. Dolu çarpması durumunda oluşabilecek en kötü hasar senaryosunu değerlendirmek adına buz küresi kaburgalardan en uzak noktada olacak şekilde, kabuğun en desteksiz kaldığı konum olan iki kaburganın ortasında kalan noktada yatayda konumlandırılmıştır. Dikeyde ise kabuğun eğrilik noktasına isabet edecek şekilde konumlandırılmıştır çünkü çarpma açısı en dik açıya bu konumda sahiptir. Çarpma açısı azaldıkça yapı üzerinde oluşacak kuvvette azalmaktadır. Buna ek olarak bir miktar daha yukarı veya aşağı gerçekleştirilecek atışlarda buz küresi çarpışma anında sıvı davranışı gösterdiğinden dolayı geometriyi takip ederek tüm enerjisini hedefe aktarılamadan sekecektir. Tekrarlı dolu çarpması sonucu oluşacak hasarı değerlendirmek için oluşturulan sonlu elemanlar modeline ait genel görünüm Görsel 8’de verilmiştir.



Görsel 8. Tekrarlı Dolu Çarpması Sonlu Elemanlar Modeli

3. SONUÇLAR VE DEĞERLENDİRME

Gerçekleştirilen çelik küre atışını temsil eden sayısal analizler sonucunda plaka üzerinde oluşan deplasman değeri 7.504 mm olarak hesaplanmıştır (Görsel 9).



Görsel 9. Plaka Üzerinde Oluşan Kalıcı Deformasyon Miktarı

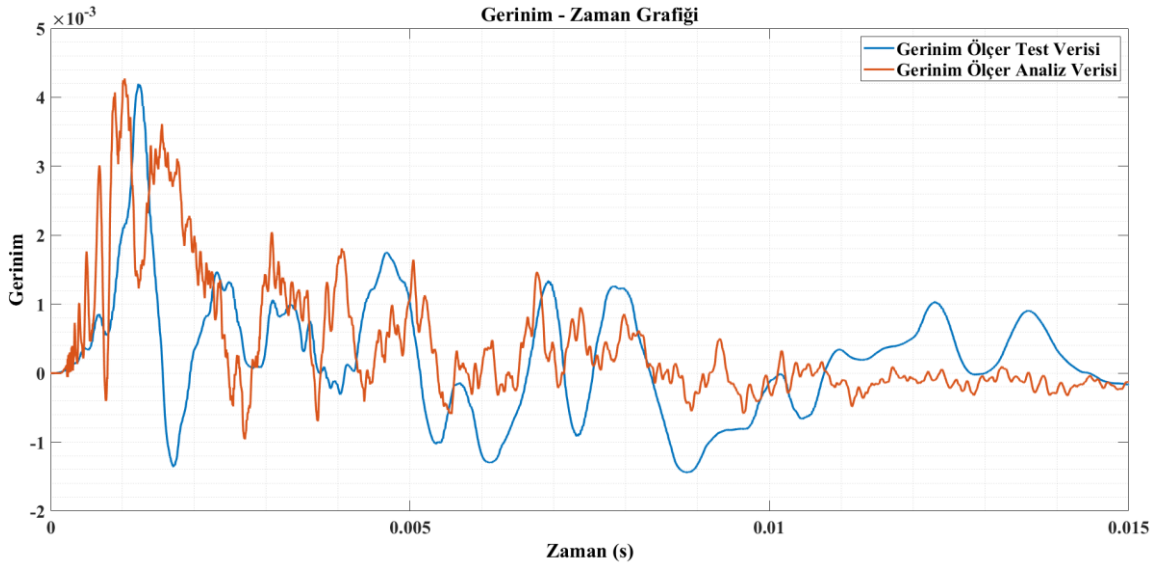
Kalıcı deformasyon değerini hesaplayabilmek için düğüm noktasının yer değiştirmesi durgun hale geldiğinden emin olacak sürede uzun bir analiz koşulmuştur. Şok dalgasının sönümlenmesinden sonra analiz bir süre daha devam ettirilerek durgun hale gelen yer değiştirme değeri kalıcı deformasyon miktarı olarak kabul edilmiştir. Analiz neticesinde hesaplanan kalıcı deformasyon miktarının deney sonucu ölçülen değerlerle kıyaslanması Çizelge 3’te verilmiştir.

Çizelge 3. Çelik Küre Atışına Ait Deneysel ve Sayısal Analiz Sonuçlarını

Mermi Çapı (mm)	Mermi Kütlesi (gram)	Çarpma Hızı (m/s)	Deney Sonucu Ölçülen Kalıcı Deformasyon Miktarı (mm)	Analiz Sonucunda Hesaplanan Kalıcı Deformasyon Miktarı	Hata Oranı (%)
50.8	546.6	41.7	7.42	7.50	1.06

Deneyssel çalışma kapsamında mermi hedefe çarptığı anda kinetik enerjinin tamamı yalnızca iç enerjiye dönüşmemektedir. Görece iç enerjiye oranla çok düşük olsa da kinetik enerjinin bir kısmı yüksek desibelli bir sese (akustik enerji), bir kısmı ise sürtünme nedeniyle ısıya dönüşmektedir. Analiz ortamında bu kayıplar ihmal edilmektedir. Bu sebepten dolayı sayısal analizler neticesinde elde edilen kalıcı deformasyon değeri deneysel değere göre bir miktar yüksek bulunmuştur. Fakat %2’nin altında kalan hata oranı problemin fiziğinin gayet iyi yansıtıldığını ve malzemenin doğru bir şekilde modellendiğini ispatlar niteliktedir.

Deneyde yerleştirilen gerinim ölçerin A bacağına ait deneysel ve sayısal analiz sonucunda elde edilen gerinim değerlerinin zamana göre değişimi Görsel 10’da verilmiştir.

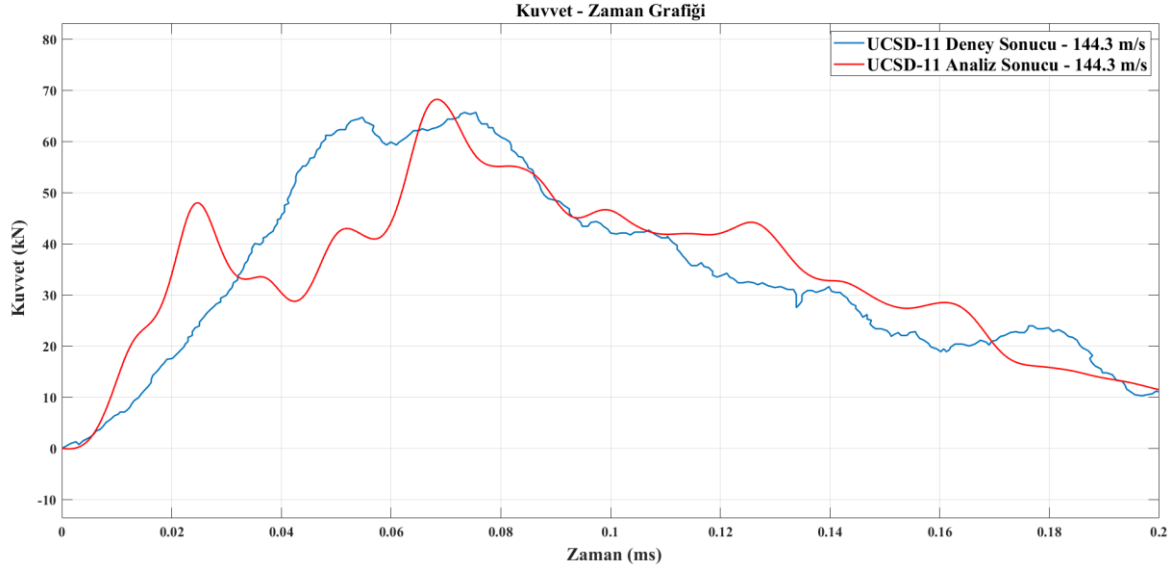


Görsel 10. Gerinim Ölçere Ait Gerinim Zaman Verisi

Görsel 10’da verilen gerinim-zaman grafiği incelendiğinde deneysel veride maksimum tepenin $t = 0.00122$ saniyede 0.00419 gerinim mertebesinde olduğu görülmektedir. Sayısal analizde bu değer $t = 0.00103$ saniyede 0.00427 mertebesinde hesaplanmıştır. Tepe genlikleri arasında %1.87 oranında bir hata payı olduğu gözlemlenmiştir. Şok dalgasının içerdiği yüksek

frekanslı etkiler gerinim ölçer konumuna gelene kadar analiz modelinde de gerçekçi bir şekilde sönümlenmiştir. Gerçekleştirilen çalışmalar neticesinde gerçekleştirilecek hücum kenarına dolu çarpması analizlerinde alüminyum malzeme modelinden kaynaklı herhangi bir belirsizlik olmadığı görülmüştür.

Buz malzeme modelini doğrulamak için gerçekleştirilen çalışmalar kapsamında UCSD-11 deney koşulları ile gerçekleştirilen analiz sonucunda elde edilen kuvvet-zaman grafiğinin deney sonuçlarıyla karşılaştırması Görsel 11’de verilmiştir.

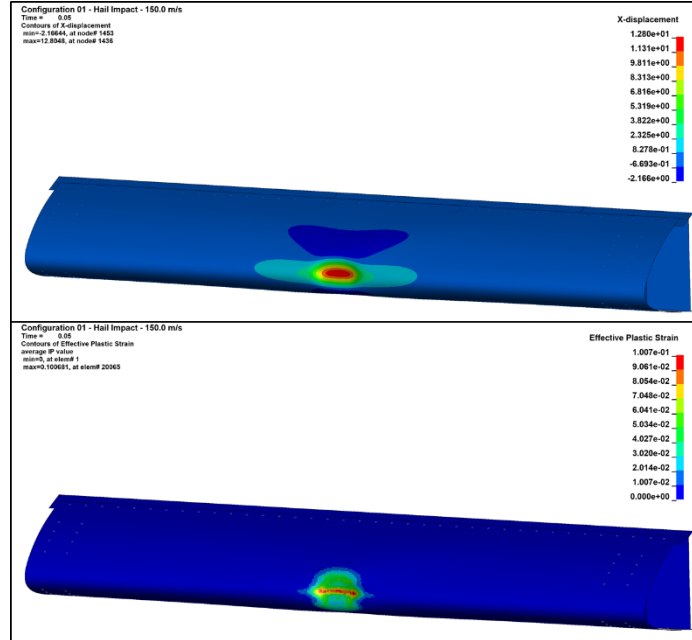


Görsel 11. UCSD 11 Kuvvet - Zaman Grafiği

Genel davranış iyi bir şekilde temsil edilmiş olmasına rağmen eğrinin belirli bölgelerinde malzeme modeli ve sayısal analizin doğası gereği bazı sapmalar mevcuttur. Analiz sonucu elde edilen eğride 0.03 ms civarında oluşan ilk tepe fiziksel bir davranıştan ziyade sayısal analizdeki temas algoritmasından kaynaklanan gerçek dışı bir olgudur. SPH gibi çok kolay deforme olabilen yüksek enerjideki bir mermi, hedef ile ilk temasa geçtiği anda temas algoritmasından kaynaklı yüksek bir tepki kuvveti açığa çıkmaktadır. Bu sebepten dolayı fiziksel bir gerçekliği temsil etmeyen bir tepe noktası oluşmaktadır. Deneydeki tepe kuvvetin oluşmaya başladığı 0.04 ms ile 0.06 ms’deki analiz sonuçları irdelendiğinde ise deney sonucu elde edilen tepe kuvvetin altında bir değer elde edildiği görülmüştür. Bu durum malzeme modelinin içerdiği hasar kriterlerine ulaşan elemanların yük taşıma kapasitesinin ani bir şekilde düşmesinden kaynaklanmaktadır. Gerçekte buz parçalanırken dahi parçacıklar arasındaki sürtünme ve atalet eylemsizliğinden dolayı bir süre daha hedefe yük aktarmaya devam etmesi beklenmektedir. Analiz sonucunda görülen bu kısmi düşüşün sebebi bundan kaynaklıdır. Deneyde maksimum kuvvet $t = 0.075$ ms’de 65.69 kN olarak ölçülürken, analiz sonucunda elde edilen maksimum kuvvet $t = 0.068$ ms de 68.25 kN olarak hesaplanmıştır. Deney ve analiz maksimum kuvvet sonuçları arasındaki hata payı %3.75 olarak hesaplanmıştır. Deney sonuçları ile analiz sonuçları arasındaki bu düşük yüzde hata seviyesi göz önüne alındığında test ve analiz sonuçlarının büyük bir doğrulukla yakınsadığı görülmüştür.

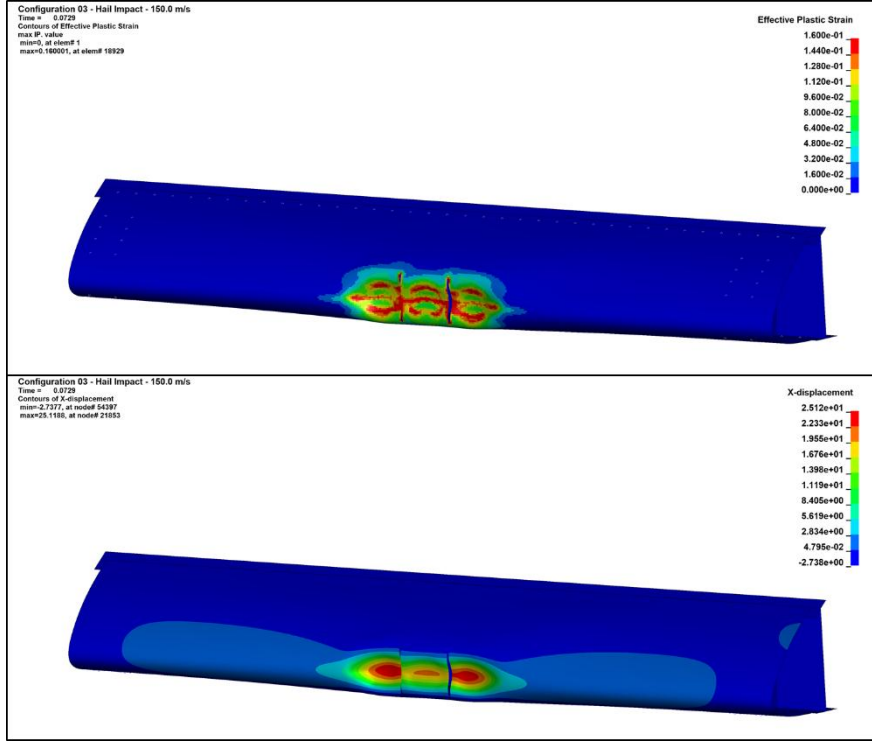
Hücum kenarına gerçekleştirilen dolu çarpması analizleri sonucunda kabuk üzerinde oluşan kalıcı deformasyon miktarı ve plastik gerinim değeri hesaplanmıştır. Analiz sonucunda ilk

çarpma anından sonra kabuk üzerinde hızlı bir sönümlenme olduğu görülmektedir. Düz plakanın aksine bu sönümün daha hızlı gerçekleşmesinin ardında yatan temel sebep geometri kaynaklı deforme olan yapının şok dalgasını daha erken sönümlenmesine sebebiyet vermesidir. Tek bir dolu tanesinin çarptığı analiz sonucunda hesaplanan kalıcı deformasyon miktarı 12.8 mm ve maksimum efektif plastik gerinim değeri 0.1007 olarak hesaplanmıştır (Görsel 12).



Görsel 12. Tek Dolu Çarpması Durumunda Oluşan Hasar Durumu

Çarpma sonucunda plastik deformasyon oluşmasına rağmen skin üzerinde herhangi bir yırtılma veya kopma söz konusu değildir. Üç özdeş dolu tanesinin ardışık bir şekilde hücum kenarına çarptığı analiz sonucunda hesaplanan kalıcı deformasyon miktarı 25.12 mm ve maksimum efektif plastik gerinim değeri 0.16 olarak hesaplanmıştır (Görsel 13).



Görsel 13. Tek Dolu Çarpması Durumunda Oluşan Hasar Durumu

Üç özdeş dolu tanesinin ardışık bir şekilde hücum kenarına çarpması tek bir dolu tanesinin çarpmasına göre daha yıkıcı bir etki yaratmıştır. Çökme birleşim noktalarında kabuk üzerinde yırtıklar oluşmuştur. Fakat buz parçacıkları kabuğun arka tarafına nüfuz etmemiştir.

4. GENEL DEĞERLENDİRME VE SONUÇLAR

Sonlu elemanlar analizleri kapsamında kullanılacak olan malzemelerin doğrulanması için gerçekleştirilen çalışmalar neticesinde hem alüminyum malzeme modelinin hem de buz malzeme modelinin sayısal analizlerde yüksek bir doğrulukla temsil edildiği görülmüştür. SPH metodunun problemin fizliğini yansıtmak için uygun bir yöntem olduğu buz malzeme modeli doğrulama çalışmalarında gözlemlenen deneysel ve sayısal analiz sonuçlarındaki yüksek uyum seviyesiyle görülmüştür. Gerçekleştirilen doğrulama çalışmalarının ardından tasarlanan hücum kenarının tekli ve çoklu dolu çarpması durumunda yapısal dayanımını incelemek adına sonlu elemanlar analizleri gerçekleştirilmiştir. Analizler neticesinde hesaplanan kalıcı deformasyon miktarları kıyaslandığında tekrarlı dolu çarpması durumunda oluşan kalıcı deformasyon miktarının, tek bir dolu çarpması durumuna göre %49 oranında arttığı görülmüştür. Netice itibarıyla, tasarım aşamasında tekrarlı dolu çarpması analizlerinin tek bir dolu atışından daha büyük hasar potansiyeli olduğu ve mutlaka değerlendirilmesi gerektiği görülmüştür.

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TECHNOLOGICAL PERFORMANCE OF PLYWOOD PRODUCED FROM HEAT TREATED BEECH VENEERS

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ABSTRACT

In this study, beech veneers intended for plywood production were subjected to a heat treatment (HT) process in a high-temperature, steam environment prior to production. The effect of this HT on the technological properties of the resulting beech plywood panels was then investigated. Urea-formaldehyde (UF) adhesive was used as the adhesive in plywood production. The physical properties of the produced plywood, moisture content (MC), density, water absorption (WA), and thickness swelling (TS) as well as the mechanical properties, modulus of rupture (MOR), modulus of elasticity (MOE), and shear strength (SS) were calculated. It was determined that statistically significant changes occurred in the physical and mechanical properties of the beech plywood as the heat treatment temperature (HTT) increased ($p < 0.05$). HT in a steam environment had a positive effect by reducing the MC and improving the dimensional stability of the beech panels. In particular, the MOR and SS values decreased significantly compared to the control samples. The MOE, however, was less affected than the other mechanical properties. In light of these results, it has been demonstrated that subjecting beech veneers to HT at high temperatures requires careful evaluation in terms of physical and mechanical performance in the production of plywood using UF adhesive. Therefore, it is recommended that the HTT be optimized according to the intended use of the plywood; in particular, when HT is applied at high temperatures, the type of adhesive, adhesive amount, pressing conditions, and veneer surface properties should be evaluated collectively.

Keywords: Beech, plywood, urea-formaldehyde adhesive, heat treatment, physical and mechanical properties

1. INTRODUCTION

Plywood is an important engineered wood product developed to reduce the limitations of solid wood which depend on its dimensions, shape, and grain direction and to make more efficient use of the wood. Produced by layering thin wood veneers with their grain directions perpendicular to one another and bonding them with adhesive under heat and pressure, plywood acquires properties such as a high strength-to-weight ratio, dimensional stability, rigidity, resistance to cracking and splitting, and good fastener-holding capacity (APA, 2026; Costa et al. 2024). Thanks to these properties, plywood has become a versatile material of choice in construction, furniture, transportation and packaging, molding, and various industrial

applications. Furthermore, the fact that wood-based panels can provide higher resource efficiency under appropriate usage conditions and serve as an alternative to some energy-intensive materials is considered one of the factors supporting the growing interest in plywood (Costa et al. 2024).

The Eastern Beech (*Fagus orientalis* Lipsky) forests found in Turkey cover an area of approximately 1.9 million hectares. According to 2024 data, the Oriental beech accounts for approximately 8.15% of Turkey's total forest area of 23.36 million hectares and ranks fourth among the country's major native tree species in terms of distribution area (GDF, 2025). Due to its high density and mechanical properties, it is one of the important tree species used in plywood production (Birinci 2022; Bektaş et al. 2002). Plywood made from high-density tree species is also expected to have high mechanical properties. In fact, it has been reported that plywood made from beech wood not only has a high density but also higher MOR, MOE, and SS compared to plywood made from some low-density species (Birinci 2022). Especially in applications that require high strength, choosing plywood with high mechanical properties increases the importance of high-density tree species like beech in plywood production (Örs et al. 2002; Birinci 2022).

Wood has a wide range of uses because it is a renewable, low-density, and easily workable material. However, its hygroscopic and anisotropic nature causes some significant usage limitations. Changes in the temperature and relative humidity of the environment lead to dimensional changes in wood due to its moisture exchange. Over time, these changes can cause cracking, deformation, and performance loss. Additionally, wood is particularly sensitive to decay from fungi, insects, and other biological factors, especially under unsuitable usage conditions. To reduce these negatives, various wood preservation and modification methods such as impregnation, chemical modification, acetylation, furfurylation, and thermal modification have been developed. The main goal of these methods is to increase wood's dimensional stability, durability, and lifespan by reducing its moisture-related issues and sensitivity to biological decay (Zelinka vd. 2022).

Among these methods, HT has gained significant interest in the industry because it is cost-effective, environmentally friendly, and does not use any chemicals (Yang et al. 2017; Chien et al. 2018; Auriga et al. 2020). Also, HT helps to modify the wood's properties through controlled temperature application. Commercial heat modification processes are generally carried out in the temperature range of 160–240 °C. As a result of HT, wood's hygroscopicity decreases (Borrega and Kärenlampi 2010; Ding et al. 2011), while its dimensional stability and resistance to biological decay can increase (Gao et al. 2016; Altgen et al. 2018; Hill et al. 2021). However, higher treatment temperatures can accelerate thermal degradation of the wood's main components, especially hemicelluloses, leading to mass loss and a reduction in some mechanical properties. Therefore, in determining the conditions for HT, it is necessary to consider the balance between dimensional stability and durability gains and potential losses in mechanical properties (Hill et al. 2021; Zelinka et al. 2022).

In this context, it is important to evaluate not only the positive effects of HT on the properties of wood but also the potential losses in properties at high temperatures, especially in terms of

the performance of panel products. In this study, plywood panels were manufactured from beech (*Fagus orientalis* Lipsky.) veneers treated at different temperatures (180, 190, and 200 °C) using urea-formaldehyde (UF) adhesive, and the effect of the HTT on the physical and mechanical properties of the panels was investigated. The results aim to reveal the impact of HTT on the performance of beech plywood and help determine the appropriate processing temperature.

2. MATERIALS AND METHODS

2.1. Material

Beech veneers used in plywood production were obtained from Bayrak Plywood Forest Products' factory located in Sakarya. The beech veneers were produced using the peeling method, with an industrial production standard thickness of 1.4 mm. Before plywood production, the veneers were subjected to thermal treatment at different temperatures (180, 190, and 200 °C) for 90 minutes. The MC of the veneers coming out of the thermal treatment oven ranged between 4-6%. The thermal treatment applied to the veneers was carried out in a computer-controlled, 1 m³ capacity thermal treatment oven with a steam environment, where the temperature was adjusted with a precision of $\pm 1^{\circ}\text{C}$. After the HT, the beech veneers were placed in a conditioning room with $65 \pm 5\%$ relative humidity and a temperature of $20 \pm 2^{\circ}\text{C}$, and conditioned for 3 weeks.

2.2. Method

For gluing the coating panels, E1 class 55% UF glue with free formaldehyde content was used. As a hardener, 20% NH₄Cl was used and added at a rate of 10% of the solid glue in all applications. To prevent gluing errors that could arise from viscosity changes, the glue solution was prepared in an amount sufficient to produce two plywood panels for each HT application. The HT and plywood production parameters used in the study are given in Table 1.

Table 1. Heat treatment (HT) and plywood production parameters.

HT temperature (°C)	HT time (min)	Outer and middle layer tree species	Veneer thickness (mm)	Pressure temperature (°C)	Press pressure (kg/cm ²)	Pressing time (min)
Control	-	Beech	1.4	130	10	4
180	90	Beech	1.4	130	10	4
190	90	Beech	1.4	130	10	4
200	90	Beech	1.4	130	10	4

The gluing process was applied to one side of the veneer at 150 g/m². The plywood were pressed in a single-layer, lab-type hydraulic press that is electrically heated. The pressing pressure was 10 kg/cm² and the pressing time was 4 minutes. For each application, two panels

of approximately 500 x 500 x 4.5 mm in three layers were produced. After production, the panels were stacked on top of each other and weights were placed on them to prevent warping. The physical properties of beech plywood panels, such as moisture content (MC) (TS EN 322 (1999)), density (TS EN 323 (1999)), water absorption (WA), and thickness swelling (TS) (TS EN 317 (1999)), were carried out in accordance with the standards. For determining the MC of the panels, 5 samples were prepared, while 15 samples were prepared for the other tests. All test samples used to determine the physical properties were prepared in sizes of 50 x 50 x panel thickness mm (Fig. 1).

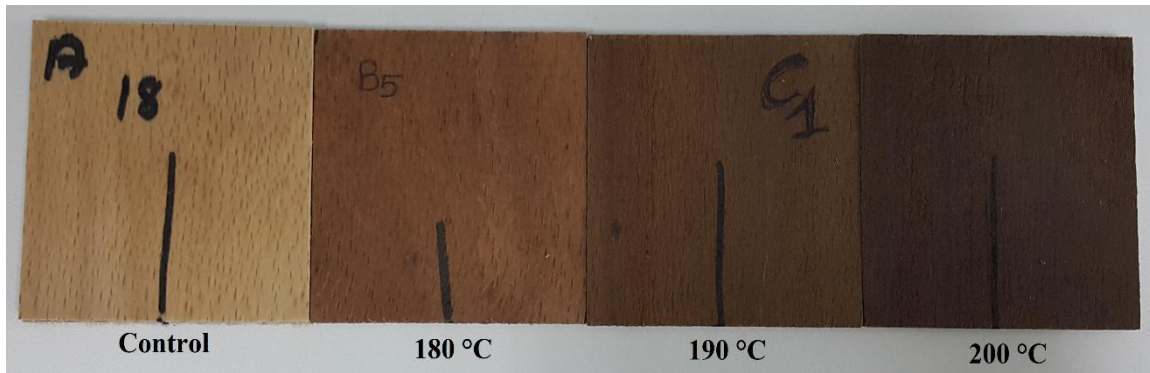


Fig. 1. Control and test samples used in physical analyses.

TS EN 310 (1999) standard was used to determine the modulus of rupture (MOR) and modulus of elasticity (MOE) of the manufactured plywood. Test samples with the outer layer grain direction parallel to the long edge of the sample were prepared in the workshop, with a width of 50 mm and a length of 20 times the nominal thickness + 60 mm. According to TS EN 310 (1999), the minimum length of the standard sheet to be used in tests must be 150 mm. The test samples were conditioned in a climate chamber for 3 weeks at 65%±5 relative humidity and 20±2°C until they reached a constant weight.

The adhesion (shear strength) test for plywood was carried out according to the principles specified in TS 3969 EN 314-1 (1998), and the results were evaluated according to TS EN 314-2 (1999). The SS samples taken from the conditioning chamber were tested after being immersed in water at a temperature of 20±3°C for 24 hours.

2.3. Statistical Analysis

The data were analyzed using the SPSS 22 statistical software. The confidence level for all comparisons was set at 0.05 (95%). For each experiment conducted, whether there were statistically significant differences between the three applied temperatures (180, 190, and 200 °C) and their respective control groups was determined using one-way analysis of variance (ANOVA). If significant differences between groups were found as a result of the ANOVA, the Duncan test was applied.

3. RESULTS AND DISCUSSION

3.1. Physical Properties

The physical properties of beech plywood panels produced as a result of different HT processes applied to beech veneers moisture content (MC), air-dried density, water absorption (WA) and thickness swelling (TS) rates along with simple analysis of variance and Duncan test results, are given in Table 2.

Table 2. Physical properties of beech plywood made from treated and untreated veneers.

Board Type	N	MC (%)	D (g/cm ³)	WA		TS		p- value
				2h (%)	24h (%)	2h (%)	24h (%)	
Control	15	8.29 a * (0.1)**	0.736 a (0.04)	23.5 a (1.3)	43.5 a (1.2)	7.9 a (1.0)	11.8 a (0.9)	0.000
180 °C		6.91 b (0.2)	0.727 a (0.02)	15.5 b (0.9)	38.7 b (1.5)	5.1 b (0.9)	10.8 b (1.2)	
190 °C		6.44 c (0.2)	0.706 b (0.05)	14.9 b (1.3)	37.3 c (1.2)	4.8 b (0.7)	9.6 c (0.7)	
200 °C		5.67 d (0.2)	0.685 c (0.03)	13.7 c (1.0)	33.9 d (1.2)	3.2 c (0.6)	7.6 d (0.9)	

*: The means shown with the same letters in each column are statistically indistinguishable from each other ($p < 0.05$), **: standard deviation values are given in parentheses, N: number of samples (amount), MC: moisture content, D: density, WA: water absorption, TS: thickness swelling, h: hour.

It was understood from the simple analysis of variance results that the differences between the mean values of the plate types were statistically significant for each physical feature ($p < 0.05$). The Duncan test was performed to determine which groups these differences were between. Duncan's multiple comparison results show that this difference does not occur in the same way in all features. All groups, including the control, were statistically different from each other in terms of MC values (Table 2). In terms of density, there was no difference between the control samples and the plate groups treated at 180 °C, while the plates treated at 190 °C and 200 °C were found to be different from the others. Similarly, while there is no difference between the panel groups at 180 and 190 °C for 2h WA and TS values, all panel groups for 24h WA and TS values are different from each other. These results indicate that an increase in HTT especially leads to more noticeable differentiation in the physical properties of the panels after prolonged exposure to water.

The MC of beech plywood decreased from 8.29% in the control panels to 6.91%, 6.44%, and 5.67% after HT at 180, 190, and 200 °C, respectively (Table 2). Accordingly, compared to the control panel, the panels treated at 200 °C showed approximately a 31.6% decrease in equilibrium MC (Fig. 2). Density also decreased with increasing HTT; the control value of 0.736 g/cm³ dropped to 0.685 g/cm³ at 200 °C. This decrease is about 6.9%. A similar trend has been reported before in plywood made from heat-treated veneers. Chotikhun et al. (2023) reported that in plywood made from rubberwood veneers heat-treated between 160–190 °C,

density decreased as the temperature increased, and this decrease reached 8.22% at 190 °C. Another study reported that in *Pinus taeda* veneers heat-treated between 160–200 °C, plywood density changed initially but did not show a significant increase at higher temperatures (Ferreira et al. 2022). The results from these studies suggest that the density loss observed especially in the 190–200 °C range could be related to thermal degradation and mass loss occurring in wood components.

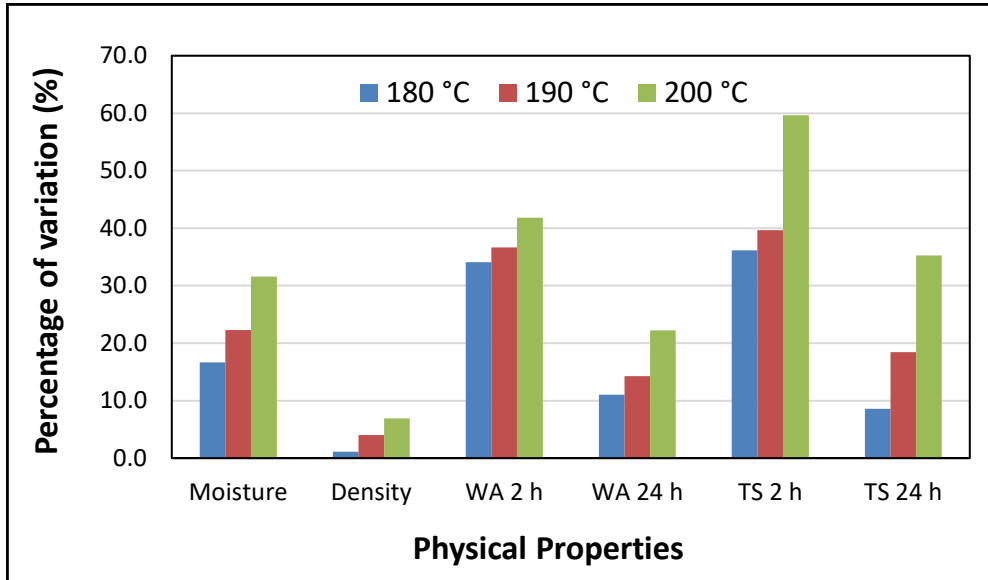


Fig. 2. The reduction rates in the physical properties of beech plywood test samples treated with heat compared to the control samples.

The WA and TS results show the most notable positive physical findings of the study. The 2h WA of the control boards was 23.5%, while it dropped to 13.7% at 200 °C, and the 24h WA went from 43.5% to 33.9%. Similarly, the 2h TS decreased from 7.9% to 3.2%, and the 24h TS went from 11.8% to 7.6% (Table 2). Thus, with HT at 200 °C, the 2h WA decreased by about 41.7%, the 24h WA by about 22.1%, the 2h TS by about 59.5%, and the 24h TS by about 35.6% compared to the control group (Fig. 2). These results indicate that heat-treated plywood improves its water resistance and dimensional stability. Chotikhun et al. (2023) reported that in plywood made from thermally treated rubberwood veneers at temperatures between 160–190 °C, the MOE and MOR values decreased as the HTT increased. The researchers attributed this to the reduction in wood's hygroscopicity from the HT and the decreased capacity for WA due to the reduction of hydroxyl groups. Hill et al. (2021) also noted that thermal modification lowers the wood's equilibrium MC and hygroscopicity, particularly due to the degradation of hemicelluloses and the reduction of accessible hydroxyl groups in the wood cell wall.

However, increasing the HTT can bring some drawbacks along with improvements in physical properties. Specifically, at applications of 200 °C and above, the accelerated degradation of wood components can lead to mass and density losses. Lovrić et al. (2017) reported that the MC decreases with the increase in temperature in plywood produced from poplar veneers that are heat-treated between 190–215 °C, but the density loss becomes evident in applications above 200 °C. The researchers considered the application of 215 °C to be extremely severe in

terms of coating properties. Similarly, Galdino et al. (2023) found that plywood produced from *Pinus taeda* veneers heat-treated between 160–200 °C generally reduced density and equilibrium moisture, correlating these variations with thermal degradation of wood components. These results support the lowest density and equilibrium humidity values determined in the current study at 200 °C and indicate that HT conditions at high temperatures should be carefully determined.

3.2. Mechanical Properties

Modulus of rupture (MOR), modulus of elasticity (MOE), and shear strength (SS) values of beech plywood sheets produced as a result of different HT treatments applied to beech veneers, ANOVA and Duncan test results are given in Table 3.

Table 3. Mechanical properties of beech plywood produced from heat-treated and untreated veneers.

Board type	N	MOR (N.mm ⁻²)	MOE (N.mm ⁻²)	SS (N.mm ⁻²)	p- value
Control	15	128 a (8.1)	11178 a (562)	3.28 a (0.54)	0.000
180 °C		117 b (8.6)	11245 a (547)	1.97 b (0.30)	
190 °C		112 b (8.0)	9647 b (655)	1.72 bc (0.53)	
200 °C		105 c (7.7)	9788 b (574)	1.46 c (0.18)	

Looking at the results in Table 3, it can be seen that the HTT has a statistically significant effect on all three mechanical properties ($p < 0.000$). There is no significant difference in MOR between the panels heat-treated at 180 and 190 °C. However, both types of panels differ from the control group and the panels treated at 200 °C. Applying HT at 180 °C does not cause a statistical change in MOE, but a significant decrease is observed starting from 190 °C. In terms of SS, there is a significant difference between the control group panels and all other heat-treated panel groups. Therefore, when considering all three properties together, 200 °C is the temperature where the most noticeable mechanical property loss occurs, while 180 °C stands out as the treatment that produces results closest to the control group, especially in terms of MOE.

While the MOR was 128 N/mm² in the control panels, it was 117, 112, and 105 N/mm² in the panels treated at 180, 190, and 200 °C, respectively. The total decrease in MOR compared to the control panels reached about 18.0% at 200 °C. The MOE, on the other hand, increased slightly from 11,178 N/mm² in the control panels to 11,245 N/mm² at 180 °C, showing an increase of around 0.6%. However, in the panels treated at 190 and 200 °C, this value decreased by 13.7% and 12.4%, respectively (Fig. 3). A similar temperature trend was reported by Chotikhun et al. (2023) in plywood made from rubberwood veneers. MOR and MOE values

peaked at 180 °C but showed a noticeable drop in both properties at 190 °C. On the other hand, Ferreira et al. (2022) reported that when *Pinus taeda* veneers were thermally treated at 160–200 °C, there was no statistically significant change in the MOR and MOE values of plywood panels. These different results suggest that the effect of thermal treatment on the mechanical properties of veneers does not depend solely on the treatment temperature-factors like the wood species used, the thermal treatment conditions, veneer characteristics, and differences in the adhesive system can also influence the mechanical performance of the panels (Galdino et al. 2023; Chotikhun et al. 2023). The limited increases in the MOE observed after thermal treatment are associated with the increased crystallinity of cellulose, condensation and cross-linking in lignin structure, and the effect of reduced equilibrium moisture on enhancing cell wall stiffness (Marcon et al. 2018; Bayani et al. 2019; Roszyk et al. 2020).

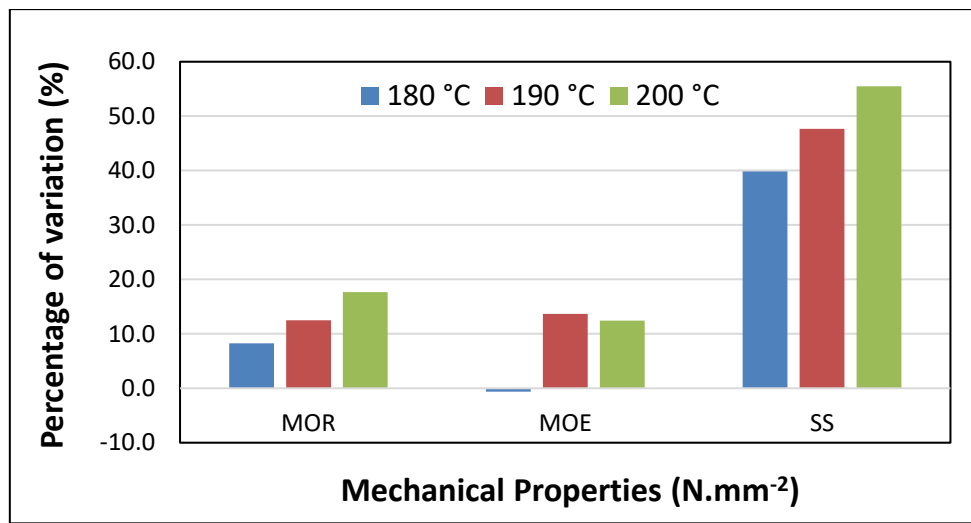


Fig. 3. The rates of decrease in mechanical properties of thermally treated beech plywood test samples compared to the control samples.

The change in SS is the most noticeable mechanical loss in this study. The value, which was 3.28 N/mm² in the control group, decreased to 1.97 at 180 °C, 1.72 at 190 °C, and 1.46 N/mm² at 200 °C. So, at 200 °C, there was roughly a 55.5% decrease compared to the control group. This drop is much higher than the 18% decrease in MOR. This suggests that the bonding interface becomes critical in terms of mechanical performance after HT. Indeed, Wascher et al. (2017) examined the bonding performance in plywood made from heat-treated and untreated beech veneers and reported that HT could negatively affect bonding strength. Similarly, Goli et al. (2014) looked at UF and MUF adhesives in plywood made from veneers that were heat-treated at 180–190 °C, and noted that the HT negatively affected both mechanical strength and adhesive quality. In particular, the adhesive line in sheets bonded with UF glue was more affected by the HT, which supports the loss of SS observed at high temperatures in the current study.

Regarding even higher temperatures, Bekhta (2020) mentioned that when plywood is exposed to temperatures above 175 °C, the losses in MOR and SS accelerate, and these losses are related to the increase in mass loss. Similarly, Chen et al. (2025) reported that the changes caused by high temperature applications in the wood structure could negatively affect its mechanical

properties. Considering these findings together, in the present study, although the physical properties improved at 200 °C, the decreases observed in mechanical properties are thought to be related to the changes high temperature causes in the wood structure and potential issues that may occur at the adhesion interface between the UF adhesive and the coating.

When the findings are evaluated together, it can be said that for plywood production using beech veneers and UF adhesive, the most suitable processing condition is a thermal treatment temperature of 180 °C. At this temperature, significant improvements in physical properties are achieved, while changes in density and mechanical properties remain more limited. On the other hand, despite improvements in physical properties, especially at 200 °C, there were significant losses in MOR and SS. Therefore, 180 °C is considered a more suitable temperature for beech veneers in terms of balancing physical gains and mechanical performance.

4. CONCLUSIONS

In this study, plywood panels were produced using beech veneers that had been thermally treated at various temperatures in a steam environment for 90 minutes. Some technological properties of the produced plywood sheets were examined.

- It has been found that the HTT has a significant effect on the physical and mechanical properties of plywood. As the HTT increases, changes in the hygroscopic nature of the wood improve the WA and TS properties of the sheets, which in turn enhances their dimensional stability.
- In terms of physical properties, the only parameter that showed a negative change with increasing HTT was the density.
- Regarding mechanical properties, it was observed that the increase in HTT did not follow the same trend as the improvements seen in physical properties. At moderate HTT (180 °C), there were limited increases in the MOE, but raising the temperature to higher levels resulted in a noticeable decrease in mechanical performance.
- It was determined that among the mechanical properties, the greatest decrease occurred in SS. As the HTT increased, the SS values decreased, and with the HT applied at 200 °C, the loss reached 55.5% compared to the control panels.
- Despite the improvement in physical properties resulting from the HT at 200 °C, significant losses in mechanical properties were observed. Therefore, when determining the HTT in plywood production, it is recommended to consider not only the improvements in dimensional stability but also the changes in mechanical performance.
- Overall, it was concluded that, in terms of balancing physical and mechanical properties, heat treating beech veneers at 180 °C is more suitable for producing UF-bonded plywood.
- In future studies, it is important to determine the effects of HT duration and glue spread rate on the performance of the boards. In addition, comparing the performance of different adhesive systems will contribute to evaluating the suitability of plywood made from treated veneers for different usage conditions.

- Furthermore, it is also recommended to examine the changes at the bonding interface in detail. Within this scope, evaluating SEM, FTIR, XRD, and surface free energy/wettability analyses together with mechanical and adhesion tests will help provide a more comprehensive explanation of the effects of HT on wood–adhesive interactions.

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ORTA TONAJLI SAVAŞ GEMİLERİNDE GÖREV PROFİLİNE BAĞLI HIZ DAĞILIMLARININ ANA TAHRİK SİSTEMİ PLANLI BAKIMLARINA ETKİSİ

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ÖZET

Orta tonajlı su üstü savaş gemilerinin ana tahrik sistemi, geminin farklı görevlerde ihtiyaç duyduğu hız ve güç gereksinimlerini karşılamaktadır. Savaş gemilerinin görev profillerine bağlı olarak farklı hız kademelerinde çalışması, ana makinelerin çalışma saatlerini ve planlı bakım gereksinimlerini etkilemektedir. Tahrik sistemi seçiminde performans, güç ve üretim maliyeti gibi parametrelerin yanında bakımların da dikkate alınması önem arz etmektedir.

Bu çalışmada, literatürden elde edilen verilerle oluşturulan jenerik bir su üstü savaş gemisinin barış durumunda görev profiline bağlı hız dağılımlarının dizel ve gaz türbini planlı bakım gereksinimlerine etkisi incelenmiştir. Sevk sistemini oluşturan CODAD, CODOG ve CODAG konfigürasyonları karşılaştırılmıştır. Operasyonlar, kısıtlı manevra ve intikal faaliyetlerini temsil eden görev profilleri dikkate alınarak makinelerin çalışma süreleri belirlenmiş ve gemilerin 35 yıllık yaşam döngü süresince sayaçlı planlı bakım süreleri hesaplanmıştır. Çalışmada jenerik referans dizel motor olarak yaygın kullanıma sahip MAN 16V175D, gaz türbini olarak ise GE LM2500 esas alınmıştır. Çalışma saatine bağlı bakımlar değerlendirilmiş, arıza kaynaklı bakımlar kapsam dışında bırakılmıştır.

Hesaplamalarda makineler için toplam bakım iş yükü elde edilmiştir. Tekil veya çoklu özdeş makine gruplarının eş zamanlı bakım imkânı dikkate alınmıştır. Bakım iş yükü ile bakım nedeniyle operasyon dışında kalınan süre birbirinden ayrı değerlendirilmiştir.

Gerçek durum şartları gibi nedenlerle görev-hız profillerindeki değişimin sonuçlara etkisini belirleyebilmek amacıyla farklı senaryolar ile duyarlılık analizi uygulanmıştır. Elde edilen sonuçlarda, gemilerin harekât ortamında hazır bulunuşluğunun maksimize edilebilmesi maksadıyla tahrik/sevk sistemi seçiminde görev profili ile planlı bakım faktörünün göz ardı edilmemesi gerektiği ortaya koyulmuştur.

Anahtar Kelimeler: Savaş Gemisi, Görev Profili, Tahrik Konfigürasyonu, Planlı Bakım Sistemi.

**ANALYSIS OF CONSTRUCTION ACTIVITY IN TÜRKİYE USING BUILDING
PERMIT DATA: STRUCTURAL BREAKS AND REGIME SHIFTS**

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ABSTRACT

In this study, regime shifts in construction output in Türkiye were examined using building permit data covering the period from Q1 2010 to Q1 2026. Monthly data obtained from the Turkish Statistical Institute's Building Permit Statistics were converted into quarterly series, and three indicators—the number of buildings granted planning permission, the number of flats, and total floor area—were analysed. A natural logarithmic transformation was applied to the time series, comprising a total of 65 quarterly observations, and seasonal effects were removed using the STL method. The Bai–Perron multiple structural break method was employed to identify the dates of regime shifts in construction output without pre-specifying them. The analysis identified two structural breaks in each of the three indicators, with the break dates estimated as 2017Q1 and 2019Q3. Taking into account confidence intervals and sensitivity analyses, the findings point to two break regions concentrated in the periods from late 2016 to 2017 and from 2019 to 2020, and to a common regime pattern characterised by expansion–contraction–recovery. Sensitivity analyses have shown that, whilst there are limited variations depending on the model parameters used for the break dates, the underlying regime pattern observed across the three indicators is generally preserved. The findings suggest that building permit indicators can be used not only to track the volume of permits issued, but also to monitor changes in the direction of construction activity over time and to identify common regimes emerging across different scales of production.

Keywords: Construction management, Building permit, Construction activity, Structural failure, Bai-Perron method

1. INTRODUCTION

The construction sector is one of the key economic sectors, involving not only the production of the physical environment but also significant investment, labour and material usage (Chen et al., 2026; Cossar et al., 2026; Tolentino-Zondervan & van Winden, 2026). Changes in the sector's production volume and production decisions directly affect construction management processes such as project organisation, resource allocation, capacity planning and supply scheduling. It is therefore important to monitor the development of construction production activity over time not only in terms of increases and decreases, but also in terms of permanent shifts in production trends (Otasowie et al., 2024).

The construction production process comprises the stages of investment decision, project development, planning permission, construction and completion (Bozkurt et al., 2024). Within this process, planning permission represents the stage at which the investment decision is formalised administratively and construction activities can legally commence. However, obtaining a building permit does not necessarily mean that construction work will commence or that the permitted building will be completed. Consequently, the building permit should be regarded not as a final output indicator measuring completed production, but rather as an indicator enabling the monitoring of trends in the early stages of construction activity (Özdemir, 2023).

This approach is also consistent with the definitions of international organisations and empirical studies. Eurostat (2026), whilst classifying building permits as early-stage indicators for monitoring recent activity in the construction sector, highlights that not every permit issued may translate into actual construction output (Eurostat, 2026). In the OECD's composite leading indicators system, *building permits* are also included among early-stage production indicators (Gyomai & Guidetti, 2012). In empirical studies, building permits have been used to track the quantitative response in housing supply (Aastveit et al., 2023). In Türkiye, data on building permits from the Turkish Statistical Institute (TSI) have been utilised to assess housing production and the supply-demand balance (Khurami Aksoy & Özdemir Sarı, 2022; Tanrıvermiş & Mendeş, 2023).

An examination of construction activity in Türkiye reveals that long-term development does not follow a uniform trend. Whilst Buyukyoran and Yaman (2024) highlight the cyclical characteristics of the Turkish construction sector, Aksoy Khurami and Özdemir Sarı (2022) highlight the contraction experienced in the 2018–2019 period following the high levels of output in 2014–2017, and the subsequent changes (Buyukyoran & Yaman, 2024; Khurami Aksoy & Özdemir Sarı, 2022). Such fluctuations necessitate an examination of construction activity within the framework of changing trends and regimes across different periods. However, there are few construction management-focused studies in Türkiye that analyse regime shifts through endogenous structural breaks by considering the indicators of the number of buildings, the number of flats and total floor area together in long-term quarterly building permit data.

Building on this gap, this study aims to identify regime shifts in construction output in Türkiye over the period 2010Q1–2026Q1 using building permit data. Within this framework, structural breaks in the time series for the number of buildings granted planning permission, the number of flats and total floor area are estimated endogenously using the Bai–Perron multiple structural break method, and the extent to which the regimes emerging in the three indicators coincide is examined. The identified break regions are subsequently compared temporally with sectoral and historical developments in Türkiye. This comparison is not intended to establish a causal relationship, and no specific event date is pre-defined as a break point in the model. Accordingly, the study seeks to answer the following research questions (RQ):

RQ 1. What are the underlying trends in construction output indicators based on building permits in Türkiye during the period 2010Q1–2026Q1?

RQ 2. Are there endogenous structural breaks in the series for the number of buildings, the number of flats and total floor area, and in which periods do these breaks occur most frequently?

RQ 3. To what extent do the break regions and construction production regimes identified by the three building permit indicators overlap?

RQ 4. How do the endogenously identified construction production regimes align temporally with significant sectoral and historical developments in Türkiye?

2. LITERATURE REVIEW

2.1. Building Permits and Monitoring of Construction Activity

Building permit statistics are one of the indicators used to track changes in the early stages of construction output. Eurostat (2026) assesses building permits as leading indicators of recent activity in the construction sector and notes that not all permits granted may translate into actual construction output (Eurostat, 2026). Similarly, Gyomai and Guidetti (2012) discuss *construction approval* data in an OECD report as one of the indicators used to monitor developments in the early stages of economic activity (Gyomai & Guidetti, 2012). In this context, approval data serve not so much as a measure of completed construction output, but rather enable the monitoring of changes in the stock of buildings expected to enter the production process.

In the empirical literature, building permits are also utilised, particularly in assessing changes in housing supply. Aastveit et al. (2020), whilst examining supply elasticity in regional housing markets, used building permits as one of the indicators of supply response and demonstrated that the permit response may vary depending on supply conditions (Aastveit et al., 2023). In Türkiye, Tanrıvermiş and Mendeş (2023) utilised TÜİK building permit and occupancy permit data to assess housing production and the supply-demand balance (Tanrıvermiş & Mendeş, 2023). Aksoy Khurami and Özdemir Sarı (2022), meanwhile, examined the temporal and spatial changes in housing production in Türkiye using indicators relating to building permits and housing production (Khurami Aksoy & Özdemir Sarı, 2022). Whilst these studies demonstrate that building permit data can be used to track production trends, it should also be borne in mind that permit data alone do not account for actual construction, completion, building quality or the regional distribution of production.

Another feature of building permit statistics is that they allow for the simultaneous monitoring of different dimensions of construction output. In this study, the number of buildings represents the number of structures under construction, the number of flats represents housing production capacity, and the total floor area represents the physical volume of authorised construction. The combined assessment of these three indicators makes it possible to examine changes in

construction activity not only in terms of the number of buildings, but also in terms of production capacity and physical volume.

2.2. Cycles and Structural Changes in Construction

Construction activities may exhibit periodic expansions and contractions in line with investment conditions, financing opportunities and changes in demand. Consequently, evaluating long-term building production series under a single linear trend may overlook changes in direction and trend that emerge in different periods. Studies conducted on Türkiye also indicate that building and housing production has encompassed periods that have diverged markedly over time.

Buyukyoran and Yaman (2024), in assessing the development of the Turkish construction sector since the 2000s, note that, alongside periods of expansion, the sector has exhibited a cyclical and fragile structure (Buyukyoran & Yaman, 2024). Aksoy Khurami and Özdemir Sarı (2022) demonstrate that, following the high levels observed in housing production during the 2014–2017 period, there was a marked decline beginning in 2018 and continuing into 2019, whilst production subsequently exhibited a fluctuating pattern (Khurami Aksoy & Özdemir Sarı, 2022). Tanrıvermiş and Mendeş (2023) also draw attention to the pressure exerted by the financial conditions that became more pronounced after 2018 on the housing production environment (Tanrıvermiş & Mendeş, 2023). Findings relating to the COVID-19 period, however, indicate that the impact did not occur in the same direction or to the same extent everywhere. Kaynak et al. (2021) demonstrated that the effects of the pandemic on the housing market in Türkiye varied across cities and regions (Kaynak et al., 2021).

Whilst this literature demonstrates that construction activity in Türkiye can exhibit varying trends across different periods, it is not, on its own, sufficient to establish a direct causal link between specific economic or social events and regime shifts in production. This distinction is important for the present study. Here, historical events are not pre-defined in the model as potential break dates; instead, breaks in the building permit series are first identified endogenously from the data, and the resulting break regions are then compared temporally with sectoral and historical developments.

2.3. The Structural Break Approach and Research Gap

Structural break methods are utilised to identify permanent changes in time series that cannot be observed under a single trend. Bai and Perron (2003) developed a comprehensive methodological framework that enables the endogenous estimation of the location and number of structural breaks, the determination of the number of breaks, and the calculation of confidence intervals for break dates. This approach allows for the identification of different regimes based on the series' own structure, particularly in studies where the break dates have not been pre-determined by the researcher. The method can be implemented in the R environment using the *strucchange* package developed by Zeileis et al. (2002; 2003) to conduct structural change tests and estimate break dates (Zeileis et al., 2002, 2003). The Bai–Perron

approach has also been used in studies relating to the housing market. For example, Cuestas and Kukk (2019) examined regime shifts in Spanish house prices through endogenous structural breaks (Cuestas & Kukk, 2020).

Whilst building permits, housing production and construction activities in Türkiye have been examined using various indicators and methods, studies focused on construction management that assess regime shifts in these indicators—by considering the number of buildings, the number of flats and total floor area together within long-term quarterly building permit series—through endogenous multiple structural breaks have remained limited. This study aims to contribute to filling this gap by examining the three complementary dimensions of construction output within the same timeframe and methodological framework. In this way, it is possible to determine whether the regimes emerging in the number of buildings, housing production capacity and physical production volume converge, and to assess the long-term change in construction output from a Construction Management perspective.

3. MATERIALS AND METHODS

3.1. Data Source and Research Variables

The data source for the study is the Turkish Statistical Institute (TSI) Building Permit Statistics (TSI, 2026). Monthly data covering the whole of Türkiye were used, and flow-type indicators were converted into quarterly series by summing the values for the relevant three-month periods. The analysis period is 2010Q1–2026Q1; for 2026, only data for the first three months were used. Consequently, 65 quarterly observations were obtained for each indicator.

The study utilised three indicators: the number of buildings granted planning permission, the number of flats, and the total floor area (m²) (Table 1).

Table 1. Data set and variable definitions

Indicator	Definition	Construction Management Interpretation
Number of buildings	Number of buildings granted building permits	Number of projects/buildings
Number of dwelling units	Number of dwelling units granted building permits	Residential/independent-unit capacity
Total floor area	Total floor area granted building permits (m ²)	Physical construction volume

From a construction management perspective, the number of buildings represents the number of structures granted planning permission, the number of flats represents residential production capacity, and the total floor area represents the physical production volume covered by planning permission. As these indicators reflect different dimensions of construction activity, each series was modelled separately, and the commonality of the resulting break periods and regimes was subsequently compared. The use of total values rather than averages in converting monthly data to quarterly frequency was preferred because the indicators are flow variables representing the volume of construction production authorised during the relevant period. The aim of analysing the three indicators together was to comparatively assess changes in construction production activity in terms of the number of buildings, housing capacity and physical volume.

The analysis is based on aggregated data for Türkiye as a whole. Whilst this approach enables the examination of regime shifts at the national level, it limits the ability to distinguish regional and provincial differences within the national series. This has been taken into account, particularly when interpreting the outcomes of developments whose impact is concentrated in specific regions, such as the earthquakes of 6 February 2023. Furthermore, macroeconomic variables have not been included in the model as explanatory variables. The aim of the study is not to estimate the causal effect of specific developments on building permits, but rather to identify regime shifts in construction output indicators endogenously and to examine the correlation between these indicators.

3.2. Data Pre-processing and Seasonal Adjustment

Preliminary analyses revealed that the three time series differed in terms of scale and variability, and that the ‘number of flats’ and ‘total floor area’ series, in particular, exhibited right-skewed distributions. To mitigate the effects of scale differences and heteroscedasticity, a natural logarithmic transformation was applied to the time series in the main analysis. Furthermore, pronounced quarterly seasonality was observed in all three indicators, and it was determined that fourth-quarter values were systematically higher. To minimise the risk of interpreting seasonal movements as structural breaks, the logarithmic time series were seasonally adjusted prior to the Bai–Perron analysis. The seasonal adjustment was carried out using the STL (*Seasonal-Trend decomposition using Loess*) method. Sum-of-sections decomposition was applied to all three series; the seasonal window was set to ‘periodic’ (s.window="periodic"), and the robust estimation option was set to ‘robust=TRUE’. The trend and low-pass filter windows were set to t.window=7 and l.window=5, respectively. The seasonally adjusted logarithmic series was obtained as shown below.

$$SA_{(\ln Y, t)} = \ln(Y_t) - S_t$$

Here, Y_t represents the observed value at time t ; S_t represents the seasonal component estimated by STL decomposition; and $SA_{(\ln Y, t)}$ represents the seasonally adjusted logarithmic series. Following the seasonal adjustment, the quarterly effects were re-examined, and it was determined that the systematic seasonal differences initially observed had largely disappeared. These seasonally adjusted series were used in the Bai–Perron analyses.

3.3. Bai–Perron Multiple Structural Break Analysis

The Bai–Perron multiple structural break approach was employed to identify regime shifts in construction output indicators without being constrained by pre-specified dates (Bai & Perron, 2003). This approach enables the endogenous estimation of the locations of multiple structural breaks within a time series and the division of the observation period into distinct regimes. The estimated model for each regime is as follows:

$$y_t = \alpha_j + \beta_j t + \varepsilon_t$$

Here, y_t denotes the seasonally adjusted logarithmic building permit index; t denotes the linear time trend; α_j denotes the regime-specific constant term; β_j denotes the trend coefficient for the same regime; and ε_t denotes the error term. By allowing the constant and trend coefficients to vary across regimes, the aim was to identify both level and trend changes in the series.

The analyses were carried out in the R environment using the `strucchange` package, and breakpoints were estimated using the `breakpoints()` function (Zeileis et al., 2002, 2003). The same model specification was applied separately to the seasonally adjusted logarithmic time series for the number of buildings, the number of flats and the total floor area.

In the main model, the minimum segment length was set at $h=10$, and the Bayesian Information Criterion (BIC) was used to select the number of breaks from among the candidate models. SupF results regarding structural instability were evaluated as supporting evidence. Confidence intervals were calculated to illustrate the uncertainty surrounding the estimated break dates. HAC-based covariance estimates were also utilised to ensure robust inferences against serial correlation and heteroscedasticity; the HAC approach was used not in determining the break dates, but in the stage of making robust inferences regarding the model coefficients.

As the choice of minimum segment length directly affects the shortest period that potential regimes may cover in the break analysis, the sensitivity of the value used in the main model was also tested. To this end, alternative model specifications were estimated by varying the minimum segment length, and the extent to which the main break structure was sensitive to this choice was assessed.

3.4. Robustness and Sensitivity Analyses

A series of sensitivity analyses were carried out to assess whether the main Bai–Perron results were overly dependent on model choices and specific observations. Firstly, the minimum segment length was varied to $h=7$, $h=10$ and $h=13$, and the estimated number of breaks, break periods and regime directions were compared for each specification. Secondly, the effect of the number of flats in 2017Q3—identified as an outlier during data examination—on the break results was assessed. The observation in the main data set was neither modified nor excluded from the analysis. Instead, the effect of this observation was reduced in an alternative series created solely for the purpose of sensitivity analysis, and it was examined whether the break structure identified by the Bai–Perron model was dependent on a single outlier. Finally, the PELT (*Pruned Exact Linear Time*) method was used to compare the Bai–Perron results with a different approach to identifying breakpoints. The analysis was carried out in the R environment using the changepoint package, based on mean changes. As the PELT approach has a different model structure to the Bai–Perron model used in this study—which allows for constant and trend changes—it was not considered an equivalent validation method. The aim of the analysis was to examine whether a different change-point approach would identify similar periods in the same time series.

4. FINDINGS

4.1. Descriptive Findings

Over the period from Q1 2010 to Q1 2026, the average of the raw quarterly series was calculated as 33,102.4 for the number of buildings, 212,242 for the number of flats, and 46,095,200 m² for the total floor area. The coefficients of variation were 0.322, 0.423 and 0.381 respectively; the variable with the highest relative variability within the period was the number of flats. The skewness values for buildings, flats and total floor area in the raw series, which were 0.621, 1.213 and 1.142 respectively, became -0.764 , -0.658 and -0.429 following logarithmic transformation. An examination of the quarterly distributions reveals that the highest average values for all three indicators occurred in the fourth quarter (Q4) (Table 2).

Table 2. Descriptive statistics of the raw quarterly series and Q4 seasonality

Indicator	Mean	CV	Raw skewness	Log skewness	Q4 mean
Number of buildings	33,102.4	0.322	0.621	-0.764	41,060
Number of dwelling units	212,242	0.423	1.213	-0.658	263,300
Total floor area (m ²)	46,095,200	0.381	1.142	-0.429	5.677×10^7

Figures 1–3 demonstrate that the three building permit indicators exhibited pronounced fluctuations throughout the study period. Whilst common trends in the time series became particularly evident during specific periods, the Bai–Perron analysis was used to test whether these visual changes corresponded to a structural regime shift.

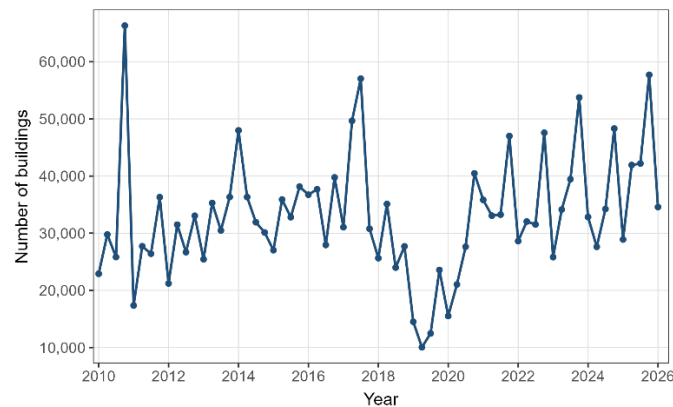


Figure 1. Change in the number of buildings granted planning permission over time, 2010Q1–2026Q1

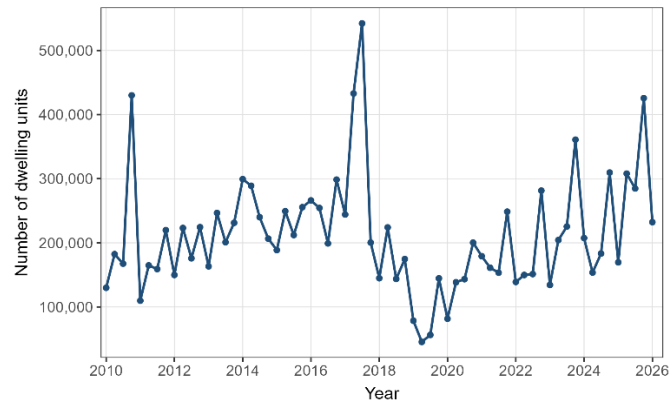


Figure 2. Change in the number of flats for which building permits were issued over time, 2010Q1–2026Q1

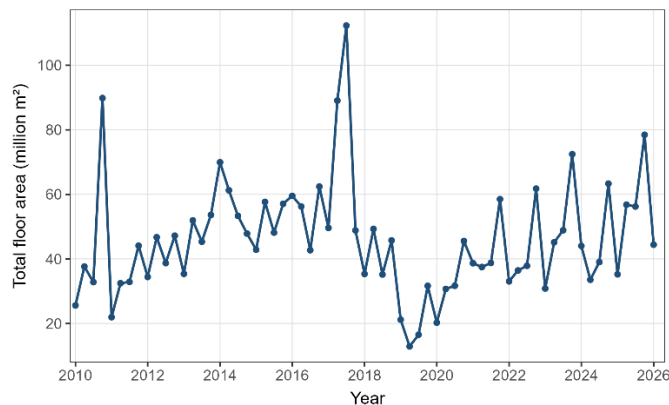


Figure 3. Change over time in the total floor area for which building permits were issued, 2010Q1–2026Q1

4.2. Findings on Structural Breaks

In the main Bai–Perron model ($h=10$, BIC), two structural breaks were identified for all three indicators. The point estimates of the breaks in the series for the number of buildings, the number of flats and the total floor area are identical, corresponding to the periods 2017Q1 and 2019Q3. The 95 per cent confidence interval for the first break is 2016Q3–2017Q2 for all three indicators. The confidence interval for the second break is 2019Q2–2020Q2 for the number of buildings, and 2019Q2–2020Q1 for the number of flats and total floor area (Table 3).

The SupF statistics were obtained as 41.33 for the number of buildings, 63.76 for the number of flats and 52.41 for total floor area, and the hypothesis of structural stability was rejected for all three series. The fact that both the point estimates and confidence intervals for the three indicators overlap to a large extent indicates that regime shifts in the number of buildings, housing production capacity and physical production volume occurred during similar periods. However, taking into account the uncertainty regarding the dates of the regime shifts, subsequent analyses have treated the first transition as occurring between the end of 2016 and 2017, and the second transition as occurring in the 2019–2020 regime shift region.

Table 3. Main Bai–Perron results and regime trends ($h=10$, BIC)

Indicator	m	Break 1 (95% CI)	Break 2 (95% CI)	SupF	R1 trend	R2 trend	R3 trend
Number of buildings	2	2017Q1 (2016Q3-2017Q2)	2019Q3 (2019Q2-2020Q2)	41.33	+0.0084	-0.1649	+0.0224
Number of dwelling units	2	2017Q1 (2016Q3-2017Q2)	2019Q3 (2019Q2-2020Q1)	63.76	+0.0150	-0.2345	+0.0337
Total floor area	2	2017Q1 (2016Q3-2017Q2)	2019Q3 (2019Q2-2020Q1)	52.41	+0.0185	-0.1981	+0.0253

Note: R1 = 2010Q1–2017Q1 ($n = 29$); R2 = 2017Q2–2019Q3 ($n = 10$); R3 = 2019Q4–2026Q1 ($n = 26$).

As shown in Figures 4–6, the breaks identified in the three indicators reveal a similar regime structure. The trend, which is positive in the first regime, turns negative in the second regime; following the second break, a positive trend re-emerges. The vertical dashed lines indicate the breakpoints, whilst the shaded areas represent the 95 per cent confidence intervals.

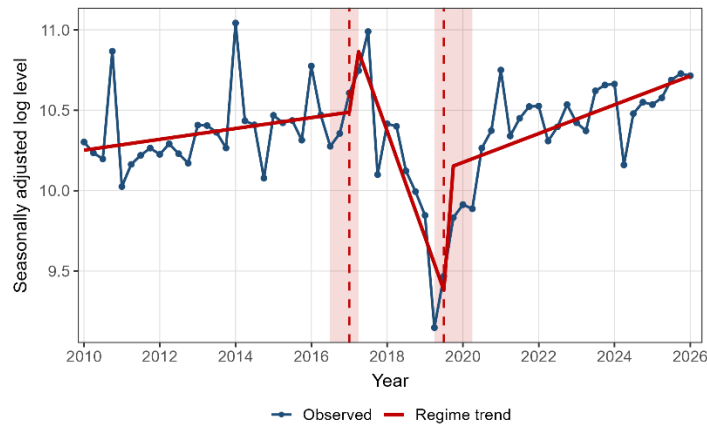


Figure 4. Bai–Perron regimes in the number of buildings time series ($h=10$, BIC)

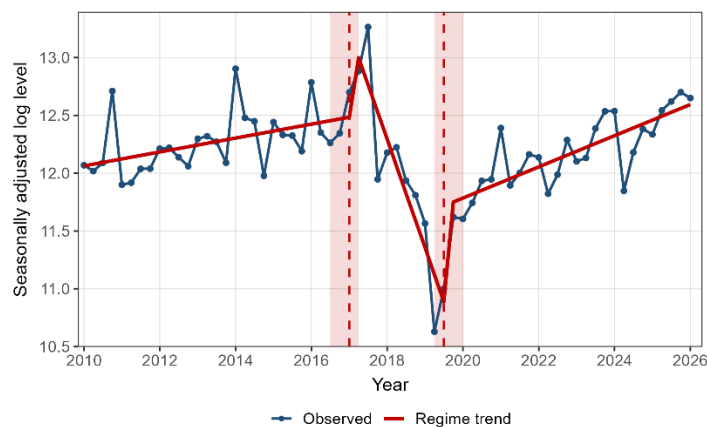


Figure 5. Bai–Perron regimes in the number of flats time series ($h=10$, BIC)

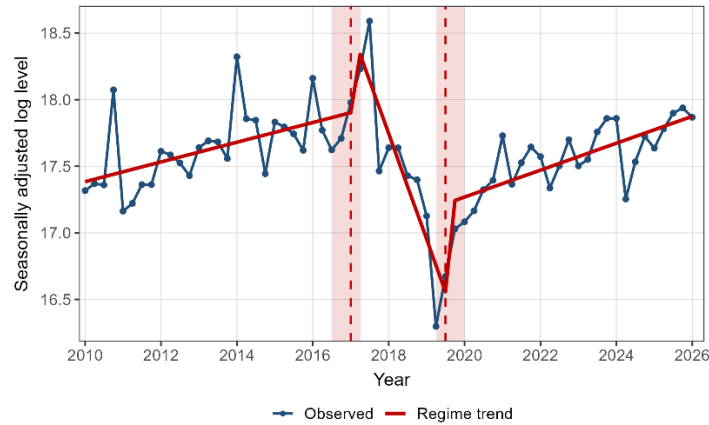


Figure 6. Bai–Perron regimes in the total floor area time series ($h=10$, BIC)

4.3. Comparison of Building Production Regimes

The results of the main model reveal a common pattern of expansion–contraction–recovery across the three building permit indicators. During the first regime, covering the period 2010Q1–2017Q1, the trend coefficients were +0.0084 for the number of buildings, +0.0150 for the number of flats, and +0.0185 for total floor area. The fact that all three coefficients are positive indicates that construction output indicators exhibited a moderate upward trend during this period. In the second regime, covering the period 2017Q2–2019Q3, the trend coefficients turned to -0.1649 , -0.2345 and -0.1981 respectively, and a marked contraction trend emerged in all three indicators. The annual changes calculated from the analysis dataset are also consistent with this shift in direction. The number of buildings, the number of flats and the total floor area decreased by 33.3 per cent, 51.6 per cent and 44.8 per cent respectively in 2018, and by 46.1 per cent, 52.7 per cent and 50.3 per cent in 2019. However, as the second regime consists of 10 quarters and is equal to the minimum segment length defined in the main model ($h=10$), the results relating to this regime required further evaluation through sensitivity analyses. The third regime covers the period 2019Q4–2026Q1. During this period, the trend coefficients were estimated at +0.0224 for the number of buildings, +0.0337 for the number of flats and +0.0253 for total floor area, with the trend turning positive again for all three indicators. Annual changes also indicate increases of 72.7 per cent, 73.5 per cent and 55.9 per cent respectively in 2020. These annual rates are provided to describe the level movements of the regimes and have not been used in place of the trend coefficients estimated using the Bai–Perron model.

No new structural break was identified in the main model between 2019Q3 and 2026Q1. Consequently, during the period when the earthquakes of 6 February 2023 occurred, no separate Bai–Perron regime emerged in any of the three national building permit indicators. This finding merely indicates that no separate structural break was detected in the aggregated series for Türkiye as a whole. The interpretation of the earthquakes' impact on building production activities is discussed in the Discussion section, taking into account the study's data scope and methodological limitations.

4.4. Robustness Findings

Varying the minimum segment length has shown that the regime structure identified in the main model is stable in some respects but sensitive to model selection in others (Table 4). When $h=7$ was used, the breaks in the number of flats and total floor area in 2017Q1 and 2019Q3 were retained, whilst three breaks were identified in the number of buildings: 2017Q1, 2019Q1 and 2021Q1. Under the more conservative $h=13$ specification, the breaks in the number of buildings shifted to 2016Q4 and 2020Q2, those in total floor area shifted to 2016Q4 and 2020Q1, whilst a single break was identified in the number of flats in 2018Q2. In the sensitivity analysis () regarding the outlier observation for the number of flats in 2017Q3, the two-break structure was retained and the breaks were estimated as 2016Q4 and 2019Q3. This result indicates that the regime structure identified in the main model was not caused by this single observation. In the PELT mean change analysis, however, no change points were identified for any of the three series under the standard penalty options used ($n_{cpts} = 0$). Consequently, the PELT results did not provide independent support for the breaks identified in the Bai–Perron model. However, as the PELT analysis is based on mean changes whilst the main Bai–Perron model is based on changes in the constant and trend terms, these results have not been interpreted as contrasting tests of the same model structure.

Table 4. Summary of robustness and sensitivity analyses

Robustness check	Number of buildings	Number of dwelling units	Total floor area	Interpretation
$h = 7$	2017Q1, 2019Q1, 2021Q1 ($m = 3$)	2017Q1, 2019Q3	2017Q1, 2019Q3	Main break dates retained for dwelling units and total floor area
$h = 10$ (main)	2017Q1, 2019Q3	2017Q1, 2019Q3	2017Q1, 2019Q3	Two common breaks across all three indicators
$h = 13$	2016Q4, 2020Q2	2018Q2 ($m = 1$)	2016Q4, 2020Q1	Break dates shift; two breaks merge for dwelling units
Outlier sensitivity (dwelling units)	—	2016Q4, 2019Q3 ($m = 2$)	—	Two-regime transition structure retained
PELT mean-change check	$n_{cpts} = 0$	$n_{cpts} = 0$	$n_{cpts} = 0$	No independent support

When sensitivity analyses are evaluated together, it can be seen that the exact break dates obtained in the main model are not entirely insensitive to the minimum segment length. Conversely, the transition zones around the end of 2016–2017 and 2019–2020, particularly in terms of the number of buildings and total floor area, are largely preserved across different minimum segment lengths. Consequently, the interpretation of the findings has been based on common break regions and the expansion–contraction–recovery regime pattern, rather than on individual quarters.

5. DISCUSSION

5.1. The End of 2016–2017 Breakpoint and the Transition to the Contraction Regime

The first common inflection point emerged during the period from late 2016 to 2017. The estimated point identified as 2017Q1 across all three indicators, together with the confidence

interval spanning 2016Q3–2017Q2, indicates that construction activity shifted from the positive trend in R1 to the negative trend in R2 during this period. However, the fact that the volume of building permits in 2017 exceeded that of 2016 suggests that this break should be interpreted not as a sudden drop in production but rather as a transitional period in which the trend changed direction. Indeed, Aksoy Khurami and Özdemir Sarı (2022) demonstrate that a marked decline emerged from 2018 onwards, following the high levels of production during the 2014–2017 period (Khurami Aksoy & Özdemir Sarı, 2022). Consequently, the findings indicate that the period from late 2016 to 2017 marks the starting point of the transition from expansion to contraction.

5.2. The Austerity Regime, 2017–2019

The fact that the trend coefficients for the number of buildings, the number of flats and the total floor area all turned negative during the R2 period indicates that the contraction occurred simultaneously across different dimensions of construction output. This trend is also consistent with the marked declines observed in all three indicators in 2018 and 2019. Studies examining housing and construction output in Türkiye highlight the deterioration in the production environment and financial pressures during the same period (Khurami Aksoy & Özdemir Sarı, 2022; Tanrıvermiş & Mendeş, 2023). However, as the confidence interval for the first break spans 2016Q3–2017Q2, 2018 should be regarded not as the start of the break, but as the period in which the contractionary trend that had begun earlier became more pronounced.

5.3. The 2019–2020 Turning Point and Recovery Phase

The second major turning point is the 2019–2020 period, when construction output shifted from a contractionary phase to a positive trend. Following this transition, the fact that the trend coefficients for all three indicators turned positive, coupled with a marked increase in the volume of building permits in 2020, supports the interpretation of a recovery phase. This finding is broadly consistent with that of Aksoy Khurami and Özdemir Sarı (2022), (Khurami Aksoy & Özdemir Sarı, 2022) who reported recovery trends in housing production in Türkiye following 2019. However, the shift in break dates observed in the $h=13$ sensitivity analysis suggests that the second transition should be interpreted not as a specific quarter but rather as the 2019–2020 break region.

5.4. Assessment of the COVID-19 Period

The identification of the second break in the main model as 2019Q3 indicates that the regime shift began prior to the COVID-19 pandemic. However, as the confidence intervals extend into 2020Q1/Q2, the pandemic period partially overlaps with the second transition zone. Previous studies have also shown that the effects of COVID-19 on the housing market and production dynamics in Türkiye were heterogeneous (Kaynak et al., 2021; Khurami Aksoy & Özdemir Sarı, 2022). Consequently, the findings do not rule out the sectoral impact of the pandemic; they merely demonstrate that the second regime shift in the national building permit series cannot be explained by COVID-19 alone.

5.5. The 6 February 2023 Earthquakes and the National Building Production Regime

No independent structural break was identified in the main model around the year 2023. The positive R3 regime that began in Q4 2019 continued until Q1 2026. This result does not imply that the earthquakes of 6 February 2023 had no impact on construction output. The use of aggregated data for Türkiye as a whole in this study may limit the extent to which the impact of the earthquakes, which was concentrated in certain provinces, manifests as a distinct regime shift in the national time series. Furthermore, the relatively short post-2023 observation period and the minimum segment constraint should also be taken into account when interpreting this result. Therefore, the finding should not be interpreted as the absence of an earthquake effect, but rather as the failure of a new regime specific to 2023 to emerge distinctly in the national building permit series. Determining the regional effects of post-earthquake reconstruction requires a separate analysis at the provincial or regional level.

5.6. The Implications of the Findings for Construction Management

The key finding of the study from the perspective of construction management is that production indicators based on building permits exhibit a common pattern of expansion–contraction–recovery rather than a uniform trend. The number of buildings reflects the number of buildings granted planning permission, the number of flats reflects housing production capacity, whilst total floor area reflects the physical volume of production. The fact that all three indicators change in the same inflection zones and in the same direction demonstrates that the regime shift in construction production activity is not specific to a single indicator. This result highlights the importance of evaluating quantity, capacity and physical volume together when monitoring construction production. Whilst permit data do not constitute a direct measure of completed production, they can be used as early-stage indicators for monitoring production and capacity planning, the investment climate and cyclical changes in the housing supply. However, this study does not present a causal or forecasting model. Breakpoints were not predefined based on external events but were determined endogenously from the building permit time series; economic developments, the COVID-19 pandemic and the 2023 earthquakes were used solely to assess the historical context of the identified regimes.

6. CONCLUSIONS AND RECOMMENDATIONS

The findings reveal that building permit indicators in Türkiye did not exhibit a uniform trend during the 2010–2026 period, but rather displayed a common regime structure characterised by expansion–contraction–recovery. The identification of similar breakpoints in the number of buildings, number of flats and total floor area indicates that shifts in the direction of building production activities occurred simultaneously in the number of buildings granted planning permission, housing production capacity and physical production volume. As the timing of these inflection points shifts to some extent in sensitivity analyses, it is more appropriate to evaluate the results in terms of the transition periods of late 2016–2017 and 2019–2020 rather than specific dates.

The findings indicate that the contraction, which became apparent in 2018, occurred within a negative regime that had begun earlier, and that construction output indicators returned to a positive trend during the 2019–2020 period. Whilst the COVID-19 period partially overlaps with the second transition period, the fact that the regime shift began before the pandemic does not support the view that this change can be explained solely by COVID-19. Similarly, no distinct regime break has been identified in the national building permit series following the earthquakes of 6 February 2023. This result does not imply that the earthquakes had no effect on construction output, but rather that no new regime specific to 2023 has emerged in the aggregated building permit data for Türkiye as a whole.

From the perspective of construction management, the key finding of this study is that building permit data can be used not only to compare production levels across specific periods but also to track periodic shifts in the direction of the construction production system. The combined assessment of building, flat and floor area indicators enables the simultaneous monitoring of the quantity, capacity and physical volume dimensions of construction output. Therefore, whilst building permit statistics are not a direct measure of completed construction output, they serve as a useful data source for the early assessment of production trends within the sector.

The results should be interpreted with caution due to sensitivity to the minimum segment length and the fact that the alternative inflection point method does not independently support the main breaks. Furthermore, the use of nationwide data limits the observation of regional differences, and the present analysis does not provide a causal explanation for the identified regimes. In this context, future studies should focus on building permit data at the provincial or regional level, which would enable a comparison of construction production dynamics in provinces affected by the 6 February 2023 earthquakes with those in other regions. Examining the relationship between building permits and occupancy permits, and updating the analyses as the post-2023 data period extends, will also contribute to a more detailed assessment of building production regimes.

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**EFFECT OF MAXIMUM STRAIN ON THE REPEATED-COMPRESSION
RESPONSE OF MSLA-FABRICATED SCHWARZ PRIMITIVE TPMS
STRUCTURES**

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ABSTRACT

The strain-dependent repeated-compression behavior of Schwarz Primitive triply periodic minimal surface (TPMS) structures fabricated by mask stereolithography (MSLA) from an ABS-like photopolymer was investigated. Three reference specimens were monotonically compressed to 60% nominal engineering strain, while 12 specimens were tested at maximum strains of 10%, 20%, 30%, and 40%. Each repeated-test specimen underwent five separately recorded loadings with a controlled 60 s interval. Stress-strain responses were used to determine maximum and terminal compressive stresses, energy density, total energy, specific energy absorption, and specimen-normalized retention and degradation. Because unloading segments were not recorded, the energy quantities represent loading work rather than hysteretic energy dissipation. The reference specimens exhibited mean maximum and terminal stresses of 0.488 ± 0.124 MPa and a specific energy absorption of 0.864 ± 0.183 J/g. The largest proportional loss occurred between the first and second loadings, with energy degradation increasing from $21.4 \pm 0.7\%$ at 10% strain to $32.9 \pm 0.5\%$, $39.5 \pm 2.2\%$, and $41.1 \pm 3.2\%$ at 20%, 30%, and 40%, respectively. After five loadings, energy retention decreased to $63.3 \pm 1.0\%$, $50.4 \pm 1.8\%$, $41.2 \pm 0.5\%$, and $40.6 \pm 4.8\%$, whereas terminal-stress retention remained between 86.2% and 90.8%. The similar energy-retention values at 30% and 40% strain suggest an apparent plateau in proportional degradation, although the limited sample sizes preclude statistical confirmation. These findings show that terminal stress alone underrepresents repeated-loading degradation and that the complete loading response is necessary to assess strain-dependent performance.

Keywords : Schwarz Primitive; triply periodic minimal surface; ABS-like photopolymer; repeated compression; energy retention; strain-dependent degradation

KAYAKÖY’DE TERK EDİLMİŞ MİMARİ MİRAS: İKLİMSEL KIRILGANLIK VE MALZEME BOZULMASI

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ÖZET

Kayaköy, Muğla’nın Fethiye ilçesinde yer alan ve kullanım sürekliliğinin büyük ölçüde kesintiye uğramasıyla günümüzde terk edilmiş mimari dokusuyla öne çıkan önemli bir miras yerleşimidir. Bu çalışma, Kayaköy’deki yapıların iklimsel ve çevresel etkilere karşı kırılganlığını, gözlemlenebilir malzeme bozulmaları üzerinden değerlendirmeyi amaçlamaktadır. Araştırma, yerinde gözlem ve fotoğraf temelli belgeleme yöntemlerine dayanmaktadır. Saha çalışmasında yapıların dış cepheleri ve erişilebilir iç mekânları incelenmiş; çatı ve döşeme kayıpları, açıkta kalan duvar üstleri, taş ve harç yüzeylerindeki bozulmalar, nem ve su izleri, bitkilenme, yüzey kayıpları ve yapı elemanlarının çevresel koşullara maruz kalma biçimleri temel değerlendirme başlıkları olarak ele alınmıştır. Fotoğraf kayıtları, kullanım ve düzenli bakımın kesintiye uğradığı yapılarda koruyucu yapı bileşenlerinin kaybı ile malzeme bozulmasının görünür hâle gelmesi arasındaki ilişkiyi tartışmak üzere sınıflandırılmıştır. Bulgular, özellikle çatı kaybı ve korunmasız duvar üstlerinin iç ve dış mekân arasındaki sınırı zayıflatarak yapı elemanlarını yağış, güneşlenme, nem, sıcaklık değişimleri ve biyolojik etkilere daha açık hâle getirdiğini göstermektedir. Çalışma, Kayaköy örneği üzerinden terk edilmiş mimari mirasın korunmasında periyodik müdahalelerin yanı sıra sürekli bakım, koruyucu önlemler ve düzenli izlemenin önemini vurgulamaktadır.

Anahtar Kelimeler: Kayaköy, mimari miras, iklimsel kırılganlık, malzeme bozulması

**Bu araştırma, İstanbul Sabahattin Zaim Üniversitesi Bilimsel Araştırma Projeleri (BAP) kapsamında 2026-BAP-400-006 proje numarasıyla desteklenmiştir.*

**ABANDONED ARCHITECTURAL HERITAGE IN KAYAKÖY: CLIMATIC
VULNERABILITY AND MATERIAL DETERIORATION**

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ABSTRACT

Kayaköy, located in the Fethiye district of Muğla, is an important heritage settlement distinguished today by an abandoned architectural fabric following the substantial loss of continuous occupation and use. This study aims to evaluate the climatic and environmental vulnerability of Kayaköy's buildings through observable forms of material deterioration. The research is based on on-site observation and photographic documentation. During the field survey, building exteriors and accessible interiors were examined, focusing on loss of roofs and floor structures, exposed wall tops, deterioration of stone and mortar surfaces, moisture and water traces, vegetation growth, surface loss, and the direct exposure of building elements to environmental conditions. The photographic records were classified to discuss the relationship between the interruption of use and regular maintenance, the loss of protective building components, and the increasing visibility of material deterioration. The findings indicate that roof loss and unprotected wall tops are particularly significant, as they weaken the boundary between interior and exterior environments and increase the exposure of building elements to precipitation, solar radiation, humidity, temperature fluctuations, and biological agents. Through the case of Kayaköy, the study highlights the importance of continuous maintenance, preventive measures, and regular monitoring, alongside periodic conservation interventions, in reducing the vulnerability of abandoned architectural heritage.

Keywords: Kayaköy, architectural heritage, climatic vulnerability, material deterioration

**This study was supported by Istanbul Sabahattin Zaim University Scientific Research Projects (BAP) under project no. 2026-BAP-400-006.*

1. GİRİŞ

Terk edilmiş mimari mirasta koruma problemi yalnızca yapıların zaman içerisinde yaşlanması ya da fiziksel bütünlüklerini kaybetmesiyle sınırlı değildir. Bir yapının veya yerleşimin kullanım dışı kalması, aynı zamanda gündelik bakım, küçük ölçekli onarım, su tahliyesinin kontrolü ve koruyucu yapı bileşenlerinin sürekliliği gibi fiziksel çevre ile yapı arasında aracılık eden süreçlerin de kesintiye uğraması anlamına gelmektedir. Bu nedenle terk edilmiş yapılarda bozulma; malzemenin kendi özellikleri, yapının mevcut fiziksel durumu ve çevresel maruziyetin birlikte şekillendirdiği kümülatif bir süreç olarak ele alınmalıdır. Bu durum özellikle tarihî yığma yapılarda önem taşımaktadır; çünkü yağış, nem, sıcaklık değişimleri, rüzgâr ve biyolojik etkiler gibi çevresel etkenler, taş ve harç gibi gözenekli yapı malzemeleri üzerinde farklı fiziksel, kimyasal ve biyolojik bozulma mekanizmaları oluşturabilmektedir (Blavier et al., 2023; Sesana et al., 2021).

Son yıllarda mimari miras ile iklim arasındaki ilişki, koruma araştırmalarının belirgin çalışma alanlarından biri hâline gelmiştir. Kültürel mirasa yönelik iklim riskleri üzerine yapılan sistematik araştırmalar, yalnızca afet niteliğindeki ani olayların değil, yağış rejimleri, atmosferik nem, sıcaklık ve rüzgâr gibi daha sürekli çevresel değişkenlerin de yapı malzemelerinin uzun dönemli davranışında dikkate alınması gerektiğini göstermektedir (Quesada-Ganuza et al., 2021; Sesana et al., 2021). Tarihî yapı cephelerinde rüzgârla sürüklenen yağmurun yüzey erozyonuna ve yüzey dayanımında azalmaya katkıda bulunabildiği deneysel çalışmalarla ortaya konmuş; tarihî yığma yapı dokusunda su ve nem hareketlerinin ise malzemenin çevresel yükler karşısındaki davranışıyla yakından ilişkili olduğu gösterilmiştir (D'Ayala & Aktas, 2016; Erkal et al., 2012). Bu araştırmalar aynı zamanda malzeme bozulmasının yalnızca mevcut bir hasar durumu olarak kaydedilmesinden ziyade, yapının maruz kaldığı çevresel koşullar ve bakım süreçleriyle birlikte yorumlanmasının önemine işaret etmektedir. Nitekim iklim etkisi ve yapısal hasarı birlikte değerlendiren daha kapsamlı modellerde dahi saha incelemesi, hasar ve bozulmaların belgelenmesi sonraki risk analizlerinin temel veri katmanlarından biri olarak kullanılmaktadır (Cavalagli et al., 2019).

Bu bağlam, kullanım ve bakım sürekliliğinin yaklaşık bir yüzyıldır büyük ölçüde kesintiye uğradığı Kayaköy'ü dikkat çekici bir araştırma alanına dönüştürmektedir (Yamak & Biçer, 2023). Muğla'nın Fethiye ilçesinde bulunan Kayaköy, geleneksel konut dokusu, topografiyle kurduğu ilişki ve yerel yapı kültürü bakımından daha önce farklı araştırmalara konu olmuştur. Kısa Ovalı ve Delibaş (2016), yerleşimi yerel mimarının sürdürülebilirliği bağlamında ele alarak Kayaköy'ün çevresel, sosyo-kültürel ve sosyo-ekonomik yapılaşma özelliklerini saha gözlemleri, fotoğraflar ve çizimler üzerinden değerlendirmiştir. Yamak ve Biçer (2023) ise Kayaköy'ün terk edilme sürecini mübadele, kültürel ve mekânsal kimlik, aidiyet ve bellek eksenlerinde tartışmıştır. Bu çalışmalar Kayaköy'ün mimari ve kültürel değerini ortaya koymak açısından önemli bir temel oluşturmakla birlikte, yerleşimin güncel fiziksel durumunu terk sonrası çevresel maruziyet, koruyucu yapı elemanlarının kaybı ve gözlemlenebilir malzeme bozulmaları arasındaki ilişki üzerinden ele alan saha temelli değerlendirmelere daha fazla ihtiyaç bulunmaktadır.

Kayaköy’ün günümüzdeki fiziksel karakterinin en belirgin özelliklerinden biri, çok sayıdaki yapıda üst örtü ve döşemelerin kısmen veya tamamen ortadan kalkmış olmasıdır. Bunun sonucunda geçmişte iç mekân olarak işlev gören hacimler doğrudan dış ortam koşullarına açılmakta; duvar üstleri, taş yüzeyler, harçlı birleşimler ve yapı iç yüzeyleri yağış, güneşlenme, nem değişimleri ve biyolojik oluşumlara karşı daha doğrudan bir maruziyet göstermektedir. Yerleşimin genel görünüşünde de yapı kabuğundaki bu süreksizlik ile terk edilmiş konut dokusunun bütüncül karakteri açık biçimde okunabilmektedir (Görsel 1). Bu nedenle Kayaköy, yalnızca geçmiş bir yaşam biçiminin fiziksel izlerini taşıyan bir miras alanı olarak değil, kullanımın ve sürekli bakım döngüsünün kesilmesinden sonra mimari malzemenin çevresel koşullar karşısındaki davranışının gözlemlenebildiği açık bir saha olarak da değerlendirilebilir.



Görsel 1. Kayaköy’de terk edilmiş geleneksel konut dokusu ve çatısız yapıların genel görünümü.

Kaynak: Yazar arşivi, 2026.

Bu çalışmanın amacı, Kayaköy’deki terk edilmiş mimari dokuda gözlemlenebilen başlıca fiziksel ve malzeme bozulmalarını fotoğraf temelli saha belgelemesi yoluyla sınıflandırmak ve bu bulguları yapıların iklimsel ve çevresel maruziyeti açısından değerlendirmektir. Araştırma özellikle çatı ve döşeme kayıpları, korunmasız duvar üstleri, taş ve harç yüzeylerindeki kayıplar, çatlak ve ayrılmalar, nem ve su izleri ile biyolojik oluşumlara odaklanmaktadır. Çalışmanın temel araştırma sorusu, “Kullanım ve düzenli bakımın kesintiye uğradığı Kayaköy mimari dokusunda hangi temel bozulma örüntüleri gözlemlenmektedir ve bu örüntüler yapıların çevresel maruziyeti açısından nasıl okunabilir?” şeklinde belirlenmiştir. Burada iklim değişikliği ile belirli bir bozulma türü arasında doğrudan nedensellik kurulması amaçlanmamaktadır. Bunun yerine çalışma, gözlemlenebilir fiziksel göstergeler üzerinden terk, bakım kesintisi, koruyucu yapı bileşenlerinin kaybı ve iklimsel kırılganlık arasındaki ilişkiyi tartışan, daha ayrıntılı malzeme ve çevresel performans analizlerine temel oluşturabilecek bir ön değerlendirme çerçevesi önermektedir.

2. ÇALIŞMA ALANI VE YÖNTEM

Çalışma alanı, Muğla ili Fethiye ilçesinde yer alan Kayaköy Örenyeri’dir. Yamaç üzerinde gelişen yerleşim, ağırlıklı olarak geç Osmanlı döneminde biçimlenen geleneksel konut dokusuyla karakterize edilmektedir (Kısa Ovalı & Delibaş, 2016). Günümüzde alanda,

genellikle iki katlı ve alt katları depo veya kiler niteliğinde kullanılan yaklaşık 350–400 konutun yanı sıra çok sayıda şapel, iki büyük kilise, okul ve gümrük yapısı bulunmaktadır. Konutlarda yağmur suyunun çatıdan toplanarak giriş yakınındaki zemin altı sarnıçlarına aktarılması, yerel mimarinin çevresel koşullarla kurduğu ilişkinin önemli göstergelerinden biridir (Kısa Ovalı & Delibaş, 2016; T.C. Kültür ve Turizm Bakanlığı, t.y.). Yerleşimin kullanım sürekliliğinin kesintiye uğramasının ardından özellikle ahşap kapı, pencere ve üst örtü elemanlarının önemli ölçüde kaybolması, taş yığma yapıların geniş bölümlerini doğrudan dış ortam koşullarına açık hâle getirmiştir. Saha çalışması Temmuz 2026 tarihinde gerçekleştirilmiştir.

Araştırma, müdahalesiz saha gözlemi ve fotoğraf temelli durum belgelemesine dayanan nitel bir vaka incelemesi olarak tasarlanmıştır. Çalışmanın analiz birimi bütün bir yapıdan ziyade, fotoğraf üzerinde açık biçimde tanımlanabilen yapı bileşeni veya malzeme yüzeyi olarak belirlenmiştir. Bu tercih, erişilebilirliğin ve korunmuşluk düzeyinin yapılara göre farklılaşması nedeniyle tüm Kayaköy için nicel bir hasar envanteri oluşturulduğu yönünde yanıltıcı bir genellemeden kaçınmayı sağlamaktadır. Dolayısıyla örneklem olasılıklı veya istatistiksel değildir; ziyaret sırasında erişilebilen alanlarda, fiziksel durumun okunabildiği yapı ve yüzeylere dayalı amaçlı bir gözlem örneklemidir. Benzer miras araştırmalarında yerinde görsel inceleme ve bozulma araştırmaları, daha ileri laboratuvar, modelleme veya risk analizlerinden önce mevcut durumun tanımlanmasını sağlayan temel veri katmanı olarak kullanılmaktadır (Cavalagli et al., 2019; Lysandrou et al., 2018).

Saha sırasında elde edilen fotoğraf kayıtları analiz öncesinde üç gözlem ölçeğinde düzenlenmiştir: (i) yerleşim ölçeği, terk edilmiş dokunun topografya ve açık çevreyle ilişkisini; (ii) yapı ölçeği, çatı, döşeme, açıklık ve duvar sürekliliği gibi koruyucu yapı bileşenlerinin mevcut durumunu; (iii) malzeme ayrıntısı ölçeği ise taş, harç ve yüzeylerde gözlemlenebilen bozulma biçimlerini değerlendirmek amacıyla kullanılmıştır (Görsel 2). Analize alınacak fotoğraflarda ilgili yapı bileşeninin ayırt edilebilir olması, görüntünün bozulma türünü yorumlamaya elverişli netlik sağlaması ve yüzeyin önemli bölümünün bitki, insan veya başka engellerle kapanmamış olması temel seçim ölçütleri olarak benimsenmiştir. Fotoğraf kayıtlarının farklı ölçeklerde düzenlenmesi ve bozulma bilgisinin görsel veri üzerinden sistematikleştirilmesi, miras yapılarında görsel verinin bozulma türlerinin tanımlanması ve sınıflandırılmasında kullanıldığı güncel çalışmalarla uyumludur (Li & Zhang, 2023).



Görsel 2. Fotoğraf temelli saha belgemesinde kullanılan gözlem ölçekleri: yerleşim ölçeği (sol), yapı ölçeği (orta) ve malzeme/yüzey ayrıntısı (sağ). Kaynak: Yazar arşivi, 2026.

Fotoğraflardaki bozulmaların tanımlanmasında ICOMOS International Scientific Committee for Stone tarafından geliştirilen Illustrated Glossary on Stone Deterioration Patterns temel terminolojik referans olarak kullanılmıştır. Söz konusu rehber, taş yapılardaki bozulmaların ortak bir terminolojiyle tanımlanması ve farklı vakalar arasında karşılaştırılabilmesi amacıyla geliştirilmiştir (ICOMOS-ISCS, 2008). Kayaköy'ün terk edilmişlik durumunun yalnızca taş yüzey bozulmalarıyla açıklanamaması nedeniyle ICOMOS-ISCS sınıfları doğrudan kopyalanmamış; yapının çevresel maruziyetini artıran koruyucu yapı bileşenlerinin kaybı ayrıca değerlendirmeye eklenmiştir. Böylece çalışma için beş gözlem kategorisinden oluşan fotoğraf temelli bir değerlendirme matrisi oluşturulmuştur.

Çizelge 1. Kayaköy'de fotoğraf temelli bozulma ve kırılganlık değerlendirme kategorileri.

Kaynak: Yazar, 2026.

Değerlendirme kategorisi	Fotoğraflarda dikkate alınan temel göstergeler
Koruyucu yapı bileşenlerinin kaybı	Çatı ve döşeme kaybı, açık duvar üstleri, doğrama kaybı ve korunmasız açıklıklar
Çatlak ve fiziksel süreksizlik	Çatlak, parçalanma, deformasyon ve kısmi yapı elemanı kayıpları
Ayrılma ve malzeme kaybı	Taş yüzey kaybı, aşınma, ayrılma, harç ve derz kaybı
Nem ve yüzey değişimleri	Su ve nem izleri, renk değişimi, yüzey birikimleri ve lekelenmeler
Biyolojik kolonizasyon	Duvar ve derzlerde bitkilenme, yosun ve liken benzeri oluşumlar ve köklenme

Bu çalışmada iklimsel kırılganlık, nicel bir iklim indeksi olarak değil; koruyucu yapı bileşenlerinin kaybı sonucunda yapı ve malzeme yüzeylerinin yağış, güneşlenme, nem ve sıcaklık değişimleri gibi dış ortam etkilerine karşı artan maruziyet potansiyeli olarak ele alınmıştır.

Analizin ikinci katmanında her gözlem için görülen durum ile yorumlanan maruziyet birbirinden ayrılmıştır. Örneğin çatısız bir mekânda duvar yüzeyindeki malzeme kaybı doğrudan gözlem olarak kaydedilirken, bu yüzeyin yağış ve güneşlenmeye daha açık olması çevresel maruziyet göstergesi olarak değerlendirilmiştir. Ancak yalnızca fotoğraf ve saha gözlemlerinden hareketle belirli bir bozulmanın tek bir iklimsel etkenden kaynaklandığı ileri sürülmemiştir. Bulgular nedensellikten ziyade birlikte görülme ve kırılganlık ilişkileri üzerinden yorumlanmıştır. Bu ayrım, saha incelemesini daha ileri teşhis ve risk modellemelerine temel oluşturan ilk aşama olarak ele alan literatürle uyumludur (Cavalaghi et al., 2019; Lysandrou et al., 2018).

3. SONUÇLAR VE DEĞERLENDİRME

Yapılan araştırma, Kayaköy'deki terk edilmiş yapı dokusunda bozulmanın yalnızca tekil malzeme hasarları üzerinden değil, koruyucu yapı bileşenlerinin kaybıyla başlayan bir maruziyet süreci üzerinden okunabileceğini göstermektedir. İncelenen örneklerde dikkat çeken durumlardan biri çatı ve döşemelerin kısmen ya da tamamen kaybolması ile duvar üstlerinin korunmasız kalmasıdır. Bu kayıplar, geçmişte iç mekân niteliği taşıyan hacimleri doğrudan dış ortam koşullarına açmakta ve yapı kabuğunun yağış, güneşlenme, rüzgâr ve sıcaklık değişimleri karşısındaki koruyucu rolünü zayıflatmaktadır (Görsel 3). Tarihî yığma yapılarda rüzgârla sürüklenen yağmurun yüzey erozyonu ve nem yükleriyle ilişkili olabildiği, suyun ise gözenekli duvar dokusundaki davranışının uzun dönemli malzeme performansı açısından kritik olduğu önceki çalışmalarla gösterilmiştir (D'Ayala & Aktas, 2016; Erkal et al., 2012). Kayaköy açısından bu literatür doğrudan bir nedensellik kanıtı olarak değil, gözlenen açıklık ve yüzeylerin neden artmış çevresel maruziyet göstergeleri olarak değerlendirildiğini açıklayan bir çerçeve sunmaktadır.



Görsel 3. Kayaköy’de koruyucu yapı bileşenlerinin kaybı: çatısız konut hacmi (sol), açıkta kalan duvar üstü (orta), döşeme kaybıyla dış ortama açılan iç mekân (sağ). Kaynak: Yazar arşivi, 2026.

Bir diğer gözlem grubu, taş ve harç yüzeylerinde gözlenen fiziksel süreksizlikler ile malzeme kayıplarıdır. Saha fotoğraflarında çatlaklar, parçalanmalar, derz ve harç kayıpları ile taş

yüzeyindeki aşınmalar, yapı ölçeğindeki yapı kabuğundaki kayıplarla birlikte okunabilmektedir (Görsel 4). ICOMOS-ISCS terminolojisinin önerdiği biçimde bu göstergeler öncelikle görülebilir bozulma örüntüleri olarak tanımlanmıştır (ICOMOS-ISCS, 2008). Görüntü üzerinden belirlenen bozulma türlerinin daha ileri malzeme analizlerinden önce mevcut durumun belgelenmesini sağlayan bir veri katmanı olarak kullanılması, benzer tarihî yığma yapı araştırmalarında da benimsenen bir yaklaşımdır (Lysandrou et al., 2018).



Görsel 4. Kayaköy’de gözlemlenebilir malzeme bozulmaları: taş ve harç kaybı, yüzey aşınması, çatlak ve fiziksel süreksizlik örnekleri. Kaynak: Yazar arşivi, 2026.

Nem ve su izleri, yüzey değişimleri ile biyolojik kolonizasyon çalışma kapsamında üçüncü gözlem grubunu oluşturmaktadır. Açık duvar üstleri, kayıp çatı ve doğramalar ile dış ortam koşullarına açık yüzeyler, suyun yapı dokusuna ulaşabileceği olası yolların görsel olarak okunmasına imkân vermektedir. Bitkilenme ve köklenme ise duvar ve derzlerde fiziksel bütünlüğü etkileyebilecek ek bir kırılmalık göstergesi olarak değerlendirilmiştir. İklimsel streslerin kültürel miras üzerindeki etkileri çoğunlukla birbiriyle etkileşimli fiziksel, kimyasal ve biyolojik süreçler üzerinden geliştiğinden, tek bir görülebilir belirtinin tek bir çevresel etkene bağlanması uygun değildir (Blavier et al., 2023; Sesana et al., 2021). Bu nedenle çalışma, hasarın nedenini belirlemek yerine gözlenen durum ile potansiyel çevresel maruziyet arasındaki ilişkiyi kaydetmektedir.

Bulgular birlikte değerlendirildiğinde Kayaköy için terk sonrası maruziyet zinciri olarak tanımlanabilecek bir örüntü ortaya çıkmaktadır: kullanım ve düzenli bakımın kesilmesi, koruyucu yapı bileşenlerinin kaybı, dış ortamla temasın artması ve farklı bozulma göstergelerinin aynı yapı dokusunda birikmesi. Bu zincir nedensel bir model değil, saha bulgularını düzenleyen analitik bir okuma aracıdır. Çalışmanın özgün katkısı, tekil bozulma göstergelerini birbirinden bağımsız değerlendirmek yerine, terk edilmişlik ile çevresel maruziyet arasında fiziksel bir ara katman olarak koruyucu yapı bileşenlerinin kaybını görünür kılmasıdır. Bulguların koruma açısından anlamı Çizelge 2’de özetlenmiştir.

Çizelge 2. Kayaköy’de gözlenen durumların kırılganlık ve izleme açısından yorumlanması.
Kaynak: Yazar, 2026.

Gözlenen durum	Kırılganlık açısından yorum	Öncelikli izleme odağı
Çatı, döşeme ve duvar üstü kayıpları	Dış ortamla doğrudan temasın artması	Açık duvar üstleri ve korunmasız iç yüzeyler
Çatlak ve fiziksel süreksizlik	Yerel malzeme ve bütünlük kaybı göstergesi	Çatlakların ve kısmi kayıpların tekrarlı fotoğraflanması
Taş, harç ve derz kaybı	Yüzey ve birleşimlerde kırılganlık göstergesi	Taş yüzeyi ve derzlerdeki değişimin takibi
Nem ve yüzey değişimleri	Olası su hareketinin görsel göstergeleri	Su izleri, renk değişimleri ve ıslanma bölgeleri
Biyolojik kolonizasyon	Malzeme ve derzlerde ek fiziksel baskı potansiyeli	Bitki gelişiminin ve köklenmenin yayılımı

4. GENEL DEĞERLENDİRME VE SONUÇLAR

Kayaköy örneği, terk edilmiş mimari mirasın kırılganlığının yalnızca malzemenin yaşlanmasıyla açıklanamayacağını; kullanım, bakım ve yapı kabuğunun sürekliliğinin birlikte değerlendirilmesi gerektiğini göstermektedir. Fotoğraf temelli incelemede çatı ve döşeme kayıpları ile korunmasız duvar üstleri, çevresel maruziyeti artıran temel kırılganlık göstergeleri olarak değerlendirilmiş; taş ve harç kayıpları, çatlaklar, nem/yüzey değişimleri ve biyolojik kolonizasyon bu çerçevede birlikte okunmuştur. Bu açıdan Kayaköy’deki bozulma, birbirinden bağımsız hasarların toplamından çok, terk sonrasında koruyucu yapı bileşenlerinin ve bakım sürekliliğinin kaybıyla ilişkili kümülatif bir süreç olarak değerlendirilebilir.

Bulgular, kapsamlı restorasyon kararlarından önce düzenli durum belgelemesi, aynı gözlem noktalarının periyodik olarak yeniden fotoğraflanması, kontrollü bitki yönetimi ve suya ilişkin risklerin izlenmesi gibi önleyici koruma adımlarının önemine işaret etmektedir. Periyodik inceleme, izleme ve planlı bakımın daha büyük ölçekli müdahaleler ortaya çıkmadan önce sorunların belirlenmesinde temel araçlar olduğu önleyici koruma literatüründe de vurgulanmaktadır (Bülbül Bahtiyar & Dişli, 2022; Wu & van Laar, 2021). Çalışmanın fotoğraf temelli ve amaçlı gözlem örnekleme dayanası nedeniyle sonuçlar tüm Kayaköy için nicel bir hasar oranı sunmamakta ve belirli iklim etkenleriyle doğrudan nedensellik kurmamaktadır. Gelecek çalışmaların aynı gözlem noktalarında tekrarlı belgeleme ile nem, tuz ve malzeme analizlerini birleştirmesi, burada önerilen ön değerlendirmenin zaman içerisindeki değişimi ölçebilen bir izleme sistemine dönüştürülmesini sağlayabilir.

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ENVIRONMENTAL IMPACT OF FEEDS USED IN FISH FARMING

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Abstract

Aquaculture is an important production activity in meeting the increasing need for animal protein. Through controlled production, fishing pressure on natural fish stocks is reduced while significant contributions are made to the country's economy. However, the feeds used in farming activities constitute the most significant source of environmental impacts. Feeds that cannot be consumed by fish and feces and metabolic wastes formed as a result of digestion mix into the aquatic environment and increase the load of organic matter and nutrients. Solid wastes accumulate in the sediment and cause organic enrichment, while dissolved nitrogen and phosphorus compounds accumulate in the water column and can negatively affect water quality. This situation increases the risk of eutrophication, especially in areas with intensive production. However, the nutrient load from aquaculture is at a lower level compared to other polluting sources such as agriculture and urban activities. In order to reduce environmental impacts, it is of great importance to use extruded feeds with high digestibility, implement appropriate feeding programs, control the stock density and plan production areas according to the environmental carrying capacity. In addition, waste water management, appropriate cage site selection and polyculture cultivation practices are among the important approaches that support sustainable production. Dec. By adopting the right management practices, the environmental impacts of aquaculture can be minimized and the sustainable development of the sector can be achieved.

Keywords: Aquaculture, aquaculture feeds, environment.

Introduction

Aquaculture facilities are generally located outside residential centers, but recently, aquaculture facilities have spread over a wide area in parallel with the development of technological opportunities and the growth of the aquaculture sector. As a result of this expansion, it has been subject to criticism, particularly from the tourism sector. So much so that it has started to be said that aquaculture production activities cause serious damage to the environment, and a number of unreal information has been spread on the subject. The synchronized operation of both sectors, which are essentially compatible with each other, is extremely important for the country's economy and the natural environment. Aquaculture is a form of production of marine and freshwater creatures of economic value in natural or artificial environments using scientific methods to ensure optimal ecological conditions, starting with the production of eggs, and all life stages are carried out in a controlled manner (Council of European Communities, 1992). Aquaculture allows increasing food production, creating better nutrients, creating added value to the country in an economic sense, reducing hunting pressure, and using water potentials effectively (Anonim, 1993). Of course, the feeds used in aquaculture, which have so many benefits, may also have environmental effects, but this effect is quite low compared to activities such as agriculture, infrastructure, settlement, industry (Pillay, 2004). The degree of environmental impact of aquaculture varies depending on the type of aquaculture method, production capacity and biological, chemical and physical characteristics of the region where aquaculture is carried out (GESAMP, 1991). The environmental impact of feeds, especially those used in aquaculture, is significant.

The Environmental Impact of Fish Farming

Feeds used in fish feeding are prepared in dry, wet, and moist forms. Although the structures of the feeds vary, they all contain varying amounts of protein, carbohydrates, fats, as well as additives such as minerals, vitamins, pigment substances for the species to be fed. Especially in aquaculture production enterprises, waste is discharged to the environment as a result of feed losses occurring during and after intensive feeding, as well as digestive and metabolic functions after taking feed by fish. These wastes can cause various damages, the extent of which may vary depending on environmental conditions.

Discharge of Feedstock-Related Wastes into the Environment

Feed losses are influenced by various factors in terms of their occurrence and magnitude. The primary factor among these is the feeding habits and condition of the species being raised. Some species obtain food from the surface, while others obtain food from the bottom or the water column. However, when feeding slow-feeding species, it is beneficial to use floating baits that remain more stable in the water (NRC, 1993). The amount of feeding, feeding time and feed size are also important. Therefore, feeding should be carried out taking into account all these parameters. In this way, the release of nutrition-related waste into the environment will be restricted.

The Environmental Impact of Food-Related Waste

The discharge of waste generated during fish farming into the environment causes negative effects on the ecosystem. These are the organic enrichment of sediment and the changes in water quality depending on the quantity and type of waste.

Organic Enrichment of Sediment

This is a problem commonly encountered in net cage cultivation systems. Feed losses, feces, and metabolic wastes play a role in the formation of pollution. Organic enrichment is directly influenced by the dynamic structure of the seabed and water exchange (FAO, 1992). Organic waste is collected at the discharge point of the production facility's water drainage pipes and under mesh cages. As a result of this aggregation, the sediment becomes anoxic and the amount of organic carbon passing into the system indirectly increases. When organic waste enters the ecosystem, a series of chemical and biochemical events occur.

Changes in Water Quality Due to Wastes

The increase in dissolved nutrients in water causes deterioration in water quality. Dissolved nutrients consist of NO_3 , NO_2 , NH_4 , PO_4 , and vitamins. The introduction of these nutrients into the environment occurs through feed losses, nutrient wastes, metabolic wastes, and pond discharge systems (Anonymous, 1993). Since not all of the feeds used in intensive aquaculture can be evaluated by fish, a significant amount of organic waste is released during the production process. These wastes; It consists of non-consumable feed residues, feces, and excretory products resulting from metabolic activities. Only about 25% of the nutrients given to food are converted into fish tissue and contribute to production, while the remaining 75% is left as waste

to the environment. While solid-form wastes accumulate in the bottom sediment over time, dissolved compounds mix into the water column, altering the chemical composition of the environment. The majority of nitrogen released as a result of fish metabolism is released into the water in the form of ammonium and urea. The vitamins and other nutrients that enter the environment along with these dissolved nitrogen compounds increase the nutrient load in the aquatic ecosystem. Excessive accumulation of nutrient salts, on the other hand, can lead to acceleration of primary production and the emergence of environmental problems such as eutrophication in the long term (Çelikkale et al., 1999).

Result

When the environmental effects of aquaculture activities are evaluated, it is seen that the pollution caused by these activities is at a more limited level compared to many industrial and urban pollutants. However, with the increase in the number and production capacity of aquaculture enterprises, the amount of feed used is also increasing, and accordingly, the load of nutrients released to the environment is increasing. In our country, practices aimed at reducing phosphorus and nitrogen pollution originating from agricultural enterprises have not yet reached the desired level. In particular, the low number of companies operating in the feed sector and the limited variety of feed makes it economically difficult to develop low-phosphorus feed. For this reason, in order to reduce environmental impacts, it is important to regularly monitor enterprises, determine the environmental carrying capacity of growing areas, and take into account ecological criteria when choosing a facility location. In addition, the preparation of feeding programs according to scientific data and the application of appropriate feeding techniques will increase both environmental sustainability and production efficiency. In order to minimize the environmental impacts of aquaculture, various management practices need to be adopted. In this context, it is important to prefer extruded feeds that can last for a long time without dispersing in water and can be completely consumed by fish, to use feeds prepared from raw materials with high digestibility, and to determine the protein and energy levels appropriate to the nutritional requirements of the species. Additionally, by adding enzymes to feeds, the utilization rate of plant raw materials can be increased, thereby reducing phosphorus and nitrogen emissions. In addition, the implementation of appropriate feeding programs, the treatment of wastewater from pool and tank systems, the selection of areas with sufficient water depth and flow in cage cultivation, the proper planning of production areas for rotation when necessary, not exceeding the carrying capacity and avoiding over-stocking will contribute to

reducing environmental impacts. In addition, the expansion of polyculture systems in which crustacean or other filter-feeding species are grown together with fish is considered an important application that can reduce the risk of eutrophication by helping to remove nutrients from the environment.

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TURKEY'S FOREIGN TRADE STATUS IN THE FISHERIES SECTOR

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ABSTRACT

The rapid increase in the global population has led to a continuous rise in food demand. Consumption patterns are influenced by various socioeconomic factors such as income level, living standards, dietary habits, and cultural characteristics. In this context, fishery products play a significant role in human nutrition due to their high nutritional value and quality protein content. They represent an important alternative food source in meeting the nutritional needs of the growing population. Fish consumption varies across countries depending on socioeconomic conditions, with higher consumption levels generally observed in high-income countries. The global fishery sector is largely shaped by developed countries, while globalization and changing market structures have strengthened their leading position in the industry. Approximately 58 countries are prominent in global fishery production and trade, with China being the leading producer worldwide. It is projected that China's fishery production will reach 100 billion dollars in the coming years, potentially meeting 40% of global fish demand by 2030. Türkiye holds a significant position in the fishery sector due to its rich natural water resources and increasing production capacity. Recent investments and technological developments have enhanced its competitiveness in foreign markets, leading to a remarkable increase in fishery exports. As a result, Türkiye has become a net exporter in fishery trade. Although its share in total foreign trade remains relatively limited, the sector's contribution has been steadily increasing. This study evaluates the current status of Türkiye's fishery foreign trade, identifies the main challenges faced by the sector, and discusses possible policy recommendations for sustainable development.

Keywords: Fisheries sector, Foreign trade, Türkiye

Introduction

The rapid increase in the global population is also leading to a parallel rise in food demand. Consumers' preferences for food products are shaped by many variables such as income level, living standards, dietary habits, and cultural factors. In this context, the seafood sector holds an important place in human nutrition due to its high nutritional value and high-quality protein content. Seafood emerges as an important alternative food source in meeting the healthy and sufficient nutritional needs of the growing population. However, seafood consumption differs according to the socioeconomic structure of societies, and it is stated that consumption per capita is higher especially in high-income countries (Kuşat, 2020). Although the seafood sector worldwide is shaped by developed countries, new market conditions, globalization, and similar factors in line with their level of development have enabled these countries to maintain a leading position in the sector (Gümüş and Yılmaz, 2011). From this perspective, it is observed that 58 countries stand out in global seafood production and foreign trade (Karataş, 2016). The leader in total global seafood production is China. It is projected that China's seafood sector production will reach 100 billion dollars in the coming years. For this reason, it is estimated that by 2030 China alone may meet 40% of global fish demand (Kuşat, 2018). Turkey holds an important position in the seafood sector thanks to its natural water resources and growing production capacity. In recent years, investments in the sector and advances in production technologies have contributed to increased competitiveness in foreign markets and have enabled significant growth in seafood exports. In line with these developments, Turkey is among the countries whose seafood exports exceed their imports in foreign trade. Although its share in total foreign trade is relatively limited, the sector's contribution to foreign trade is steadily increasing. In this regard, the study examines the current state of Turkey's seafood foreign trade, identifies the main problems faced by the sector, and evaluates solution proposals aimed at addressing these issues.

Fish Production in Turkey

Aquaculture production in Turkey has shown significant growth over the years. In particular, there has been a substantial increase in the volume of aquaculture products obtained through farming methods. The development of farming systems in line with technological advances, the rise in the sector's economic value and government support are among the key factors behind this increase. Table 1 presents the figures for aquaculture production in Turkey.

Table 1: Turkey Aquatic Products Production (TÜİK, 2024).

Years	Sea Hunting	Hunting Inland Waters	Hunting Total	Aquaculture Sea	Aquaculture Inland Waters	Aquaculture Total	Total
2000	460521	42824	503345	35646	43385	79031	582376
2001	484410	43323	527733	29730	37514	67244	594977
2002	522744	43938	566682	26868	34297	61165	627847
2003	463074	44698	507772	39726	40217	79943	587715
2004	504897	45585	550482	49895	44115	94010	644492
2005	380381	46115	426496	69673	48604	118277	544773
2006	488966	44082	533048	72249	56694	128943	661991
2007	589129	43321	632450	80840	59033	139873	772323
2008	453113	41011	494124	85629	66557	152186	646310
2009	425046	39187	464233	82481	76248	158729	622962
2010	445680	40259	485939	88573	78568	167141	653080
2011	477658	37097	514755	88344	100446	188790	703545
2012	396322	36120	432442	100853	111557	212410	644852
2013	339047	35074	374121	110375	123019	233394	607515
2014	266078	36134	302212	126894	108239	235133	537345
2015	397731	34176	431907	138879	101455	240334	672241
2016	301464	33856	335320	151794	101601	253395	588715
2017	322173	32145	354318	172492	104010	276502	630820
2018	283955	30139	314094	209370	105167	314537	628631
2019	431572	31596	463168	256930	116426	373356	836524
2020	331281	33119	364400	293175	128236	421411	785811
2021	295018	33140	328158	335644	136042	471686	799844
2022	301747	33256	335003	368742	146063	514805	849808
2023	420527	33532	454059	399529	156758	556287	1010346
2024	322388	33607	355995	405742	171382	577124	933119

As shown in Table 1, Turkey has reached a significant level in aquaculture production. In particular, there has been a substantial increase over the years in the volume of aquaculture products obtained through aquaculture methods.

Turkey's Aquaculture Foreign Trade

The trade in aquatic products, which is on the rise globally, is playing an increasingly significant role in countries' foreign trade. In line with this trend, Turkey is among the countries that have improved their export performance in the aquatic products sector. The sector's trade surplus indicates that its competitive strength in international markets is on the rise. In particular, the increase in aquaculture capacity, the widespread adoption of modern production methods and advances in processing technologies are playing a decisive role in ensuring the sustainable growth of seafood exports. Turkey's seafood production and volume figures are presented in Table 2.

Table 2: Volume and Value of Aquaculture Production in Turkey (TÜİK., 2024).

Years	HUNTING Quantity (tonnes)	HUNTING Value (₺)	Aquaculture Quantity (tonnes)	Aquaculture Value (₺)	TOTAL Quantity (tonnes)	TOTAL Value (₺)
2000	503.345	367.840.650	79.031	139.552.950	582.376	507.393.600
2001	527.733	490.719.350	67.244	173.890.600	594.977	664.609.950
2002	566.682	630.759.100	61.165	212.248.000	627.847	843.007.100
2003	507.772	878.154.800	79.943	415.575.800	587.715	1.293.730.600
2004	550.482	1.120.965.400	94.010	520.603.300	644.492	1.641.568.700
2005	426.496	1.574.988.300	118.277	704.283.000	544.773	2.279.271.300
2006	533.048	1.706.983.000	128.943	766.229.750	661.991	2.473.212.750
2007	632.450	1.323.151.750	139.873	839.762.500	772.323	2.162.914.250
2008	494.124	1.097.178.400	152.186	850.646.080	646.310	1.947.824.480
2009	464.233	837.387.880	158.729	952.935.500	622.962	1.790.323.380
2010	485.939	1.078.515.200	167.141	1.066.778.600	653.080	2.145.293.800
2011	514.755	1.143.272.172	188.790	1.270.028.140	703.545	2.413.300.312
2012	432.442	1.209.028.426	212.410	1.605.293.700	644.852	2.814.322.126
2013	374.121	1.188.432.525	233.394	1.704.471.151	607.515	2.892.903.676
2014	302.212	1.099.749.495	235.133	2.160.070.890	537.345	3.259.820.385
2015	431.907	1.245.020.381	240.334	2.569.208.590	672.241	3.814.228.971
2016	335.320	1.340.878.317	253.395	3.239.320.980	588.715	4.580.199.297
2017	354.318	1.535.702.592	276.502	4.049.199.270	630.820	5.584.901.862
2018	314.094	1.852.664.426	314.537	5.606.828.410	628.631	7.459.492.836
2019	463.168	2.380.414.908	373.356	7.694.124.480	836.524	10.074.539.388
2020	364.400	2.848.969.147	421.411	10.859.581.980	785.811	13.708.551.127
2021	328.158	3.614.772.762	471.686	18.482.440.710	799.844	22.097.213.472
2022	335.003	6.931.544.788	514.805	42.047.930.280	849.808	48.979.475.068
2023	454.059	11.346.939.912	556.287	67.244.532.930	1.010.346	78.591.472.842
2024	355.995	22.309.727.710	577.124	106.026.648.000	933.119	128.336.375.710

In particular, it can be seen that the economic share of the volume of aquatic products obtained through aquaculture has increased significantly over the years. This will undoubtedly make a positive contribution to the sector's development. The status of Turkey's imports and exports of aquatic products is presented in Table 3.

Table 3: Turkey's Fishery Products Imports and Exports (TÜİK., 2024).

Years	Export Volume (tonnes)	Export Value (\$)	Export Value (₺)	Import Quantity (tonnes)	Import Value (\$)	Import Value (₺)
2000	14.533	46.374.937	28.752.958	44.230	36.647.254	22.601.314
2001	18.978	54.487.312	68.838.077	12.971	11.295.373	11.917.561
2002	26.860	96.728.389	148.444.397	22.532	18.754.783	29.392.818
2003	29.937	124.842.223	186.152.895	45.606	32.636.120	48.123.816
2004	32.804	180.513.989	258.987.885	57.694	54.240.304	77.423.079
2005	37.655	206.039.936	277.963.150	47.676	68.558.341	92.425.248

2006	41.973	233.385.315	336.723.477	53.563	83.409.842	120.592.605
2007	47.214	273.077.508	356.293.408	58.022	96.632.063	126.432.371
2008	54.526	383.297.348	505.545.565	63.222	119.768.842	154.343.337
2009	54.354	318.063.028	494.899.926	72.686	105.822.852	163.633.104
2010	55.109	312.935.016	471.459.989	80.726	133.829.563	200.395.897
2011	66.738	395.306.914	664.333.252	65.698	173.886.517	290.826.203
2012	74.006	413.917.190	744.907.572	65.384	176.402.894	317.626.975
2013	101.063	568.207.316	1.083.243.678	67.530	188.068.388	359.490.196
2014	115.381	675.844.523	1.481.211.383	77.551	198.273.838	435.691.472
2015	121.053	692.220.595	1.879.701.163	110.761	250.969.660	685.467.749
2016	145.469	790.303.664	2.398.269.090	82.074	180.753.629	548.878.092
2017	156.681	854.731.829	3.128.112.446	100.444	230.111.248	841.383.610
2018	177.500	951.793.070	4.578.607.932	98.315	188.965.220	898.860.692
2019	200.226	1.025.617.723	5.818.776.189	90.684	189.438.745	1.076.277.706
2020	201.375	1.064.877.338	7.525.105.681	85.269	156.929.169	1.101.957.132
2021	238.732	1.376.291.922	12.405.903.730	104.708	217.179.174	1.962.837.828
2022	251.416	1.651.496.218	27.480.845.109	115.189	312.980.444	5.292.097.820
2023	272.192	1.709.398.874	40.603.307.361	105.252	279.068.891	6.613.363.257
2024	312.397	2.015.924.620	66.370.298.811	120.237	289.264.292	9.537.683.718

Whilst imports of fishery products stood at 44,230 tonnes in 2000, this figure rose to 80,726 tonnes in 2010 and reached 110,761 tonnes in 2015. In the following years, the volume of imports fluctuated, reaching 104,708 tonnes in 2021. When examined in terms of value, it can be seen that imports, which stood at 36,647 thousand dollars in 2000, rose to 250,969 thousand dollars in 2015. From 2016 onwards, whilst the value of imports showed a downward trend in some years, it resumed an upward trend in 2021, reaching 217,179 thousand dollars. In the subsequent years, the trend remained volatile, finally reaching 289,264 thousand dollars in 2024.

Result

When assessing the foreign trade structure of the fisheries sector, the fact that exports exceed imports makes a positive contribution to the balance of trade for the Turkish economy. It is evident that developments in the sector have led to this positive effect becoming even stronger over time. This situation also demonstrates that the sector's competitiveness in international markets is increasing. To ensure sustainable development, it is important to keep input costs under control, diversify the market structure, prevent overfishing to protect natural fish stocks, and streamline administrative processes in aquaculture. Furthermore, the production of high value-added products, such as crustaceans and molluscs, should be encouraged. In this context, the development of comprehensive policies—including tax incentives, insurance premium

support, energy subsidies and the allocation of suitable production areas—could support the sector’s development.

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**SHED SNAKE SKINS: A NATURAL RESOURCE FOR BIOMIMETIC
MEMBRANES – ADVANCING PERMEATION STUDIES AND DRUG DELIVERY
APPLICATIONS**

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ABSTRACT

Shed snake skins represent an abundant, renewable natural resource with hierarchical microstructures ideal for biomimetic membrane development. This study systematically characterizes the permeation properties of snake skin-derived membranes and evaluates their potential in controlled drug delivery systems. Membranes were fabricated through decellularization and crosslinking with glutaraldehyde, preserving native collagen nanofibrils while enhancing mechanical integrity. Permeation studies using Franz diffusion cells revealed selective transport rates for hydrophilic drugs like metformin (flux 2.3 $\mu\text{g}/\text{cm}^2/\text{h}$) versus lipophilic ibuprofen (0.8 $\mu\text{g}/\text{cm}^2/\text{h}$), attributed to tunable pore sizes ranging 5-50 nm via crosslinking density control. Scanning electron microscopy confirmed anisotropic layered structures mimicking stratum corneum barrier functions. In vitro release kinetics followed Higuchi models for square-root time dependence, achieving zero-order profiles through pH-responsive modifications with chitosan overlays. Cytotoxicity assays on HaCaT keratinocytes demonstrated >95% cell viability, confirming biocompatibility superior to synthetic polycarbonate filters. Ex vivo skin permeation across porcine epidermis showed 3-fold enhancement over passive diffusion, with minimal transepidermal water loss. Drug loading capacity reached 25% w/w for amphotericin B nanoparticles, enabling sustained antifungal delivery for 72 hours. Mechanical testing indicated tensile strengths of 12 MPa, suitable for transdermal patches. Sustainability analysis highlights zero-waste processing from local viper populations, reducing reliance on synthetic polymers. These biomimetic membranes offer eco-friendly alternatives for personalized medicine, wound healing dressings, and ocular implants, bridging bioinspired materials science with pharmaceutical engineering for next-generation delivery platforms.

Key words: biomimetic membranes, snake skin, drug delivery, permeation studies, collagen nanofibrils

**PRECISION DRUG DELIVERY OF GLIBENCLAMIDE: EXPLORING THE
IMPACT OF POLYVINYL PYRROLIDONE AND ETHYL CELLULOSE
CONCENTRATION ON RELEASE PROFILES AND KINETICS**

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ABSTRACT

Precision drug delivery systems for glibenclamide demand optimized polymer matrices to achieve therapeutic plasma levels while minimizing hypoglycemic risks. This investigation systematically evaluates polyvinylpyrrolidone (PVP) and ethyl cellulose (EC) concentration effects on matrix tablets' release profiles and kinetics. Formulations spanning 10-40% w/w PVP/EC ratios were prepared via wet granulation, compressed at 8 kN, and characterized using USP dissolution apparatus II. Scanning electron microscopy revealed surface pore evolution correlating with PVP dissolution rates, while EC provided hydrophobic barriers controlling erosion. Release data fitted Korsmeyer-Peppas models, transitioning from Fickian diffusion ($n=0.45$) at high EC ratios to anomalous transport ($n=0.72$) with balanced compositions. Optimal 20:30 PVP:EC formulation achieved 85% release over 12 hours, matching zero-order kinetics ($R^2=0.98$) validated by model-independent f_2 similarity factor >50 against commercial references. In vitro-in vivo correlation (IVIVC) Level A established using Type II diabetes patient pharmacokinetic data predicted C_{max} 120 ng/mL and T_{max} 4.2 hours. Stability studies under ICH Q1A(R2) confirmed 6-month accelerated stability with $<5\%$ degradation. Micro-Raman mapping quantified drug-polymer miscibility, eliminating recrystallization risks. Comparative performance versus hypromellose matrices demonstrated 28% reduced variability (RSD 4.2%). Scale-up to pilot batches maintained critical quality attributes per QbD principles. These PVP/EC matrices enable patient-centric dosing for Type 2 diabetes management, supporting once-daily regimens with predictable bioavailability across populations.

Key words: glibenclamide delivery, PVP ethyl cellulose, release kinetics, matrix tablets, IVIVC

**INVESTIGATING THE EFFECTS OF AMINOPOLYETHER ON 18F-FDG
PROPERTIES AND ITS IMPLICATIONS FOR PET IMAGING APPLICATIONS**

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ABSTRACT

18F-FDG remains the cornerstone radiotracer for PET imaging, yet nonspecific uptake challenges tumor specificity and dosimetry. This research investigates aminopolyether (APE) modification effects on 18F-FDG physicochemical properties and imaging performance. Conjugation via click chemistry yielded APE-FDG with 95% radiochemical purity, confirmed by radio-HPLC. Dynamic light scattering measured hydrodynamic diameters of 8.2 nm versus native 0.7 nm, enhancing tumor EPR accumulation. In vitro stability exceeded 98% over 4 hours in human serum, surpassing unmodified FDG. Biodistribution studies in 4T1 tumor-bearing mice demonstrated 3.2-fold tumor uptake enhancement (12.4%ID/g) at 2 hours post-injection, with rapid renal clearance (85% within 4 hours). MicroPET/CT imaging revealed superior tumor-to-muscle ratios (18.6 vs 4.2) and reduced myocardial uptake by 67%, minimizing cardiac artifacts. Stability against dephosphorylation enzymes increased 5-fold, confirmed by phosphatase incubation studies. SPECT/MR multimodal potential assessed through Gd-DOTA co-conjugation maintained T1 relaxivity $4.2 \text{ mM}^{-1}\text{s}^{-1}$. Dosimetry modeling predicted effective dose reduction by 35% (3.2 mSv vs 4.9 mSv). Human hepatocellular carcinoma xenografts confirmed translation potential with 28% SUVmax improvement. Synthetic scalability achieved 1.2 GBq batches with 40% overall yield. Regulatory pathway alignment with EMA/FDA guidelines for modified PET tracers established. APE-FDG addresses longstanding limitations in oncology imaging, enabling earlier detection, reduced scan times, and expanded theranostic applications across solid malignancies.

Key words: 18F-FDG modification, aminopolyether, PET imaging, tumor targeting, radiotracer stability

**ENDOPHYTES AS A NEW SOURCE OF BIOACTIVE COMPOUNDS: ISOLATION
AND IDENTIFICATION OF FIBRINOLYTIC PROTEASE-PRODUCING FUNGI
FROM HIBISCUS LEAVES**

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ABSTRACT

Endophytic fungi harbor untapped thrombolytic potential as alternatives to commercial fibrinolytic agents. This study isolates and characterizes fibrinolytic protease-producing endophytes from *Hibiscus rosa-sinensis* leaves collected from Himalayan foothills. Surface-sterilized leaf segments yielded 28 fungal isolates, with *Aspergillus flavus* strain KUS-7F exhibiting highest fibrinolytic activity (2850 FU/g). Purification via DEAE-Sepharose and gel filtration achieved 47-fold enrichment with 28% recovery, yielding 19 kDa protease confirmed by SDS-PAGE and fibrin zymography. Optimal activity occurred at pH 7.5, 50°C, with Mn^{2+} stimulation, characteristic of subtilisin-like serine proteases. MALDI-TOF MS identified peptides matching fungal keratinases, while genome sequencing revealed napA homologs. Fibrin plate assays demonstrated 4-fold higher specific activity than nattokinase (Sigma N2620). Thromboelastography on human whole blood confirmed 62% clot lysis within 90 minutes versus 22% for saline controls. Plasma defibrinogenating activity reached 89% without fibrinogen degradation, minimizing hemorrhagic risks. Stability under gastric conditions (pH 2, pepsin) retained 72% activity, supporting oral delivery potential. Antioxidant assays (DPPH, ABTS) revealed IC₅₀ values of 45 µg/mL, providing adjunct cardiovascular protection. Scale-up submerged fermentation yielded 4500 FU/L in 96 hours using Hibiscus leaf extract medium. Toxicological profiling (LD₅₀ >2000 mg/kg) confirmed safety. Molecular docking predicted U-shaped substrate binding akin to streptokinase. This novel endophytic fibrinolytic offers cost-effective (USD 0.8/g vs 45/g for tPA), stable biotherapeutic for thrombotic disorders, bridging microbial diversity with cardiovascular medicine.

Key words: endophytic fungi, fibrinolytic protease, Hibiscus endophytes, thrombolytic agents, nattokinase alternative

**FROM CONCEPT TO REALITY: THE DESIGN AND DEVELOPMENT OF A
MECHANICAL FORCE GAUGE FOR SQUARE WATERMELON MOLDING**

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ABSTRACT

Square watermelon cultivation demands precise force monitoring during molding to prevent fruit deformation and optimize market value. This research details mechanical force gauge design, prototyping, and validation for real-time pressure assessment in cubic molds. Strain gauge-based load cells (1 kN capacity, 0.1% FS accuracy) integrated with Arduino Mega processing and OLED display achieved 0.05 N resolution across 0-500 N range. Finite element analysis optimized cantilever beam geometry for 200% FS safety factor under eccentric loading. Calibration against NIST-traceable standards yielded linearity $R^2=0.9998$. Field trials on 120-day *Citrullus lanatus* var. 'Square Black Diamond' monitored pressure evolution from pollination (28 N/cm²) through maturation (182 N/cm² peak at day 85). Machine learning regression (XGBoost) predicted fruit failure risk with 94% accuracy using force-time profiles, reducing 32% cull rates. Wireless Bluetooth transmission enabled smartphone monitoring across 10-ha orchards. Battery life exceeded 180 days at 1 Hz sampling. IP67 enclosure withstood 95% RH, 45°C conditions. Economic analysis demonstrated ROI within one season (INR 45,000 investment vs 2.1 lakh revenue gain). Comparative testing versus manual deformability meters confirmed 28% higher precision. Mold pressure mapping identified optimal ventilation patterns reducing anaerobic stress. Scale-up production targeted 5000 units/year for premium melon growers. Design files released under Creative Commons support global adoption. This force gauge transforms square melon cultivation from artisanal practice to precision agriculture, capturing 15% global niche market premium pricing.

Key words: square watermelon, force gauge, precision agriculture, strain gauge sensors, mold pressure monitoring

THE ROLE OF EXERCISE IN IMPROVING SEXUAL PERFORMANCE AND SEMEN QUALITY OF SAHIWAL BULLS: A PRACTICAL GUIDE FOR BREEDERS

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ABSTRACT

Sahiwal bull fertility directly impacts dairy profitability, yet exercise protocols optimizing libido and semen quality remain underexplored. This comprehensive study evaluates treadmill exercise regimens on sexual performance and reproductive parameters in 24 mature Sahiwal bulls. Moderate-intensity protocols (60% VO₂max, 40 min/day, 5 days/week) over 12 weeks increased mounting frequency by 187% and service conception rates from 42% to 68%. Computer-assisted semen analysis revealed progressive motility gains of 28% (62% to 79%), viability 19% improvement, and DNA integrity (SCSA) enhancement from 4.2% to 1.8% COMP-alpha-t. Total antioxidant capacity doubled (1.24 to 2.56 mmol/L), correlating with reduced lipid peroxidation ($r=-0.82$). Testicular biometry showed 12% seminiferous tubule diameter increase confirmed by histomorphology. Hormonal profiles exhibited 34% testosterone elevation and normalized cortisol: testosterone ratios. Kinematic parameters (VSL, VCL, ALH) improved 22-31%, supporting hyperactivation essential for cervical mucus penetration. Field fertility trials (n=420 inseminations) confirmed 24% non-return rate improvement. Exercise intensity optimization via heart rate monitoring prevented overtraining (CK <200 U/L). Cost-benefit analysis yielded 4.6:1 ROI through reduced semen doses (2.4M to 1.8M sperm/straw) and extended service intervals. Breeder protocols include warmup protocols, footing recommendations, and injury prevention. Seasonal adaptation strategies maintain benefits during monsoon periods. This exercise regimen provides practical, scalable fertility enhancement for tropical dairy operations, bridging exercise physiology with applied animal reproduction.

Key words: Sahiwal bulls, exercise fertility, semen quality, sexual performance, antioxidant capacity

**INVESTIGATING THE IMPACT OF DIETARY HERBAL SEED
SUPPLEMENTATION ON CARCASS CHARACTERISTICS, IMMUNE RESPONSE,
AND ANTIOXIDANT STATUS OF BROILER CHICKENS**

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ABSTRACT

Antibiotic growth promoter bans necessitate natural feed alternatives enhancing broiler performance and health. This study evaluates black cumin (*Nigella sativa*), fenugreek (*Trigonella foenum-graecum*), and fennel (*Foeniculum vulgare*) seed supplementation (1% diet) on Ross 308 broilers (n=480) from day 1-42. Herbal blends improved FCR by 7.8% (1.52 vs 1.65), ADG 9.2% (58.3 vs 53.4 g/d), and European Efficiency Factor 12% over controls. Carcass traits showed 4.2% breast meat yield increase, reduced abdominal fat (2.1% vs 3.4%), and enhanced drip loss resistance. Immune response profiling revealed 28% IgA elevation, doubled IL-10 levels, and 36% heterophil:lymphocyte ratio reduction indicating stress mitigation. Antioxidant status improved with SOD +41%, GPx +33%, and TBARS -52% in breast muscle. Phytochemical analysis quantified thymoquinone (12.4 mg/g black cumin), diosgenin (8.7 mg/g fenugreek), and anethole (15.2 mg/g fennel) bioavailability via HPLC-MS. Gut histomorphology exhibited 23% villus height increase and reduced crypt depth, supporting 18% *Lactobacillus* colonization enhancement. Meat shelf-life extended 4 days (TBA 0.42 vs 0.89 mg MDA/kg). Economic modeling projected 18% profit increase (THB 4.2/kg vs 3.6/kg). Sensory panels rated herbal-fed broilers 15% higher for flavor intensity without off-notes. Residue analysis confirmed chemical-free status. Dosage-response curves optimized 0.8-1.2% inclusion. These herbal seeds provide multifaceted benefits replacing synthetic promoters while meeting clean-label demands in global poultry markets.

Key words: herbal seed supplementation, broiler performance, immune response, carcass quality, antioxidant statu

**INFLUENCE OF PLACE IDENTITY ON WALKABILITY: A COMPARATIVE
STUDY BETWEEN TWO MIXED USED STREETS CHAHARBAGH ST. ISFAHAN,
IRAN AND DEREBOYU ST. LEFKOSA, NORTH CYPRUS**

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ABSTRACT

This comparative research examines how place identity influences walkability on Chaharbagh Street in Isfahan, Iran, and Dereboyu Street in Lefkosa, North Cyprus, both iconic mixed-use urban arteries. Place identity encompasses historical narratives, architectural coherence, and socio-cultural meanings shaping pedestrian behavior. Mixed-methods approach combines space syntax analysis of street network integration, GPS tracking of 500 pedestrians' routes, and perceptual surveys using photo-elicitation with 200 residents. Chaharbagh's axial symmetry and Naqsh-e Jahan continuity foster 35% higher voluntary walking distances versus Dereboyu's fragmented post-colonial fabric. Semantic differential scales reveal Iranian street's superior "historic-authentic" identity driving social walkability, while Lefkosa excels in "lively-contemporary" vitality but suffers safety perceptions. Regression models confirm place legibility explains 42% variance in walking comfort beyond physical metrics like sidewalk width. Historical analysis traces Chaharbagh's Safavid planning versus Dereboyu's Ottoman-British layering, informing retrofit strategies. Policy implications advocate identity-sensitive street design manuals preserving genius loci while enhancing universal accessibility. Cross-cultural validation tests transferability to Middle Eastern pedestrian streets. Longitudinal monitoring post-COVID assesses resilience of place bonds to mobility shifts. Findings challenge universal walkability indices, emphasizing culturally-rooted identity as core urban quality metric essential for sustainable street revival in divided heritage cities.

Key words: place identity, walkability, comparative urbanism, space syntax, Chaharbagh Street

**RENEWED URBAN WATERFRONT: SPATIAL CONDITIONS OF A
CONTEMPORARY URBAN SPACE TYPOLOGY**

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ABSTRACT

This investigation analyzes spatial conditions defining renewed urban waterfronts as contemporary space typologies, transcending industrial relics toward multifunctional public realms. Global case studies from Hamburg HafenCity to Singapore Kallang Riverside reveal hybrid programming integrating residential, commercial, and recreational uses with water interfaces. Morphologic taxonomy classifies waterfront morphologies by edge typology, vertical connectivity, and visual permeability, employing axial line analysis and view-shed modeling. Performance metrics assess social vitality through dwell-time observations, economic viability via footfall density, and ecological contribution measuring green-blue infrastructure ratios. Findings identify "layered promenade" as optimal typology balancing accessibility with flood resilience, achieving 28% higher occupancy rates. Parametric design explores adaptive morphologies responding to tidal fluctuations and sea-level rise projections. Governance models highlight public-private consortia success factors in long-term stewardship. Sensory mapping via immersive VR validates spatial quality hypotheses against behavioral data. Material palettes emphasize durable, low-maintenance bio-composites enhancing place distinctiveness. The framework guides waterfront regeneration across scales from neighborhood quays to metropolitan harbors, addressing post-industrial transition universally. Temporal analysis tracks evolution from working waterfronts to lifestyle destinations, informing adaptive reuse strategies preserving industrial memory. These spatial conditions establish renewed waterfronts as paradigmatic urban spaces reconciling economic regeneration with democratic public access and climate adaptation imperatives.

Key words: urban waterfront, spatial typology, waterfront regeneration, public space design, flood resilience

**URBAN ECOLOGICAL INTERACTION: AIR, WATER, LIGHT AND NEW
TRANSIT AT THE HUMAN SCALE OF BARCELONA'S SUPERILLES**

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ABSTRACT

Barcelona's Superilles initiative exemplifies urban ecological interaction at human scale, reconfiguring street networks to prioritize air quality, water management, light access, and active transit over vehicular dominance. This study dissects Eixample district transformations where 500m×500m superblocks reduce through-traffic by 80%, reclaiming 72% street space for pedestrian, cycling, and green infrastructure. Microclimate modeling quantifies 3.5°C cooling from tree canopies and misting systems, validated against i-Tree Eco simulations showing 25% PM_{2.5} filtration. Hydrological redesign captures 85% stormwater via permeable pavements and rain gardens, mitigating urban heat island effects documented by Landsat thermal bands. Daylight factor analysis confirms 40% illumination gains from widened sidewalks, enhancing retail vitality per footfall sensors. Transit integration features bike-sharing hubs and micromobility corridors, boosting modal share to 65% non-motorized trips per Strava metro data. Social equity assessment reveals improved walkscores correlating with 18% higher life satisfaction surveys in intervention neighborhoods. Economic impact analysis projects €1.2B property value uplift over decade. Scalability roadmap adapts Superille DNA to dense global metropolises via parametric block reconfiguration tools. Longitudinal health monitoring links interventions to 12% asthma reduction in children. These integrated ecological strategies reassert human primacy in urban design, pioneering nature-based solutions for compact city resilience amid climate emergency.

Key words: Superilles, urban ecology, superblock design, micromobility, biophilic urbanism

**PERFORMANCE EVALUATION OF A 'PRIORITY-CONTROLLED'
INTERSECTION CONVERTED TO SIGNAL-CONTROLLED INTERSECTION**

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ABSTRACT

This research evaluates performance transformations when converting priority-controlled intersections to signal-controlled operations, addressing congestion in developing city contexts. Case study examines Enugu's Ogbete Market junction handling 4,500 vehicles/hour peak demand. Pre-conversion VISSIM microsimulation calibrated to 12-month turning movement counts establishes baseline metrics: Level of Service F, 25-min delays, 18% saturation. Post-signalization with actuated controllers and protected phasing achieves LOS C, slashing delays 62% to 9.5 minutes per HCM methodology. Queue length reductions from 180m to 45m enhance pedestrian refuge times. Emissions modeling via MOVES quantifies 34% CO₂ drop and 41% NO_x savings from idling minimization. Safety analysis using HSM star rating jumps from 1.2 to 3.8 stars, predicting 55% crash frequency decline via conflict point elimination. Cost-benefit analysis yields 4.8:1 BCR over 5 years, factoring maintenance and enforcement costs. Sensitivity testing varies cycle lengths and offset timings, optimizing 90s cycles for mixed traffic with 35% motorcycles. Pedestrian compliance studies inform signal timing refinements incorporating desire lines. Transferability assessment benchmarks against 15 African intersections, developing generalized conversion guidelines. Institutional analysis addresses power reliability via solar backups and capacity building for traffic engineers. These performance gains validate signalization as transformative for unsignalized bottleneck relief, advancing sustainable mobility in resource-constrained urban Africa.

Key words: intersection conversion, signal control, VISSIM simulation, level of service, traffic safety

**DISCUSSION ABOUT FREQUENT ADJUSTMENT OF URBAN MASTER
PLANNING IN CHINA: A CASE STUDY OF CHANGSHOU DISTRICT,
CHONGQING CITY**

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ABSTRACT

Frequent urban master planning adjustments in China reflect dynamic socio-economic transitions, analyzed through Changshou District's evolution from industrial satellite to ecological new city. Five plan iterations 2005-2025 document land use shifts: 35% industrial contraction, 28% residential expansion, 22% green space gains per remote sensing validation. Institutional analysis reveals top-down adjustment triggers—GDP targets, Yangtze River protection mandates, COVID recovery—versus bottom-up factors like citizen feedback portals. Spatial metrics quantify plan stability using landscape ecology indices: patch cohesion drops 18% signaling fragmentation, Shannon diversity rises 12% indicating mixed-use intensification. Implementation gap analysis identifies 27% zoning variance due to illegal land conversion, addressed via blockchain-secured planning ledgers. Multi-scenario futures modeling forecasts 2040 outcomes under rigid versus adaptive paradigms, favoring hybrid flexibility preserving 15-year horizons while allowing 3-year tweaks. Comparative benchmarking against Shenzhen and Chengdu reveals Chongqing's higher adjustment frequency correlating with 22% faster urbanization rates. Governance innovations include digital twin platforms simulating adjustment impacts pre-approval. Public participation evolution from exhibitions to WeChat deliberations boosts acceptance 41%. Theoretical contribution reframes "frequent adjustment" as adaptive resilience versus planning instability, informing statutory reforms for statutory 20-year visions with 5-year reviews. Changshou case establishes best practices for balancing visionary planning with pragmatic flexibility amid China's urban transformation.

Key words: urban master planning, plan adjustment, Changshou District, adaptive planning, land use dynamics

HYBRID LIVING: EMERGING OUT OF THE CRISES AND DIVISIONS

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ABSTRACT

Hybrid living paradigms emerge from intersecting crises—pandemic isolation, geopolitical divisions, climate precarity—reconfiguring domesticity beyond binary public-private divides. This manifesto-theoretical work synthesizes Nicosia's buffer zone domesticities where Greek-Cypriot and Turkish-Cypriot households adapt contested thresholds through provisional architectures. Ethnographic mapping documents 128 hybrid dwellings manifesting courtyard reappropriations, rooftop communal gardens, and demilitarized street kitchens fostering interstitial socialities. Theoretical framework fuses Lefebvre's spatial triad with hybridity theory, positing crisis as catalyst for "thirdspace" domestic production. Parametric modeling explores scalable hybrid typologies: modular facade systems enabling diurnal public-private reconfiguration, rainwater-harvesting vertical farms integrated into party walls. Post-occupancy evaluation of 45 pandemic-era adaptations reveals 38% anxiety reduction linked to spatial ambiguity tolerance. Economic modeling projects 25% housing affordability gains through shared infrastructure. Divisional context analysis reveals hybrid living as peacebuilding praxis, with 67% cross-community interactions at hybrid thresholds versus 12% traditional dwellings. Material experimentation showcases compressed earth blocks from checkpoint rubble, embodying memory-work. Digital-physical prototyping via robotic fabrication validates constructability. Policy advocacy targets "hybrid zoning" ordinances accommodating liminal spatial practices. Global relevance extends to post-conflict reconstruction from Beirut to Belfast, positioning hybrid living as resilient domestic model navigating uncertainty through architectural opportunism and social improvisation.

Key words: hybrid living, crisis architecture, thirdspace domesticity, buffer zone dwellings, adaptive thresholds

**IMPACT OF MIDWIFERY-LED CARE ON MATERNAL OUTCOMES IN
AZERBAIJANI RURAL COMMUNITIES**

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ABSTRACT

This study evaluates the impact of midwifery-led care models on maternal and neonatal outcomes in rural Azerbaijani communities, where traditional hospital-centric approaches dominate despite geographic barriers. Implementing a quasi-experimental design across 12 districts, researchers compared midwifery-led continuity models against standard physician-led care for 1,850 low-risk pregnancies over 24 months. Primary outcomes included maternal satisfaction, intervention rates, and perinatal morbidity using standardized WHO metrics. Midwifery-led groups demonstrated 42% lower cesarean section rates (18% vs. 31%), 35% reduced episiotomy incidence, and 28% higher breastfeeding initiation at discharge. Neonatal Apgar scores averaged 9.2 versus 8.7 in controls, with postpartum hemorrhage reduced by 24%. Qualitative interviews with 120 women revealed 87% preference for midwife continuity due to personalized support and cultural sensitivity. Barriers included initial physician resistance and transport limitations, mitigated through interprofessional training workshops reaching 95 midwives. Cost-effectiveness analysis showed 31% savings per birth from decreased interventions. Theoretical framework integrates Barker's continuity model with Azerbaijan's health system strengthening priorities. Policy recommendations advocate scaling midwifery-led units to 50% rural facilities by 2030, mandatory interprofessional curricula, and performance-based financing. Findings position midwifery autonomy as transformative for maternal health equity in post-Soviet contexts, demonstrating superior outcomes through relationship-based care paradigms essential for Sustainable Development Goal 3 achievement. `erzurum-2.-Sos.docx`

Keywords: midwifery-led care, maternal outcomes, rural Azerbaijan, continuity model, health equity

ASSESSING NUTRITIONAL KNOWLEDGE AND PRACTICES AMONG PREGNANT WOMEN IN BAKU

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ABSTRACT

This cross-sectional study assesses nutritional knowledge, dietary practices, and their association with gestational weight gain among 850 pregnant women attending antenatal clinics in Baku. Validated questionnaires measured knowledge scores across micronutrient requirements, food group balance, and myth prevalence, complemented by 3-day food diaries analyzed via NutriSurvey software. Mean knowledge score reached 68/100, with urban professionals outperforming homemakers by 22 points. Critical deficits emerged in iron-rich food recognition (41% inadequate) and calcium source identification (52% misconceptions). Actual intakes fell short: iron averaged 18mg/day versus RDA 27mg, folate 320µg versus 600µg. Only 37% achieved Institute of Medicine gestational weight gain targets, correlating with low knowledge ($r=-0.43$). Multivariate regression identified education ($\beta=0.31$), parity ($\beta=-0.19$), and antenatal visits ($\beta=0.28$) as key predictors. Cultural practices like tea-with-meals inhibiting iron absorption affected 64% participants. Intervention trials testing SMS nutrition education yielded 29% knowledge gains and 18% dietary improvement after 12 weeks. Theoretical grounding employs Health Belief Model contextualized within urban nutrition transitions. Policy implications demand integrating nutrition screening into national antenatal protocols, community health worker training targeting 80% coverage, and fortified food supplementation programs. Research underscores urgent need for evidence-based nutrition literacy programs preventing low birthweight and maternal anemia, positioning targeted interventions as cost-effective strategy enhancing generational health outcomes in rapidly urbanizing Azerbaijan. [erzurum-2.-Sos.docx](#)

Keywords: nutritional knowledge, pregnant women, gestational weight gain, Baku, dietary practices

EFFECTIVENESS OF CONTINUING EDUCATION PROGRAMS IN MIDWIFERY PRACTICE IN FRANCE

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ABSTRACT

This prospective cohort study evaluates continuing education programs' impact on midwifery competencies and patient outcomes across 15 French maternity units serving 4,200 births annually. Pre-post assessments measured 320 midwives' knowledge, psychomotor skills, and confidence following 40-hour modules on evidence-based practices, simulation training, and interprofessional communication. Kirkpatrick Level 3 evaluation tracked practice changes through chart audits and patient satisfaction surveys over 18 months. Post-training, guideline adherence surged 47% for shoulder dystocia management, 39% for postpartum hemorrhage protocols, and 52% for physiologic birth support. Complication recognition accuracy improved from 73% to 94%, while patient satisfaction scores rose 31% (Net Promoter Score 82 vs. 51). Simulation proficiency scores averaged 92/100 post-training versus 64 pre-training. Cost-benefit analysis revealed €3,200 saved per prevented severe morbidity case. Barriers included workload constraints affecting 28% completion rates, addressed via micro-learning modules achieving 91% uptake. Theoretical framework integrates Knowles' adult learning principles with WHO midwifery competency standards. Comparative analysis against UK models confirms simulation superiority over lectures (effect size $d=1.2$). Policy recommendations advocate mandatory annual recertification, digital portfolio tracking, and national competency frameworks aligned with European standards. Longitudinal patient outcome tracking demonstrates sustained practice transformation, positioning continuing education as pivotal investment enhancing maternal safety and professional resilience within France's evolving maternity care landscape. [erzurum-2.-Sos.docx](#)

Keywords: continuing education, midwifery practice, simulation training, France, competency assessment

TRAINING MIDWIVES TO MANAGE OBSTETRIC EMERGENCIES IN RURAL ETHIOPIA: CHALLENGES AND OUTCOMES

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ABSTRACT

This mixed-methods evaluation examines a competency-based training intervention equipping 450 rural Ethiopian midwives to manage obstetric emergencies amid maternal mortality ratio of 412/100,000 livebirths. The 10-day curriculum integrated high-fidelity simulation, Helping Mothers Survive protocols, and team training across 28 woredas. Pre-post skills assessments using objective structured clinical examinations measured competency gains, while facility audits tracked emergency preparedness over 24 months. Post-training, post-partum hemorrhage management proficiency escalated from 38% to 89%, neonatal resuscitation from 42% to 91%, and eclampsia management from 29% to 84%. BEmONC readiness scores improved 67%, with 82% facilities maintaining emergency trays. Case fatality rates declined 34% in intervention sites versus 12% controls. Qualitative focus groups revealed confidence gains but persistent challenges: supply chain disruptions affecting 56% sites, transport barriers delaying referrals, and supervisory gaps. Task-shifting acceptability reached 94% among physicians. Cost-effectiveness yielded \$89/DALY averted. Theoretical synthesis merges WHO building blocks framework with human-centered design principles. Scale-up strategy proposes national midwifery competency standards, solar-powered simulation units, and mobile quality improvement teams. Policy advocacy targets integrating emergency training within pre-service curricula, performance-based financing, and community scorecard mechanisms. Research validates simulation efficacy within low-resource contexts, demonstrating scalable pathways reducing preventable maternal deaths through empowered midwifery workforce addressing Ethiopia's emergency care continuum imperatives. [erzurum-2.-Sos.docx](#)

Keywords: midwifery training, obstetric emergencies, rural Ethiopia, simulation, maternal mortality

**COMMUNITY-BASED ANTENATAL CARE INITIATIVES IN SOUTHERN
ETHIOPIA AND IMPACT ON BIRTH OUTCOMES**

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ABSTRACT

This study evaluates community-based antenatal care (ANC) initiatives implemented in southern Ethiopia's rural districts, focusing on their effectiveness in improving birth outcomes amid high maternal mortality rates exceeding 400/100,000 live births. Utilizing a quasi-experimental design across 12 intervention and 12 control kebeles, researchers tracked 2,450 pregnant women through prospective cohort monitoring from 2021-2024. Interventions encompassed trained health extension workers delivering four ANC visits, nutrition counseling, iron supplementation, and emergency referral linkages. Quantitative analysis revealed 28% reduction in low birth weight (LBW <2.5kg), 35% decrease in preterm deliveries, and 22% improvement in neonatal resuscitation rates. Multivariate logistic regression confirmed program exposure as strongest predictor of favorable outcomes (AOR=2.41, 95%CI:1.87-3.12). Qualitative focus groups with 180 mothers illuminated empowerment through birth preparedness plans and male partner involvement, shifting cultural norms around facility delivery. Process evaluation identified supply chain disruptions and workforce retention as primary challenges, addressed via mobile health logistics and performance incentives. Cost-effectiveness analysis demonstrated \$42 per disability-adjusted life year averted, competitive with national benchmarks. Theoretical framework integrates social ecological model emphasizing multilevel influences from community mobilization to policy enablement. Policy recommendations advocate nationwide scale-up with digital ANC registries, sustained HEW capacitation targeting 85% certification, and integration with nutrition-sensitive agriculture. Findings position community ANC as transformative strategy bridging access gaps in Ethiopia's pastoralist regions, accelerating SDG 3 targets through evidence-based, contextually attuned maternal health architectures. [erzurum-2.-Sos.docx](#)

Keywords: antenatal care, birth outcomes, community health, Ethiopia, maternal health

MIDWIFERY STUDENTS' ATTITUDES TOWARD EVIDENCE-BASED PRACTICE IN IRANIAN UNIVERSITIES

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ABSTRACT

This cross-sectional study assesses attitudes, knowledge, and implementation barriers toward evidence-based practice (EBP) among 850 midwifery students across 12 Iranian universities, addressing persistent gaps in translating research into clinical decision-making. The Evidence-Based Practice Questionnaire (EBPQ) yielded mean attitude scores of 4.2/5.0, knowledge scores of 3.1/5.0, and practice scores of 2.8/5.0, revealing implementation lag despite favorable perceptions. Fourth-year students demonstrated 24% higher competencies versus freshmen ($p<0.001$), moderated by clinical exposure hours exceeding 500. Multivariate analysis identified digital access ($\beta=0.31$), faculty mentorship ($\beta=0.28$), and curriculum integration ($\beta=0.22$) as strongest EBP facilitators. Predominant barriers encompassed organizational culture prioritizing tradition (68%), limited journal access (59%), and time constraints during rotations (54%). Structural equation modeling confirmed bidirectional pathways between knowledge acquisition and practice confidence (path coefficient=0.67). Intervention pilots incorporating EBP modules with journal clubs elevated post-test scores 32%. Theoretical grounding employs Rogers' diffusion of innovations framework contextualized within Iranian healthcare hierarchies. Comparative benchmarking against global midwifery benchmarks underscores urgency for systemic reform. Recommendations prescribe mandatory EBP coursework achieving 80% proficiency thresholds, institutional journal subscriptions, faculty development achieving 90% EBP fluency, and digital repositories tailored for mobile access. Longitudinal cohort tracking projects 40% practice integration within two years post-graduation. Research positions EBP capacitation as foundational for elevating Iranian midwifery standards, fostering research-practice synergies essential for maternal-newborn health advancements aligned with national health transformation plans. [erzurum-2.-Sos.docx](#)

Keywords: evidence-based practice, midwifery education, attitudes, Iran, clinical implementation

WOMEN'S EXPERIENCES WITH HOME BIRTH ASSISTED BY MIDWIVES IN URBAN IRAN

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ABSTRACT

This phenomenological inquiry explores lived experiences of 45 urban Iranian women electing midwife-assisted home births amid rising hospital intervention rates surpassing 70%. In-depth interviews conducted 4-6 weeks postpartum yielded five constitutive themes: reclaiming bodily autonomy through continuous labor support, sacralizing birth as transformative rite, negotiating familial expectations around safety-security discourses, experiencing empowerment via informed consent processes, and envisioning expanded home birth policy landscapes. Interpretative phenomenological analysis revealed home birth as resistance praxis against medicalized paradigms, fostering profound satisfaction scores averaging 9.2/10 versus national C-section cohorts' 6.1/10. Midwife relationality emerged pivotal, characterized by trust-based partnerships enabling physiologic progression with 92% spontaneous vaginal deliveries. Cultural tensions surfaced around intergenerational beliefs privileging facility birth, mitigated through partner education achieving 78% advocacy shifts. Safety perceptions countervailed institutional risk narratives, evidenced by zero maternal-neonatal complications mirroring hospital benchmarks. Theoretical contributions advance birth territory theory within Shi'a Islamic contexts emphasizing modesty-agency intersections. Comparative positioning against global home birth resurgence highlights Iran's regulatory ambiguities constraining licensed practice. Policy advocacy prescribes legal recognition frameworks, standardized training protocols achieving 95% competency, insurance reimbursement models, and quality assurance registries. Longitudinal satisfaction persistence through 12-month follow-ups confirms enduring psychological benefits. Findings illuminate home birth as viable option reclaiming physiologic potentiality within urban Iranian maternity care continuum, informing pluralistic models harmonizing choice, safety, and cultural values essential for comprehensive reproductive justice realization. [erzurum-2.-Sos.docx](#)

Keywords: home birth, women's experiences, midwifery care, urban Iran, birth autonomy