

**RESILIENT, INCLUSIVE, AND SMART CITIES:
CONTEMPORARY PERSPECTIVES ON
URBAN DEVELOPMENT**



Resilient, Inclusive, and Smart Cities: Contemporary Perspectives on Urban Development

<i>Editor:</i>	Marija Miloshevska Janakieska
<i>Publisher:</i>	Balkan University Press
<i>Place of Publication:</i>	Skopje, North Macedonia
<i>Year of Publication:</i>	2026
<i>Edition:</i>	1st Edition
<i>No. of BUP Publication:</i>	60
<i>Name of Book Series:</i>	Architecture & Design
<i>Book Series Editor:</i>	Marija Miloshevska Janakieska
<i>No. of Publication Within Book Series:</i>	3
<i>Design:</i>	Seyfullah Bayram
<i>ISBN:</i>	978-608-4868-70-5
<i>DOI:</i>	https://doi.org/10.69648/OAKY7871

This edition is published by the Balkan University Press in Skopje, North Macedonia, 2026

Makedonsko Kosovska Brigada, Skopje 1000

Balkan University Press is a brand of the International Balkan University.



This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

**RESILIENT, INCLUSIVE, AND SMART CITIES:
CONTEMPORARY PERSPECTIVES ON
URBAN DEVELOPMENT**

Edited by:

Marija Miloshevska Janakieska



Contents

Foreword xxi

PART 1: Resilient Ecologies And Sustainable Urban Futures

- Circular Strategies for Urban Regeneration Through
Applying Environmental R's in the Redesign of the
Museum of Contemporary Art in Skopje 3
Marija Miloshevska Janakieska
- The Impact of Coastal Urban Agglomeration on Landscape
Fragmentation: A Temporal and Spatial Approach 21
Merve Yilmaz
- The Skopje 1963 Post-Earthquake Reconstruction
as a Model for Disaster Relief 47
Marko Icev
- Tools for Sustainable and Resilient Riverfronts:
The Role of Building Certificates and Design Manuals
in Hafencity, 3land, and Neckarbogen 61
Sanja Avramoska
- Rethinking Green Infrastructure in Skopje through
Regional Best Practices 87
Faton Kalisi

The Sustainability of the Urban Renewal After Earthquake
Disasters: Comparison of the Experiences of North
Macedonia and Türkiye 111
Kefajet Edip

Analyzing Spatial Pattern of Relatively Cooler Areas to
Mitigate Urban Heat Islands in İzmir 139
Kemal Mert Cubukcu, Yasemin Şentürk

PART 2: Urban Inequalities, Identities, and Collective Agency

Rural Areas in the Shadow of Urbanization: An Analysis
of Spatial and Socio-Economic Transformation in
Kayapınar District, Diyarbakır 169
Sevilay Akalp, Dilan Kakdaş Ateş

The Individual Traces in Public Space: An Evaluation
of Place Attachment and Personalization Practices 189
Ece Kaya, Eren Kürkçüoğlu

**PART 3: Smart Urbanisms, Governance,
and Spatial Innovation**

Transport Authorities and Innovation: Understanding
Barriers for MaaS Implementation in Turkey 217
Berna Çalışkan

Reimagining the Role of Skopje Aqueduct in
Contemporary Urban Life 249
*Mimoza Klekovska, Jasna Grujoska-Kuneska,
Arbresha Ibrahim*

Digital Governance and Urban Space Production: Smart City Applications on the Examples of Istanbul, Barcelona, and Amsterdam	267
<i>Hatice Savaş Demir</i>	
Urban Diplomacy and Toponymic Gift-Giving in Çanakkale	283
<i>Canan Zehra Çavuş, Sevim Kocabaş</i>	
Public Toilets in Istanbul: A Spatial and Socio-Cultural Assessment	305
<i>Ali Yılmaz, Cihan Mert Sabah</i>	

About the Editor

Marija Miloshevska Janakieska holds a PhD and a Master's degree in Civil Engineering, as well as a Master's degree in Architecture from the University of Ss. Cyril and Methodius in Skopje, Macedonia. She is a Professor and Head of the Department of Architecture at the Faculty of Engineering, International Balkan University, where she teaches design, architecture, and construction courses, and mentors students in both research and practical studio work.

In addition to her academic career, she is the manager and lead architect at A2M2 Architecture, where she focuses on innovative, sustainable, and material-driven architectural solutions. She has gained extensive professional experience in renowned studios, contributing to diverse projects in architecture, engineering, and design.

Her research and teaching interests center on architectural structures, facade design and construction, building materials, with emphasis on wood, EWPs, and glass, sustainability and energy efficiency, and biophilic and nature-integrated design.

Her academic and professional achievements have been recognized through several awards, including: IBU Academic Team Award for the International Architectural Competition for the urban quarter Rasadnik in Skopje (2023); Engineers Ring (2011), which is awarded to the best graduated students from the technical faculties in Macedonia; and “26th July – Frank Manning” Award for Academic Excellence (2009) for the best student in the final year of studies.

Marija Miloshevska Janakieska serves as Editor-in-Chief of the Journal of Balkan Architecture and Series Editor of the Architecture and Design book series at Balkan University Press. She has authored numerous publications in international journals and conference proceedings and is the author of two recent books dedicated to wood and Engineered Wood Products (EWPs).

In this book, she is the author of the first chapter titled “Circular Strategies for Urban Regeneration through Applying Environmental R’s in the Redesign of the Museum of Contemporary Art in Skopje.”

Marija Miloshevska Janakieska continues to bridge academia, research, and practice through a strong commitment to sustainable and innovative design.

ORCID: 0009-0008-9813-6235

About the Authors

Merve Yılmaz was awarded a PhD in Urban Planning in 2019 for her thesis on the effects of socio-economic development characteristics of coastal cities on urban spatial development. She has conducted her postdoctoral research on ecosystem services, advanced quantitative research methodologies, and data management. She currently holds the position of assistant professor in the Department of City and Regional Planning at Gebze Technical University in Türkiye. Her research concentrates on deep learning, artificial neural networks, and digital urban science, with the development of innovative geospatial quantitative tools and methods that inform the future development of urban areas. She continues her research on human-centered energy approaches in cities, spatial data-driven advanced analysis methods, and information technologies applied to planning. Her ongoing research and projects address energy, mobility, and carbon emissions within urban contexts.

ORCID: 0000-0002-5049-3224

Marko Icev is an architectural historian, urbanist, and architect. He is currently an Assistant Professor in architecture at International Balkan University in Skopje. He received his doctorate degree from the University of California, Los Angeles, with a dissertation titled “Building Solidarity: The case of the 1963 Skopje post-earthquake reconstruction.” Previously, he received his MSc. in Architecture and Urban Design from the Pratt Institute and his B.Arch from Jefferson University. He has worked in education and in the private sector in the US and in N. Macedonia. His interests include architectural modernity of

the 19th and 20th centuries, disaster relief and reconstruction, and labor practices.

ORCID: 0009-0003-5738-8309

Sanja Avramoska holds a Master of Architecture degree, which she completed in 2018 at the Faculty of Architecture, Ss. Cyril and Methodius University in Skopje, where she has been working as a teaching assistant since 2020. She is also a PhD candidate at the Faculty of Architecture at TU Darmstadt. Her research explores resilient cities, riverfront redevelopment, and the role of architectural and urban engineering in shaping urban transformation. She has presented her work at international conferences and has been recognized through platforms such as the Future Architecture Platform and the LINA Platform.

ORCID: 0000-0002-5119-6029

Faton Kalisi is a teaching assistant at the International Balkan University in Skopje, North Macedonia. He holds a master's degree in architecture from the Faculty of Architecture at the International Balkan University, awarded in 2023 following a full-time programme in Engineering Architecture. His research interests centre on sustainable and green architecture, with a focus on architectural mitigation strategies for indoor and urban air pollution. His scientific work includes journal publications on algae-based systems for indoor air purification and bio-facades for air pollution reduction, as well as a conference paper examining the impact of wood treatments on indoor air quality. He has also completed a study on green infrastructure strategies in Skopje based on regional best practices.

ORCID: 0009-0008-4927-6100

Kefajet Edip is Master of Architecture with broad experience both as a project architect and lecturer. She holds a PhD in technical sciences in the field of earthquake engineering, and her research interest is focused on the sustainability and resilience of urban development in seismic risk zones. She presented her most recent research work, solely authored by her, titled: “Urban Planning in Skopje and the Inclusion of the Community in the Decision Making Process, Case Studies: Municipalities of Cair, Butel and Karposh” at the UPRUN conference at the Faculty of Architecture at Ss. Cyril and Methodius University in Skopje in March 2025. Kefajet Edip is an Assistant Professor at the Faculty of Engineering at International Balkan University.

ORCID: 0009-0003-4241-9897

Yasemin Şentürk graduated with a second-class degree from the Department of Urban and Regional Planning at Izmir Institute of Technology in 2012. She was a YÖK 100/2000 scholar in the Urban and Regional Planning PhD program at Dokuz Eylül University, focusing on Smart and Sustainable Cities. Her academic research focuses on climate resilience, mitigation of urban heat islands, green space planning, GIS, spatial statistics, and remote sensing. She began her professional career as a research assistant and has been working as an urban planner in local governments since 2021. She is currently employed as a project coordinator at the Strategy Development Department of Karşıyaka Municipality, where she is involved in national and international project application and management processes.

ORCID: 0000-0002-7158-6657

Kemal Mert Cubukcu completed his undergraduate studies in the Department of City and Regional Planning at METU and received his master's and doctoral degrees from the Department of City and Regional Planning at The Ohio State University. His research interests include quantitative planning methods, spatial statistics, transportation planning, and transportation modeling. He has published extensively in academic journals. He is the author of two books titled Classical Quantitative Methods in Planning and Basic Statistics and Spatial Statistics in Planning and Geography. Prof. Çubukçu is a recipient of the I. Stollmann Award and the Regional Science Association International (RSAI) Dissertation Contest (Second Prize) and is currently a faculty member at the Department of City and Regional Planning at Dokuz Eylül University in İzmir.

ORCID: 0000-0003-3604-7014

Dilan Kakdaş Ateş is an architect and a faculty member at Bitlis Eren University. She earned her PhD from Dicle University. She is currently working at Bitlis Eren University. Her main research interests include architectural restoration, conservation, and historical building architecture, with a particular focus on the preservation of cultural heritage.

ORCID: 0000-0002-5984-3462

Sevilay Akalp is an architect and a University Lecturer. She completed her Master's degree at Dicle University in 2018 and earned her PhD from Gazi University in 2024. She is currently working as a Lecturer in the Department of Architecture at Harran University. Her major research interests include

computational design, energy analysis modelling, vernacular architecture, and energy-efficiency building design.

ORCID: 0000-0002-4624-3476

Ece Kaya is an urban planner and academician. Since 2024, she has been engaged in her academic career as a research assistant in the Department of Urban and Regional Planning at Gebze Technical University. She graduated from Istanbul Technical University's Department of Urban and Regional Planning in 2022. She is currently pursuing a Master's degree in Urban Design at Istanbul Technical University, with an upcoming thesis titled 'Place Attachment, Personalisation and Tracing Practices in Public Spaces: The Case of Kurtuluş-Bozkurt Neighborhood'. Her research interests include urban design, public space design, and environmental behavior theories.

ORCID: 0009-0003-3360-1152

Eren Kürkçüoğlu is an urban planner, an architect, and academician at Istanbul Technical University, Department of Urban and Regional Planning. He received his PhD with his dissertation titled "Spatial and Psychological Impact Assessment of Pedestrian Movements in Urban Pattern" in 2015 and his associate professorship in 2023. His research interests include urban design, urban morphology, spatial perception, environmental psychology, and urban history. He's an active member of TNUM (Turkish Network of Urban Morphology).

ORCID: 0000-0002-3723-9803

Berna Çalışkan graduated from Yıldız Technical University, Istanbul, with a bachelor's degree in 2003 and completed her master's degree in Transportation Engineering at Istanbul Technical University in 2005. She earned her PhD from Istanbul Technical University in 2023. Her academic experience includes serving as a part-time lecturer at Okan University, Faculty of Engineering and Natural Sciences, during the 2025–2026 academic year.

ORCID: 0000-0001-9625-3237

Mimoza Klekovska received a PhD degree in the field of Graphic Engineering from the University “St. Kliment Ohridski” - Bitola, an MSc degree in Computer Graphics from the University of St. Cyril and Methodius - Faculty of Electrical Engineering and Information Technologies (FEIT), and a BSc degree from the Faculty of Architecture in Skopje. She was elected as a full-time professor in the fields of Graphic Engineering and Artificial Intelligence.

She is an author of scientific papers published in international journals, conference proceedings, and book sections in the areas of pattern recognition, education, and artificial intelligence. Her experience is in both the education and business sectors. Her teaching subjects were in the fields of digital forensics, descriptive geometry, and urbanism. Currently works at Municipality of Karpoš, sector of urbanism.

ORCID: 0009-0009-1916-7808

Jasna Grujoska-Kuneska is an Assistant Professor in the Department of Architecture at International Balkan University in Skopje. She holds a PhD in Technical Sciences (Earthquake Engineering) from the Institute of Earthquake Engineering and Engineering Seismology (IZIIS). With professional experience in architectural design, her research centers on architecture and cultural heritage, with a particular focus on the study and conservation of historic buildings, using non-destructive diagnostic methods in earthquake-prone regions. She has contributed to academic research and projects, including Monitoring the Orthodox Cultural Heritage, led by the National Committee of ICOMOS Macedonia, supporting initiatives in heritage assessment and preservation.

ORCID: 0009-0007-7875-8136

Arbresha Ibrahim is an Assistant Professor at the Department of Architecture, Faculty of Engineering, at International Balkan University. She holds a Ph.D. in Architecture from the University of Ljubljana, a master's degree earned in 2014 from St. Cyril and Methodius University in Skopje, and a bachelor's degree from the State University of Tetovo (2012). Her research interests center on the impact of social and cultural buildings on urban identity and community cohesion, with a strong publishing focus on museum architecture and museum-led urban regeneration. Alongside academia, she is engaged in architectural practice and collaborates with the Young Designers Circle of the World Design Organization.

ORCID: 0009-0008-3502-6901

Hatice Savaş Demir works as a research assistant in the Department of Interior Architecture (TR) at Istanbul Beykent University, Faculty of Engineering-Architecture. She completed her master's degree in Architectural History and Theory at Yıldız Technical University. She is currently a PhD candidate in Architectural Design at Yıldız Technical University. Her research focuses on virtual reality, the use of digital tools in design, participatory design, and the reuse of historic buildings. She has contributed to academic publications and conferences on related topics. She is also conducting research on the use of VR in interior architecture design education at the Department of Interior Architecture (TR) at Istanbul Beykent University.

ORCID: 0000-0003-0189-3544

Canan Zehra Çavuş got her BS, MS, and PhD degrees, respectively, in 2000, 2004, and 2014 from Çanakkale Onsekiz Mart University. The title of her doctoral thesis was "Evaluation of Land Use Suitability for Settlement in the Eastern Çanakkale Strait." In 2022, she became an associate professor. Dr. Çavuş currently works as an associate professor in the Department of Geography, Human and Economic Geography Division, at Çanakkale Onsekiz Mart University. She is the Vice Head of the department and the Chair of the Human and Economic Geography Division. Dr. Çavuş's main research fields include settlement geography, urban geography, and contemporary urban studies; urban land use and change; urbanization processes and spatial transformation; urban cultural heritage areas and management; urban identity, toponymy, and spatial memory; local governments; and urban planning processes. She teaches undergraduate and graduate courses in these fields.

ORCID: 0000-0002-9544-4901

Sevim Kocabaş is a graduate student in the Geography Department of the Graduate School of Çanakkale Onsekiz Mart University. She completed her undergraduate degree in geography at the same university. She is currently conducting her master's thesis entitled "Urban Toponymy in Çanakkale", basically focusing on the spatial, cultural, and political dimensions of place-naming practices in urban environments. Together with graduate study, she is also enrolling in undergraduate programs in Political Science & Public Administration and Energy Management. Her primary research interests include toponymy, urban and cultural geography, critical place-name studies, and the intersection of geography with political processes. She received a research article award for an article she authored in the field of toponymy.

ORCID: 0009-0005-9740-1349

Ali Yılmaz graduated from the Department of Urban and Regional Planning at Istanbul Technical University (ITU) in 2018. He completed his M.Sc. degree in the Urban Design Program at ITU in 2022 with a thesis focusing on pedestrian movement. He is currently pursuing his Ph.D. in Urban and Regional Planning at ITU. Alongside his doctoral studies, he has been working as a research assistant at the Department of Urban and Regional Planning at ITU. His research interests include spatial quantitative methods, disaster studies, and post-disaster recovery processes, with a particular emphasis on urban resilience and analytical approaches in planning.

ORCID: 0000-0003-2203-8416

Cihan Mert Sabah graduated from the Department of Urban and Regional Planning at İzmir Institute of Technology in 2018 and continued his graduate studies at Istanbul Technical University (ITU). He received three honour certificates between 2013 and 2017 and participated in the Erasmus+ Programme in Greece (2018) and Portugal (2023). He completed his M.Sc. thesis on ethics in planning within the Regional Planning Program between 2018 and 2020, focusing on planning dynamics and ethical perspectives. He began his Ph.D. studies in Urban and Regional Planning at ITU in 2020. Since 2022, he has been working as a research assistant at the ITU Faculty of Architecture and was a visiting scholar at the University of Lisbon between 2022 and 2023. His research interests include place attachment in temporary spaces, regional planning, disaster risk management, planning theory, and ethics.

ORCID: 0000-0001-8994-5112

Foreword

Cities are very complex systems, and they are shaped by different factors – historical, social, economic, and environmental. We live in an era of rapid urbanization, climate changes, technological transformations, and deep social inequalities. Therefore, understanding urban development has become an urgent matter, but also a challenging one. This edited volume brings together selected research contributions presented at the 10th Urban Studies Congress, held on October 22-24, 2025, in Skopje, under the theme “Urban Development: Processes, Challenges, and Solutions”.

The congress was hosted by the Department of Architecture, Faculty of Engineering, at International Balkan University. It provided an interdisciplinary platform for researchers, academicians, practitioners, and policymakers to be engaged in one of the most pressing issues of our time – urban development. The choice of Skopje as a host city is also interesting, since Skopje as a city is shaped by layered histories, post-earthquake reconstruction, fast

transformation, and ongoing relations between heritage, identity, and modernization.

The congress received more than 180 paper submissions from diverse backgrounds, including urban and regional planning, landscape design, architecture, sociology, geography, environmental sciences, and political studies. After a rigorous peer-review and editorial evaluation process, a careful selection of papers was made so that they could be included in this volume. The selected papers are organized in three separate but interrelated thematic sections.

The first section – Resilient Ecologies and Sustainable Urban Futures explores climate adaptation, resilience, environmental performance, urban regeneration, and sustainable design strategies.

The second section - Urban Inequalities, Identities, and Collective Agency is focused on social justice, inequality, identity, migration, gender, and activism in urban contexts.

The last section - Smart Urbanisms, Governance, and Spatial Innovation covers governance, technology, design, spatial systems, and post-pandemic innovation.

As editor of this volume, I would like to express my sincere gratitude to all authors for their valuable contributions, to the scientific and organizing committee of the congress for their dedication throughout the whole process, and to the reviewers whose careful evaluations ensured a high academic quality of the selected papers. This volume stands as a collective effort, reflecting the richness of ideas for improving cities.

I hope that this book will serve as a meaningful resource for researchers, students, academicians, and practitioners, and it will contribute to ongoing discussions on how cities can evolve and become more resilient, inclusive, and sustainable.

Editor

PART 1

Resilient Ecologies And Sustainable Urban Futures

Circular Strategies for Urban Regeneration Through Applying Environmental R's in the Redesign of the Museum of Contemporary Art in Skopje

Marija Miloshevska Janakieska

International Balkan University, Skopje, North Macedonia

ORCID: 0009-0008-9813-6235

Abstract

Cities are facing many issues nowadays connected with urban growth and social changes. Circular economic strategies for urban regeneration can help address some of the issues that cities are facing. This paper is focused on the environmental R's, such as Reuse, Repair, Recycle, Repurpose, Rethink, Refuse, Response, and Reduce, and how these R's can be applied in the urban regeneration of one building and its surroundings. The research is focused on the Museum of Contemporary Art in Skopje, the capital city of North Macedonia. The first part of the paper is focused on theoretical frameworks and analyses, trying to identify the negative features of the case study. As part of a Sustainable Architecture course, students worked on redesigning the Museum of Contemporary Art to create better connections

with its surroundings, use local materials, and adopt sustainable practices, aiming to make the museum and its nearby area more welcoming for visitors. The second part of the paper is focused on several design proposals given by the students where the environmental R's are implemented.

The findings suggest that circular regeneration can lower carbon emissions, encourage social inclusivity, and revitalize urban spaces while preserving their historical significance. The paper concludes by stressing the importance of integrating environmental principles into urban renewal processes to create resilient and sustainable urban areas.

Keywords: circular design, urban regeneration, environmental R's, adaptive reuse, urban sustainability

Introduction

Urban regeneration has emerged as a solution to an issue related to cities' changes and environmental, social, and economic challenges. In addition, the concepts of sustainability, circular economy, and energy efficiency are crucial when it comes to urban regeneration. These concepts are essential for creating more resilient cities. The circular design principles are trying to find different solutions, unlike the traditional linear economy and the concept of "take-make-dispose". The application of the environmental principles, such as Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recovery, has become popular, especially in architectural and urban design (Lehmann, 2011).

This paper focuses on the connection between the circular design strategies, sustainability, and urban regeneration and redesign, analyzing a case study of the Museum of Contemporary Art in Skopje, North Macedonia. The building is a beautiful architectural masterpiece with a significant cultural meaning. The building location is in the city center, positioned on a hill, making it visible from different sides. Besides these positive features, the building and its surroundings also have many disadvantages. One of them is that the space around the museum is underutilized. This makes the museum a perfect building for urban regeneration using sustainable design and circular principles. The research aims to explore how design can transform urban environments using the environmental R's.

The study is conducted based on an educational project which was part of one course in the 4th year at the Department of Architecture, Faculty of Engineering, at International Balkan University. The course was Sustainable Architecture, and it was suitable for this kind of educational project on this topic. The students were given an assignment to redesign the museum and its surroundings by using principles of sustainability, energy efficiency, and circular economy, to improve the negative aspects of the building and to reinforce the relationship between the building and its urban context. Students were encouraged to think about sustainability, adaptive reuse, and spatial justice as a pedagogical goal.

The structure of the paper contains a theoretical overview of the circular economy and its impact on the built environment, the environmental R's, adaptive reuse, spatial justice, and educational framework. Furthermore, the methodology

and the methods used in this paper are explained. The methodology is followed by a discussion where different design proposals are analyzed. The results are given in a separate section, which is followed by the conclusions, where a summary of the research is given.

Theoretical Framework

Circular Economy in the Built Environment

Circular Economy (CE) is a well-known term today, which emerged as a strategic response to the global environmental crisis and resource depletion. The CE is a completely opposite concept of the linear economy. CE is regenerative by design, aiming to retain the value of materials, components, and products for as long as possible (Ellen MacArthur Foundation, 2013). When taking into consideration the built environment, strategy promotes design with minimum waste, maximizing the efficiency of the resources, and extending the life cycle of the buildings (Pomponi & Moncaster, 2017). In architecture, circular strategies include disassembly, material recovery and reuse, adaptive reuse, modular and multifunctional design, which contribute to reduced carbon emissions and waste. However, these strategies are not just limited to materials and construction methods, but they are also focused on spatial, cultural and social development. Buildings and urban spaces are increasingly viewed as “material banks” (Rios et al., 2019), where every component has the potential for future use. This mindset challenges conventional demolition-based redevelopment and supports more sustainable forms of urban regeneration.

The Environmental R's in Architecture and Urban Design

Environmental R's— Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle and Recovery —serve as practical and conceptual tools for applying CE in architecture (Miloshevska Janakieska, 2024). Initially popularized in waste management discourse, the R's have expanded into design thinking and sustainability education (Kirchherr et al., 2017). Each “R” implies a distinct strategy that can be translated into architectural decisions. These strategies are contributing to a multi-dimensional approach for urban transformations.

Table 1.

CE strategies (Morseletto, 2020)

Category	Code	Strategy	Description
Smarter product use and manufacture	R0	Refuse	Make a product redundant by abandoning its function or by offering the same function through a radically different product.
	R1	Rethink	Make product use more intensive (e.g., through sharing products or placing multifunctional products on the market).
	R2	Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources.

Category	Code	Strategy	Description
Extend lifespan of product and its parts	R3	Reuse	Reuse by another consumer of a discarded product that is still in good condition and fulfills its original function.
	R4	Repair	Repair and maintain a defective product so it can be used with its original function.
	R5	Refurbish	Restore an old product and bring it up to date.
	R6	Remanufacture	Use parts of a discarded product in a new product with the same function.
	R7	Repurpose	Use a discarded product or its parts in a new product with a different function.
Useful application of materials	R8	Recycle	Process materials to obtain the same (high-grade) or lower (low-grade) quality material.
	R9	Recovery	Incineration of material with energy recovery.

Adaptive Reuse and Spatial Justice

Adaptive reuse is the process of reconfiguring an existing building for a purpose other than the purpose for which it was originally built. This concept has become an important

segment of sustainable architecture (Bullen & Love, 2011), especially for the preservation of architectural and cultural heritage, while allowing functional changes and upgrades to meet current societal needs. Combining the adaptive reuse with the circular economy contributes to minimizing waste and retaining cultural memory.

Moreover, the concept of spatial justice (Soja, 2010) is focused on equitable distribution and accessibility of urban space. Regenerative urban strategies should prioritize inclusion, accessibility, and social awareness. By applying environmental R's in ways that enhance public engagement, reduce social exclusion, and respond to local needs, architects and designers can support more just urban futures.

Educational Frameworks for Circular Design

Design education has a high role in shaping future architects with skills and mindsets for sustainable transformation. Courses such as Sustainable Architecture introduce students to real-world problems, encouraging them to integrate environmental thinking with creative design (Leah, 2020).

The redesign of the Museum of Contemporary Art in Skopje was chosen as an ideal platform for this type of learning. The building's architectural significance, coupled with its underutilized surroundings, challenged students to develop design proposals that embodied environmental R's and responded to both spatial and societal needs.

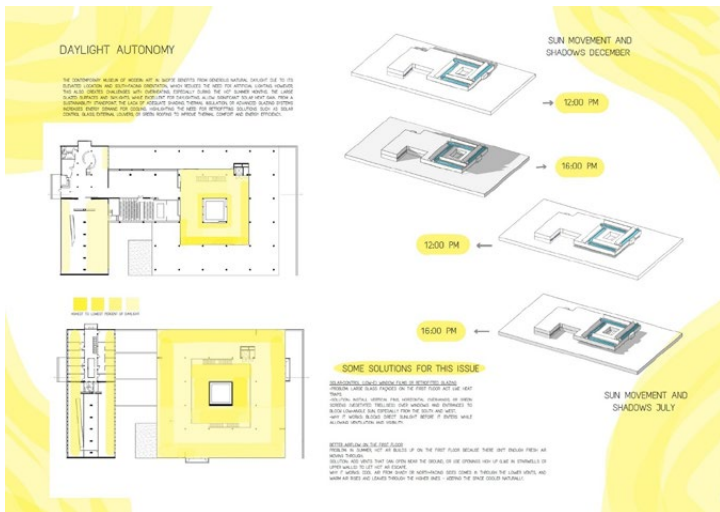
Methodology

The methodology consisted of several steps:

- A site visit and an introductory lecture by the museum curator.
- Analytical phase, including location analysis, climate study, functional assessment, material inventory, and identification of weaknesses of the existing structure (some of which are shown in Figure 1).
- Iterative feedback sessions throughout the semester.
- Two presentations during the semester: a midterm presentation focusing on research and analysis, and a final presentation where students presented their design proposals.
- Final design proposals.

Figure 1.

Daylight analysis as a part of the analytical part of the project



Findings

The building of the Museum of Contemporary Art in Skopje is a landmark of post-earthquake modernist architecture, known for its distinct shape, cultural and architectural significance, and prominent position on a hill overlooking the city.

One of the main disadvantages of the existing condition of the Museum of Contemporary Art in Skopje was its lack of accessibility. The building is situated on a high elevated site, which offers the visitors a remarkable view of the city. Unfortunately, the museum is only accessible by stairs, which represents a big challenge for people with disabilities. This influences the building's sustainability, particularly equity, which is one of the main sustainable development goals. To address this issue, the students implemented pedestrian ramps that are placed parallel to the existing stairs. These new ramps were integrated into the landscape design and ensured universal access for everyone (Figure 2).

Figure 2.

New access routes with inclusive ramps for people with disabilities

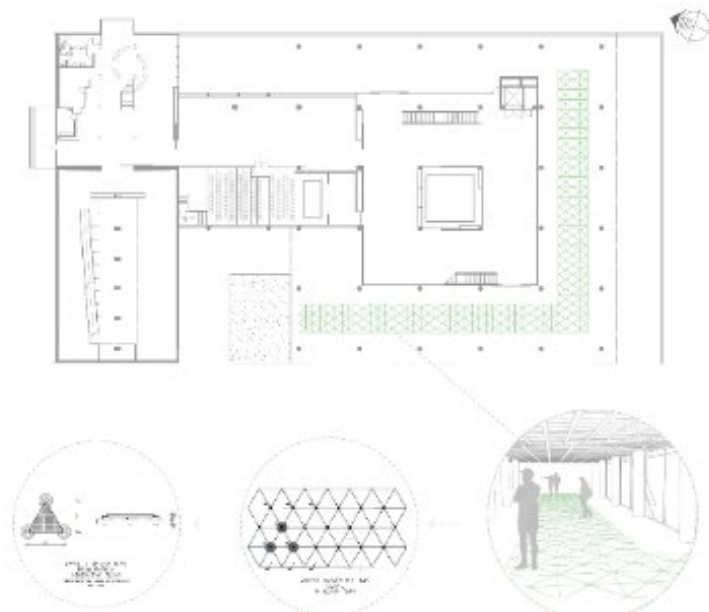


The space around the museum is underutilized, and this was detected as one of the weakest points of the building and its surroundings. The proposal for this problem was energy-gathering floor tiles on the museum's terraces in

the back part. These terraces are beautiful, with amazing waffle structure on the ceiling, and by walking here, one can enjoy the amazing, breathtaking views towards the river Vardar. These energy-gathering floor tiles are transferring the kinetic energy from the movement of the people into electrical energy that can be used for the purposes of the museum. By implementing this, the neglected areas are transformed into vibrant spaces, where people will be motivated to move and enjoy the beauty of the building and the location. Moreover, these tiles do not interfere with the identity of the building, since they are imperceptibly placed on the floors (Figure 3).

Figure 3.

Energy-generating floor tiles installed in the outdoor area





In order to enrich the space around the museum and support community engagement, students designed different parts of urban equipment, such as elements for multifunctional seating, sculptural installations, solar panels, etc. By using these elements, shaded areas for rest and gathering were created all around the museum. Moreover, these features are used for gathering electricity that can be used for the purposes of the museum. These elements will enrich the outside space and will contribute to social engagement (Figure 4).

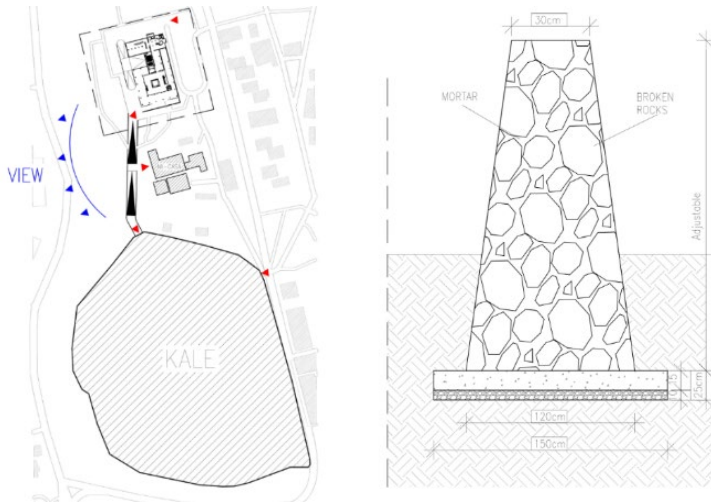
Figure 4.

Shaded resting areas, gathering points, and energy-producing art features



Figure 5.

Pedestrian connection between the museum and the nearby Kale Fortress with stones from the fortress



One of the most important parts of the assignment was that students were analyzing the museum in a broader context. The Fortress Kale is located near the museum. The students detected that the fortress is also neglected, and they wanted to make a connection between these two landmarks. Therefore, the students proposed a pedestrian path that will connect the museum and the fortress. When walking from one landmark to another, one can enjoy the amazing views that are offered of the city and the river. The pathway is constructed with the stones sourced from surplus materials at Kale. This creates a symbolic connection to the space and continues the identity of the fortress. Here, the environmental R – reuse is also taken into consideration. This is a proposal where not only the circular aspect is

taken into consideration, but also the contextual sensitivity, historical continuity, and identity (Figure 5).

Discussion and Evaluation

The students' projects were focused on ideas for improving the negative characteristics analyzed in the first stage of the project, as explained in the methodology section. Students were addressing real architectural and urban challenges that they detected at the location. Table 2 summarizes the student design strategies and how they are aligned with the environmental R's. The inclusive ramp systems that were implemented along the stairs are connected to response, rethink, and reduce, and they have a major impact on universal accessibility and spatial justice, as one of the main sustainable development goals (Figure 2). The energy-generating kinetic floor is connected to reduce and rethink, and it has an impact on renewable energy production and interactive public space (Figure 2). The urban equipment added in the surroundings is connected to repurpose, reuse, and response. This reflects on the community engagement and sustainable infrastructure (Figure 5). Finally, the pedestrian path that connects the museum with the fortress is associated with reuse, response, and rethink, and it influences the identity of the place and historical continuity (Figure 5).

Table 2.

Summary of Student Design Strategies Aligned with Environmental R's

Design Intervention	Associated Environmental R's	Primary Impact	Figure
Inclusive ramp systems integrated into landscape	Response, Rethink, Reduce	Universal accessibility, spatial justice	Figure 2
Energy-generating kinetic floor tiles	Reduce, Rethink	Renewable energy production, interactive public space	Figure 3
Multifunctional seating, solar-powered art installations	Repurpose, Reuse, Response	Community engagement, sustainable infrastructure	Figure 4
Pedestrian path paved with reused stones from Kale Fortress	Reuse, Response, Rethink	Historical continuity, material circularity, contextual design	Figure 5

Conclusion

The paper aimed to explore the use of the environmental R's in urban regeneration practices. It focuses on a case study – the Museum of Contemporary Art in Skopje, North Macedonia. The museum is used as a base to demonstrate how urban and architectural design can implement circular practices such as reuse, response, rethink, repurpose, etc.

Through student proposals developed during a Sustainable Architecture course, this research shows that circular strategies can enhance accessibility, inclusiveness, energy efficiency, sustainability, and ecological awareness. The results of the study show how important it is to think about the environmental R's while designing. Circular principles can offer low-cost, but high-impact solutions. Designers are critical thinkers and leaders, and a more diverse approach is needed. Focusing just on the function and the aesthetic is no longer enough, but a serious, sustainable approach is needed.

In addition, including these elements in educational practices at universities is crucial. Implementing the environmental R's into design curricula can create a new generation of designers and architects equipped to address the problems and issues with a more responsible, sustainable approach.

Acknowledgment:

The author of the paper would like to extend a gratitude to all the students from the department of Architecture, Faculty of Engineering at International Balkan University who were listening to the course Sustainable Architecture

in the 2024/2025 academic year for their dedication and commitment throughout the semester, especially the students Devleta Shabani, Ivona Atanasoska, Hakim Kaya, and Ersin Sarilar for their significant contributions in the research.

References

- Atta, N. (2023). Circular re-strategies in building design and management: Reviewing basic concepts. In *Green approaches in building design and management practices* (pp. 1–20). Springer. https://doi.org/10.1007/978-3-031-46760-8_1
- Bullen, P. A., & Love, P. E. D. (2011). Adaptive reuse of heritage buildings. *Structural Survey*, 29(5), 411–421. <https://doi.org/10.1108/026308011111182439>
- Cruz Rios, F., & Grau, D. (2019). Circular economy in the built environment: Designing, deconstructing, and leasing reusable products. In *Handbook of Environmental Management*. <https://doi.org/10.1016/B978-0-12-803581-8.11494-8>
- Ellen MacArthur Foundation. (2013). *Towards the circular economy Vol. 1: An economic and business rationale for an accelerated transition*. Ellen MacArthur Foundation. <https://www.ellenmacarthurfoundation.org/towards-the-circular-economy-vol-1-an-economic-and-business-rationale-for-an>
- Gibbons, L. (2020). Regenerative—The new sustainable? *Sustainability*, 12(13), 5483. <https://doi.org/10.3390/su12135483>
- Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation & Recycling*, 127, 221–232. <https://doi.org/10.1016/j.resconrec.2017.09.005>
- Lehmann, S. (2011). Optimizing urban material flows and waste streams in urban development through principles of zero waste and sustainable consumption. *Sustainability*, 3(1), 155–183. <https://doi.org/10.3390/su3010155>

- Miloshevska Janakieska, M. (2024, May 15). The challenges of re-use of wood in building construction in Macedonia. In Proceedings of the 17th International Scientific Conference WoodEMA 2024: Green Deal Initiatives, Sustainable Management, Market Demands, and New Production Perspectives in the Forestry-Based Sector (pp. 359–364).
- Morseletto, P. (2020). Targets for a circular economy. *Resources, Conservation and Recycling*, 153, 104553. <https://doi.org/10.1016/j.resconrec.2019.104553>
- Pomponi, F., & Moncaster, A. (2017). Circular economy for the built environment: A research framework. *Journal of Cleaner Production*, 143, 710–718. <https://doi.org/10.1016/j.jclepro.2016.12.055>
- Soja, E. (2010). *Seeking spatial justice*. University of Minnesota Press.

The Impact of Coastal Urban Agglomeration on Landscape Fragmentation: A Temporal and Spatial Approach

Merve Yilmaz

Gebze Technical University

ORCID: 0000-0002-5049-3224

Abstract

From past to present, coastal regions have been important points in the development and growth of coastal regions, thanks to their strategic location and attractiveness in many respects. According to the geographical location of the coasts, the level of socioeconomic development and the physical environmental characteristics, the attractiveness varies and differs. In this process, the units formed by the expansion of settlements on the coasts approached each other over time and grew together, leading to the formation of urban agglomeration in coastal areas. This situation has created anthropogenic pressures on natural resources. The transformation of natural land cover into land uses in an increasing trend corresponds to these anthropogenic pressures. This transformation causes habitat fragmentation, loss of biodiversity, and more fragile coastal ecosystems due to the destruction of the natural environment. This

research focuses on examining the ecological effects of urban agglomerations in settlements located on the Marmara, Mediterranean and Aegean coasts of Türkiye, which have been spatially integrated over time, with spatial statistical methods and geographic information systems analysis. The aim of the research is to reveal the deterioration caused by spatial development trends in coastal areas in a temporal and spatial framework. Spatial analysis tools such as Shape Index, Global Moran's I, and Standard Deviation Ellipse were used in the research. These selected methods are among the explanatory tools for making comparisons between periods and determining ecological thresholds. Research areas differ and vary from each other in terms of socioeconomic structure, population dynamics, and physical geography. This diversity enables us to evaluate the aspects in which spatial pressures differ on a macro scale in coastal areas. These evaluations reveal the development trends of coastal urban agglomerations by examining the changes and transformations over time in terms of spatial relations. As a result of the research, it was obtained that the natural areas in the sample areas, which differed geographically and socioeconomically, decreased and habitat fragmentation increased at various thresholds. These dynamics of urban agglomeration, which emerge in different locations, focus on evaluating the relationship between spatial growth and landscape fragmentation.

Keywords: Urban Agglomeration, Landscape Fragmentation, Coastal Ecosystems, Spatial-Statistic Analysis, Geographic Information Systems

Introduction

From the past to the present, coastal regions have been important points in the development of coastal regions, thanks to their strategic location and attractiveness in many respects. Among the attractive qualities, the fact that they have natural harbors, the abundance of agricultural production areas, and their location on trade routes have made significant contributions to the development of the coastal regions in socio-economic, socio-cultural, and many other aspects. In addition to this development, the negative effects arising from spatial growth have also become increasingly significant. The spatial growth and economic development of coastal settlements have led to confronting environmental pressures from the past to the present. Spatial expansion occurring in coastal zones through mergers or combinations over time will create new metropolitan areas. These metropolitan areas, when they combine or integrate, will reveal specific patterns of urban agglomeration along the coasts. Urban agglomeration can have many influences and effects; however, one of the most impactful is the disruption of natural ecosystems. As such, there is consensus that the growth of spatially related changes in coastal areas not only provides for economic growth and urbanization, but they also make coastal areas ecologically sensitive and complex.

Spatial growth along the coast has direct and indirect effects upon ecological systems and creates a multiple-layered and complex transformation process. The transformation of natural land cover to different forms of land use results in the fragmentation of landscapes, which then irreversibly

reduces biodiversity. Spatial expansion increases the amount of impermeable surface area, as a result of which hydrological cycles are disrupted, and coastal ecosystems become increasingly vulnerable to the pressures exerted upon them. Therefore, when the ecosystem services provided by micro-scale to macro-scale perspectives of holistic systems are examined, it becomes clear that the above-mentioned processes result in a decline of overall ecosystem services and deteriorate their function. Therefore, the ecological impacts of coastal areas provide a multifaceted field of research.

Studies in the literature also show that the ecological effects of coastal urbanization vary and differ from region to region. This situation reveals that the consequences of urban agglomerations cannot be explained only by spatial size, but socioeconomic and geographical contexts are also decisive. Türkiye's Marmara, Aegean, and Mediterranean coasts offer a suitable area for a comparative analysis as they differ in terms of population dynamics, economic structures, and physical geographical features.

The aim of this study is to reveal the deterioration caused by spatial development trends in coastal areas in natural areas in a temporal and spatial framework. In this context, the ecological pressures caused by urban agglomerations on the Marmara, Aegean, and Mediterranean coasts of Türkiye were analyzed with spatial statistical methods. Statistical methods such as CORINE land cover data, Shape Index, Global Moran's I and Standard Deviation Ellipse were used. These analytical tools enable quantitative description of the complexity of urban morphology and its environmental

relationships, assessment of spatial autocorrelation levels, and joint evaluation of urban development trends.

Literature Review

Urbanization can be said to contribute to land use and land cover change. Spatially as well as temporally, urbanization contributes to an expansion of city boundaries and the connection of the city and its surroundings, ultimately creating land cover degradation and fragmentation impacts on the surrounding ecosystems (Alberti, 2005; Song et al., 2024). Land cover transformation, or loss of natural vegetation, has been shown to have impacts on both fragmentation of habitats and biodiversity loss (Henein & Merriam, 1990; Todd et al., 2019; Wu, 2019). As a result of these impacts, hydrologic processes are impacted as a result of an increase in impervious surfaces (Ahmed et al., 2020; Bikis et al., 2025; Delibaş, 2023), and the entire ecosystem is disrupted. Degradation of natural ecosystems (Elmqvist et al., 2015; Martínez et al., 2020) through spatial development in coastal systems, the subject of this study, has generated a variety of risks (pollution, erosion, loss of species), which threaten the ecological integrity of coastal systems (Todd et al., 2019). This process makes it necessary to find planning and management models for sustainable development in coastal regions.

Spatial growth models are different between countries/regions and can be different from one another in the way they treat the specific ecological impacts of their geographies. These differences can be seen and will be varied based upon

different physical, environmental, and socio-economic factors of the growth of cities (Tang et al., 2020; Wang et al., 2025b). Examples include the mangrove loss and reduction of carbon sequestration due to rapid urbanization in the coasts of Southeast Asia and Central America capacity (Friess et al., 2019; Hamilton & Friess, 2018); the fragmentation of coastal ecosystems and the decline of the ecosystem services in China (Wang et al., 2024); and the reduction of habitat loss in European and North American coasts through the integration of more compact and green infrastructures into the spatial development processes (Syphard et al., 2011; Wang et al., 2024).

From a methodological standpoint, the ways of both qualitative and quantitative evaluation of the ecological impacts of urbanization along coasts at present using a wide range of methods are those that combine remote sensing, spatial analysis, and ecological risk assessment frameworks. Technologies of remote sensing and Geographic Information Systems, including satellite images, are being used effectively and widely to study spatiotemporal trends to capture the multidimensional impacts on land use and coastal ecosystems (Bikis et al., 2025; Manikandababu et al., 2025; Tang et al., 2020; Yanes et al., 2019). These tools provide a solid methodological base for making broader, especially quantitative, evaluations of the ecological impacts of coastal development in many different geographic locations. Research on the many ecological impacts of coastal development also gives useful information for more sustainable planning by identifying ecosystem fragility or resilience models (Li et al., 2024; Li et al., 2016; Lu et al., 2022; Shah et al., 2025; Wang et

al., 2025a). Such studies also support policy development to promote resilience from many different viewpoints by integrating sensitivity, pressure, and resilience indices within an ecological framework, and they lead the way in reducing the vulnerability of ecosystems.

Balancing urban development and maintaining ecosystem health through nature-based solutions and green planning practices emphasizes the need to develop policy and governance mechanisms that support both urban development and long-term coastal ecological sustainability. Therefore, effective, sustainable land use and multi-scalar planning will be critical in supporting the alignment of coastal urban development with the ecological sustainability of these systems.

Methodology

The section of the study addresses the methodology of the study; specifically, the sampling strategy used to select the sample areas studied, the spatial data collected, and the spatial analysis procedures used to evaluate changes in the study areas. Subsequent sub-sections outline the sample cities studied, the spatial data used to study these sample cities and the spatial analytical techniques employed.

Study Area

Sample cities were chosen in the three coastal settlement regions of Türkiye (the Marmara, Aegean and Mediterranean coasts) based upon their socio-economic and demographic structures and geographic diversity.

Urban development in the Marmara Region is among the highest levels of industrialization in Türkiye and represents a significant area geographically, with a complex array of urban forms and dynamics. On the other hand, Izmir, located in the Aegean Region, encompasses a variety of economic activities, whereas Manisa is an industrialized city with many agricultural activities. Finally, the ports of Mersin and Adana, along with being important agricultural and industrial centers in the Mediterranean Region, are rapidly developing and represent highly heterogeneous regions experiencing rapid population growth due to migration, the growth and consolidation of coastal industries and the presence of fertile agricultural lands.

Data Collection

Spatial data used in this study were provided by the CORINE (Coordination of Information on the Environment) Project, which was developed under the European Union's Copernicus Program (EEA, 2019). The CORINE Land Use/Land Cover Database provides standardized land use/land cover (LULC) data across all of Europe and has been shown to have very good reliability for ecological studies.

The term 'ecological threshold' is defined as "transition points between alternative states or regimes" (Alberti, 2008). Urbanization is commonly associated with environmental degradation, where ecological function is substituted with human-made services. Ecological biodiversity is often considered a proxy measure of ecological function or ecological resilience. However, urban growth and other human activities result in irreversible alterations to

biodiversity (Alberti, 2008; Alberti & Marzluff, 2004; Fisher et al., 2009; Marzluff et al., 2008). The separation of CORINE land cover classes into ecological thresholds and vulnerable areas is a widely applied approach in ecological planning, environmental impact assessment, and landscape ecology studies (Alberti & Marzluff, 2004; Forman, 2016; Henein & Merriam, 1990; Pili et al., 2017).

The concept of ecological thresholds encompasses natural systems that provide significant ecosystem services, as well as biodiversity core areas, where degradation may result in irreversible changes. These include forest ecosystems (CORINE codes: 311, 312, 313), natural vegetation types (CORINE codes: 322, 323, 324), wetlands (CORINE codes: 411, 412), coastal ecosystems (CORINE codes: 421, 422, 423, 521, 522, 523), and aquatic systems (511, 512).

Conversely, vulnerable areas are distinguished by their sensitivity to human pressures, limited carrying capacity, and susceptibility to erosion, pollution, and biodiversity loss. The following geographical areas are to be considered within this category: agricultural lands (CORINE codes: 211–244), pastures and grasslands (CORINE codes: 231, 321), coastal strips (331, 332), and steep or erosion-prone areas (CORINE codes: 333, 334, 335). It is important to note that these areas are particularly vulnerable to fragmentation and functional loss when subjected to intense human use. Consequently, the implementation of sustainable management strategies is essential for the conservation of these environments (Forman, 1995; Scolozzi & Geneletti, 2012). For temporal change analysis, the CORINE datasets from 1990, 2000, 2006, 2012, and 2018 were utilized.

Spatial Analysis

The methodological framework utilizes three core analytical techniques: the Shape Index, Global Moran's I, and the Standard Deviational Ellipse.

The Shape Index is a quantitative metric employed to evaluate landscape patterns, with the purpose of assessing the degree of spatial complexity and fragmentation (Long et al., 2013; Pereira et al., 2013). The Shape Index, a measure of spatial efficiency, is assigned a value of 1 for a circle, signifying its optimal compactness. Values greater than 1 indicate deviations from circularity, reflecting more irregular and fragmented forms. The calculation of perimeter and area is conducted using the same unit of measurement.

$$\text{Shape Index} = \frac{P}{2\sqrt{\pi A}}$$

P = perimeter of the polygon

A = area of the polygon

Global Moran's I analysis is utilized to assess spatial autocorrelation, thereby identifying the presence of clustering or dispersion in ecological pressures (Getis & Ord, 1992; Ord & Getis, 1995). Moran's I is interpreted by comparing its value with the expected mean. In the event of the greater than or equal to sign being employed, values of a similar nature are grouped together. In the event of $I < E[I]$, the high and low values are located in close proximity to each other.

$$I = \frac{N \sum_i \sum_j \omega_{ij} (x_i - \bar{x})(\bar{x} - x_j)}{W \sum_i (x_i - \bar{x})^2}$$

In this context, N shows the number of observations, represents the values of the spatial units, S is the spatial weight matrix, and W signifies the total weight.

The Standard Deviational Ellipse (SDE) analysis evaluates how much the distribution of density deviates from a circular shape in terms of its spread and orientation. The major and minor axes of the ellipse and its orientation are determined using variance and covariance (Rousseau et al., 2018). The objective of this analysis in this study is to identify changes in built-up and unbuilt-up areas over time. This tool was used to quantitatively reveal spatial orientation and its trends. In the analysis, the mean center was calculated, and the distribution of scores relative to this center was examined. Therefore, this method relies on basic statistical measures (mean, variance, and covariance) and angle and rotation calculations. Collectively, these three methods facilitate temporal comparisons and support the identification of potential ecological thresholds, thereby contributing to sustainable coastal planning.

Findings

This section includes the subheadings of Land Use Land Cover Change, Ecological Thresholds and Vulnerable Areas, and Statistical Analysis.

Land Use Land Cover Change

From 1990 to 2018, there was a marked increase in urban areas across all three regions (see Table 1 and Figure 1). The Marmara Region demonstrated the most rapid growth,

particularly during the period between 1990 and 2000, with an approximate increase of 50%. In the same period, the Aegean Region grew by 46%, while the Mediterranean Region demonstrated a more limited expansion. During the period 2000–2006, growth rates underwent a decline, although a positive trend was observed across all regions (Marmara: 7.9%, Aegean: 15.16%, Mediterranean: 14.35%). In the period between 2006 and 2012, the rate of growth in the Marmara and Aegean regions was less than 5%, whereas the Mediterranean region experienced a significant increase of 17.5%. In the most recent period (2012–2018), growth rates stabilized across all regions, ranging between 5% and 8.7%.

It is evident that Marmara is distinguished by its substantial size and rapid primary expansion, while the Aegean exhibits medium-scale but balanced growth. In contrast, the Mediterranean region experienced a significant surge during the period 2006–2012.

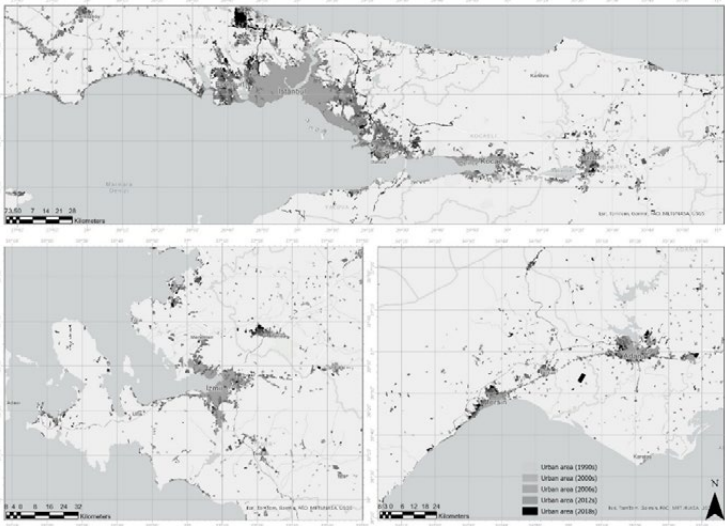
Table 1.

Area and Percentage Change

Region/ Years (ha-change rate)	1990	2000	2006	2012	2018
Marmara	112 773 ha / -	169 190 ha / 50,03%	182 563 ha / 7,90%	193 160 ha / 5,80%	210 088 ha / 8,76%
Aegean	52 751 ha / -	77 030 ha / 46,02%	88 707 ha / 15,16%	92 995 ha / 4,83%	98 261 ha / 5,66%
Mediterra- nean	39 150 ha / -	49.903 ha / 27,47%	57 067 ha / 14,35%	67 064 ha / 17,52%	73 533 ha / 9,65%

Figure 1.

Urban Area Changes by years (1990s, 2000s, 2006s, 2012s, 2018s)



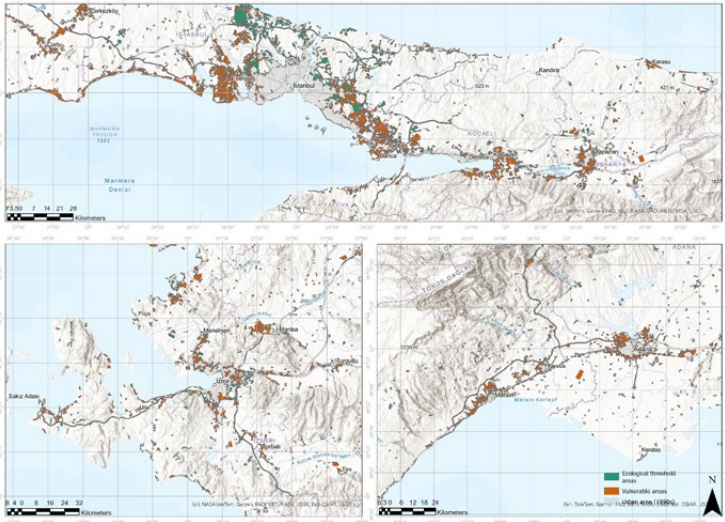
Ecological Thresholds and Vulnerable Areas

Variability of ecological threshold areas was found to be significant throughout the Mediterranean Region. Area of the region studied was approximately 935 hectares in the 1990-2000 time frame, which showed a 21% decrease in the 2000-2006 time frame and then increased significantly (388%) reaching an approximate area of 3600 ha in the 2006-2012 time frame; however, the area continued to decrease in the 2012-2018 time frame (72%), returning to an area of approximately 1000 ha. This data indicates that ecological thresholds are sensitive to environmental pressures over a short time frame.

The area of vulnerable land in the Mediterranean Region started at 10,223 ha in 1990 and had increased by 27% to 13,000 ha by the 2000-2006 time frame. However, in subsequent time frames, the area of vulnerable land had substantially decreased, especially in the 2012-2018 time frame, where the area decreased by 53% and returned to 5,800 ha. These findings suggest that the area of vulnerable land in the Mediterranean Region had initially expanded prior to 2006, and then rapidly decreased after 2006. In the Aegean Region, the area of ecological threshold zones decreased from 5,694 ha in the 1990-2000 time frame to 2,536 ha in the 2000-2006 time frame and remained relatively constant at this level until the 2006-2012 time frame (a decrease of -5%). Following the 2006-2012 time frame, the area of ecological threshold zones had decreased by 42% and the area in 2012-2018 was 1,398 ha. These findings support a decreasing trend for ecological threshold zones. The trend for vulnerable areas was similar, with a total decrease in the area of 17%, 62%, and 35% in each time frame following 2000. Therefore, the area of vulnerable land in the Aegean Region was 3,892 ha in 2018. In the Marmara Region, the area of ecological threshold zones had been 16,107 ha in the 1990-2000 time frame; however, the area decreased by 53% and 58% in the 2000-2012 time frame. Between 2012 and 2018, the area of ecological threshold zones had increased by 179% to 8,823 ha. The area of vulnerable land had started at a high value (44,384 ha) in 1990-2000 and continued to decrease through subsequent time frames (42%, 37%, 45%), to a minimum of 8,946 ha in 2018. The spatial distribution of these changes is illustrated in Figure 2.

Figure 2.

Spatial Distribution of Urban Area Changes (1990s, 2000s, 2006s, 2012s, 2018s)



Statistical Analysis

This section presents the findings of the Shape Index, Global Moran's I, and Standard Deviational Ellipse (SDE) Analysis.

Shape Index

The average Shape Index (SI) values for all of the regions varied significantly over time from 1990 to 2000; specifically, SI values ranged from 93 for the Mediterranean Region, to 62 for the Aegean Region, and 70 for the Marmara Region. The SI values reflect varying degrees of settled land use, indicating both irregular and identified settlement patterns. Between 2000 and 2012, SI values decreased substantially in

all regions, indicating the growth of compact urban land use (Mediterranean: 41, Aegean: 28, Marmara: 22). In particular, SI values for the Marmara Region and the Mediterranean Region fell below 10. In the interval of 2012-2018, SI values increased in most of the studied regions; however, the median values remained relatively low, showing that most settlements had compact configurations and that only a few settlements were irregular, thus increasing the average SI value.

Global Moran's I

The Global Moran's I analysis was performed using the morphological features of built-up areas to test the suggestion that distributed and irregular settlement patterns produce higher levels of fragmentation than compact forms of development. The Moran's I index was used to test whether the fragmentation of landscapes is spatially aggregated or dispersed.

During the period of 1990 to 2000, Moran's I values were significantly positive in all regions, which indicates a pattern of spatial aggregation in the distribution of the SI values (Mediterranean: 0.674; Aegean: 0.697; Marmara: 1.037). The Marmara Region exhibited a particularly strong positive spatial autocorrelation based on the very high z-scores and very low p-values. Positive autocorrelation continued during the periods of 2000 to 2006 and 2006 to 2012, but it was lower in the Aegean Region. The Marmara Region and the Mediterranean Region showed a continued high degree of clustering during the entire study period. Differences among the regions emerged after 2012, as the Mediterranean Region presented a positive Moran's I value of .742, while the

Aegean Region showed a negative Moran's I value of $-.813$. The results suggest that high and low SI values tend to be proximal to one another in the Aegean Region, whereas in the Mediterranean Region, they tend to be dispersed. The Marmara Region also exhibited a positive trend, albeit at a lower level ($.513$).

Overall, the results indicate that SI values were highly clustered in the Marmara and Mediterranean Regions, whereas in the Aegean Region, the values were increasingly heterogeneous, leading to an emerging pattern of sprawl from 2012 to 2018.

Standard Deviation Ellipse (SDE) Analysis

Although the SDE analysis showed that the settlement areas have changed with respect to the new urban growth, especially along coastlines, as indicated in Figure 1, it was shown that the standard deviation of distances in Marmara has slightly increased. It can be seen that the standard deviations of distances for the years 1990 and 2018 are 69,746 meters and 72,031 meters, respectively. This indicates that the settlements in Marmara have become slightly more spread out in terms of their distance from each other.

In the Mediterranean region, the StdDist values ranged from 70,000 to 75,000 m, indicating that spatial densities in these regions were relatively stable despite new growth in the area. Also, the StdDist values in the Aegean region were approximately 54,000 – 55,000 m, indicating that the compactness of the settlement expansions in this area remained the same.

However, if we focus on the new urban developments specifically in the areas of interest, then all three regions showed some form of spatial expansion, but most notably in the Marmara region. The StdDist values for the Marmara region showed an increase in both the magnitude and degree of the new urbanizations' dispersal from about 67,568 m in the 1990-2000 time frame to 86,243 m in 2018. Although the expansion in the Mediterranean and Aegean regions was less extensive than in Marmara, they still represented relatively compact forms of growth, with the Aegean region having the lowest standard deviation (55,000 – 60,000 m).

Overall, the results show that Marmara's recent urban expansion is characterized by both larger spatial extents and greater dispersions, whereas the Mediterranean and Aegean regions represent more compact forms of growth. The settlement dynamics in the coastal regions are determined by a combination of geographical and socio-economic pressures. The expansions toward Manisa in the Aegean and Adana in the Mediterranean regions are representative of urban development trends that are influenced by regional gravity effects and thus support the concept of urban agglomeration.

Evaluation

This study demonstrated that there are numerous spatial and ecological factors in place, due to the spatial expansion and unification of the Marmara, Aegean, and Mediterranean coastal areas, resulting in a coastal area effect. In terms of land use and land cover change, the Marmara area was the most rapidly expanding area with an increase of nearly

50% from 1990 to 2000; however, it has followed a relatively stable trend since 2000. Although the Aegean area has shown a constant development rate, the Mediterranean area, especially, has had a strong growth during the last decade.

The study presented here shows that the development in coastal areas can't always be explained only by the demographic or economic pressures on these zones, and that the pressure on the land behind the coast (hinterland) could also have an effect. Changes in neighboring towns, investment in the surrounding areas, and the regional development policy could all have an influence, too.

In conclusion, the Marmara area developed very rapidly and uniformly between 1990 and 2000; the Aegean area has shown a balanced and compact development, while the Mediterranean area shows peaks and troughs depending on the variability of each region.

These differences in spatial growth models were analyzed using spatial statistical methods. The Shape Index showed that all three regions had fragmented and dispersed developments from 1990 to 2000, but then showed a transition to more compact development from 2000 to 2012, and another highest-decline phase after 2012. Moran's I analysis showed a continued positive spatial autocorrelation for the Marmara and Mediterranean regions, which indicates clustering in the two regions. However, the Aegean region showed a negative autocorrelation since the last period, which leads to a more heterogeneous and dispersed urban structure. Additionally, the analysis demonstrated that the Aegean region's compactness has evolved through the years and is now going in the opposite direction of being compact.

Lastly, the Standard Deviation Ellipse analysis showed that the Marmara region has the largest spatial extension, the Aegean region continues to develop compactly, and the Mediterranean region has an urban form of large scale, but high density.

Overall, when looking at the overall picture of the results, it appears that the coasts of Marmara experience the most pressure both in terms of space and irregularity of urban agglomeration. On the other hand, the Aegean region has shown a more steady development, but it is gradually degrading its ecosystems' capacities. In contrast, the Mediterranean region displays periodic variation in its ecological system, a condition that has been shown to heighten ecological vulnerability. The spatial orientation of growth in the Aegean region toward Manisa (from the sea toward the land) and in the Mediterranean region toward Adana (from the sea toward the land) illustrates how coastal development is driven as much by the dynamic of the hinterland as by those along the coast. These developments suggest an inter-relationship between urban agglomeration and both geographical and socio-economic factors; therefore, there is a need to use an integrated approach to analyze the spatial structure of these regions.

Conclusion

This study examined, through quantitative analysis, the spatial growth of cities on Türkiye's Mediterranean and Aegean coasts between 1990 and 2018, in order to demonstrate the relationships between ecological parameters and the agglomerations of cities. The results indicate that the

rapid and spatially variable growth of the settlements in the Marmara region over time has caused the settlements to merge and grow across a large area, thereby creating ecological transformation and change. A relatively more balanced spatial growth pattern was observed in the Aegean Region; however, the region experienced dramatic changes. The Mediterranean Region exhibited increased vulnerability as a result of periodic changes. The decreases in rates of conversion of ecological threshold zones into built-up areas and losses of sensitive zone areas represent the necessity of strategic policymaking to preserve the long-term viability of ecosystem services in these regions. Additionally, the data indicated that while the effective implementation of planning policies during certain time frames can increase ecological capacity by protecting ecological threshold zones or vulnerable areas and strengthening patchiness in the landscape, statistical analysis revealed that the structural transformation of settlement patterns and correlation are part of urbanization processes. Ultimately, it is evident that coastal urbanization is a multi-dimensional phenomenon that cannot be solely attributed to population growth or economic growth. Coastal urbanization is comprised of several elements: ecological threshold values, spatial coherence, the influence of the hinterland, and socio-economic forces.

References

- Ahmed, H. A., Singh, S. K., Kumar, M., Maina, M. S., Dzwairo, R., & Lal, D. (2020). Impact of urbanization and land cover change on urban climate: Case study of Nigeria. *Urban Climate*, 32, 100600. <https://doi.org/10.1016/J.UCLIM.2020.100600>
- Alberti, M. (2005). The effects of urban patterns on ecosystem function. *International Regional Science Review*, 28(2), 168–192. <https://doi.org/10.1177/0160017605275160>
- Alberti, M. (2008). *Advances in Urban Ecology: Integrating Humans and Ecological Processes in Urban Ecosystems*. Springer.
- Alberti, M., & Marzluff, J. M. (2004). Ecological resilience in urban ecosystems: Linking urban patterns to human and ecological functions. *Urban Ecosystems*, 7(3), 241–265. <https://doi.org/10.1023/b:ueco.0000044038.90173.c6>
- Bikis, A., Engdaw, M., Pandey, D., & Pandey, B. K. (2025). The impact of urbanization on land use land cover change using geographic information system and remote sensing: a case of Mizan Aman City Southwest Ethiopia. *Scientific Reports*, 15(1), 12014. <https://doi.org/10.1038/s41598-025-94189-6>
- Delibaş, M. (2023). *Assessing the impacts of urban land use/land cover change on soil ecosystem services*. Doctoral Thesis, Istanbul Technical University.
- EEA. (2019). *CORINE Land Cover*. <https://land.copernicus.eu/pan-european/corine-land-cover>. Accessed date: 05Aug2025
- Elmqvist, T., Zipperer, W. C., & Güneralp, B. (2015). Urbanization, habitat loss and biodiversity decline: Solution pathways to break the cycle. In *The Routledge Handbook of Urbanization and Global Environmental Change*, 1st Ed., 139–151, Routledge.
- Fisher, B., Turner, R. K., & Morling, P. (2009). Defining and classifying ecosystem services for decision making. *Ecological Economics*, 68(3), 643–653. <https://doi.org/10.1016/j.ecolecon.2008.09.014>
- Forman, R. T. T. (1995). *Land Mosaics: The Ecology of Landscapes and Regions*. Cambridge University Press.

- Forman, R. T. T. (2016). Urban ecology principles: are urban ecology and natural area ecology really different? *Landscape Ecology*, *31*, 1653–1662. <https://doi.org/10.1007/s10980-016-0424-4>
- Friess, D. A., Rogers, K., Lovelock, C. E., Krauss, K. W., Hamilton, S. E., Lee, S. Y., Lucas, R., Primavera, J., Rajkaran, A., & Shi, S. (2019). The State of the World's Mangrove Forests: Past, Present, and Future. *Annual Review of Environment and Resources*, *44*, 89–115. <https://doi.org/10.1146/annurev-environ-101718-033302>
- Getis, A., & Ord, J. K. (1992). The analysis of spatial association by use of distance statistics. *Advances in Spatial Science*, *24*(3), 189–206. https://doi.org/10.1007/978-3-642-01976-0_10
- Hamilton, S. E., & Friess, D. A. (2018). Global carbon stocks and potential emissions due to mangrove deforestation from 2000 to 2012. *Nature Climate Change*, *8*(3), 240–244. <https://doi.org/10.1038/s41558-018-0090-4>
- Henein, K., & Merriam, G. (1990). The elements of connectivity where corridor quality is variable. *Landscape Ecology*, *4*(2–3), 157–170. <https://doi.org/10.1007/BF00132858>
- Li, X., Fan, Z., Sha, J., Guo, X., Zheng, C., Shifaw, E., & Wang, J. (2024). The comparative study of urban ecosystem health change in Asian and African coastal cities—Changle in China and Suez in Egypt. *Ecological Indicators*, *159*, 111648. <https://doi.org/10.1016/J.ECOLIND.2024.111648>
- Li, Y., Zhang, X., Zhao, X., Ma, S., Cao, H., & Cao, J. (2016). Assessing spatial vulnerability from rapid urbanization to inform coastal urban regional planning. *Ocean & Coastal Management*, *123*, 53–65. <https://doi.org/10.1016/J.OCECOAMAN.2016.01.010>
- Long, Y., Mao, Q., & Shen, Z. (2013). Urban Form, Transportation Energy Consumption, and Environment Impact Integrated Simulation: A Multi-agent Model. In M. Kawakami, Z. Shen, J. Pai, X. Gao, & M. Zhang (Eds.), *Spatial Planning and Sustainable Development: Approaches for Achieving Sustainable Urban Form in Asian Cities*, 227–247, Springer Netherlands. https://doi.org/10.1007/978-94-007-5922-0_13

- Lu, L., Qureshi, S., Li, Q., Chen, F., & Shu, L. (2022). Monitoring and projecting sustainable transitions in urban land use using remote sensing and scenario-based modelling in a coastal megacity. *Ocean & Coastal Management*, 224, 106201. <https://doi.org/10.1016/J.OCECOAMAN.2022.106201>
- Manikandababu, C. S., Alzaben, N., Maashi, M., & Geetha, M. (2025). Mapping coastal urbanization impacts with object-based image classification and land use/land cover change detection: A focus on sustainable development. *Journal of South American Earth Sciences*, 161, 105559. <https://doi.org/10.1016/J.JSAMES.2025.105559>
- Martínez, C., López, P., Rojas, C., Qüense, J., Hidalgo, R., & Arenas, F. (2020). A sustainability index for anthropized and urbanized coasts: The case of Concón Bay, central Chile. *Applied Geography*, 116, 102166. <https://doi.org/10.1016/J.APGEOG.2020.102166>
- Marzluff, J. M., Alberti, M., Bradley, G., Endlicher, W., Ryan, C., & Shulenberger, E. (2008). *Urban Ecology: An International Perspective on the Interaction Between Humans and Nature*, 1. Ed.. Springer-Verlag. <https://doi.org/10.1007/978-0-387-73412-5>
- Ord, J. K., & Getis, A. (1995). Local spatial autocorrelation statistics: Distributional issues and an application. *Geographical Analysis*, 27(4), 286–306. <https://doi.org/10.1111/j.1538-4632.1995.tb00912.x>
- Pereira, R. H. M., Nadalin, V., Monasterio, L., & Albuquerque, P. H. M. (2013). Urban centrality: A simple index. *Geographical Analysis*, 45, 77–89. <https://doi.org/10.1111/gean.12002>
- Pili, S., Grigoriadis, E., Carlucci, M., Clemente, M., & Salvati, L. (2017). Towards sustainable growth? A multi-criteria assessment of (changing) urban forms. *Ecological Indicators*, 76, 71–80. <https://doi.org/10.1016/j.ecolind.2017.01.008>
- Rousseau, R., Egghe, L., & Guns, R. (2018). Statistics. In R. Rousseau, L. Egghe, & R. B. T.-B. M.-W. Guns (Eds.), *Chandos Information Professional Series*, 67–97. Chandos Publishing. <https://doi.org/https://doi.org/10.1016/B978-0-08-102474-4.00004-2>
- Scolozzi, R., & Geneletti, D. (2012). Assessing habitat connectivity for land-use planning: a method integrating landscape graphs and Delphi survey. *Journal of Environmental Planning and Management*, 55(6), 813–830. <https://doi.org/10.1080/09640568.2011.628823>

- Shah, M. A. R., Van Dau, Q., & Wang, X. (2025). Social-ecological vulnerability and risk to coastal flooding and erosion in major coastal cities. *International Journal of Disaster Risk Reduction*, 118, 105286. <https://doi.org/10.1016/J.IJDRR.2025.105286>
- Song, X., Chen, F., Sun, Y., Ma, J., Yang, Y., & Shi, G. (2024). Effects of land utilization transformation on ecosystem services in urban agglomeration on the northern slope of the Tianshan Mountains, China. *Ecological Indicators*, 162, 112046. <https://doi.org/10.1016/J.ECOLIND.2024.112046>
- Syphard, A. D., Clarke, K. C., Franklin, J., Regan, H. M., & McGinnis, M. (2011). Forecasts of habitat loss and fragmentation due to urban growth are sensitive to source of input data. *Journal of Environmental Management*, 92, 1882–1893. <https://doi.org/10.1016/J.JENVMAN.2011.03.014>
- Tang, F., Fu, M., Wang, L., & Zhang, P. (2020). Land-use change in Changli County, China: Predicting its spatio-temporal evolution in habitat quality. *Ecological Indicators*, 117, 106719. <https://doi.org/10.1016/J.ECOLIND.2020.106719>
- Todd, P. A., Heery, E. C., Loke, L. H. L., Thurstan, R. H., Kotze, D. J., & Swan, C. (2019). Towards an urban marine ecology: Characterizing the drivers, patterns and processes of marine ecosystems in coastal cities. *Oikos*, 128(9), 1215–1242. <https://doi.org/10.1111/oik.05946>
- Wang, H., Han, B., Wu, T., Leung, F., & Ren, Y. (2025a). Pre-adopting new urban areas to climate change with coastal Nature-based solutions. *Ecological Indicators*, 177, 113693. <https://doi.org/10.1016/j.ecolind.2025.113693>
- Wang, J., Liu, J., Wang, T., & Jia, M. (2025b). Scenario based land use simulation for climate adaptability in coastal urban agglomerations of Guangdong Hong Kong and Macao Bay area. *Scientific Reports*, 15, 27489. <https://doi.org/10.1038/s41598-025-11866-2>
- Wang, Y., Liao, J., Ye, Y., O'Byrne, D., & Scown, M. . (2024). Implications of policy changes for coastal landscape patterns and sustainability in Eastern China. *Landscape Ecology*, 39(1), 1–22. <https://doi.org/10.1007/S10980-024-01801-7/FIGURES/10>

Wu, J. (2019). Landscape Ecology. In *Encyclopedia of Ecology*. Vol. 4, 527–531. <https://doi.org/10.1016/B978-0-12-409548-9.10919-4>

Yanes, A., Botero, C. M., Arrizabalaga, M., & Vásquez, J. G. (2019). Methodological proposal for ecological risk assessment of the coastal zone of Antioquia, Colombia. *Ecological Engineering*, 130, 242–251. <https://doi.org/10.1016/J.ECOLENG.2017.12.010>

The Skopje 1963 Post-Earthquake Reconstruction as a Model for Disaster Relief

Marko Icev

International Balkan University, Skopje, North Macedonia

ORCID: 0009-0003-5738-8309

Abstract

This paper will explain the historical circumstances of the Skopje 1963 post-earthquake reconstruction, particularly the role played by the United Nations, and how these circumstances set the project apart from its contemporaries. This reconstruction effort after the devastating earthquake created a possibility for new urban planning ideas and methodologies to be tested and deployed in Skopje. The effort was guided by the UN, and it proposed a new methodology of combining the international and the local expertise, as well as providing a guideline for the development of the city along a more sustainable and holistic approach, as opposed to the typical Modern approach present at the time. The paper relies on archival and theoretical research to explain how the Skopje reconstruction effort can be an example of urban reconstruction, disaster relief, and humane urbanism.

Keywords: urbanism, disaster relief, reconstruction

Introduction

On July 26th, 1963, a devastating earthquake in Skopje, Yugoslavia, practically leveled the city of about 250,000 people and left two-thirds of that population homeless. In the following days, emergency relief started to arrive in the city. Due to the scale of the clearing and possible rebuilding effort, the Yugoslavian government immediately solicited the international community for assistance, and within weeks, international experts of various fields arrived in Skopje. Part of the material assistance that was delivered was prefabricated houses that were transported by train to Skopje in parts and were assembled on site. The first 800 arrived within 10 days of the earthquake as a gift from the British organization War on Want, together with a British “expert on prefabricated houses,” Robert Fitzmaurice (Senior, 1970, p. 93). In 8 months, 14,000 single-family prefabricated houses were built, complete with utilities and infrastructure as donations from various countries (Senior, pp. 93-98). By 1973, there will be 35,000 of these houses built, constituting the 17 new neighborhoods of the city, with streets named after the countries and cities that donated the dwellings (Davis, 1978, p. 100). These efforts at the beginning of the reconstruction were an important part of the long-term planning strategy for the rebuilding of Skopje, organized and led by the United Nations - an unprecedented effort in multilaterally coordinated relief and planned development (Icev, 2021).

Disaster relief on an international scale existed before the Skopje earthquake, but it was mostly run on a need-basis, delivering emergency provisions, and was not established as

a multiyear effort in reconstruction. The Skopje earthquake delivered a chance to the international humanitarian community to produce a strategy for reconstruction that would develop the future city, going beyond the immediate clearing of the disaster. This effort to rebuild the city was turned into an experimental model of disaster relief for other such recoveries. This was due to a particular historical convergence of ideas, politics, and architecture that allowed for a more humane and holistic approach to be applied, as opposed to relegating the effort to military contractors, which was the usual practice. The effort was also meant to converge ideas from the East and West of the Iron Curtain, and the design, plans, and projects for the city showed a new way of working after disaster and a new way of collaboration. This paper will explain some of the historical circumstances that made the Skopje reconstruction project a unique effort in disaster relief, urban planning, and architecture, and how this experimental working model could be helpful for future disasters.

The Skopje Urban Plan Project (UPP -1964-1966) was devised by a large team of architects, planners, sociologists, geodesists, seismologists, and engineers that worked under the management of the International Board of Consultants, jointly appointed by the United Nations (UN) and the Yugoslavian governments to oversee the project, and heralded by Ernest Weissmann of the UN. It included a regional plan for Skopje and its surroundings, a Contour plan for the city providing new concepts and ideas for development, and a separate plan for the central area based on an international competition, won by Kenzo Tange, all based on multiple surveys of the city's population,

geographical and cultural opportunities (Senior, 1970). The UPP was devised through a “Planning Circus” – a round table where international architects were partnered with local ones to collaborate and metabolize the ideas from the foreign practices into the local context and language. This resulted in the so-called “Contour Plan” that envisioned the development of the city for the next 30 years and was based on the neighborhood unit, the idea that all the amenities for everyday life should be included within walking distance of the dwellings. The plan included the new construction, the historic buildings, and the newly constructed neighborhoods with prefabricated houses.

The deployment of these houses was a result of a few separate actions: a sites-and-services effort by the Yugoslavian government, that quickly after the disaster nationalized agricultural land in Skopje’s surroundings, repurposed it for housing, and extended public utilities to these places, while also insisting that donations of shelter should avoid tents because of Skopje’s climate which led a lot of countries to send donations as prefabricated units that would quickly be erected to alleviate the homelessness problem (Senior, pp.93-98). It was not unusual for countries to aid distraught areas before 1963, but what we see in Skopje is a sustained, multilateral effort to rebuild the city in a new light after its disaster. This sustained effort, which included the surveying, reconstruction, and long-term planning of the future city, is what sets Skopje apart from similar disaster relief efforts of the time.

International humanitarian aid after World War II was developed on several different levels as a separate idea from

“development”. In 1943, an international conference on food and agriculture led by President Roosevelt would lead to the establishment of the Food and Agriculture Organization (FAO - 1945) within the United Nations, which would establish the World Food Program (launched in 1961 on a trial basis). The US-led Food for Peace program was established by President Eisenhower and expanded by President Kennedy into a political development program in 1961 to serve as a tool of investment and influence in the developing world, especially on the communist frontier. Both programs had emergency provisions, providing agricultural aid in foodstuffs for projects in modernizing and industrializing agriculture. The Food for Peace program was also a way for the US government to indirectly influence governments of the Third World away from communism, or in the case of communist countries to sway economic policy toward the opening of markets (Wallerstein, 1980, pp. 1-45; Shaw, 2001, pp. 1-80; Prasad, 1980, pp. 1-43.) In communist countries, the program was used as a discreet way to improve relations with the domestic public and create an American presence. The Food for Peace program was instrumental in the maintenance of Yugoslavia’s neutrality and independence from the USSR, while swaying its trade market towards the West, as well as an important bridge in US-Yugoslav relations, and a major stabilizer of the Yugoslavian currency (Markovich, 1968; Lampe et al., 1990; Lees, 1997; Lin, 2010).

The understanding and practice of aid was largely taking shape in the 40s and 50s, while by the 1960s it was experimenting on new ground, expanding its operations with a strengthening bureaucratic army of experts, and creating its own divergences and convergences with the ideas

about altruism, shelter, international agency, collaboration, and “development”(Ramsamy, 2006, pp. 8-18). The rise of international development as opposed to emergency relief coincides with the Skopje rebuilding efforts, the expansion of the UN planning apparatus and the use of the house as a calculable metric for development.

International Help Before 1963

Previously to the 1960s, a typical response to a natural disaster was executed by the nation or the neighboring armies, and the efforts were mostly connected to the immediate clearing of rubble, evacuation of residents, emergency aid in the form of tents, food, medication, and other basic needs. It was not customary for other countries to be involved in the rebuilding of the distressed areas.

The largest disasters of the postwar period - the monsoon floods in India and Pakistan in 1955 and the Concepcion earthquakes in Chile in 1960 saw a standard response from the rest of the world, mostly in the form of material aid such as tents, food and other emergency aid in the period right after the disaster and mostly carried out by humanitarian agencies such as the Red Cross, and other religious charities. Chile formed a local agency to deal with the aftermath and the rebuilding of the Concepcion region. The 1960 Agadir earthquake in Morocco saw a similar form of emergency aid, but the town quickly descended into chaos due to governmental mishandling of the crisis.

So far, the general format of emergency response consists of the bare necessities that a population might need for

survival, and the manpower present is there to help the victims and clear the site. The nature of the responses is clearly temporary and mostly provided by airlifting supplies or by possible navy vessels nearby. No agency is tasked with rebuilding the community. The shelter that is provided is in the form of tents and field hospitals, and perhaps Nissen huts.

A slight exception to this is the 1953 earthquake in the Ionian Islands. This earthquake physically destroyed the island town of Cephalonia, and the response by the Greek government left the residents with no choice but to leave the island and move elsewhere. During the aftermath of this earthquake, the British government sent 20,000 feet of a light steel frame called Slotted Angle, donated by its inventor, Demetrius Comino, a British printing entrepreneur with Greek origins. The Slotted Angle was a construction part that was supposed to produce the frame of a house, a prototype for which was designed and assembled in 10 days. The prototype was fully capable of disassembly for later possible relocation. The distribution of these housing materials was done by the British army engineers; however, despite this effort, the islands were mostly abandoned by the residents. The next European disaster will be the 1963 earthquake in Skopje, where a completely different response arises.

Daniel Bertrand Monk and Andrew Herscher argue that the nature of humanitarianism today is not only coeval with architectural modernism but also codependent. In other words, humanitarianism is specifically focused on the physical relationship of the affected to their dwellings. Forced displacements, migrations, and rapid urbanization

of the 20th century created an inevitable condition “during which expertise in the provision of temporary shelter and humanitarian government was increasingly forced to contend with the permanence of the impermanent”, such that even the categorization of the recipients of humanitarian efforts is based on their physical and spatial relationship to homelessness based on escalating need for permanent shelter i.e. displaced people, migrants, refugees, asylum seekers (Monk & Herscher, 2015). The expansion of efforts from immediate relief to housing in the 60s and 70s intensified the focus on housing with proper dwellings as the preventative measure against further disasters, both natural and manmade, and as an assurance against the spread of political ideas (Monk & Herscher, pp. 71-80).

Housing as a method of development became a constituent of international humanitarian efforts once the more extended network of food aid was reaching its influence peak in the late 1960s, even though several agencies of the United Nations were exploring human settlements on a more theoretical level for a decade before. The global network of humanitarian agencies that operates today with development as their primary objective (UNDP, the World Bank, UN-Habitat) was forged in the middle of the 1960s from a tangle of efforts directed towards the betterment of the lives of people in the Third World. During the 40s, the US programs had a different political goal from the UK-based ones, while the United Nations was a mixture of both agendas, slowly but surely moving under the influence of the United States (Harris & Giles, 2003, pp. 168-170). Interest in housing in the Third World existed in the United States and the UK even before the foundation of the UN,

but these were bilateral programs (in the case of the UK, colonial) that were not operating on the global level yet, and were territorially and economically focused, not as part of humanitarian efforts. The fledgling institutions of the UN were slowly gaining speed during the 50s and 60s while gaining territory of influence with the decolonization of the world. The United Nations had several conferences and bureaus studying human settlements, on a need-based and theoretical level, but with the rising urgency, a method was needed for providing housing as a binding agent of humanitarian and monetary policies. The earthquake of 1963 in Skopje provided a chance to experiment in the deployment of housing by testing out a metric of housing that can be calculated and possibly reproduced. Once housing became part of the effort, relief was transformed into development, and with that, international aid became an extended bureaucratic power of the Western world with transpolitical operating capability.

Housing Agencies, Food Programs

Many international agencies, such as the US Housing and Home Finance Agency and the British Colonial Office, governmental agencies, as well as the novice United Nations and some private organizations, took an interest in the international housing problem. Soon, they began a field mission providing guidance and assistance in policy making to national governments on a bilateral level, building up a network of experts across the globe (Harris & Giles, 2003, 168). The most influential agencies during this time dealing with housing were the United Nations, together with the

International Labor Organization operating on a global level, the US agencies (such as the HHFA) primarily operating in Latin America, and the Inter-American Development Bank (precursor to the Agency for International Development (USAID)) in 1961, and the British Colonial Office, primarily focusing on Britain's remaining colonies, with different policies that included the public housing policy, the aided self-help method, and later the market oriented -"enabling" approach (Harris & Giles, 2003, p. 168). These governments and agencies shared a similar agenda, recognizing the need to improve the living conditions of the ever-increasing population of urban poor, as well as the promotion of democracy, political stability, and economic development, mainly because their officers were in close dialogue and relied on the same pool of experts for policy advice (Harris & Giles, 2003, p. 170; Icev, 2021).

The US housing initiatives were centered in the HHFA, founded in 1947 with American planner Jacob Crane as the director, which advises the Department of State about housing issues and coordination with other US agencies, and technical assistance programs, which would be incorporated in the USAID. A significant turning point at the UN was the arrival of Ernest Weismann as the director of the UN Social Commission on Economic Affairs in 1951 who would be influential in steering the UN housing policy more exclusively on low-cost housing which ultimately led to the development of a long range program of action, approved in 1959 and defining the UN activity of 1961-1965 making the early 60s as the UN's most active period of housing involvement since its formation (Harris & Giles, 2003, p. 171; Weissmann, 1981; Icev, 2021).

Jacob Crane, Ernest Weissmann, and G.A. Atkinson (of the BCO) formed the expert triad leading the most influential agencies in dictating housing policies in the Third World, which were developed during various conferences, collaborations, travels, and visits amongst the offices (Harris & Giles, 2003, pp. 173–174). The agencies, however, were still mostly involved in policy advising and funding but were not directly involved in the building or planning processes on a local scale. The policies of these housing agencies fell under three categories: public housing, aided self-help, and the market option. The public housing option was the least favorite of all agencies, since in the eyes of Western governments it promoted a welfare state, and also it was very difficult for the states to meet their building standards, housing needs, and budgetary constraints. The aided self-help option is the general idea that, through technical assistance (in the form of infrastructure or training) and funding (credits and grants to the states), people could build up on the dwellings they were currently occupying, bringing them to a better standard. This was the much preferred option, later known as ‘slum upgrading’, it allowed people on the ground to build their own homes over time, promoted owner-occupancy, and took the government out of the housing business. The third option was supporting the private construction sector through grants and credits to develop and eventually produce low-cost housing for the poor (Harris & Giles, 2003, p. 171; Icev, 2021).

The earthquake of Skopje provided the opportunity for a clean slate where the UN could exercise its nascent institutions and develop methods that might be used in other situations. The political neutrality and joint interest

of Yugoslavia between the adversary blocs made Skopje the most suitable experimentation platform where the international authority of the UN could be trusted and elevated if the experiment were to prove successful. In Skopje, the UN seized this opportunity and ascended with all its institutional might and expertise, not only to help the devastated city, but to validate the expertise and growth of the UN Committee on Housing, Building and Planning, and the entire United Nations Development Program (established as the merger of the Social Fund, and the Extended Program for Technical Assistance), and later UN Habitat (Icev, 2021).

Conclusion

The Skopje reconstruction effort occurred at a specific historical convergence of ideas about development, housing, and humanitarian aid. Ernest Weissmann, who was leading the projects, allowed for a methodology of combining local and international expertise through the “Planning Circus” model, which paired experts from abroad with local ones. The production of the UPP Contour Plan, as opposed to a “master-plan” which was typical for the time, further distinguished the Skopje effort from its contemporaries. The sheer volume and caliber of aid that arrived in Skopje, which was partially due to the large media coverage of the reconstruction and the efforts of the IBC, allowed for Skopje to become not only a technologically modern city but also a symbol of solidarity and efficient disaster reconstruction (Tolic, 2011). These systems of work organization established by Weissmann will become valuable examples of city recovery after disaster during the 1960s and beyond. Post-disaster relief today

focuses on finding ways to maintain and build communities and place-making, which are crucial for continuity in place (Cuff, 2023). In this way, the Skopje reconstruction effort of 1963 can be seen as an early example of abandoning the “master-plan” approach of modernism and developing a new form of “non-aligned”, grounded-in-context model that can deliver various options for specific geographies and needs.

References

- Allais, L. (2018). *Designs of destruction*. University of Chicago Press.
- Bjažić Klarin, T. (2015). *Ernest Weissmann: Društveno angažirana arhitektura, 1926–1939 / Ernest Weissmann: Socially engaged architecture, 1926–1939*. Hrvatska akademija znanosti i umjetnosti / Croatian Academy of Sciences and Arts.
- Bjažić Klarin, T. (2022). Ernest Weissmann's architectural and planning practices: Continuity of original concerns of “New Architecture” and post-war reconstruction. *Prostor*, 30(1–2), 2–13.
- Brenner, R. (2003). *The boom and the bubble*. Verso.
- Cuff, D. (2023). *Architectures of social justice*. MIT Press.
- Davis, I. (1978). *Shelter after disaster*. Oxford Polytechnic Press.
- Deamer, P. (2020). *Architecture and labor*. Routledge.
- Dexion house. (1953). *[Newsreel]*. British Pathé. <http://www.britishpathe.com/video/dexion-houses/query/dexion>
- Harris, R., & Giles, C. (2003). A mixed message: The agents and forms of international housing policy, 1945–1973. *Habitat International*, 27(2), 167–191.
- Horn, E. (2018). *The future as catastrophe: Imagining disaster in the modern age*. Columbia University Press.
- Icev, M. (2021). *Building solidarity: Architecture after disaster and the Skopje 1963 reconstruction* (Doctoral dissertation). University of California, Los Angeles.

- Lampe, J. R., Prickett, R. O., & Adamović, L. S. (1990). *Yugoslav-American economic relations since World War II*. Duke University Press.
- Lees, L. M. (1997). *Keeping Tito afloat: The United States, Yugoslavia, and the Cold War*. Pennsylvania State University Press.
- Lin, Z. (2010). *Kenzo Tange and the Metabolist movement*. Routledge.
- Markovich, S. C. (1968). *The influence of American foreign aid on Yugoslav policies, 1948–1966* (Doctoral dissertation). University Microfilms.
- Mitchell, T. (2011). *Carbon democracy: Political power in the age of oil*. Verso.
- Monk, D. B., & Herscher, A. (2015). The new universalism: Refugees and refugees between global history and voucher humanitarianism. *Grey Room*, 61, 71–80.
- Prasad, D. N. (1980). *Food for peace: The story of U.S. food assistance to India*. Asia Publishing House.
- Ramsamy, E. (2006). *The World Bank and urban development: From projects to policy*. Routledge.
- Senior, D. (1970). *Skopje resurgent: The story of a United Nations Special Fund town planning project*. United Nations.
- Shaw, D. J. (2001). *The UN World Food Programme and the development of food aid* (pp. 1–80). Palgrave.
- Tolić, I. (2011). *Dopo il terremoto*. Diabasis.
- Wallerstein, M. B. (1980). *Food for war, food for peace*. MIT Press.
- Weissmann, E. (1981). *Human settlements: Struggle for identity*. Centre for Human Settlements, University of British Columbia.

Tools for Sustainable and Resilient Riverfronts: The Role of Building Certificates and Design Manuals in Hafencity, 3land, and Neckarbogen

Sanja Avramoska

Faculty of Architecture, Ss. Cyril and Methodius University in Skopje

ORCID: 0000-0002-5119-6029

Abstract

Urban riverfront megaprojects in Germany recently rely on two instruments to steer quality and sustainability: building certificates that translate policy targets into measurable performance, and design manuals that codify morphological and material standards. This paper compares how these tools are deployed in three high-profile cases from the German context: HafenCity (Hamburg), 3Land (Basel – Huningue - Weil am Rhein), and Neckarbogen (Heilbronn).

The research performs document analysis and comparison of documents such as the HafenCity Ecolabel, DGNB certificate schemes, the certification process manual for 3Land, and the Design manual developed for Neckarbogen. The document analysis will be accompanied by a spatial analysis of the redevelopment areas.

Certificates are responsible for legitimizing higher construction costs. They also help to quantify climate resilience, energy, and social equity. Manuals translate the abstract criteria into site-specific design codes.

Findings show that certificates and manuals operate as a mutually reinforcing quality matrix for such redevelopments and play a key role in achieving sustainability and resilience goals. The insights from this research can inform both policymakers and practitioners when designing the next generation of climate-adaptive, sustainable, and resilient urban riverfronts.

The paper offers three contributions: Firstly, an overview of how certificates and design manuals operationalize sustainability and resilience in waterfront districts; secondly, evidence-based recommendations for public authorities on how to sequence regulatory instruments and reduce stakeholder friction; and finally, lessons for transboundary projects (such as the 3land project) on how to successfully harmonize different national certification cultures and practices.

Keywords: building certification, design manuals, resilience, sustainability, urban waterfronts

Introduction

Riverfront redevelopments of former industrial and port areas incorporate multiple infrastructural systems at once: flood management infrastructures, blue-green, high-quality public spaces, mobility infrastructures, and sustainable and resilient vertical superstructures. This complexity

of infrastructures in riverfronts is often implemented by hybrid governance instruments which include publicly led corporates and public-private partnerships. As these developments are situated in central urban areas, the expectations and pressure for achieving social and environmental sustainability and resilience are always high. Certification systems for sustainable neighborhoods started to emerge around two decades ago. Local governments implement building certificates and labels, which are joined by design manuals, to steer more sustainable outcomes.

This paper compares how these instruments are operationalized in three key riverfront redevelopments from the German context: HafenCity (Hamburg), 3Land (Basel-Weil-Huningue), and Neckarbogen (Heilbronn). These three cases are situated in three different contexts, differ in scale, governance models, and planning process, but are comparable as they are all placed in an urban context, are recent port redevelopments (From the last 3 decades), and all rely on certificates and labels as instruments that ensure building qualities.

The paper employs not only comparative analysis on three specific cases, but it also foregrounds the engineering of standards, and it aims to answer the following research question: How do local governments enforce urban sustainability and resilience certification systems in Germany, and how are these systems shaped to respond to the specific context in riverfront redevelopments?

Literature Review and Conceptual-Theoretical Framework

Most of the existing scientific literature maps or critiques the main neighborhood and district certification schemes. Comparative analyses find that certification systems sometimes focus on procedures and features over measured performance, have fewer mandatory targets than needed, and, with that risk, “certifying without being sustainable” if credits can be traded off. Other indicator-level comparisons focus on the use of sustainable materials and show divergence across design guidelines and neighbourhood sustainability assessment tools (Wangel et al., 2016; Yoon & Park, 2015). Research that reviews post-certification performance on buildings shows inconsistent post-occupancy evaluation methods and reporting, and calls for a standardized and cohesive post-occupancy evaluation approach (Evans et al., 2025; Hersh, 2012). Research that reviews post-certification performance on buildings shows inconsistent post-occupancy evaluation methods and reporting, and calls for a standardized and cohesive post-occupancy evaluation approach (Afroz et al., 2020; Zhao et al., 2024). With respect to the topics, methodologies used in these research are: comparative content analysis of scheme criteria (Wangel et al., 2016; Yoon & Park, 2015), case-study research on specific redevelopments often with mixed-methods for data collection (Hersh, 2012), and post-occupancy evaluation and performance reviews (Afroz et al., 2020; Zhao et al., 2024).

There are many comparisons of certification systems and labeling, but very few studies examine how sustainability targets (which are expressed firstly in redevelopment visions) become enforceable through concrete instruments

and what the governance network that operationalizes them. This paper traces exactly that translation pathway. Furthermore, waterfront research argues for resilience governance, but the link between flood-risk engineering and certification targets is rarely mapped. This research is based on a network perspective that views riverfronts as systems-of-systems and aims to map the links and networks from vision to inscription into certificates, labels, or manuals. To frame the concepts, certificates and manuals are seen as inscriptions that shape metrics and thresholds which regulate typologies, materials, and details for architecture. When the authorities adopted instruments such as certification systems, they created a new translation moment (in ANT terms) and a new Obligatory Passage Point (OPP) (Latour, 2005) for investors, architects, and developers.

Methodology

The methods combine document analysis (certification criteria, design manuals, land-sale contracts, planning ordinances) and institutional analysis (who owns, verifies, and enforces the certifications). Each certification instrument is reviewed across nine dimensions: scope, legal/contractual force, administrator, verification, core metrics, resilience, enforcement levers, and interaction with other tools, and the certification systems are compared through these two perspectives. The analysis is limited as it focuses only on the structure and design of the certification systems, their implementation strategy, and the governance structures that enable them, rather than long-term performance monitoring. One of the cases – 3Land is treated as an evolving

practice as it is still not obligatory and widely implemented in the redevelopment.

Case Contexts and Instrument Genealogies

HafenCity (Hamburg)

The instrument set for HafenCity was evaluated from a local and voluntary system to a hybrid local-state mandatory system. The Hafen City Eco Label (v 1.0) launched in 2007 (Figure 3c). The label was not mandatory and awarded “silver” and “gold” category labels based on the performance of the building. In 2010, “HafenCity Eco-Label Gold” became mandatory, which changed procedures for land-sale contracts and building permitting. In 2017, City Eco Label (v 3.0) (Figure 3b) (GFÖB & HCH, 2010) was launched, which introduced the “platinum” category and stricter sustainability criteria. Finally, in 2023, the local Eco-Label joined the German national DGNB¹ standards (Figure 3d) and evolved into the DGNB Special Award: Ecolabel for HafenCity, Billebogen, Grasbrook, and Science City districts (DGNB, 2023). The label became contractually mandatory on HafenCity Hamburg GmbH (HCH)²- developed plots and became a rare example of making certification binding through development contracts. To operationalize the label, other instruments were employed: plot-specific guidelines, land-sale contracts, flood-resilience norms, and mobility targets.

1 German Sustainable Building Council; runs the DGNB certification systems for buildings and urban districts.

2 HafenCity Hamburg GmbH: city-owned developer/landowner for HafenCity that ties plot sales to sustainability requirements.

HCH acts as a land developer and a manager, which translates the local authorities' policy into contracts with obligations. Independent experts and certification bodies verify compliance at the building permit and handover stages.

Figure 1.

Public space in-between blocks of Neckarbogen, with seating/play elements. Source: author, 2023

Figure 2.

Les Jetées residential tower, Huningue. Source: author, 2024

Figure 3.

HafenCity district, residential buildings. Source: author, 2023



Land (Basel – Weil am Rhein – Huningue)

The instrument set for the 3Land (Figure 2) project consists of several layers. Firstly, a couple of trinational planning agreements (Canton of Basel-Stadt et al., 2022; Kanton Basel-Stadt et al., 2011) establish the governance and quality procedures in the area. Furthermore, the IBA Basel 2020#_ftn1 Label was used as a quasi-certification for cross-border projects to signal quality and access to funding. The redevelopment is tri-national (France – Germany – Switzerland), so national,

municipal design codes, manuals for riverbanks, bridges, and public realm affect each part of the district differently. Building-certificate regimes by country are another layer of requirements for ensuring quality and sustainability. Finally, in 2019, a trinational Criteria Catalog (TEB, 2019) (Figure 3a) was published, which is a non-binding guideline for the buildings in the 3Land area. “Nachhaltiges 3Land durable” certificate is awarded to each project that follows these criteria, the first one being the residential quarter Les Jetées in France (Figure 2). To embed the Criteria Catalog institutionally, the Trinational Eurodistrict Basel (TEB) provides a platform for coordination. Each municipality/canton/commune retains its own statutory powers, and the cross-border projects use harmonized criteria via memoranda, competition briefs, and design-review procedures.

Neckarbogen (Heilbronn)

The instrument set for Neckarbogen district (Figure 1) was a product of an integrated planning process, which produced an Integrated Framework Plan and a Design Manual (Figure 3e) that sets requirements for façades, materials, building heights, ground-floor use, public-space typologies, rainwater handling, and biodiversity for each plot. This district was the first one to ever pre-awarded DGNB (Urban District) certification in the first construction phase. To achieve the sustainability targets and BUGA 2019 milestones, instruments such as contractual obligations via investor selection and development contracts were utilized. The City of Heilbronn and BUGA 20193 GmbH

3 Bundesgartenschau - Federal Garden Show is a large-scale horticultural exhibition in Germany, held every two years in different cities.

Figure 1.

Key instruments reviewed across the three case studies (cover thumbnails): (a) 3Land – Criteria Catalogue (2019); (b) Ecolabel HafenCity guide (version 3.0/2017); (c) Sustainable Building in HafenCity (brochure, 2010); (d) DGNB System – Criteria catalog (2020); (e) Design Manual – Modellquartier Neckarbogen, Heilbronn (2015). Covers shown for identification; full citations in the References



used the manual and the competition results to organise the phasing of the project, and DGNB provided third-party verification at the area level. Plot developers were obligated by contracts to meet both DGNB credits and the Design Manual's prescriptions.

Analytical Framework

To be able to compare the sustainability certificates, each is treated as an engineering specification that carries performance metrics, design codes, and label-enforcing protocols. Therefore, the following information is encoded: operational and embodied carbon, energy demand and supply, materials and circularity, mobility modal split, biodiversity and soil treatment, indoor environmental quality, social mix and affordability.

Findings

Certificates translate policy into quantified indicators. They provide cross-project comparability, enable auditable claims in land-sale contracts and marketing. In flood-prone waterfronts, certificates and their accompanying technical rules embed: minimum finished-floor elevations above design storm level, dry access and emergency routes, critical services above flood lines, backup power, and nature-based solutions. They also require the use of cool materials, shading, and ventilation corridors. Manuals consolidate rules on façade articulation, materials, heights, ground-floor permeability, courtyard typologies, rain-infrastructure, and street sections. In Neckarbogen, the manual's open-space

typologies (parks, waterfront promenades) and SUDS prescriptions support DGNB water and ecology credits. In HafenCity, elevated urban terraces and flood-safe waterfronts shape the entire district identity. The pairing of certificates and manuals, such as Neckarbogen's example, creates redundant controls: the certificate ensures outcomes are measured and verified; the manual ensures they are visibly and spatially embedded.

Comparative Analysis

Governments enforce the sustainability and resilience criteria through different mechanisms (Table 1). In HafenCity's case, sustainability targets are made contractually mandatory through HCH land-sale agreements, which tie them to acceptance. The verification of compliance with the standards includes expert audits and HCH acceptance tests. The 3Land project provides a voluntary tri-national criteria framework and awards the projects that comply with it. For now, any legal requirement comes only when local authorities embed specific requirements in their own plans and permit procedures. Neckarbogen uses the Design Manual and investor contracts to make its targets binding. The DGNB certificate is applied as a project-level requirement with third-party auditing.

Table 1.*General comparison*

	HafenCity	3Land	Neckarbogen
Certificate/ label	HafenCity Eco-Label v1.0; HafenCity Eco-Label v3.0; DGNB Special Award Eco Label	IBA Basel 2020 label; 3Land Durable certificate	DGNB Urban District Pre-certificate; BUGA Label
Manual/ code	Plot and public-realm manuals; 2002 Flood protection ordinance	Trinational criteria catalog	Design Manual
Administrator	HafenCity Hamburg GmbH; BSU ⁴	TEB platform; Municipalities; Canton; Commune	City of Heilbronn; BUGA 2019 GmbH
Legal/ contractual force	Embedded in land-sale contracts; building permits	Label via IBA; statutory force via local permits	Binding via investor contracts

4 Behörde für Stadtentwicklung und Wohnen - Hamburg's Ministry/Authority for Urban Development and Housing (since 2015)

	HafenCity	3Land	Neckarbogen
Verification	Independent experts; HCH acceptance tests; certificate audits	IBA evaluation panels; local permitting bodies	DGNB auditors; municipal review

HafenCity Eco-Label (now DGNB Eco-Label Special Award) is mandatory on HCH-sold plots; 3Land Durable is a certificate given to voluntary compliance with sustainability criteria; Neckarbogen DGNB requirements are binding via investor contracts. As shown in the cases observed, early pilot projects in each of the cases often set criteria voluntarily to signal quality and set precedents that later became contractual norms. Finally, BUGA and IBA labels are recognition mechanisms that catalyze implementation but do not create statutory obligations; obligations arise when cities embed criteria in contracts, design manuals, and permits.

As shown in Tables 2 and 3, the metrics for each certificate and manual are shaped by context. Only some of the metrics in the documents are mapped in these tables. HafenCity's core is accessibility, use of certified materials, and indoor comfort targets. Neckarbogen positions itself as a model district; it leverages DGNB criteria, but also a design manual that sets these criteria into a context and focuses on innovation in the district and the 1/3 building, 1/3 water, 1/3 green rule. 3Land puts its focus on the cross-border corridor continuity and harmonization across the countries into a single code.

Table 2.*Sustainability metrics comparison.*

	Energy and Carbon	Flood and Water	Mobility
HafenCity Ecolabel (v1-v3)	<p>Measurable: Primary energy demand; Transmission heat loss; Renewable energy share; 2-year energy monitoring</p> <p>Non-measurable: low CO₂-limit-based district heating; Early planning integration of energy goals</p>	<p>Measurable: Compliance with the reference value for water demand; Design % of the roof area as either a green roof, solar-active surfaces, and/or roof terrace</p> <p>Non-measurable: Proof of heavy metal-free roof/ façade runoff</p>	<p>Measurable: maximum parking spaces per apartment; max distance from entrances</p> <p>Non-measurable: integration of HafenCity's subway, bus, and walkable city</p>
DGNB System – Criteria Catalogue for New Buildings (Version 2023 / Operational 2020)	<p>Measurable: Annual greenhouse gas emissions of the building; Proportion of renewable energy generated on-site; Solar utilization rate; Agenda 2030 bonus: TRY-based thermal comfort simulation/ calculation</p> <p>Non-measurable: Documentation and evaluation of the user survey conducted to increase energy efficiency</p>	<p>Measurable: Water Use Index (WEI+); Fixture flow classified by flow rates; % non-potable water for irrigation; Sponge City bonus: ≤10% deviation from natural water balance (infiltration, evap, runoff)</p> <p>Non-measurable: Integration with district water infrastructure</p>	<p>Measurable: Modal split % (share of trips by walking, cycling, and public transport); Proximity to public transport stops</p> <p>Non-measurable: Mobility management plans and operational concepts are evaluated qualitatively</p>

DGNB Special Award Ecolabel (2023-2024)	<p>Measurable: Climate neutrality target (net-zero 2045); CO₂ balance requirement; Integrated with EU taxonomy</p> <p>Non-measurable: Climate adaptation strategies; Integration with funding programs</p>	<p>Measurable: Irrigation concept for outdoor areas</p> <p>Non-measurable: Sustainability and adaptation; Resilience to heavy rainfall and flooding</p>	<p>Non-measurable: Integration with city-wide transport systems; Electromobility readiness</p>
3L and Kriterienkatalog	<p>Measurable: Building energy demand limits; Share of renewable energy in supply systems</p> <p>Non-measurable: Sustainable construction principles; Minimize reliance on external energy sources</p>	<p>Non-measurable: The Rhine as an ecological free space must be preserved.</p>	<p>Non-measurable: Priority on walking, cycling, PT; Dense pedestrian network and cyclist user-friendly infrastructure; Prioritisation of car reduction</p>

Neckarbogen Design Manual	<p>Measurable: DGNB Platinum criteria: CO₂ reduction below the legal standard expected in the future; Primary energy demand benchmarks (EnEV-based); Energy efficiency measured in operational phase</p> <p>Non-measurable: Energy concept as a binding part of the Baukommission review; Preference for regional building materials</p>	<p>Measurable: Water retention requirements in courtyards/streets (DGNB-linked)</p> <p>Non-measurable: Integration of Altneekar as open space and blue-green corridor; Lakes (Stadtsee, Freizeitsee) as floodable urban landscape</p>	<p>Measurable: Bicycle parking facilities mandatory at every building; Car-sharing stations as a planning obligation</p> <p>Non-measurable: Mobility concept part of Baukommission approval; Encouragement of public transport use and walkability</p>
3Land Free Space and Nature Protection Strategy (2020)	<p>Non-measurable: Climate adaptation and mitigation through urban greening; Support for climate adaptation through green-blue infrastructure</p>	<p>Non-measurable: Improve Rhine accessibility and continuity of waterfront; Protection of natural river landscapes</p>	<p>Non-measurable: Creation of cross-border green mobility corridors and bridge; “soft mobility” and trinational accessibility of public spaces.</p>

BUGA Label / City Exhibition requirements from the integrated framework plan	<p>Measurable: primary energy demand, CO₂ emissions, renewable energy share; targets for reduced heating demand, connection to district heating, monitoring</p> <p>Non-measurable: Showcase “Smart City” housing with efficient energy systems; Integration of energy, mobility, water, and climate as “holistic” systems</p>	<p>Measurable: Surface of development land allocated to water areas (Stadtsee, Freizeitsee); Rainwater management integrated into DGNB certification criteria</p> <p>Non-measurable: Sustainable water management” as a guiding principle (BUGA 2019 link); Re-integration of the Neckar River</p>	<p>Measurable: Pedestrian- and bicycle-friendly layout explicitly stated: dense cycle and footpath network, direct connections to main station and city center</p> <p>Non-measurable: Mobility change modelled through city exhibition; “City of short distances” principle</p>
--	--	--	---

Table 3.*Sustainability metrics comparison.*

	Materials and Circularity	Biodiversity and Microclimate	Social and Governance
HafenCity Ecolabel (v1-v3)	Measurable: certified wood; Falling below the reference values for global warming (CO ₂ , eutrophication, acidification) Non-measurable: Ban on toxic substances	Measurable: at least 80% of roof area greened or accessible; Non-measurable: Design for pleasant outdoor microclimate in roof design and public spaces	Measurable: % barrier-free accessible spaces; Indoor air quality; Thermal comfort; Acoustic comfort Non-measurable: Public ground floor or mound floor use
DGNB System (NB 2023 / Op. 2020)	Measurable: % secondary/ recycled raw materials; Verification of compliance with ILO conventions, OECD guidelines, and LkSG Non-measurable: Qualitative evaluation of ethical procurement practices and anti-corruption measures	Measurable: Ratio sealed vs. green surface; Agenda 2030 bonus: local evapotranspiration rates Non-measurable: Integration of greenery into urban design	Measurable: User satisfaction surveys; Interior comfort Non-measurable: Continuous improvement processes are evaluated for building operations and governance

DGNB Special Award Ecolabel (2023-2024)	<p>Measurable: Use of secondary raw materials in certified products</p> <p>Non-measurable: Responsible sourcing aligned with EU taxonomy</p>	<p>Measurable: Outdoor biodiversity promotion quantified</p> <p>Non-measurable: Climate adaptation bonus</p>	<p>Measurable: Proof of EU Taxonomy and QNG compliance</p> <p>Non-measurable: Certification mandatory in HCH land allocation contracts</p>
3Land Kriterienkatalog	<p>Non-measurable: Encourage circularity and ecological materials</p>	<p>Measurable: creation of green space); greening coverage of technical structures</p> <p>Non-measurable: Promote cross-border ecological connectivity</p>	<p>Measurable: Certification score)</p> <p>Non-measurable: Mandatory expert review process once certification is sought</p>
Neckarbogen Design Manual	<p>Measurable: DGNB LCA benchmarks for embodied carbon in materials</p> <p>Non-measurable: Recommendation for traditional/regional materials in façade</p>	<p>Measurable: Planting catalogues and greening rules per plot (species mix, tree quotas)</p> <p>Non-measurable: Improve urban climate through green courtyards, roof gardens</p>	<p>Measurable: DGNB social quality indicators (accessibility, participation, mix of uses)</p> <p>Non-measurable: Investor selection by Baukommission with quality review</p>

<p>3Land Free Space and Nature Protection Strategy (2020)</p>	<p>Non-measurable: Reuse of industrial/ brownfield land suggestion</p>	<p>Non-measurable: Define biodiversity priority zones; strengthen ecological corridors</p>	<p>Non-measurable: Governance tool for trinational cooperation; Inclusion of public interests</p>
<p>BUGA Label / City Exhibition requirements from the integrated framework plan</p>	<p>Measurable: DGNB certification requires life-cycle assessment Non-measurable: Encouragement of innovative building typologies and materials</p>	<p>Measurable: Land allocation principle: 1/3 green landscape areas Non-measurable: Community gardens, vertical/ hanging gardens as a climate adaptation showcase; reintegration of Neckar as an ecological corridor</p>	<p>Measurable: 51% rental vs. 49% owner-occupied housing quota; 3,500 residents + 1,000 jobs target for quarter Non-measurable: Civic participation via exhibitions and events;</p>

Looking at the metrics one by one, energy and carbon criteria follow broadly similar logic across all three: Measurable targets for energy demand, CO2 reduction, lower water demand, and innovation in building. The flood and water dimension focuses on targets for reduced water demand, integration with the district water infrastructures, improvement of the continuity of waterfronts and their accessibility, and their use as flood infrastructures. The mobility targets focus mainly on improving soft mobility,

increasing public transport use, and lowering private car use. For the materials and circular dimensions, life cycle assessment is required; the use of secondary materials and the use of wood is encouraged. Biodiversity measures converge on habitat enhancement, corridors, and green roofs. façade greening (explicitly supported by Neckarbogen). Mixed social structures, opportunities for different social groups, and proximity to public amenities recur in all three cases, which support the social dimension of sustainability.

Discussion and Evaluation

Each case is treated as a chain of translations⁵. The first translation represents the process from policy to certificate, where public goals are turned into specific indicators and thresholds. The second translation is from certificates to contracts and manuals. The criteria here are embedded in landsale contracts and design manuals that lead investors, architects, and developers through the design to implementation process. The third translation is from the delivery of a project to its verification. In this translation, audit reports, acceptance tests, and design reviews help stabilize the networks into a built form. The fourth translation is from the revision of the projects certified for scaling of the requirements. As demonstrated in the cases analysed, lessons learned from initial certified projects often lead to stricter or more specific rules.

5 The process by which actors redefine problems and align others around an obligatory passage point, typically through four “moments”: problematization, interessement, enrolment, and mobilization. The products of a translation can be inscriptions (e.g., plans, contracts, standards).

In the analysed case studies, how and when standards and requirements are inscribed in the process differ. The nature of the analysed documents is different as well. EcoLabel HafenCity and DGNB are certification systems that specify quantitative indicators and are mandatory. Both certification systems go through four translations: policy-certificate-verification-scaling. The 3 Land strategy is a soft, guiding framework that is mostly an active actor in the first and second translation: The Criteria Catalog is a directional rather than mandatory handbook, relevant in the first translation – from policy to criteria. Design Manual in Neckarbogen is a quality guideline that is a mix of fixed and flexible rules, active from the first to the third translation (Table 4).

Table 4.

*Comparison of certification systems across the four translations.
Source: Author, based on the analysed documents*

Instrument	1. Policy - Certificate	2. Certificate - Contracts / Manuals	3. Delivery - Verification	4. Revision - Scaling
HafenCity EcoLabel	Developed from public goals into EcoLabel v1-v3	Mandatory in land-sale contracts	Independent auditors check compliance	Evolved across 3 versions
3 Land Criteria Catalog	Goals, criteria, and indicators derived from Spatial concept and planning agreements	Used in competitions and planning guidance, but not mandatory	No systematic verification	No formal scaling

3Land Free Space and Nature Strategy	Political agreement	Functions as argumentation tool	No formal verification	Lessons inspire cooperation
DGNB (Neckarbogen)	DGNB district criteria	DGNB certification tied into framework plan	DGNB audit/scorecard verifies built projects	Lessons from Neckarbogen inform later DGNB system refinements
Neckarbogen Design Manual	Public quality goals are translated into guidelines	Integrated into purchase agreements	Baukommission reviews and approves individual projects	Feedback from BUGA 2019 tightens later rules

Some recommendations can also be derived from the analysed cases. Resilience should be made non-negotiable and visible by fixing target elevations and emergency access. Where possible, certificates and manual compliance should be made binding through land-sale contracts. There should be sequencing of the certification process, and redevelopments should be started by the pilot phase, as shown by the City Exhibition in Neckarbogen, the first buildings in HafenCity that received the EcoLabel certificate, and the Les Jetées neighbourhood in the 3Land area. Not over-prescribing and leaving flexibility for innovative and alternative solutions (if they match performance specifications) is an asset. Finally, important indicators like carbon, circularity, and urban heat indicators should be measured, and a transparent post-occupancy evaluation should be done. I argue that for the transboundary districts,

a practical approach is to build a side-by-side mapping and translation of other criteria. First, equivalent credits should be mapped. Furthermore, non-overlaps should be mapped, and a minimum common set should be decided. Authority of auditors should be decided, and the criteria should be implemented into competition briefs, development agreements, and design-review checklists. Finally, early pilot projects can serve as learning instruments for further scaling of the requirements.

Conclusion

Certificates and design manuals are complementary tools that can help in delivering resilient, sustainable, and high-quality riverfront districts. However, results show that enforcement frameworks are more important in delivering sustainability and resilience into districts than labels and certificates. This is shown in the contractual embedding in HafenCity and Neckarbogen. Labels often do not create a statutory obligation. Visible in the case of IBA and BUGA labels (exhibitions that raise profile but do not set hard performance metrics), they can help in better visibility of projects and better coordination, but obligations arise only when criteria are cited in contracts and permits. Voluntary pilots are an important tool to prefigure norms into mandatory criteria. In all three cases, pilot projects adopted the rules to signal better quality. Finally, context shapes the metrics and the processes of governance and verification of the certificates/labels.

References

- Afroz, Z., Burak Gunay, H., & O'Brien, W. (2020). A review of data collection and analysis requirements for certified green buildings. *Energy and Buildings*, 226, 110367. <https://doi.org/10.1016/j.enbuild.2020.110367>
- Canton of Basel-Stadt, Stadt Weil am Rhein, Ville de Huningue, Landkreis Lörrach, Saint-Louis Agglomération, Collectivité européenne d'Alsace, Ville de Saint-Louis, & Eurodistrict Trinationale de Bâle (ETB/TEB). (2022). *Convention de planification trinationale 2022–2025 / Trinational Planning Agreement 2022–2025 (“3Land”)* (Cooperation for the development of the area around the border triangle between Palmrain Bridge and Dreirosen Bridge). Eurodistrict Trinationale de Bâle (ETB/TEB).
- DGNB. (2023). *DGNB special award Ecolabel*. DGNB GmbH. <https://www.dgnb.de/en/certification/specific-applications-of-the-dgnb-system/dgnb-special-award-ecolabel>
- Evans, C., Harris, M. S., Taufen, A., Livesley, S. J., & Crommelin, L. (2025). What does it mean for a transitioning urban waterfront to “work” from a sustainability perspective? *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, 18(3), 349–372. <https://doi.org/10.1080/17549175.2022.2142648>
- GFÖB & HCH. (2010). *Sustainable Construction in HafenCity – HafenCity Ecolabel (Fully Revised Edition)*. HafenCity Hamburg GmbH.
- Hersh, B. F. (2012). *The Complexity of Urban Waterfront Redevelopment* (pp. 1–52). NAIOP Research Foundation.
- Kanton Basel-Stadt, Ville de Huningue, & Stadt Weil am Rhein. (2011). *3Land—Absichtserklärung / Déclaration d'intentions: Entwicklungsvision / Vision de développement* [Letter of intent (agreement)]. Kanton Basel-Stadt; Ville de Huningue; Stadt Weil am Rhein.
- Latour, B. (2005). *Reassembling the social: An introduction to actor-network-theory*. Oxford University Press.
- TEB. (2019). *Der Trinationale Kriterienkatalog: Gemeinsam nachhaltig entwickeln*. <https://3-land.net/de/timeline/2019-kriterienkatalog.html>

- Wangel, J., Wallhagen, M., Malmqvist, T., & Finnveden, G. (2016). Certification systems for sustainable neighbourhoods: What do they really certify? *Environmental Impact Assessment Review*, 56, 200–213. <https://doi.org/10.1016/j.eiar.2015.10.003>
- Yoon, J., & Park, J. (2015). Comparative Analysis of Material Criteria in Neighborhood Sustainability Assessment Tools and Urban Design Guidelines: Cases of the UK, the US, Japan, and Korea. *Sustainability*, 7(11), 14450–14487. <https://doi.org/10.3390/su71114450>
- Zhao, J., Abdul Aziz, F., Deng, Y., Ujang, N., & Xiao, Y. (2024). A Review of Comprehensive Post-Occupancy Evaluation Feedback on Occupant-Centric Thermal Comfort and Building Energy Efficiency. *Buildings*, 14(9), 2892. <https://doi.org/10.3390/buildings14092892>

Rethinking Green Infrastructure in Skopje through Regional Best Practices

Faton Kalisi

International Balkan University Skopje, North Macedonia
ORCID: 0009-0008-4927-6100

Abstract

Ljubljana, Slovenia; Krakow, Poland, and other Central European cities that are known for implementing the ecological principles into the urban development, by using comparative analyses from these cities, this article looks into the gaps between the strategic planning of Green Infrastructure and its implementation in Skopje, North Macedonia. The environmental stressors that have impacted Skopje's planning systems are air pollution, urban heat islands (UHI), and ecosystem fragmentation, among others. For that reason, green corridors, urban forests, rainwater management, and small-scale interventions are proposed as a solution in order to help mitigate these challenges. However, implementation of these strategies is not yet consistent and is only theoretical.

Regarding the methodology used, this article reviews national and local planning policies, then compiles the

existing research, and finally compares Skopje's goals for the green infrastructure with the examples from the region taken as a reference. Financial sources, the institution's capacity, and consistency of policies are all taken into consideration in the evaluation methodology. As a standard for evaluation for Skopje's future development, the vertical green systems, tree-line bike lanes, the riverbank of Ljubljana, as well as the green-blue corridors and air quality projects of Krakow, are taken into consideration. Based on the findings, Skopje's goals are in line with global urban sustainability, but due to underfunding, lack of institutional coordination, and design standards, this progress is limited.

In the conclusion, three recommendations are given: 1) creating a Green Infrastructure Unit across municipalities; 2) setting ecological urbanism design guidelines at different scales that would be mandatory; and 3) testing and evaluating nature-based projects that involve stakeholders and use quantifiable performance indicators. By placing Skopje's urban sustainability goals within the broader regional context, this study helps to contribute to the current issue of ecological urbanization, policy innovation, and the role of Green Infrastructure in climate-resilient cities.

Keywords: green infrastructure, urban sustainability, policy implementation

Introduction

Urban heat islands (UHI), flooding hazards, decline in air quality, and ecosystem fragmentation are some of the growing ecological and social stressors affecting

European cities (Chatzimentor et al., 2020; Slätmo et al., 2019). These pressures are especially visible in Central and Eastern Europe, where cities' rapid urbanization, outdated infrastructure, and fragmented governance are limiting the cities' ability to adapt. (Herman & Drozda, 2021; ESPON, 2019). The implementation of sustainability solutions is frequently a challenge for post-socialist cities like Skopje, leading to uneven ecological urbanism growth (Herman & Drozda, 2021).

In response to these stressors, green infrastructure (GI), which is characterized as a carefully designed network of natural and semi-natural places that offer ecological, social, and economic benefits, has gained popularity (Chatzimentor et al., 2020; Slätmo et al., 2019). Urban forests, tree-lined streets, permeable surfaces, and restored riverbanks are examples of multifunctional landscapes that can simultaneously improve air quality, regulate temperatures, lower the risk of flooding, and increase biodiversity (Sanesi et al., 2017; Siedlarczyk et al., 2019). European cities like Krakow and Ljubljana have shown how ecological design principles and integrated green-blue corridors may enhance urban resilience and produce benefits (Davies et al., 2019; Slätmo et al., 2019).

Even though the importance of GI is widely acknowledged, its implementation is very different in different European cities. Particularly in smaller and less wealthy cities, this progress is limited by a lack of funding, fragmented institutional structures, and weak design standards (Chatzimentor et al., 2020; ESPON, 2019). Skopje's Green City Action plan emphasizes the need for urban trees, ecological corridors,

and rainwater management, but the implementation has been slow, and in most cases purely symbolic. In order to identify the challenges and provide useful suggestions, this paper compares Skopje's approach to GI by taking into account the examples from the successful regional experiences.

Literature Review

Defining Green Infrastructure

In sustainable urban development, green infrastructure (GI) has become a crucial concept. According to Chatzimontor et al. (2020) and Slätmo et al. (2019), it refers to well-organised networks of natural and semi-natural regions intended to provide a variety of ecological, social, and economic benefits. Green infrastructure (GI), opposed to traditional “grey” infrastructure, which handles individual concerns through constructed systems, incorporates natural processes into the urban fabric, promoting climate adaptation, biodiversity, recreation, and health outcomes. Green Infrastructure has been promoted since the 2011 EU Biodiversity Strategy, at the European policy level, and is being implemented through frameworks like the ESPON GRETA project, which focuses on multifunctionality and cross-border planning (ESPON, 2019).

Regional Best Practices

There are a couple of European cities that have implemented the GI policies, with evidence showing the concept's practical application.

- By incorporating green corridors, restoration of its riverbanks, and using tree-lined cycling structures, with a strong emphasis on accessibility and participatory design, Ljubljana has become a role model. With this, GI is positioned as both an ecological infrastructure and a public asset (Davies et al., 2019).
- Krakow, on the other hand, with the help of the used i-Tree Eco model, used to evaluate the impact urban trees may have on the reduction of air pollution and climate control (Siedlarczyk et al., 2019). This shows how using scientific tools may help strengthen and enhance decision-making.
- Milan has implemented GI measures on a metropolitan scale at the Città Metropolitana that included urban forests, natural corridors, and peri-urban agriculture. These methods emphasise the need to combine city and regional planning levels (Sanesi et al., 2017).

Urban Stressors Addressed by GI

European cities encounter a variety of stressors that GI is positioned to address:

- Air pollution is a significant health issue. Urban trees and green corridors may filter particulate matter, as shown by the empirical evidence through quantitative monitoring (Siedlarczyk et al., 2019).
- Milan's urban forestry projects how canopy covers are positioned as core green-infrastructure measures that may manage local microclimates and help control and reduce Urban heat islands (UHI) intensification due to dense built environments. (Sanesi et al., 2017).

- Climate change has increased the need for effective flood and stormwater management. Permeable surfaces and repaired riverbanks in Scandinavian and Central European situations provide efficient responses (Slätmo et al., 2019; ESPON, 2019).
- Chatzimentor et al. (2020) propose using ecological corridors and multi-scalar GI networks to mitigate biodiversity loss and ecosystem fragmentation.

Barriers to Implementation

Despite the obvious benefits, GI adoption confronts significant barriers:

- According to Chatzimentor et al. (2020), municipalities typically face financial restrictions that prevent them from expanding beyond experimental initiatives. According to Slätmo et al. (2019) and ESPON (2019), institutional fragmentation that divides responsibility for water, transportation, and green space hinders effective planning.
- According to Chatzimentor et al. (2020), a lack of design standards leads to variable quality and worse public approval in cities throughout Europe.
- In post-socialist countries like Central and Eastern Europe, difficulties such as poor governance, outmoded infrastructure, and conflicting urban development agendas might arise (Herman & Drozda, 2021).

Figure 1.

Conceptual framework for GI strategies addressing Skopje's environmental challenges.



Methodology

This research uses a comparative case study approach to investigate how green infrastructure (GI) might manage urban environmental stressors in post-socialist countries. Skopje serves as the study's main instance because of its severe air pollution problems, heat island effects, and lack of green space (Andonova et al., 2023). Comparative references to other European cities provide context but do not replace the local analysis.: Ljubljana (Slovenia) and Kraków (Poland), each having a different direction of ecological and urban governance.

Literature and Policy Review

Peer-reviewed studies, municipal planning documents, and international policy frameworks were examined to provide context for GI growth in Skopje. Also, the Ministry of Environment and Spatial Planning's Green Infrastructure/Spatial Planning strategy was one of the national reports on GI and spatial planning that were examined (Bodanova Ajceva et al., 2022). Key sources were Andonova et al. (2023) and Mirakovski et al. (2020) on air quality, Miletić et al. (2023) on emissions modelling, and Bukovetz et al. (2022) on urban heat islands. This stage highlights both formal and structural impediments in the urban planning system, which will guide the ensuing study.

Environmental Data Analysis

Quantitative data on PM_{10} , CO_2 , and UHI were gathered from literature and government repositories. The relative contributions of traffic, industrial, and residential pollutants were determined using receptor modelling and emission source assessments (Mirakovski et al., 2020; M.M. et al., 2023). In the research by Bukovetz et al. (2022), thermal mapping and remote sensing data were used to compare the temperatures of built and vegetated areas in the city of Skopje.

Comparative Thematic Coding

Literature and planning documents were analyzed in order to identify common patterns, such as governance capacity, public involvement and participation, technical standards, and strategies for climate adaptation plans.

Attention was paid to how GI treatment can address significant stressors:

- Air pollution (Andonova et al., 2023; Mirakovski et al., 2020)
- Urban heat islands (Bukovetz et al., 2022)
- Ecosystem fragmentation (Andonova et al., 2023)

Cross-Validation and Synthesis

The results of both qualitative and quantitative investigations were combined to determine the main obstacles to GI implementation. A strong foundation for suggestions based on evidence is provided by this method, which offers triangulation between planning/technical frameworks and empirical environmental data.

Results

Air Pollution and Green Infrastructure Potential

In Skopje, air quality continues to be one of the most urgent environmental issues. Adonova et al. (2023) show that open burning of agricultural residues, coal and wood-based heating, and poor urban morphology all contribute to PM₁₀ peaks in wintertime. Mirakovski et al. (2020) confirm that industrial and residential heating contribute more significantly to PM₁₀ than traffic emissions. Similarly, M. M. et al. (2023) demonstrate through emission modelling that industrial activity and seasonal heating contribute more to CO₂ and PM₁₀ than transportation. The advantages of GI for air quality are very context-specific and dependent on placement, density, and connectivity, according to Slätmo et

al. (2019). Vegetated lanes along Skopje's transport arteries might offer localised pollution interception, but according to data from Skopje, industrial emissions and heating continue to be the main causes of PM₁₀ and CO₂ levels (Andonova et al., 2023; Mirakovski et al., 2020; M. M. et al., 2023). This suggests that if these sources are not addressed, the city will continue to surpass EU air quality thresholds.

Urban Heat Island (UHI) Mitigation

Bukovetz et al. (2022) remote sensing data confirms the cooling capability of urban vegetation by showing temperature variations of up to 7.9 °C between Skopje's parks and treeless streets. Sanesi et al. (2016) reported Milan's urban forestry initiative, which offers a transferable example: local heat island intensity was dramatically lowered by targeted canopy cover extension. In Skopje, using similar tactics might enhance thermal comfort and lower health risks, especially in crowded areas without shade. Micro-scale interventions, such as strategically placing trees in parking lots, have been demonstrated to minimise localised warming at Ljubljana's Park & Ride facilities (Fikfak et al., 2021). This shows that even small, targeted plant projects might supplement bigger canopy and corridor plans in Skopje to improve thermal comfort in high-density urban areas.

Flooding and Water Management

Due to insufficient drainage and periodic heavy precipitation, flooding is nevertheless a latent issue in Skopje, while being less obvious than air pollution and UHI. According to Chatzimentor et al. (2020), multifunctional GI (such as wetlands and river corridors) offer biological connections

and flood control. One example of incorporating riparian GI into more comprehensive urban resilience plans is Ljubljana, a European Green Capital (Slätmo et al., 2019). In contrast, Skopje lacks flood-adaptive design and systematic riverside greening, leaving peri-urban areas vulnerable.

Fragmented Green Spaces and Missing Connections

Skopje's green covering is fragmented, particularly in peri-urban regions where industrial zones, informal settlements, and agricultural landform disjointed ecological patches, according to Andonova et al. (2023). This fragmentation could be the cause of reducing the multipurpose advantages of GI and restricting biodiversity. The results of Bogdanova Ajceva, Brajanoska, and Jovanovska (2022), who point out that Skopje is located inside the Balkan Green Belt but has poor ecological connection and inadequate GI integration into strategic planning, are in line with this diagnosis.

Using i-Tree Eco, Siedlarczyk et al. (2019) demonstrated how mapping ecological services might direct more strategic GI connections in their Kraków research. Skopje's planning structure still mostly lacks such methods.

Governance and Delivery Problems

Weak governance appears as a structural obstacle across the literature. As stated by Herman & Drozda (2021), post-socialist cities often struggle with institutional fragmentation, outdated planning tools, and different groups that want conflicting types of development. These are evident in Skopje as well, where the evidence clearly shows that the

green spaces are not prioritised enough, the coordination process is not proper, and policies tend to prioritise grey over green infrastructures, especially when it comes to land use and heating (Andonova et al., 2023). Similarly, Bogdanova Ajceva et al. (2022) emphasise that although there are national-level initiatives on GI connectivity, they are not effectively implemented at the local level, thereby furthering governance fragmentation.

This implies that just as crucial as the technical GI designs is organising capacity, which includes defined roles, standards, and budgets (Chatzimentor et al., 2020; Herman & Drozda, 2021).

Table 1.

Key environmental challenges in Skopje, corresponding GI strategies, and transferable European cases

Environmental Challenge	GI Potential	Evidence from Skopje	Reference European Example
Air pollution (PM10, heating, transport)	Vegetated corridors, urban forests	Skopje exceeds EU PM10 limits; transport and solid-fuel heating are major sources (Andonova et al., 2023; Mirakovski et al., 2020)	Urban trees in the US remove ~711,000 metric tons of air pollutants annually (Nowak et al., 2006); service quantification with i-Tree Eco in Kraków (Siedlarczyk et al., 2019)

Environmental Challenge	GI Potential	Evidence from Skopje	Reference European Example
Urban Heat Island (UHI)	Tree canopy expansion, shading, cooling surfaces	Skopje shows significant intra-urban temperature differences; limited shading in dense areas (Bukovetz et al., 2022)	Shading strategies in Ljubljana's P+R facilities mitigate overheating (Fikfak et al., 2021); Milan's tree canopy reduces summer UHI intensity (Sanesi et al., 2016)
Flooding & hydrological stress	Riparian corridors, wetlands, nature-based floodplains	Weak drainage capacity and sealed surfaces exacerbate pluvial flooding (Ajceva et al., 2022)	Floodplains managed with NBS support resilience and ecosystem services (Palmer et al., 2021); ESPON GRETA (2019) highlights riparian GI as multi-scalar resilience

Environmental Challenge	GI Potential	Evidence from Skopje	Reference European Example
Fragmented peri-urban coverage	Green belts, connected ecological corridors	Disjointed ecological patches between industrial zones, agriculture, and informal settlements (Andonova et al., 2023)	ESPON GRETA (2019) emphasizes GI networks and functional connectivity across regions; Balkan Green Belt connects transboundary habitats (Bogdanova Ajceva et al., 2022)
Governance & policy gaps	Binding standards, budgets, participatory planning	GI referenced in national strategies but weakly embedded in urban practice (Bogdanova Ajceva et al., 2022)	Delivery depends on clear institutional roles, dedicated financing, and technical guidelines (Chatzimentor et al., 2020; Slätmo et al., 2019)

Overall Findings

The two most urgent problems in Skopje are air and heat; as industry and heating are the main sources of pollution, GI needs to be employed in tandem with emission control. (Slätmo et al., 2019; Mirakovski et al., 2020; Andonova et al., 2023; M. M. et al., 2023).

Trees/canopies and surrounding green areas have the highest GI value in Skopje's hot and dirty districts. (Bukovetz et al., 2022; Sanesi et al., 2017).

Standards and connectivity are crucial. Use a service-mapping approach and adopt clear local design criteria based on European best practices, like Kraków's i-Tree Eco. (Slätmo et al., 2019; Siedlarczyk et al., 2019; Chatzimentor et al., 2020).

The main limitation would be the governance; the GI organisation (roles, budgets, and rules) is essential and of utmost importance. (Andonova et al., 2023; Herman & Drozda, 2021; Chatzimentor et al., 2020).

Discussion

Green Infrastructure as a Multi-Functional Urban Strategy

The results from Skopje clearly show that GI, beyond visual appeal and recreational benefits, can be used as a multipurpose urban tool. International policy frameworks like EPSON GRETA (2019) emphasize how GI improves ecological services, biodiversity, and territorial cohesion. And because of this, it is very important for cross-sectoral planning across different sectors. In the city of Ljubljana, GI is already well integrated and included in the planning; however, the case with Skopje is quite different, demonstrating a gap between what policies prescribe and what happens in practice.

Air Quality: Limits of GI Without Structural Change

Based on the findings, vegetated lanes or streets may provide a limited reduction in the pollutant emissions, but coal and wood heating, and industrial activity still remain as the primary causes of Skopje's air pollution. This also aligns with the findings of Nowak et al. (2006), who clearly show that urban trees and shrubs may help in removing amounts of air pollutants, but their effectiveness depends on the pollution levels, which species are planted, and how well they are maintained. Simply, it is not possible to lower PM₁₀ levels in Skopje below EU standards without changing or improving heating habits.

Urban Heat Island Mitigation: Transferable Lessons

Sanesi et al. (2016) demonstrate a transferable instance from Milan, whereas Bukovetz et al. (2022) validate the cooling potential of GI in Skopje. When combined, the results indicate that canopy increase in high-exposure neighborhoods might greatly reduce the UHI problem in Skopje. This is consistent with larger European research showing that urban vegetation lowers surface temperatures by a few degrees, reducing the risks of heat-related health risks. However, Skopje still has a few obstacles. The absence of standards, maintenance schedules, and the lack of funding needed for tree-planting efforts still remain as a governance issue.

Flooding and Water Regulation

Skopje is still not well equipped to handle the periodic flooding that occurs. Wetlands and riparian buffers can improve resilience and restore biological connections (Jakubínský et al., 2021). A good example is Ljubljana, where river corridors are incorporated into GI frameworks for the entire city (Slätmo et al., 2019). In contrast, Skopje lacks adaptive drainage design and systematic riverfront greening, making peri-urban regions susceptible.

Flooding and Water Regulation

The findings of Bogdanova Ajceva et al. (2022) and Andonova et al. (2023) verify that Skopje has fragmented green areas, which reduce multifunctionality and limit biodiversity. ESPON GRETA (2019) emphasizes that connection is a fundamental requirement for GI efficacy. Strategic corridors may be identified via mapping ecosystem services, as demonstrated by Kraków's i-Tree Eco experience (Siedlarczyk et al., 2019). Skopje has not yet adopted this strategy. Therefore, the problem is not the lack of green space, but rather a lack of strategically designed, interconnected, and multipurpose GI.

Governance as Barrier

As previously shown in the Results section, the binding component is governance, not technical design. Herman and Drozda (2021) generalize these post-socialist cities: weak institutions, fragmented responsibilities, and outdated planning tools. This is relevant to Skopje, because land-use decisions rarely ever give GI priority. According to Chatzimentor et al. (2020), responsibilities, standards, and

funding are required for GI delivery, but local implementation lags far behind. ESPON GRETA (2019) emphasises that efficient GI governance requires “mainstreaming across sectoral policies,” which is lacking in Skopje.

Implications for Policy and Practice

The first step is to incorporate technical solutions (such as riparian buffers, vegetated corridors, and tree planting) into multi-scalar governance structures. Secondly, in order to prioritise GI corridors, Skopje must also use service-mapping technologies and modify Kraków’s i-Tree Eco. Third, in accordance with ESPON GRETA (2019), Skopje ought to present GI as a territorial development plan that connects social inclusion, climate adaptation, and biodiversity rather than as a side project. Individual treatments will continue to be fragmented in the absence of this synergy.

Conclusion

This study has looked at how green infrastructure (GI) may address one of the most important governance and environmental issues facing Skopje. The evidence indicates that although GI provides important co-benefits, such as stormwater management, air purification, urban cooling, and biodiversity connectivity, its potential is still limited by fragmented governance, outdated planning techniques, and the weak institutionalization of ecological values in urban development. According to these results, Skopje belongs to the larger category of post-socialist cities where governance changes prevent the systematic implementation of GI, and ecological planning traditions are still weak.

In Skopje, air pollution continues to be the most pressing environmental problem. Research indicates that the city's PM₁₀ and CO₂ levels are mainly caused by industrial activity and domestic heating, rather than transportation emissions (Andonova et al., 2023; Mirakovski et al., 2020; M. M. et al., 2023). Although GI, such as vegetated corridors or roadside planting, can offer localised pollution interception, their contributions to overall emissions are still minimal. This is in line with Nowak et al. (2006), who discovered that, in comparison to total volumes, urban trees and shrubs in American cities eliminated quantifiable but very small quantities of air pollution. Therefore, in Skopje, GI can supplement emission reductions by offering ecological connectedness, shade, and cooling, but it cannot replace them.

The second most serious problem is the consequences of urban heat islands (UHI). According to remote sensing analyses, Skopje's vegetated areas are up to 7.9 °C cooler than those without (Bukovetz et al., 2022). Targeted canopy expansion has decreased localised heat island intensity globally, such as in Milan (Sanesi et al., 2016). These results collectively imply that expanding canopy cover in Skopje's crowded and exposed neighbourhoods might greatly lower health hazards and thermal discomfort.

Flood resilience appears as a hidden yet underappreciated concern. However, Skopje is less flood-prone than other European cities; significant precipitation and inadequate drainage cause localised floods. According to Jakubínský et al. (2021), natural floodplains offer both water regulation and ecosystem services. Similarly, Chatzimentor et al. (2020)

emphasize that multifunctional GI, such as wetlands and river corridors, provide both flood control and biological connection. Slätmo et al. (2019) discuss how certain European nations have adopted the GI strategy by establishing robust and coherent ecological networks, whilst others employ it more broadly to achieve land-use planning objectives. This conceptual understanding emphasises that GI requires both biodiversity connection and spatial integration—areas in which Skopje presently falls short.

Another problem is that the green areas are fragmented. In Skopje's peri-urban areas, these exist in separate, disconnected patches that are spread between industrial areas, informal settlements, and agriculture (Andonova et al., 2023). On the other hand, the city of Krakow has used the i-Tree Eco model in the connectivity planning and quantifying services (Siedlarczyk et al., 2019). As emphasised in EPSON GRETA (2019), the importance of understanding GI as a network, and that functional connectivity improves ecosystem service delivery at various scales. Skopje may continue to achieve only limited GI benefits if such thorough measures are not taken into consideration.

Also, another obstacle that remains is the governance capability. Although North Macedonia had adopted the use of the word GI and recognised it in national policy documents, regulations, and financial sources, funding is still missing. While GI and the Balkan Green Belt are positioned as a strategic priority, their implementation into spatial and urban planning is not consistent enough and not adequate, according to Bogdanova Ajceva et al. (2022). For efficient implementation of GI, resources, concise technical documentation, and coordination among institutions are

of utmost importance. Because without addressing these issues, even well-organized GI initiatives in Skopje may result in becoming uneven and underfunded (Chatzimentor et al., 2020).

In conclusion, the need for integrating GI as a strategy in the city of Skopje is obvious: emission reduction may help in improving air quality, canopy expansion may help in decreasing urban heat islands, riparian corridors help with improving flood resistance, and ecological connectivity helps in increasing biodiversity. The European policy synthesis, such as EPSON GRETA (2019), underlines that GI functions best as a connected network that delivers many ecosystem services at once. National frameworks (Bogdanova Ajceva et al., 2022) are also good starting points; nevertheless, the most pressing need is to incorporate these models into enforceable planning and governance structures tailored to Skopje.

Limitations and Future Research

This study has significant limitations. First, the study is mostly based on literature and does not yet include primary spatial or ecological data collection in Skopje (e.g., remote sensing, biodiversity field surveys, citizen science records). As a result, the conclusions rely on secondary sources and comparable European examples.

Second, the pollution analysis is focused on PM_{10} , which was reliably observed across all monitoring stations in 2024. Other pollutants (e.g., $PM_{2.5}$, NO_2 , ozone) may be useful in evaluating GI's mitigation potential; however, the datasets were inadequate and hence excluded.

Third, the study focused on broad-scale GI functions (air quality, UHI mitigation, flood control, and connectivity) but did not simulate individual interventions at the neighborhood level. As EPSON GRETA (2019) points out, the effectiveness of GI is significantly related to the spatial layout and size, which required more GIS modelling than was possible here.

Finally, the governance study was based on public records and secondary policy assessments (Bogdanova Ajceva et al., 2022), with no interviews or participatory approaches used to assess implementation issues. This narrows the focus to a formal paper rather than actual governing processes.

Future research should be focused on these limitations. First, spatial analyses are needed, such as applying i-Tree Eco (Nowak et al., 2006; Siedlarczyk et al., 2019) to estimate Skopje's tree cover benefits and deficits. Second, flood resilience research should incorporate modelling of riparian corridors, as well as evaluating nature-based remedies in accordance with Palmer et al. (2021). Third, governance-oriented research should look at how local governments and communities may collaborate to develop GI while learning from European best practices (Slätmo et al., 2019; ESPON GRETA, 2019). Fourth, micro-scale experiments should be explored. For example, Fikfak et al. (2021) show how vegetation models in Ljubljana's parking lots lowered overheating, which is a transferable strategy for Skopje's congested and exposed built environments. Finally, comparative Balkan studies could provide insights into how transboundary projects, such as the Balkan Green Belt (Bogdanova Ajceva et al., 2022), link urban and regional GI approaches.

References

- Adonova, V., Mihajlov, A., Jovanovska, D., & Kocarev, L. (2023). Air pollution in Skopje: Sources, trends and policy challenges. *Environmental Science and Policy*, *145*, 47–58. <https://doi.org/10.1016/j.envsci.2023.01.009>
- Andonova, V., Taseska, V., & Tashkovski, I. (2023). Urban environmental challenges in Skopje: Policy and governance constraints for sustainable transitions. *Sustainability*, *15*(12), 9338. <https://doi.org/10.3390/su15129338>
- Bogdanova Ajceva, S., Brajanoska, R., & Jovanovska, D. (2022). *Green infrastructure and spatial planning in the Republic of North Macedonia: Improving connectivity on the Balkan Green Belt* [Project report]. Macedonian Ecological Society (MES) & EuroNatur.
- Bukovetz, J., Petreski, L., & Nikolova, E. (2022). Urban heat island effects in Skopje: Satellite-based assessment of vegetation and surface temperature. *Remote Sensing*, *14*(6), 1432. <https://doi.org/10.3390/rs14061432>
- Chatzimentor, A., Theodoridou, I., & Karteris, M. (2020). Nature-based solutions and multifunctional green infrastructure: A framework for urban flood resilience. *Journal of Environmental Management*, *260*, 110160. <https://doi.org/10.1016/j.jenvman.2020.110160>
- ESPON (GRETA). (2019). *Green infrastructure: Enhancing biodiversity and ecosystem services for territorial development*. ESPON policy brief. <https://www.espon.eu/greta>
- Fikfak, A., Lavtižar, K., Grom, J. P., Kosanović, S., & Zbašnik-Senegačnik, M. (2021). Study of urban greenery models to prevent overheating of parked vehicles in P + R facilities in Ljubljana, Slovenia. *Sustainability*, *13*(17), 9686. doi:10.3390/su12125160
- Herman, G., & Drozda, Ł. (2021). Green infrastructure in post-socialist cities: Planning legacies and governance challenges. *Urban Planning*, *6*(3), 221–233. <https://doi.org/10.17645/up.v6i3.4171>
- Mirakovski, D., Tanevski, B., & Kocov, A. (2020). Residential heating and industrial emissions as major contributors to winter air pollution in Skopje. *Atmospheric Pollution Research*, *11*(8), 1365–1375. <https://doi.org/10.1016/j.apr.2020.05.015>

- M. M., Stafilov, T., & Šajin, R. (2023). Spatial distribution of CO₂ and particulate matter emissions in Skopje: Modelling industrial and residential sources. *Air Quality, Atmosphere & Health*, 16(5), 553–567. <https://doi.org/10.1007/s11869-023-01367-5>
- Nowak, D. J., Crane, D. E., & Stevens, J. C. (2006). Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry & Urban Greening*, 4(3–4), 115–123. <https://doi.org/10.1016/j.ufug.2006.01.007>
- Palmer, M., Ruhi, A., & Tran, L. (2021). Managing floodplains using nature-based solutions to support flood resilience. *WIREs Water*, 8(1), e1490. <https://doi.org/10.1002/wat2.1490>
- Sanesi, G., Colangelo, G., Laforteza, R., Calvo, E., & Davies, C. (2017). Urban green infrastructure and climate change: Perceptions and practices of municipal leaders in Europe. *Urban Forestry & Urban Greening*, 21, 1–10. <https://doi.org/10.1016/j.ufug.2016.11.006>
- Siedlarczyk, M., Pietrzyk-Kaszyńska, A., & Kronenberg, J. (2019). Mapping and assessing urban ecosystem services with i-Tree Eco: Lessons from Kraków, Poland. *Urban Ecosystems*, 22, 915–928. <https://doi.org/10.1007/s11252-019-00869-9>
- Slätmo, E., Nilsson, K., & Turunen, E. (2019). *Green infrastructure: A European perspective on land use and policy*. In ESPON GRETA Project Final Report. ESPON. <https://www.espon.eu/greta>

The Sustainability of the Urban Renewal After Earthquake Disasters: Comparison of the Experiences of North Macedonia and Türkiye

Kefajet Edip

International Balkan University, Skopje, North Macedonia

ORCID: 0009-0003-4241-9897

Abstract

The urban planning in earthquake-prone regions faces the challenge of seismic risk. The level of seismic risk depends on the intensity of the earthquake and the vulnerability of the exposed entities. At the same time, urban planning in high-density regions is pressured by urbanization. Although for urban development the main factors are the social and economic aspects, the Sustainable Development Goals require human settlements to be disaster-resilient. Urban renewal as a tool is used after an earthquake disaster to plan and build a more sustainable and resilient urban environment.

In this research, a comparison is made between the urban renewal experiences in two countries developed in seismic regions, North Macedonia and Türkiye. The 1963 Skopje

earthquake has left its mark on the urban development of the city, where countries from around the world contributed to its renewal. In Türkiye, urban renewal was introduced as a seismic risk mitigation tool after the 1999 Marmara earthquakes.

The sustainability of urban renewal is analyzed by comparing the experiences of North Macedonia and Türkiye. In North Macedonia, the urban renewal after the 1963 Skopje earthquake is the most relevant example and case study analyzed for this research. While in Türkiye, the most recent Kahramanmaras earthquakes in 2023 and the renewal of the region are taken as a case study.

In both countries, urban planners take into consideration the seismic hazard. However, to build disaster-resilient urban environments, the urban planners and the decision-making authorities should take into consideration the results of seismic risk assessment. Urban renewal should be supported by seismic risk assessment to create sustainable and resilient urban environments.

Keywords: urban renewal, seismic risk, sustainable urban planning, Skopje earthquake, Kahramanmaras earthquake

Introduction

On one hand, urban planning is required to meet the principles of sustainable development and provide higher quality of living conditions in human settlements. On the other hand, especially in developing countries, urban planning is pressured by rapid urbanization due to the high density of the population (United Nations, 2019). The

11th goal of Sustainable Development Goals (United Nations, 2015) aims to make urban environments safe and resilient. Urban planning in regions that are prone to natural hazards, such as earthquakes, floods, and landslides, is faced with the challenge of natural disaster risks (United Nations, 2015a).

The disaster risk should be addressed with appropriate disaster risk reduction measures. Mainly, there are structural measures that are related to engineering fields and non-structural measures that are used to mitigate disaster risks. Urban and land-use planning have been recognized as non-structural risk mitigation tools (Menoni, 2020).

This study focuses on the sustainability of urban renewal after the earthquake disasters. Two case studies of urban renewal following earthquake disasters are analyzed. The first case study is the 1963 Skopje earthquake (Mw 6.1), which is considered one of the biggest natural catastrophes in the modern history of Skopje and North Macedonia (Milutinovic et al., 2017). The second case study is the Kahramanmaras earthquakes in Türkiye, with Mw 7.8 and Mw 7.5, which affected 11 provinces in Türkiye as well as parts of Syria in 2023. The disaster triggered by the Kahramanmaras earthquake sequences is considered one of the five most devastating disasters in the current century in the world (Galasso & Opabola, 2024).

The case studies are at different scales, in terms of the size of affected regions and intensity of earthquakes; they belong to different countries with different land-use governing systems and mechanisms for coping with disasters. The common aspect between the case studies is that they both belong to earthquake-prone regions. Lessons learned after

a disaster can contribute to building more resilient cities and regions. In seismic regions, urban planning should be supported by seismic risk assessment studies (Bahrainy & Bakhtiar, 2022). Measures for prevention and mitigation defined based on seismic risk assessment results can be more efficient, thus leading to the development of an urban environment that is more resilient to earthquake disasters. Namely, in the first place, it is crucial to increase awareness about seismic risks among urban planners, decision-making authorities, and the broader public (Edip, 2023).

Literature Review

Earthquakes as natural phenomena pose a great challenge to urban developments. Design and construction of buildings according to up-to-date seismic design codes are the main structural measures for mitigating seismic risk. Having buildings belonging to different periods, built before the formulation of seismic design codes, and non-engineered buildings constructed without any reference to seismic forces make the urban environments more vulnerable to seismic risk (Edip & Apostolska, 2022).

In the Sendai Framework for Disaster Risk Reduction (United Nations, 2015a), disaster risk is defined as the result of a combination of hazard, exposure, and vulnerability (Simmons et al., 2017). The focus of this study is the earthquake risk, where the natural phenomenon of earthquakes is the hazard component. People, buildings, and infrastructure in the urban environment exposed to an earthquake make up the exposure component, while vulnerability defines the

characteristics of the exposed entities with regard to how much damage and losses may occur depending on the intensity of the seismic hazard (Silva et al., 2017). Resilience is another term closely related to risks and can be described as the capacity to get back to the initial state of functioning as before the disaster (Menoni, 2020).

The disaster risk reduction management as a process consists of four phases, and they are: prevention, mitigation and preparedness, response, and recovery. Prevention, mitigation and preparedness are the activities that should take place before a disaster happens, while response and recovery take place after the disaster. Special attention should be paid to the prevention and mitigation phase, which is crucial for achieving disaster resilience. To have success in the prevention and mitigation of risks, the potential risks should be understood and assessed comprehensively. The response phase follows right after the disaster. To make the right decisions, the response phase should be supported by relevant and reliable information provided on time (Bower et al., 2017).

In the recovery phase, the aim should be to “Build Back Better” (United Nations, 2015a). Achieving resilient urban environments is possible only through an interdisciplinary approach to the problem of natural hazards (Menoni, 2020). Urban planning as a non-structural risk mitigation tool can immensely contribute to the creation of seismic disaster-resilient built environments (Bahrainy & Bakhtiar, 2022). Carefully choosing the location of new urban development, infrastructure, and network, based on data from other scientific studies such as geology, seismic microzoning,

zoning, defining the right standards for urban development and renewal, are some of the urban planning tools that Menoni (2020) suggests can be used for mitigating natural disaster risks.

Methodology

The study is based on qualitative methodology. The most relevant documents and scholarly articles were analyzed to obtain information about the urban renewal experiences after the earthquake disasters. For the case study of the Skopje 1963 earthquake, the book titled “Skopje Resurgent”, published by the United Nations in 1970, served as the main source of information, as additional resources were scholarly articles in the fields of urban planning and earthquake engineering. Information and data about the Kahramanmaras earthquakes and urban regeneration phase were obtained from the 2025 report of the Presidency for Strategy and Budget of Türkiye, titled “Kahramanmaraş ve Hatay Depremleri Yeniden İmar ve Gelişme Raporu” (Kahramanmaras and Hatay Earthquakes New Urban and Development Report). There are plenty of scientific papers in the field of earthquake engineering dealing with the topic of Kahramanmaras earthquakes. Also, scientific papers written by architects and urban planners served as helpful resources for this study.

Findings

The Balkan region and the territory of North Macedonia belong to a seismically active region where moderate

intensity earthquakes are frequent. The most recent studies show that in North Macedonia, there are 11 representative fault lines. Six of these fault lines are active, which means they can generate earthquakes with intensity greater than Mw 5.5, considered as destructive earthquakes (Neziri et al., 2025). In 1963, Skopje was struck by an earthquake with Mw 6.1, which had devastating consequences for the city (Milutinovic et al., 2017). There have been other earthquakes, among which were the series of earthquakes that happened in September and October 2016 in Skopje. The modern time buildings, constructed after 1963, responded well, and there was no serious damage to the structures observed (IZIIS, 2016).

In Türkiye, there are two main fault lines, the North Anatolian fault and the East Anatolian fault. In the 20th century, there have been more than 100 earthquakes with intensity higher than magnitude 5. Before the Kahramanmaras 2023 earthquakes, the most significant earthquake in the modern history of the country was the 1999 Kocaeli earthquake, with a magnitude of 7.4, in which 17.000 people lost their lives. Another high-intensity earthquake happened in 2011 in Van with a magnitude of 7.2 (Zhang et al., 2021). On February 6th, 2023, the Kahramanmaras earthquakes (Mw 7.8 and Mw 7.5) affected a large region of Türkiye and parts of Syria, resulting in approximately 60.000 fatalities (Galasso & Opabola, 2024). The recovery process is still going on in the region affected by the Kahramanmaras earthquakes (TCCSBB, 2025).

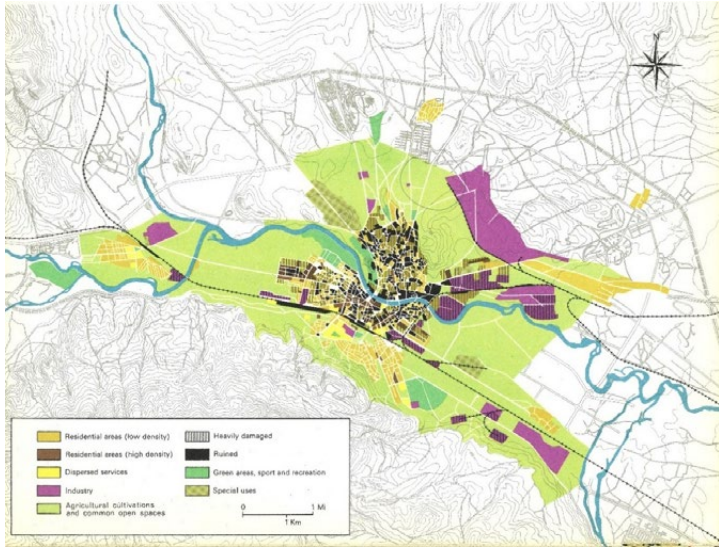
Case Study 1: The Urban Renewal of Skopje After the 1963 Earthquake

In Skopje, the most significant earthquake was the 1963 earthquake with a magnitude of 6.1. In 1963, Skopje was the capital city of the Former Yugoslav Republic of Macedonia. The population before the earthquake was 171.000 (United Nations, 1970). In the aftermath of the earthquake, 1.070 people lost their lives, 3.300 people were injured (Milutinovic et al., 2017), and 150.000 people were left homeless (United Nations, 1970).

Many buildings collapsed right after the earthquake, and many others that were heavily damaged were demolished afterwards. The devastating results of the earthquake were related to limited knowledge about earthquakes, insufficient application of the existing earthquake resistance requirements, poor construction of the buildings, and the technical regulatory framework (Milutinovic et al., 2017). Figure 1 shows the map of Skopje in July 1963, with areas that were damaged and ruined, together with the land-use typology of the city.

Figure 1.

26 July 1963, Damaged areas and land-use typology of Skopje (United Nations, 1970)



As an immediate response to the disaster, the Yugoslav Army was engaged in supplying help to the survivors of the earthquake. City parks served as a place to set up tents with an accommodation capacity of 25,000 people. The initial help arrived from other Yugoslav republics and very soon was enhanced with the help of countries from all over the world. In total, 77 countries provided their help to earthquake survivors in Skopje through monetary as well as other material help (United Nations, 1970).

Due to the big number of damaged and collapsed buildings, accommodation of homeless people was the most important priority. The Federal Executive Council of Yugoslavia decided

to temporarily place 70.000 people in prefabricated barracks and another 50.000 people in repaired buildings. The USSR (Union of Soviet Socialist Republics) donated to the City of Skopje a factory for the production of reinforced concrete elements. The factory was established in the municipality of Karposh and was named after the municipality. The fast production of the elements helped immensely in speeding up the process of building new buildings after the earthquake (United Nations, 1970).

Because of the seismicity of the region, the possible dislocation of Skopje was raised as a question immediately after the earthquake. A commission consisting of earthquake engineering experts from six universities in Yugoslavia conducted studies to decide on the future development of the city. The buildings in Skopje suffered in the earthquake because they were not designed and built to withstand the seismic forces. Also, the quality of construction work and materials used played a significant role in the earthquake response of the buildings. Based on these findings, experts decided that Skopje can continue its growth in the same area with regard to seismic maps (United Nations, 1970).

The Government of Yugoslavia undertook several steps to secure better development of the country after this disaster. Three sets of measures were undertaken for the reduction of seismic risk. The first set of measures was related to regional and urban planning, where seismic zoning and microzoning were required to be implemented in the planning at different levels of urban plans, such as national, regional, sub-regional, city, and land development planning. The second set of measures consisted of engineering measures, such

as the provision of technical regulations for design and building in seismic regions. The first seismic design code was introduced in 1964 (National Provisional Technical Regulations for Construction in Seismic Regions) (Official Gazette of SFRY, nr. 39/64), and the modern seismic design code was adopted in 1981 (Technical Regulations for Building Construction in Seismic Regions) (Official Gazette of SFRY, nr. 31/81). Emergency and disaster management regulations and solidarity funds were established as the third set of measures. All these activities undertaken by the Yugoslav Government were recognized by the United Nations 21 Rio Agenda as significant sustainable development principles (Milutinovic et al., 2017). Two years after the earthquake, the Institute of Earthquake Engineering and Engineering Seismology was founded as part of the Ss. Cyril and Methodius University in Skopje (United Nations, 1970).

The reconstruction of Skopje was processed with short-term and long-term plans. Prior to the earthquake, Skopje had a city plan prepared by the Institute of Town Planning and Architecture (ITPA) and approved by the City Council. However, a new urban plan was required for the reconstruction period. Two months after the earthquake, the Committee for the Reconstruction and Development of Skopje was established by the City Council (United Nations, 1970).

The ITPA started the initial draft town plans for the reconstruction phase while taking into consideration the seismic sensitivity maps. As part of the United Nations program, Skopje ITPA was supported by an international team of urban planning experts. The short-term

reconstruction plan for the period 1965 to 1971 was prepared in collaboration with Skopje ITPA and Doxiadis Associates, urban planning consultants from Greece. The Director General of Reconstruction and Development was Kole Jordanovski, and the international planning coordinator was George Nez. The plan estimated a residential capacity for approximately 800.000 to 900.000 citizens in the city. According to this reconstruction plan, the target was 1971 to provide accommodation for 270.000 people by building new buildings and repairing the existing ones. It should be noted that the old town part of the city couldn't be repaired or rebuilt in such a short period, and its residents would continue residing in a different area of Skopje (United Nations, 1970).

The long-term plan for the reconstruction of Skopje was the definitive plan, also called the master plan. For the realization of the definitive urban plan, the United Nations initiated the Special Fund for Skopje's Urban Plan Project in 1964, which had a total cost of 1.529.900 US dollars. The project was coordinated by the Polish architect Adolf Ciborowski together with the local authorities, while the team consisted of Skopje ITPA in collaboration with Doxiadis Associates from Greece, Polservice from Poland, and Wilbur Smith and Associates from the USA (United Nations, 1970).

For the conceptual layout plan of the city center, the United Nations organized a competition. Eight teams of architects, local and international, were invited to prepare ideas for the reconstruction of the city center. Among the international teams were Studio Scimemi led by Luigi Piccinato from Italy, Maurice Rotival from the USA, Kenzo Tange and associates

from Japan, and Jo van den Broek and Jaap Bakema from the Netherlands. Yugoslav teams consisted of Radovan Miscevic and Fedor Wrenzler from Croatia, Edvard Ravnikar and associates from Slovenia, Aleksandar Dordevic from Serbia, and Slavko Brezovski and associates from Skopje (Stefanovska & Kozelj, 2012). The conceptual layout plan of the city center was won by Kenzo Tange associates and the Croatian architects Miscevic and Wenzler (United Nations, 1970; Stefanovska & Kozelj, 2012).

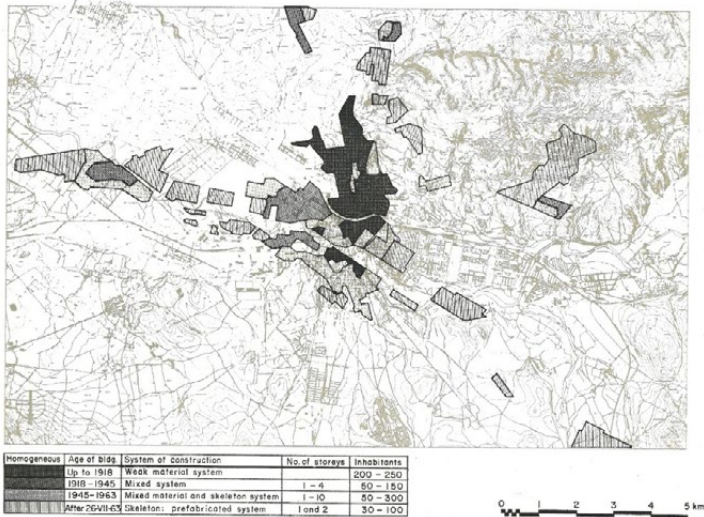
For selected buildings within the conceptual layout of the city center, the 3-D concepts were prepared by Makedonija Proekt, an architectural company from Skopje, and ITPA. The completed Skopje Urban Plan Project was presented to the public in October 1965 as an exhibition, which was also visited by the Yugoslavian president, Marshal Josip Broz Tito. The Master Plan (definitive urban plan) of Skopje was adopted by the City Council of Skopje on 16th of November 1965. In the preparation phase of the Master Plan, many studies and surveys were conducted, among which significant importance was paid to the seismicity of the region (United Nations, 1970).

In Figure 2, the map of Skopje from 1965 shows the distribution of the residential areas according to year of building, construction system, number of floors, and residents, as well as prefabricated residential settlements constructed after the 1963 earthquake.

Figure 2.

The 1965 map of Skopje shows the residential areas according to year of building, construction system, number of stories, and inhabitants (United Nations, 1970)

FIGURE III Distribution in homogeneous residential areas — 1965



Today, Skopje, the capital city of North Macedonia, based on the last census information, has a population of 526.502 residents (Makstat, 2025). For the urban planning of the city, a General Urban Plan (GUP) with a plan period of 10 years is prepared. At the municipality level, Detailed Urban Plans are prepared, and they have a plan period of 5 years (Official Gazette nr 32/2020). Urban planning law (Official Gazette No. 32/2020) requires the plans to take into consideration the natural hazards, among which is earthquake. The GUP of Skopje for the plan period of 2012-2022 (SPA, 2011) contains seismic hazard maps showing

different intensities of earthquakes relevant to the territory of Skopje (Edip, 2023).

As a structural measure for mitigation of seismic risk, seismic design codes must be applied in the phase of design as well as construction of the buildings. Since 2020, the European standards for design of structures (Eurocodes) have been adopted and are applied starting from 2023 (Official Gazette No. 211/2020). Another measure applied for seismic risk mitigation is the requirement of a report about the level of mechanical resistance, stability, and seismic safety of the buildings in the design phase and after being completed. This measure was adopted with the building law in 2013 (Official Gazette No. 163/2013), and every building with a surface area greater than 300 m² must obtain a positive report, while the report should be prepared by a scientific institution with a scope of study in the field of seismic safety of buildings. In the process of obtaining a building permit, providing a positive report for the design of the building is mandatory (Official Gazette No. 163/2013).

Case Study 2: The Urban Renewal After the 2023 Kahramanmaras Earthquakes

On the 6th of February in 2023, Kahramanmaras was hit by two high-intensity earthquakes, the first one with Mw 7.8 and the second one with Mw 7.5 (Sakarya & Bektas, 2025). The earthquakes affected areas both in Türkiye and Syria. The reported number of fatalities in Türkiye was 50.783, and more than 7.000 people died in Syria, while millions of people were affected by this disaster (Galasso & Opabola, 2024). The earthquakes affected 11 provinces,

among which the most affected were Kahramanmaraş, Hatay, Adiyaman, Gaziantep, and Malatya. It was reported by AFAD (Disaster and Emergency Management Presidency) that 651.416 structures were heavily damaged or collapsed (Sakarya & Bektas, 2024). Buildings constructed without proper application of the seismic design codes, poorly constructed buildings, as well as older buildings built without any reference to seismic forces, were the main reasons why so many buildings collapsed (Galasso & Opabola, 2024). Liquefaction of the soil was an additional problem in some territories (Varolgunes, 2025).

In the first days after the disaster in Kahramanmaraş and the neighbouring provinces, parallel to rescue activities, temporary accommodation was provided for a total of 3.6 million people, of which 2.5 million were placed in tents and the other 1.1 million in public social housing, hotels, and dormitories of the Turkish government Kredi Yurtlar Kurumu (Credit and Dormitories Institution). In 2025, it is reported that there is no more need for tents; however, there are still 395 container cities where the total number of residents is 650.000. The number of containers per container city differs from province to province. Currently, the greatest number of containers is in Hatay, populated by 171.054 people (TCCSBB, 2025).

Regarding the measures for mitigating seismic risk, the use of seismic design codes is the main structural measure. The first seismic design code in Türkiye was adopted in 1944. The 1998 updated version of the seismic design code is considered the first modern seismic design code (Zhang et al., 2021). The last update of the seismic design code was done in 2018 (Varolgunes, 2025).

After the Marmara earthquakes in 1999, the National Earthquake Insurance Program was introduced as a policy for recovering after earthquakes. The residential buildings and commercial uses within residential buildings that have a building permit have earthquake coverage of 30% rate by the Turkish Catastrophe Insurance Pool (TCIP). Besides TCIP, there is also earthquake insurance for homeowners (Zhang et al., 2021).

A recently introduced measure for mitigating seismic risk is urban transformation. After the Van earthquake in 2011, the Law for Regeneration of Areas Under the Risk of Disaster No. 6306 was adopted in 2012. Accordingly, the law defines three categories: buildings at risk, areas at risk, and reserved areas. Areas and buildings defined as at risk should be subjected to demolition and renewal. The territories with a lower potential of seismic hazard are considered as reserved areas, and they can be subjected to new urban development. However, the law does not define the criteria and parameters required for determining the areas and buildings at risk (Kizildere, 2024). The evaluation of the seismic stability of the existing buildings is done by local technical commissions formed by university professors and ministry employees under the control of the Ministry of Environment, Urbanization, and Climate Change (Zhang et al., 2021).

The construction and real estate sectors favored the urban transformation, but it was highly criticized by the public about the issues related to the right to property, public interest, and transparency. The updated version of the law, no. 6704, adopted in 2016, was also criticized because of

using earthquake safety as an excuse for prioritizing the real estate profiting through the redevelopment of urban areas. The rights of property of the future buildings is also problematic since the law allows public property to be transferred to private owners. In the last version of the law for urban transformation, updated after the Kahramanmaraş earthquakes in 2023, besides the new urban areas, also the existing urban areas can be defined as reserved areas and be subjected to redevelopment (Kizildere, 2024).

Before the 2023 Kahramanmaraş earthquakes, across the provinces that were affected by the earthquakes, 40 areas had been marked as areas at risk. A study conducted by Sakarya and Bektas (2025) analyzes 12 out of these 40 areas at risk before and after the earthquakes of 2023. Rebuilding new buildings in the place of old buildings, as well as transforming areas at risk into green areas, helped increase the earthquake resilience of the area. On the other hand, in some areas, although defined as at risk, no action was undertaken, resulting in damaged and collapsed buildings. It is important to note that some of the damaged areas were not defined as at risk, which points to the need to provide more precise seismic risk assessment. To achieve a comprehensive approach to seismic risk mitigation, urban regeneration should be integrated into the urban planning process (Sakarya & Bektas, 2025).

In the aftermath of the Kahramanmaraş earthquakes, there were also buildings that managed to withstand the seismic forces and continued functioning. The reinforced concrete buildings constructed with tunnel-form, built by

TOKI (Housing Development Administration of the Republic of Türkiye), were not damaged (Galasso & Opabola, 2024).

Hospital buildings with seismic base isolation withstood the earthquake successfully. According to the regulations of the Ministry of Health in Türkiye, hospitals with a capacity above 100 beds must have seismic base isolation (Galasso & Opabola, 2024).

The school buildings built as seismically resistant after 2017, as a result of the partnership between the Government of Türkiye and the World Bank within the program of the Global Facility for Disaster Reduction and Recovery, were not damaged in the earthquake sequences in the Kahramanmaraş region (Galasso & Opabola, 2024).

For the recovery of the earthquake-affected region, the Ministry of Environment, Urbanization, and Climate Change has initiated 140 urban plans for a territory of 198.977 ha, which will be supported with microzoning studies. Ministry of Environment, Urbanism and Climate Change, TOKI, Emlak Konut GYO, and other stakeholders carry out the construction of the residential buildings and infrastructure under the supervision of AFAD. The newly designed residential buildings consist of 3-room units and 4-room units with an approximate gross area of 90 m² and 110 m², respectively (TCCSBB, 2025).

In-situ rebuilding is applied as well for establishing permanent accommodation for the survivors of the earthquake disaster. The Government of Türkiye provides grants and loans to the landowners to rebuild new buildings in the same place as damaged buildings. The grants and

loans cover both residential and business premises (TCCSBB, 2025).

In order to overcome the consequences of the earthquake disasters, the Development Plan for the period 2024-2028 foresees recovering the socio-economic losses, building a living environment that is resilient to disasters, and providing high-quality living conditions. The top priority of this development plan is providing accommodation in permanent buildings to the people who were left homeless in the aftermath of the earthquakes. There has been progress in providing conditions for educational and healthcare facilities. Studies were conducted for the repair or rebuilding of the damaged infrastructure networks, such as sewerage, communication, energy, and transportation, in order to get back to normal life conditions (TCCSBB, 2025).

Upon the call of the Türkiye Design Council, international and local experts have been invited to take part in the reconstruction of Hatay. The Ministry of Environment, Urbanization and Climate Change and the Ministry of Culture and Tourism support the revitalization plan initiated by the Türkiye Design Council (Archdaily, 2025). For the province of Hatay and city of Antakya, a new master plan (Figure 3) has been prepared by Foster & Partners, Buro Happold, MIC-HUB, and Turkish architecture offices, such as DB Architects and KEYM Urban Renewal Center (Archdaily, 2025a).

Figure 3.

Master plan of wider Hatay priority area by Foster & Partners. Image Courtesy of Türkiye Design Council (Archdaily, 2025a)



Discussion and Evaluation

Table 1 presents a comparison between the main facts of the case studies presented in this research paper. The intensities of the earthquakes, the sizes of the affected areas, and the number of affected people are significantly different between the case studies. However, lessons can be learned from both case studies for building more resilient and sustainable cities.

Table 1.*Comparison of facts in the case studies*

Case study	Skopje, 1963	Kahramanmaras, 2023
Number of population	171.000	14.013.196 (11 provinces)
Earthquake	Mw 6.1	Mw 7.8, Mw 7.5
Death toll	1.070 (in Skopje)	50.783 (in 11 provinces)
Affected people (left homeless)	150.000	3.6 million people
Immediate accommodation	Tents for 25.000 people	Tents for 2.5 million people + hotel, dormitory for 1 million people
Temporary shelter	Prefab. barracks for 70.000 people Repaired buildings for 50.000 people	Container cities = 395 Residents = 650.000 (in 11 provinces)
Modern seismic design code	1981	1998
Last update of seismic design code	Eurocodes (adopted in 2020, applied since 2023)	2018
Urban renewal	Master plan of Skopje - 1965	Development Plan 2024-2028

The 1963 Skopje earthquake pointed out the lack of awareness about seismic risk. Important measures were undertaken in order to mitigate the seismic risk. The first seismic design codes were introduced; seismic zoning became part of the studies for urban planning; regulations for emergency and disaster management were defined (Milutinovic et al., 2017). A new urban plan for the city of Skopje was prepared by local and international teams. The recovery phase after the disaster served to create a better city. Especially the city center of Skopje was built mainly based on the urban plan adopted in 1965. The recovery period following the earthquake was in detail documented by the United Nations (1970) in the book “Skopje Resurgent”. The 1963 earthquake left a big mark on the memory of the city and is annually remembered with events dedicated to the survival of the City of Skopje.

The 2023 Kahramanmaras earthquakes showed that there is a need to increase seismic risk awareness. The importance of applying the up-to-date seismic design codes in the design and construction phases of the buildings, using good quality construction materials and good workmanship, was one of the aspects that can be highlighted (Galasso & Opabola, 2024). Other measures for seismic risk mitigation, such as urban regeneration, should be based on a precisely conducted seismic risk assessment (Sakarya & Bektas, 2025). From an urban planning aspect, the new urban plans for Kahramanmaras and Hatay are supported with seismic microzoning studies (TCCSBB, 2025), and a new master plan for Hatay has been prepared by Foster & Partners (Archdaily, 2025a).

Conclusion

Through the review of the two case studies, the Skopje 1963 earthquake and the Kahramanmaraş 2023 earthquakes, different measures applied for the mitigation of seismic risk were analyzed. Today, there is a lot of knowledge accumulated from past earthquake events that can serve to improve the seismic safety of the urban environment. Yet, there is still a need for increasing seismic risk awareness among decision-making authorities, urban planners, and the general population. Assessment of seismic risk at the urban scale can serve to understand the existing level of seismic risk and accordingly define mitigation measures (Edip, 2023).

In the disaster risk reduction management, the prevention, mitigation, and preparedness phase can contribute the most to achieving a disaster-resilient urban environment (Bower et al., 2017). The recovery phase should serve to develop resilience in line with the concept of “Build Back Better” (United Nations, 2015a).

References

- Archdaily (2025). Accessed on 10/08/2025 https://www.archdaily.com/1009071/foster-plus-partners-and-big-selected-to-revitalize-turkiyes-hatay-province-after-the-earthquake?ad_campaign=normal-tag
- Archdaily (2025a). Accessed on 10/08/2025. <https://www.archdaily.com/1019688/foster-plus-partners-reveals-master-plan-for-the-revitalization-of-earthquake-hit-region-of-hatay-turkiye>
- Bahrainy, H., & Bakhtiar, A. (2022). The Role of Urban Design. In Bahrainy, H., & Bakhtiar, A. *Urban Design in Seismic-Prone Regions* (pp. 15-19). Cham: Springer Nature Switzerland AG 2022. <https://doi.org/10.1007/978-3-031-08321-1>.

- Bower, A., Blok, J., Dali, M., Faivre, N., Fell, T., Happaerts, S., Kavvadas, I., Kockerols, P., Molnar, A. M., Quevauviller, P., Pascal, G., & Villette, F. (2017). Current Status of Disaster Risk Management and Policy Frameworks. In Poljansek, K., Marin Ferrer, M., De Groeve, T., Clark, I. (Eds.), *Science for disaster risk management 2017: knowing better and losing less* (pp. 21-31). EUR 28034 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-60679-3, doi:10.2788/842809, JRC102482.
- Edip K. (2023). *Seismic Risk Assessment as a Basis for Sustainable Urban Development*. Doctoral dissertation, Institute of Earthquake Engineering and Engineering Seismology – IZIIS at „Ss. Cyril and Methodius University“ in Skopje, North Macedonia, 2023.
- Edip, K. & Apostolska, R. (2022). *Seismic Risk Assessment as a Basis for Sustainable Urban Development – Pilot Case Karposh District in Skopje*. 3rd European Conference on Earthquake Engineering & Seismology. Bucharest, Romania, 2022.
- Galasso, C., & Opabola, E. A. (2024). *The 2023 Kahramanmaraş Earthquake Sequence: Finding a Path to a More Resilient, Sustainable, and Equitable Society*. Communications Engineering, Nature, <https://doi.org/10.1038/s44172-024-00170-y>
- IZIIS (2016). *Report for onsite seismic safety evaluation of the buildings after the earthquake of 11.09.2016 in Skopje*. IZIIS - report 2016/32-41.
- Kizildere, D. (2024). *Earthquake Disaster-Induced Urban Policies: Paradoxes and Challenges in Turkey*. Urban Research & Practice, <https://doi.org/10.1080/17535069.2024.2422627>, Routledge, Taylor & Francis Group.
- Makstat (2025). Accessed on 23.08.2025. https://makstat.stat.gov.mk/PXWeb/pxweb/en/MakStat/MakStat__Popisi__Popis2021__NaselenieVkupno__NaseleniePopis2021__Drzavjanstvo/T1021P21.px/table/tableViewLayout2/?rxid=46ee0f64-2992-4b45-a2d9-cb4e5f7ec5ef
- Menoni, S. (2020). *Risk Mitigation and Resilience of Human Settlement*. In Balducci, A., Chiffi, D. & Curci, F. (Eds.), *Risk and Resilience* (pp. 27-45). Cham, Switzerland: Springer Nature Switzerland AG 2020. <https://doi.org/10.1007/978-3-030-56067-6>.

- Milutinovic, Z., Salic, R., & Tomic, D. (2017). An Overview on Earthquake Hazard and Seismic Risk Management Policies of Macedonia. 16th World Conference on Earthquake Engineering. Santiago, Chile: 16 WCEE 2017.
- Neziri, Z., Jovanov, L., Salic-Makreska, R., Drogreshka, K., Danciu, L., Najdovska, J., & Tomic, D. (2025). Improvements and Updates of the National Databases for Seismogenic Source Modeling in the Context of Revising the National Hazard Model for North Macedonia. Proceedings of the 3rd Croatian Conference on Earthquake Engineering – 3 Cro-CEE, 2025, Split, Croatia. DOI: <https://doi.org/10.5592/CO/3CroCEE.2025.136>.
- Official Gazette of R. N. Macedonia, no. 32/2020. Urban planning legislation.
- Official Gazette of Republic of North Macedonia, Building Law – 163/2013
- Official Gazette of the Republic of North Macedonia, no. 211/2020: Regulation for updating the Regulation for Standards and Norms for Design, Skopje, North Macedonia, 2020.
- Official Gazette of the Socialist Federal Republic of Yugoslavia (SFRY), no. 39/64: Provisional Technical Regulations for Construction in Seismic Regions, Yugoslav Institute for Standardization, Belgrade, Yugoslavia, 1964.
- Official Gazette of Socialist Federal Republic of Yugoslavia (SFRY), no. 31/81: Regulation with Technical Norms for Construction of Buildings in Seismic Regions, Yugoslav Institute for Standardization, Belgrade, Yugoslavia, 1981.
- Sakarya, A., & Bektas, Y. (2025). Urban Regeneration in Response to Natural Disasters: Insights from the 2023 Kahramanmaras Earthquakes. *Journal of Housing and Built Environment*. <https://doi.org/10.1007/s10901-025-10213-1>. Springer.
- Silva, V., Dolce, M., Danciu, L., Rossetto, T., & Weatherill, G. (2017). Geophysical risk: earthquakes. In Poljansek, K., Marin Ferrer, M., De Groeve, T., Clark, I. (Eds.), *Science for disaster risk management 2017: knowing better and losing less*. (pp. 138-150). Luxembourg: EUR 28034 EN, Publications Office of the European Union.

- Simmons, D. C., Duawe, R., Gowland, R., Gyenes, Z., King, A., Riedstra, D., & Schneiderbauer, S. (2017). Understanding disaster risk: risk assessment methodologies and examples. In Poljansek, K., Marin Ferrer, M., De Groeve, T., Clark, I. (Eds.) (2017), *Science for disaster risk management 2017: knowing better and losing less* (pp. 40-43). EUR 28034 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-60679-3, doi:10.2788/842809, JRC102482.
- Spatial Planning Agency (SPA) (2011). *General Urban Plan for City of Skopje for plan period of 2012-2022*.
- Stefanovska, J. & Kozelj, J. (2012). Urban Planning and Transitional Development Issues: The Case of Skopje, Macedonia. *Journal of Urbani izziv*, volume 23, no. 1, 2012. DOI: 10.5379/urbani-izziv-en-2012-23-01-002.
- Türkiye Cumhuriyeti Cumhurbaşkanlığı Strateji ve Bütçe Başkanlığı (TCCSBB) (2025). *Kahramanmaraş ve Hatay Depremleri Yeniden İmar ve Gelişme Raporu. Şubat 2025 Ankara, Türkiye*. [Presidency for Strategy and Budget of Presidency of Republic of Türkiye (2025). *Kahramanmaras and Hatay Earthquakes New Urban and Development Report*. February 2025, Ankara, Türkiye].
- United Nations (1970). *Skopje Resurgent, The Story of a United Nations Special Fund Town Planning Project*. New York: United Nations.
- United Nations. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development*, A/RES/70/1.
- United Nations (2015a). *Sendai Framework for Disaster Risk Reduction 2015-2030*. Geneva: United Nations Office for Disaster Risk Reduction.
- United Nations (2019). *World Urbanization Prospects 2018, Highlights*. Department of Economic and Social Affairs, Population Division. United Nations, New York, 2019.
- Varolgunes, S. (2025). A Bibliometric Analysis of the 2023 Kahramanmaras Earthquakes: Trends, Gaps, and Policy Implications. *Journal of Natural Hazards*. <https://doi.org/10.1007/s11069-025-07305-0>
- Zhang, Y., Fung, J., Johnson, K., & Sattar, S. (2021). Review of Seismic Mitigation Policies in Earthquake-Prone Countries: Lessons for Earthquake Resilience in the United States. *Journal of Earthquake Engineering*. DOI:10.1080/13632469.2021.1911889.

Analyzing Spatial Pattern of Relatively Cooler Areas to Mitigate Urban Heat Islands in İzmir

Yasemin Şentürk

Dokuz Eylül University, Institute of Natural Sciences, Department of
City and Regional Planning, İzmir, Türkiye
ORCID: 0000-0002-7158-6657

Kemal Mert Cubukcu

Dokuz Eylül University, Faculty of Architecture, Department of Urban
and Regional Planning, İzmir/Turkey
ORCID: 0000-0002-7158-6657

Abstract

Urban Heat Islands (UHIs), driven by dense built-up areas, limited green spaces, and rising atmospheric temperatures, create heat-related risks in Mediterranean cities. The UHI effect is projected to expose nearly 50% of future urban populations to significant risks. This study investigates the characteristics of relatively cooler areas (RCAs) within the urban area of İzmir, Türkiye, and evaluates the effect of urban morphology, urban thermal effects, and greenery on their size. It aims to answer two research questions: (1) How can the spatial extent of cooling effects be measured in urban areas? (2) How does the extent of cooling influence local thermal comfort? Using Land Surface Temperature (LST) data derived from Landsat OLI 8, RCAs were identified through the Anselin Local Moran's I spatial autocorrelation

method. The effects of urban morphology, green abundance, and thermal factors on the cooling extent of RCAs were analyzed using multiple linear regression models. Building patch density, mean building height, building elevation ratio, maximum tree-covered patch, and presence of parks were included in the model as independent variables. Greenery abundance has the strongest effect (48%) in explaining RCA size, followed by urban morphology (37%) and thermal factors (15%). There is a significant variation in RCA sizes (0.27–1,025.28 ha). Moreover, a negative relationship was observed between RCA size and mean LST, suggesting that larger RCAs increase the cooling effect and reduce thermal stress. These findings provide quantitative insights for climate-responsive urban planning practice. Therefore, the study highlights the importance of expanding green areas, as well as optimizing urban morphology, to enhance cooling capacity in Mediterranean cities.

Keywords: urban heat island, local climate zone, land surface temperature, urban morphology, Izmir, urban cooling

Introduction

High-density development, limited vegetation, and anthropogenic heat emissions (MetLink, Royal Meteorological Society, 2023) cause higher temperatures observed in the areas compared to rural surroundings (NASA, 2025). This event is known as the urban heat island. The Intergovernmental Panel on Climate Change (IPCC, 2022) predicts that the UHI effect will expose approximately 50% of the future urban population to serious heat risks. Similarly, it was reported by C40 Cities that 350 cities are

currently exposed to air temperatures exceeding 35°C during summer. This number will rise to 970 cities by 2050, affecting 1.6 billion people, which is equal to 45% of the world's urban population. In addition, annual temperatures in the Mediterranean region are projected to increase by 1–5°C by 2100, so the region is one of the most vulnerable regions to extreme heat events. The rising UHI effect brings about a significant disaster risk, particularly in large cities. As a result, examining spatial planning interventions to mitigate and adapt to the UHI effect has become inevitable (Keppas et al., 2021). To minimize these risks, understanding the parameters related to the UHI effect is also important in urban planning practice (Zheng et al., 2023).

Findings of previous studies show that urban morphology and the configuration of green infrastructure significantly affect the spatial distribution of UHI (Li et al., 2019; Öztürk et al., 2025; Zhou et al., 2017). Studies analyzing spatial thermal patterns generally focus on mapping hotspots and cold spots (Şenlik & Yılmaz, 2024), while urban cooling extent is rarely investigated in the literature (Yüksel & Coşkun Hepcan, 2023). In addition, a high UHI effect is measured for Mediterranean cities like İzmir, characterized by compact development and fragmented green infrastructure. This study aims to investigate how urban morphology—including building patch density, building height, vertical density, and vegetation cover—affects the spatial extent of urban cooling in İzmir. Specifically, it aims to answer the following research questions: (1) How can the spatial extent of cooling in urban areas be quantified? and (2) How does the cooling extent affect local thermal comfort? By referring to these research questions, the study tests the following hypotheses:

- Hypothesis 1: Larger relatively cooler areas (RCAs) are associated with a reduction in land surface temperatures (LST).
- Hypothesis 2: In low-density, highly permeable, and greener built environments, the cooling extent increases.

Literature Review

In the literature, the Local Climate Zone (LCZ) classification method provides a useful framework to analyze the thermal characteristics of urban zones (Abougendia et al., 2020). Numerous studies state that different LCZ types have significant variations in LST. For instance, higher LSTs are generally observed on LCZs, referring to compact high-rise or mid-rise built environments, due to low vegetation cover and extensive impervious surfaces (Quan et al., 2017). In contrast, summertime temperature differences for LCZs with dense trees or vegetation are 4–6 °C higher compared to densely built-up LCZs (Alexander & Mills, 2014). Peng et al. (2024) developed a multi-scale LCZ map and analyzed the impact of 2D and 3D morphological parameters on LST by generating different LCZ scenarios. These findings provide information on the contribution of urban morphology to thermal comfort and the important role of in mitigating the UHI effect.

In addition to surface cover, urban pattern also plays an important role in shaping local microclimates. Thus, built-up density, three-dimensional parameters, and urban geometry significantly influence air ventilation and urban heat storage (Şentürk, 2024). Parameters related to urban patterns like building height, facade length, street width, and street orientation have a strongly significant relationship with

thermal comfort (Sakar, 2018). Continuous urban blocks, for example, reduce street intersections and restrict the extent of cooling effects of adjacent parks or waterbodies (Silva et al., 2018).

Several studies further focused on the role of building configuration in enhancing ventilation in the cities. Peng et al. (2017) and Qaid et al. (2016) supposed that a high-rise and low-rise urban fabric can create dynamic ventilation corridors in urban areas and lead to improved airflow in the urban periphery. As evidence, Qaid et al. (2016) measured a 4 °C temperature difference between low-rise and high-rise residential areas, and a 3 °C difference between low-rise and suburban areas. According to these findings, high-rise residential areas with adequate spacing between buildings can provide more comfortable local thermal conditions than compact low-rise developments because of improved airflow (Peng et al., 2017; Qaid et al., 2016).

Methodology

Study Area

İzmir, located in western Türkiye, is between 37°39' N latitude and 26°28' E longitude. It is the third-largest metropolitan city in Türkiye with a population of approximately 4.49 million in 2025 (TUIK 2025), and it covers an area of 11,973 km² (Şentürk, 2024). Izmir shows Mediterranean climate conditions and has a Csa (temperate arid summer, hot summer) climate type according to the Köppen-Geiger climate classification (Öztürk et al., 2017). Mountains surrounding the city lie perpendicular to the coastline,

which allows the maritime influence to spread into the inner areas. The 42 °C recorded on 26 June 2025 was the highest air temperature in İzmir from 1930 to 2025 (General Directorate of Meteorology, 2022). High temperatures were also recorded in previous years; for example, the maximum air temperature in 2024 reached 41 °C. These records present the increasing intensity and frequency of extreme heat events in İzmir (General Directorate of Meteorology, 2022).

Data and Pre-processing

For this study, cloud-free satellite imagery was used to map land surface temperature (LST) of İzmir's built-up area for selected three summer dates—June 8, August 25, and September 10, 2020. Thermal Infrared Sensor (TIRS) of Landsat OLI 8 was supplied from the platform of the United States Geological Survey (USGS) (Şentürk, 2024). TIRS (Band 10) has a 30 m spatial resolution, which is commonly accepted to map mesoscale thermal patterns (Weng et al., 2022; Zhang et al., 2023).

In this study, LST retrieval followed a three-step procedure: (1) thermal digital numbers (DN) were converted to spectral radiance, (2) spectral radiance was transformed to top-of-atmosphere (TOA) brightness temperature, and finally, (3) TOA brightness temperature was converted to LST in Celsius (Congedo & Munafo, 2014). Subsequently, the LST map of the study area was produced by calculating the mean LST of the three selected dates. This approach reduces the influence of anomalous single-date measurements and enhances the reliability of spatial analyses (Duan et al., 2023; Ma et al., 2024; Şentürk & Cubukcu, 2023).

Before calculating the values of urban morphological parameters, contiguous building polygons were merged into building blocks using the GIS database of the Izmir Metropolitan Municipality (Şentürk, 2024). This aggregation process allowed for more accurate computation of metrics such as building patch density and building elevation ratio.

Quantitative Methods

This study applied a spatial statistical method to investigate the spatial distribution of the UHI effect based on LST data and particularly focused on delineating certain boundaries of relatively cooler areas (RCAs). All spatial analyses were performed in the ArcGIS Pro environment. At the meso-scale, clusters of relatively higher and lower temperatures within the study area were mapped using spatial autocorrelation statistics, the Anselin Local Moran's I (Anselin, 1995; Li et al., 2022; Wang et al., 2023). This spatial autocorrelation analysis allows the identification of continuous and statistically homogeneous pixel groups. Besides, its outputs are clusters of higher temperatures (high-high, H-H) and clusters of lower temperatures (low-low, L-L) relative to their neighborhoods.

Three neighborhood distances—60 m, 180 m, and 240 m—were tested in this study (Şentürk, 2024). A 60 m radius was selected as the optimal result based on the aim of the study. Because a larger radius causes the loss of detail due to more generalized spatial clusters (Şentürk & Cubukcu, 2023; Zhou et al., 2021; Zhao et al., 2024).

To measure the relationship between urban morphology and the cooling capacity of the urban area, represented by

the size of RCAs, a multiple linear regression model was developed. The model can be expressed as:

$$y=f(x_1,x_2,\dots,x_n)y = f(x_1, x_2, \dots, x_n)y=f(x_1,x_2,\dots,x_n)$$

“y” represents the size of the relatively cooler areas (RCAs) as the dependent variable, and “x” represents explanatory (independent) variables related to urban morphology, green abundance, and urban thermal conditions (Table 1). The fit model with the highest adjusted R² value and the lowest standard error of estimate was selected. In order to avoid the formation of correlation among independent variables, parameters with a variance inflation factor (VIF) less than 5 were included in the fit model. In addition, standardized regression coefficients (β values) were used to evaluate the relative contribution of each independent variable in explaining RCA size (Dormann et al., 2013; Li & Zhou, 2023). Moreover, a scatter plot was generated to analyze the relationship between RCA size and the mean LST within RCA (RCA_LST). Thus, the correlation between the cooling extent and local thermal conditions within the study area was visualized and evaluated.

Table 1.*Dependent and independent variables of the RCA Regression Model*

Type	Category	Notion	Name	Abb	Explanation	Unit
Dependent		y	Relatively cooler area	CE	It describes the area where the cooling effect of the urban area is felt. In this study, RCA is equal to Anselin Moran I L-L polygons.	Ha
Independent (Explanatory)	Urban morphology	x_1	Building patch density	BPD	It represents the degree of building fragmentation. It is calculated as the ratio of the total number of building patches within the RCA to the RCA.	n/ha
		x_2	Mean building height	MBH	It refers to the average floor number of buildings located within the RCAs.	N
		x_3	Distance between building	BD	It refers to the average nearest distances between each buildings located within RCAs.	M
		x_4	Building elevation ratio	BER	It represents the ratio of the total surface area of building blocks. It is calculated by dividing the total surface area of building blocks within RCA by the area of realted RCA.	m ² /ha
	Urban thermal effect	x_6	LST of the extent area	CE_LST	It refers to average LST values within RCAs.	°C
	Greenery abundance	x_7	Maximum tree covered area	MTR	It refers to maximum area of tree covered polygons located within RCAs.	Ha
		X_8	Abundance of urban park	P	It refers abundance of urban park within RCA. It gives 0 and 1 values.	0,1

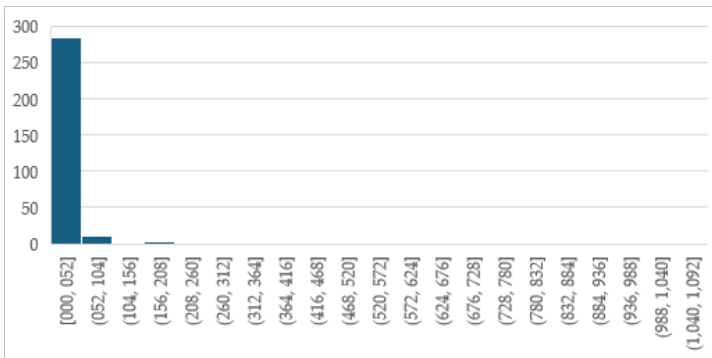
Findings

Relationship Between Urban Morphology and the Relatively Cooler Areas

The descriptive statistics in Table 2 reveal significant differences in the size of relatively cooler areas (RCAs). RCAs range between 0,27 and 1025,28 ha, with a mean of 23,08 ha and a very high standard deviation (99,47) (Figure 1, Table 2) (Şentürk, 2024).

Figure 1.

Histogram of the relatively cooler area (RCA) (ha)



According to descriptive statistics of parameters of the RCA model (Table 2), mean building height (MBH) ranges from 0 to 17 floors, with an average of 4.47 and a standard deviation of 2.76. The results of MBH show that RCAs in the research area are predominantly characterized by mid-rise buildings, but there are differences in some polygons. Building Patch Density (BPD) values have a wide range of values (Mean=11.256; SD=9.747). Mean distance between buildings (BD) exhibits a range of 0 to 320.388 m

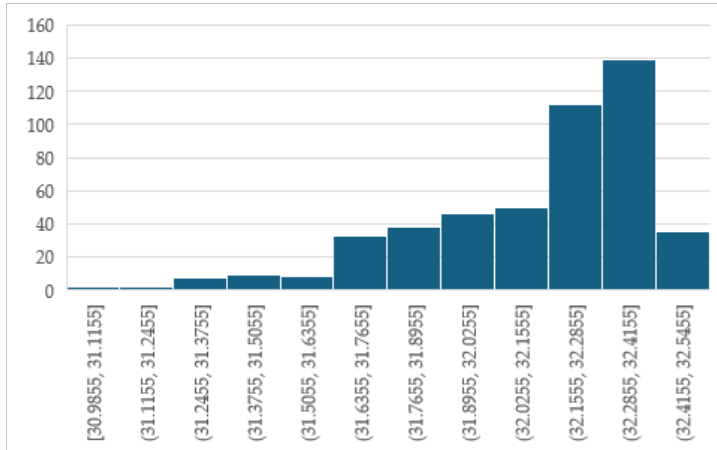
(Mean=10.670; SD=28.354). In addition, the building elevation ratio (BER) has a mean of 4.49 and a high standard deviation (8.91), with a range between 0 and 79.79. As a result, the similar distribution of BPD, BD, and BER values states that the development conditions have different characteristics across the entire RCA polygons. In other words, these high standard deviations reflect the presence of development regulations within İzmir's urban environment.

In this study, tree-covered surfaces outside park areas, such as street trees, gardens, and small green patches, were measured separately from parklands. This approach is useful to clearly investigate the role of non-park vegetation in regulating micro-climate conditions. The maximum tree-covered area (MTR) varies between 0 and 1.58 ha (Mean=0.069 ha; SD=0.18). The results show that MTR is generally low and clustered in specific areas (Table 2). In contrast, the LST of RCAs (RCA_LST) shows a much smaller range, from 30.96 to 32.54 °C (Table 2, Figure 2).

Table 2.

Descriptive statistics of parameters of the RCA model (n=292)

Descriptive Statistics				
	Minimum	Maximum	Mean	Std. Deviation
RCA	,27	1025,28	23,081	99,469
BPD	,00	55,555	11,256	9,747
MBH	,00	17,001	4,4798	2,762
BD	,00	320,388	10,670	28,354
BER	,00	79,791	4,7998	8,915
RCA_LST	30,96	32,541	32,0410	,239
MTR	,00	1,581	,0692	,184

Figure 2.*Histogram of LST of the RCAs (RCA_LST) ($^{\circ}\text{C}$)*

The regression model yields an adjusted R^2 of 0.484, indicating that around 49% of the variance in the size of RCA is explained by the selected explanatory variables. This represents a moderate level of explanatory power in examining the relationship between urban morphology and size of RCA. The Durbin–Watson statistic (1.991) indicates no significant autocorrelation in the residuals, supporting the reliability of the model. VIF values range between 1.2 and 1.9, all below the critical threshold of 5. This indicates no severe multicollinearity problems in the model.

The regression analysis highlights the role of urban morphology, urban thermal effect, and green abundance in shaping the size of RCAs. The average distance between buildings was excluded from the model, as it did not reach statistical significance at the 90% confidence level. The results of the remaining explanatory variables are as follows:

- Building patch density (BPD, $\beta = 0.147$, 95% confidence interval): This suggests that areas characterized by a higher number of smaller and more fragmented building patches tend to be associated with slightly larger cooling extents.
- Mean building height (MBH, $\beta = 0.113$, 95% confidence interval): Taller buildings show a positive relationship with the size of RCA.
- Building elevation ratio (BER, $\beta = -0.183$, 99% confidence interval): As the total surface area ratio of the building decreases, the ratio of impervious surfaces exposed to radiation decreases, which increases the cooling capacity.
- RCA_LST ($\beta = -0.178$, 99% CI): Higher land surface temperatures within RCA are strongly negatively associated with the size of RCA, as expected.
- Max tree-covered area (MTR, $\beta = 0.457$, 99% confidence interval): Tree cover exerts the strongest positive effect, significantly enhancing the cooling capacity.
- Urban park abundance (P, $\beta = 0.120$, 95% confidence interval): The presence of parks contributes to the expansion in the cooler areas.

The multiple linear regression model can be expressed as:

$$RCA = 193,480 - 0.147 \cdot BPD + 0.113 \cdot MBH - 0.183 \cdot BER - 0.178 \cdot RCA_LST + 0.457 \cdot MTR + 0.120P$$

Overall, the findings bring about a significant role of both urban morphology and greenery in shaping the size of RCAs. The model developed within the scope of the study accounts for approximately 49% of the variance in the size of RCAs.

When all explanatory variables have their maximum values, the RCA is predicted to be 187.46 ha.

Table 3.

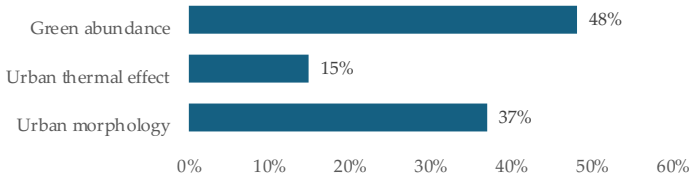
The RCA Model Estimates (n=292)

Coefficients ^a							
Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	193,480	60,394		3,293	,001		
SQ_BPD	0,344	0,136	,147	2,526	,012	,794	1,260
SQ_MBH	,641	,246	,113	2,322	,021	,634	1,577
SQ_BER	-,450	,154	-,183	-2,921	,004	,515	1,942
SQ_CE_LST	-34,253	10,679	-,178	-3,207	,001	,542	1,846
SQ_MTR	8,421	,986	,457	8,044	<,001	,646	1,547
SQ_P	,936	,382	,120	2,449	0,015	,753	1,328
Model summary: Adjusted R ² =0,484, F=38,124, Dublin-Watson=1,991							
Dependent Variable: SQ_RCA							

The results indicate that urban morphology accounts for 37% of the explained variance in cooling extent, while the urban thermal effect contributes 15%. In contrast, green abundance emerges as the most important factor, with a contribution of 48%. These findings emphasize the dominant role of greenery abundance in determining the spatial extent of cooling effects, compared to morphological and thermal characteristics of the built environment (Figure 3). However, the results also revealed that urban morphology is at least as important as the presence of greenery in spreading the cooling effect over large areas.

Figure 3.

Contribution of the parameters on the RCA model-related category

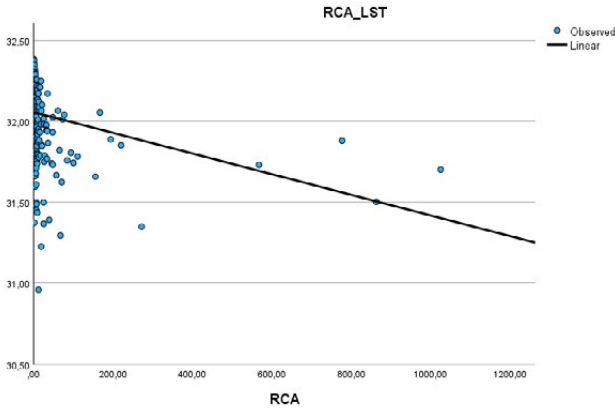


Relationship Between the Relatively Cooler Areas and Microclimate Conditions

The scatterplot illustrates a negative linear relationship between the size of RCA and the mean LST of the RCA. As the cooling extent increases, mean surface temperatures tend to decrease, indicating the mitigating urban heat island effect. However, the data distribution reveals a concentration of observations at lower intervals, with limited cases at higher ranges, which reduces the strength of the overall correlation. As a result, these results indicate that the spatial extent of relatively cooler areas is not evenly distributed (Şentürk, 2024).

Figure 4.

Scatter plot of RCA_LST ($^{\circ}C$) and size of RCA (ha)



Discussion and Evaluation

Characteristics of RCAs and Built Environment Determinants

Findings in İzmir show a very high spatial heterogeneity in the sizes of RCAs, ranging between 0.27 and 1,025.28 ha (mean = 23.08 ha; SD = 99.47 ha) (Şentürk, 2024). While most RCA polygons are small, a few extensive polygons contribute to the overall urban cooling capacity, which are generally located along the seaside. This result aligns with previous findings based on spatial autocorrelation (Li et al., 2025). Similar findings in Tehran suggest that both cluster size and contiguity significantly impact urban cooling capacity (Atri et al., 2021).

According to the analyses of İzmir's RCAs, Building Patch Density (BPD) values range from 0 to 55.56, with a mean of approximately 11.26. Entirely urban green spaces or vacant lots have a BPD value of 0. The mean value of BPD shows a similar pattern to the Local Climate Zone (LCZ) classifications of LCZ 2 (compact mid-rise) and LCZ 3 (compact low-rise), which are typically characterized by medium-density development and limited open spaces (Stewart et al., 2022).

The regression model shows a positive relation between mean building height (MBH) and RCA size; in other words, taller buildings increase RCA size. This can be explained by the characteristics of the urban environment in Izmir- detached mid-rise and high-rise buildings and attached low-rise buildings. This type of compact urban development pattern can create more open space at ground level (Bechtel et al., 2021; Shareef & Abu-Hijleh, 2020). In other words, moderate to high-rise development combined with adequate spacing between buildings can improve the urban microclimate by increasing ventilation (Bechtel et al., 2021; Shareef & Abu-Hijleh, 2020). Similarly, the total surface areas of building blocks are not very high in RCAs when the mean value of BER (4.49) is examined. This situation may stem from the low-rise adjacent and high-rise detached residential layouts in Izmir. From an LCZ perspective, this BER value is similar to LCZ 2 and LCZ 3, representing moderate building density and height. Moreover, the negative relationship between RCA size and BER aligns with the literature. A reduction in building facade surfaces can effectively mitigate the UHI's effect by decreasing the proportion of surfaces exposed to solar radiation throughout the day (Zhou et al., 2017; Li et

al., 2019). Finally, lower values of the maximum tree-covered area (MTR) (mean = 0.069 ha, max = 1.58 ha, SD = 0.18) indicate fragmented street trees and small green patches. Consequently, the characterization of İzmir's residential neighborhoods as a compact urban environment with limited green coverage is supported by the observations from MTR, BPD, and BER metrics.

According to the RCA model for İzmir, the contributions of different variable categories vary considerably. Green abundance, including park presence and maximum tree-covered area (MTR), contributes 48% to the explanation of the model. Greenery is the most effective category in regulating the microclimate. This finding aligns with previous studies. They focus on increasing the amount of green space as the most important spatial intervention in improving thermal comfort (Bowler et al., 2010; Norton et al., 2015). Parks have a crucial role in urban cooling due to shading and evapotranspiration (Bolund & Hunhammar, 1999), as well as adjacent trees support this effect by decreasing LST (Shih, 2017). Moreover, parameters related to urban morphology contribute about 37% to the model. These results are consistent with the literature. Building geometry and density shape airflow, solar exposure, and surface heat accumulation, thereby affecting the cooling extent (Li et al., 2019; Zhou et al., 2017).

Determinants of Thermal Conditions in the Urban Area of İzmir

The land surface temperature (LST) of relatively cooler areas (RCAs) in İzmir ranges between 31 °C and 32.5 °C,

with a mean of 32.04 °C. These values measured for the Izmir urban area are consistent with the results of this study in the literature. For instance, compact low-rise (LCZ-3) neighborhoods in Phoenix, Arizona, show an average LST of 32.5 °C. Similarly, LST values of LCZ-3 areas in Delhi, India, range from 31 °C to 33 °C (Gupta, 2024). For cold spots mapped using spatial autocorrelation for densely built areas of Athens, Mavrakou et al. (2018) reported LST values varying between 32.42 °C and 39.89 °C, with a mean of 35.50 °C. LST of RCA in İzmir is broadly consistent with those observed in cold spots of other cities having similar climatic and urban environment characteristics.

Although the studies generally investigate cooling effects of green spaces (Naa et al., 2024; Norton et al., 2015; Tian et al., 2025; Shih, 2017), a gap exists in the literature concerning the direct quantitative relationship between LST and the cooling extent (Şentürk & Çubukçu, 2023). Most previous studies focused on mapping hotspots and cold spots using spatial autocorrelation or classification methods (Li et al., 2025; Gupta, 2024; Núñez-Peiró et al., 2020). In addition, the cooling extent is generally studied at the micro scale by analyzing LST changes around the park (Wu et al., 2024; Şentürk & Çubukçu, 2023). Therefore, this study examined the relationship between cooling extent and thermal dynamics using various analysis methods. According to the findings obtained for the İzmir metropolitan area, the RCA regression analysis reveals a negative beta coefficient ($\beta = -1.78$) for LST of RCA (Table 3). This negative relationship between RCA size and RCA_LST is similarly observed in the scatter plot (Figure 4). These results mean that larger cooling extents bring about lower LST. Accordingly, it demonstrates

that increasing cooling extent in built-up areas should be considered an important issue in mitigating the UHI effect.

Conclusion

This study contributes to research on urban thermal environments by specifically investigating the characterization of cold spots and the built environment. It demonstrates that urban cooling extent is an important tool in reducing the UHI effect, and quantifies this for a Mediterranean city using various research methods. By combining spatial statistics techniques with regression modeling, the study provides new information about how characteristics of the urban environment determine the cooling extent. This approach not only advances methodological perspectives but also offers practical insights for climate-responsive urban planning practices and climate adaptation strategies.

However, this study has several limitations. First, the urban thermal condition was measured by using daytime LST. Yet, nighttime temperatures may exhibit different dynamics throughout the city and should be included in future analyses. Second, the dataset was limited because only RCA polygons were analyzed. In other words, the results cannot be directly compared with the hotter parts of the city. Finally, the substantial variation in RCA polygon sizes may have reduced the resolution of the raw data and limited the ability to explore more localized thermal interactions.

This study yields the following key implications regarding the urban thermal pattern of İzmir:

- **RCA Surface Temperature:** Mean LST of relatively cool areas (RCAs) in İzmir is measured at 32.04°C. In terms of urban thermal comfort, this value is considerably high, and the UHI effect poses a significant risk for İzmir's metropolitan area, considering the rising temperature trend in the Mediterranean region.
- **RCA Size and Heterogeneity:** RCA sizes vary greatly between 0.27 and 1025.28 ha. Although numerous smaller cooler areas exist, the overall cooling capacity is largely dominated by a limited number of large RCAs. This pattern states that the cooling extent is fragmented across the study area.
- **Built Environment Characteristics:** The findings of this study show that characteristics of RCAs mostly corresponded with compact urban development. However, greater permeability and tree coverage increase the cooling extent. Fragmented and smaller building mass has a positive effect on cooling extent because of reduced solar exposure on concrete surfaces. In addition, average building height has a positive relation with RCA size for Izmir. This may be explained by İzmir's high-rise detached residential areas, where vertical density often creates more open space at the ground level. Moreover, the greenery has a significant impact on urban cooling.
- **RCA Model:** The RCA model explained 53% of the variation in cooling extent. Among the explanatory variables, green infrastructure made the strongest contribution (48%), followed by urban morphology (37%) and urban thermal effect (15%).

- **RCA and LST Relationship:** There is a negative relationship between RCA size and mean LST. Thus, creating larger RCAs is a crucial tool to reduce thermal stress.

Overall, the study provides evidence-based solutions to integrate climate-responsive strategies into İzmir's future urban planning practice. As a result, the quantitative findings offer crucial insights for increasing urban resilience in Mediterranean cities under heat stress.

Acknowledgements and Information

This study was produced within the scope of the doctoral dissertation titled “*Investigation of the Cooling Effect of Urban Green Areas within the Framework of Smart Urbanism*”, conducted under the supervision of Prof. Dr. Kemal Mert Çubukçu. I would like to thank Prof. Dr. Çiğdem Coşkun Hepcan and Prof. Dr. Mediha Burcu Silaydın, members of the dissertation monitoring committee, for their valuable contributions.

References

- Abougendia, S. M., Ayad, H. M., & El-Sayad, Z. T. (2020). Classification Framework of Local Climate Zones Using World Urban Database and Access Portal Tools: Case Study of Alexandria City, Egypt”. *WIT Transactions on Ecology and the Environment*, 241, 309-322. doi:10.2495/SDP200251
- Alexander, P. J., & Mills, G. (2014). Local Climate Classification and Dublin's Urban Heat. *Atmosphere*, 5, 755-774: doi:10.3390/atmos5040755
- Anselin, L. (1995). Local indicators of spatial association—LISA. *Geographical Analysis*, 27(2), 93–115.

- Atri, M., Nedae-Tousi, S., Shahab, S., & Solgi, E. (2021). The Effects of Thermal-Spatial Behaviours of Land Covers on Urban Heat Islands in Semi-Arid Climates. *Sustainability*, 13(24), 13824. <https://doi.org/10.3390/su132413824>
- Bechtel, B., Blocken, B., & Maiheu, B. (2021). *The effect of building height diversity on outdoor microclimate and building energy performance. Building and Environment*, 190, 107567. <https://doi.org/10.1016/j.buildenv.2020.107567>
- Bowler, D.E., Buyung-Ali, L., Knight, T.M., & Pullin, A.S. (2010). Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning*, 97(3), 147–155.
- Bolund, P., & Hunhammer, S. (1999). Ecosystem services in urban areas. *Ecological Economics*, 29, 293-301.
- Budhiraja, R., Singh, S., & Kumar, A. (2019). Seasonality of surface urban heat island in Delhi city region measured via remote sensing and LCZ analysis. *Sustainable Cities and Society*, 48, 101540. <https://doi.org/10.1016/j.scs.2019.101540>
- C40 Cities. (n.d.). *Heat extremes*. <https://www.c40.org/what-we-do/scaling-up-climate-action/water-heat-nature/the-future-we-dont-want/heat-extremes/>
- Congedo, L. & Munafo, M. (2014). Urban Sprawl as a Factor of Vulnerability to Climate Change: Monitoring Land Cover Change in Dar es Salaam. Macchi, S. & Tiepolo, M. (Eds) inside Climate Change Vulnerability in Southern African Cities, London, 73-88, Springer. doi: 10.1007/978-3-319-00672-7
- Dormann, C. F., Elith, J., Bacher, S., Carré, G. C. G., García Márquez, J. R., Gruber, B., Lafourcade, B., Leitao, P. J., Münkemüller, T., McClean, C. J., Osborne, P. E., Reneking, B., Schröder, B., Skidmore, A. K., Zurell, D., & Lautenbach, S. (2013). *Collinearity: A review of methods to deal with it and a simulation study evaluating their performance*. *Ecography*, 36(1), 27–46. <https://doi.org/10.1111/j.1600-0587.2012.07348.x>
- Duan, S., Li, Z., Tang, B., Wu, H., & Tang, R. (2023). Evaluation of split-window algorithms for LST retrieval from Landsat 8/9 data under different atmospheric conditions. *ISPRS Journal of Photogrammetry and Remote Sensing*, 198, 78–92.

- General Directorate of Meteorology. (2022, April). *Resmi istatistikler*. <https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceleristatistik.aspx?m=İZMİR>
- Gupta, R. K. (2024). Identifying urban hotspots and cold spots in Delhi using the biophysical landscape framework. *Ecology, Economy and Society – the INSEE Journal*, 7(1), 137–155.
- Fung K. Y., Yang, Z. & Niyogi, D. (2022). Improving the Local Climate Zone Classification with Building Height, Imperviousness, and Machine Learning for Urban Models. *Computational Urban Science*, 2 (1). DOI: 10.1007/s43762-022-00046-x
- Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (H.-O. Pörtner, D. C. Roberts, M. Tignor, et al., Eds.). Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg2/>
- Keppas, S. C., Papadogiannaki, S., Parliari, D., Kontos, S., Poupkou, A., Tzoumaka, P., Kelessis, A., Zanis, P., Casasanta, G., de’Donato, F., Argentini, S., & Melas, D. (2021). Future Climate Change Impact on Urban Heat Island in Two Mediterranean Cities Based on High-Resolution Regional Climate Simulations. *Atmosphere*, 12(7), 884. <https://doi.org/10.3390/atmos12070884>
- Li, X., Zhou, Y., & Ouyang, Z. (2019). Urban form and microclimate: How building geometry influences temperature distribution. *Science of the Total Environment*, 658, 123–134.
- Li, X., & Zhou, W. (2023). Urban morphological indicators and their effects on urban cooling: A multi-city regression analysis. *Sustainable Cities and Society*, 99, 104893.
- Li, H., Zhang, Z., & Chen, Y. (2022). Spatial heterogeneity of urban heat islands and its driving factors: A Local Moran’s I approach. *Science of the Total Environment*, 836, 155659.
- Li, D., Hu, X., Rollo, J., Luther, M., Lu, M., & Liu, C. (2025). Spatial Cluster Characteristics of Land Surface Temperatures. *Sustainability*, 17(6), 2653. <https://doi.org/10.3390/su17062653>

- Ma, Y., Xu, H. & Li, X. (2024). Advances in remote sensing of urban heat islands: A review of methods and applications. *Urban Climate*, 52, 101680.
- Mavrakou, T., Polydoros, A., Cartalis, C., & Santamouris, M. (2018). Recognition of thermal hot and cold spots in urban areas in support of mitigation plans to counteract overheating: Application for Athens. *Climate*, 6(1), 16. <https://doi.org/10.3390/cli6010016>
- MetLink. (2023). *Royal Meteorological Society*. <https://www.metlink.org>
- Naa, N., Loua, D., Xua, D., Nia, X., Liua, Y. & Wang, H. (2024) Measuring the cooling effects of green cover on urban heat island effects using Landsat satellite imagery. *International Journal of Digital Earth*, 17 (1), 2358867. <https://doi.org/10.1080/17538947.2024.2358867>
- NASA Science – Kids. (2025) *What Is an Urban Heat Island?* Access: <https://science.nasa.gov/kids/earth/what-is-an-urban-heat-island/>
- Norton, B.A., Coutts, A.M., Livesley, S.J., Harris, R.J., Hunter, A.M., & Williams, N.S. (2015). Planning for cooler cities: A framework to prioritize green infrastructure to mitigate high temperatures in urban landscapes. *Landscape and Urban Planning*, 134, 127–138.
- Núñez-Peiró, M., Sánchez, J., & García, R. (2020). Analysis of surface temperature variation across Local Climate Zones in Madrid, Spain. *Sustainable Cities and Society*, 60, 102243. <https://doi.org/10.1016/j.scs.2020.102243>
- Öztürk, M. Z., Çetinkaya, G. & Aydın, S. (2017). Climate types of Turkey according to Köppen–Geiger climate classification. *Journal of Geography*, 35, 17–27. <https://doi.org/10.26650/JGEOG295515>
- Öztürk S. P., Özden, P., & Tikik, M. (2025). Climate change, extreme heat, and outdoor thermal comfort in urban areas: Case of İzmir, Turkey. *Hungarian Geographical Bulletin*, 74(2), 131-143. <https://doi.org/10.15201/hungeobull.74.2.1>
- Wang, Y., Xu, H. & Sun, P. (2023). Multi-scale detection of urban heat island clusters using spatial statistics. *Urban Climate*, 49, 101570.
- Peng, F., Wong, M. S., Ho, H. C., Nichol, J., & Chan, P.W. (2017) Reconstruction of historical datasets for analyzing spatiotemporal influence of built environment on urban microclimates across a compact city. *Building and Environment*, 123, 649- 660.

- Peng, E., Cao, Y., Sun, X., & Zou, B. (2024). Study on the contributions of 2D and 3D urban morphologies to the thermal environment under local climate zones. *Building and Environment*, 263, 111883. <https://doi.org/10.1016/j.buildenv.2024.111883>
- Qaid, A., Lamit, H. B., Ossen, D. R., & Shahminan, R. N. R. (2016). Urban heat island and thermal comfort conditions at micro-climate scale in a tropical planned city. *Energy and Buildings*, 133, 577-595.
- Quan, J. (2019). Multi-temporal effects of urban forms and functions on urban heat islands based on local climate zone classification. *International Journal of Environmental Research and Public Health*, 16, 2140. <https://doi.org/10.3390/ijerph16122140>
- Sakar, B. (2018). *Parametric modelling for the mitigation of urban heat island effect: A model proposal* (Master's thesis, Middle East Technical University, Ankara, Türkiye). The Graduate School of Natural and Applied Sciences.
- Shih, W. (2017). Greenspace patterns and the mitigation of land surface temperature in Taipei metropolis. *Habitat International*, 60, 69- 80.
- Silva, I., Santos, R., Lopes, A., & Araujo, V. (2018) Morphological Indices as Urban Planning Tools in Northeastern Brazil. *Sustainability*, 10, 4358. doi:10.3390.
- Shareef, S. & Abu-Hijleh, B. (2020). The effect of building height diversity on outdoor microclimate conditions in hot climate. A case study of Dubai-UAE. *Urban Climate*, 32,100611. <https://doi.org/10.1016/j.uclim.2020.100611>.
- Şenlik, Y. F., & Yılmaz, E. (2024). Relationships between land use and the distribution of the hottest and coldest spots in the cities of İzmir and Manisa. *Turkish Journal of Geography*, 86, 45–56. <https://doi.org/10.17211/tcd.1488891>
- Şentürk, Y., & Çubukçu, K. M. (2023). Investigating cooling extend in the urban area, case of İzmir. *Journal of Geographical Sciences*, 21(2), 453-480. <https://doi.org/10.33688/aucbd.1340464>
- Şentürk, Y., & Çubukçu, K. M. (2023). Impacts of urban green area on local climate: Suggestions for spatial planning. Saygın, H, Balyemez, S. & Oral, H.V. (Eds) inside *Energy Efficiency and Ecology in Sustainable Urban Planning* (103-130). Nobel Academic Publications.

- Şentürk, Y. (2024). *Investigation of the Cooling Effect of Urban Green Areas within the Framework of Smart Urbanism* (doctoral dissertation). Dokuz Eylül University, Institute of Science, İzmir, Türkiye.
- Tian, L., Yang, Z., & Zhao, L. (2025). Climate sensitivity and area efficiency threshold of urban park cooling effects: a cross-climate zone comparative analysis. *Landscape Ecol*, 40, 154. <https://doi.org/10.1007/s10980-025-02162-5>
- Turkish Statistical Institute (TUIK) (2025). *Address Based Population Registration System (ABPRS) results 2024: İzmir population*. Retrieved from <https://data.tuik.gov.tr/>
- Wang, X., Zhao, H., & Li, Q. (2018). Local climate zone classification and its impact on urban surface temperature in arid cities: A case study of Phoenix and Las Vegas. *Urban Climate*, 25, 120–133.
- Weng, Q., Fu, P., & Gao, F. (2022). Generating daily land surface temperature at Landsat resolution by fusing Landsat and MODIS data. *Remote Sensing of Environment*, 268, 112760.
- Wu, T., Wang, X., Xuan, L., Yan, Z., Wang, C., Du, C., Su, Y., Duan, J., & Yu, K. (2024). How to Plan Urban Parks and the Surrounding Buildings to Maximize the Cooling Effect: A Case Study in Xi'an, China. *Land*, 13(8), 1117. <https://doi.org/10.3390/land13081117>
- Wu, Z., Yao, L., & Ren, Y. (2020). Characterizing the spatial heterogeneity and controlling factors of land surface temperature clusters: A case study in Beijing. *Building and Environment*, 169, 106598.
- Yüksel, A. T., & Coşkun Hepcan, Ç. (2023). The relationship between land surface temperature and blue-green infrastructure: The case of Karşıyaka. *Adnan Menderes University Journal of the Faculty of Agriculture*, 20(1), 91–98. <https://doi.org/10.25308/aduziraat.1214763>
- Zhang, H., Sun, Q., & Xiao, P. (2023). Improved retrieval of land surface temperature from Landsat 8/9 TIRS data using atmospheric correction. *International Journal of Applied Earth Observation and Geoinformation*, 118, 103291.
- Zhao, J., Liu, M., & Wu, J. (2024). Advances in spatial autocorrelation methods for urban thermal environment analysis. *Landscape and Urban Planning*, 245, 104712.

- Zheng, Y., Ren, C., Shi, Y., Yim, S., Lai, D., Xu, Y., Fang, C & Li, W. (2023). Mapping the spatial distribution of nocturnal urban heat island based on Local Climate Zone framework, *Building and Environment*, 234, 110197.
- Zhou, B., Rybski, D., & Kropp, J. P. (2017). The role of urban morphology in the surface urban heat island effect. *Environmental Research Letters*, 12(5), 054002.
- Zhou, D., Zhao, S., & Liu, S. (2021). Scale effects in the detection of urban heat islands using Local Moran's I. *Remote Sensing*, 13(19), 3912.

PART 2

Urban Inequalities,
Identities, and Collective
Agency

Rural Areas in the Shadow of Urbanization: An Analysis of Spatial and Socio-Economic Transformation in Kayapinar District, Diyarbakir

Dilan Kakdaş Ateş

Department of Architecture – Restoration, Faculty of Architecture and Engineering, Bitlis Eren University
ORCID: 0000-0002-5984-3462

Sevilay Akalp

Department of Architecture – Building Science, Faculty of Fine Arts, Harran University
ORCID: 0000-0002-4624-3476

Abstract

The Kayapinar District of Diyarbakir has undergone rapid spatial transformation driven by intense urbanization and population growth, particularly since the 2000s. Accelerated housing production and infrastructure development have reshaped the district and exerted significant physical and socio-economic pressures on surrounding rural areas. As urban sprawl expanded, rural settlements began to lose their distinct character, creating a layered rural-urban transition zone.

This study examines how urbanization in Kayapinar affects nearby rural landscapes. Using satellite images, land-use maps, and zoning plans, the research identifies substantial changes in rural land use and settlement patterns. Agricultural lands once a primary livelihood source

for rural residents, have been increasingly converted into built-up areas, resulting in reduced agricultural activity and declining rural incomes.

Additionally, urban design interventions that often overlook local identity and social cohesion have altered parcel structures and weakened traditional neighborhood relations. Overall, the findings show that urbanization in Kayapinar generates multidimensional transformations that extend beyond physical expansion, reshaping social, economic, and spatial dynamics in urban–rural interface areas. The study highlights the need for holistic planning approaches that integrate social, economic, and environmental dimensions when addressing rural transformation in rapidly urbanizing regions.

Keywords: urbanization, urban transformation, urban planning, Diyarbakir, Kayapinar

Introduction

Urbanisation constitutes one of the most comprehensive social and spatial transformation processes of the modern era. Urbanization is not merely the expansion of city boundaries; it is a multidimensional socio-spatial transformation process shaped by the rural population's migration to urban centers that offer higher productivity and living standards (Zhang & Liu, 2026). It entails not only the transformation of the physical fabric of cities but also profound effects on the organisation of social relations, the functioning of economic structures and the preservation of

ecological balance. According to 2018 data from the United Nations, more than half of the world's population currently resides in urban areas, and it is projected that this proportion will increase to 70% by 2050. However, it also brings with it multifaceted crises, including infrastructure deficiencies, environmental sustainability issues, and social cohesion difficulties (Harvey, 2008; UN-Habitat, 2020). As Sassen (2001) notes, the phenomenon of global urbanization has led to a significant increase in the number of megacities around the world. This process also necessitates that a great many indigenous and traditional communities strike a delicate balance between preserving their cultural heritage and adapting to modern life practices as modernisation spreads on a global scale. Indeed, the study undertaken by Jiang and colleagues in 2025 reveals that this tension has decisive effects on spatial and social organisations.

In Turkey, the phenomenon of rural-urban migration has come to be regarded as a distinct process of social transformation since the 1950s. It was particularly the changes in the economic structure that occurred after the year 1980 which resulted in a transformation in the nature of the urbanisation process. Evidence of this may be seen in the renewal of shanty towns, an increase in the extent of intervention by the central government in planning processes, rapid housing production, and large-scale public housing projects, all of which became characteristic practices of this period (Tekeli, 1982; Keleş, 2015).

It consequently followed that cities were perceived in a new light: no longer solely as settlements characterised by increased population density, but also as centres of

social and spatial transformation. Rapid developments in transport technologies and diversification in forms of mobility intensified interactions between city centres and peripheral areas. This led to a shift in daily living spaces from the centre to the periphery and the redistribution of economic activities across different geographical areas. At this juncture, the phenomenon of ‘urban villages’ which are expanding into rapidly growing cities while retaining their historical rural characteristics, has become increasingly prevalent in numerous developing countries. Despite the significant economic and social functions performed by these areas, they are frequently overlooked in planning policies (Kasula et al., 2026).

In the contemporary era, the facilitation of fundamental urban amenities, including transportation, infrastructure, and sanitation, is encountering mounting challenges due to the intricate and interdependent character of these systems. This situation impedes the sustainable and efficient delivery of services, exacerbating the interplay among spatial, administrative and social problems and accentuating the deleterious effects of urban growth (Keleş, 2015, p. 55). The objective of this study is to ascertain the spatial transformations in rural areas that are the consequence of the urbanisation process in Kayapınar. The present study examined land use and transformations in the rural landscape in the rural surroundings of Kayapınar. To this end, satellite images from different years, land use maps and urban plans were analysed to ascertain the extent of transformation in rural areas over time. The research findings reveal that rapid urbanisation in Kayapınar has resulted in a decrease in agricultural areas, the fragmentation

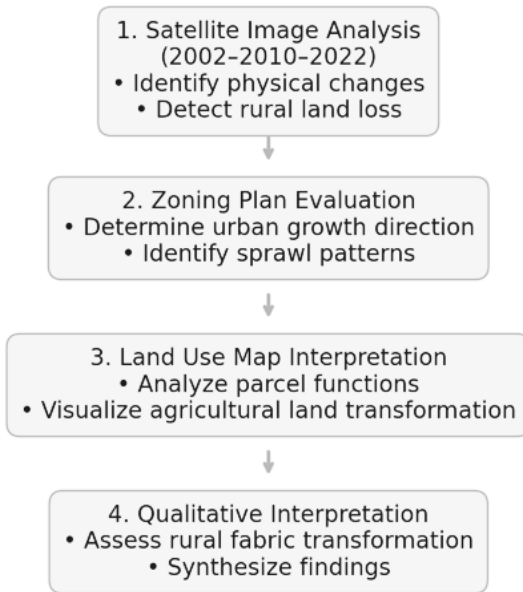
of rural communities, and increasing challenges in providing sustainable urban services.

Methodology

As part of the study, satellite images from 2002, 2010, and 2022 were compared to examine the changes in rural areas located in the Kayapınar region, where urbanization is occurring at a rapid pace and population growth is increasing daily.

Figure 1.

Study Workflow for Rural Transformation Analysis



In the first step of the study, the transformations and changes that occurred in the physical areas of rural areas were

identified using satellite images. In the second step of the study, the direction of urban growth and sprawl in the city of Diyarbakir was determined using zoning plans. Finally, using land use maps describing parcel functions, the transformation and spatial changes experienced by agricultural lands in the urbanization process were visualized and concretized. The transformation of the rural fabric was interpreted on a qualitative scale using the data obtained (Fig. 1).

Urban Development in Diyarbakir and the District of Kayapinar

People recognise Diyarbakir as a significant settlement because of its strategic location and rich cultural heritage. Its historical urban fabric has hosted numerous civilisations. Diyarbakir remained a walled city until the 19th century. After that time, it began to expand beyond the walls.

This was influenced in part by a housing shortage. Following 1930, gradual migration led to slow outward growth until the 1950s. The construction of the railway in 1935 had a direct influence on the direction of urban growth, with the city's development trajectory being shaped around the station and the rail corridor (İlik, 2020). With a population of around 40,000, the intramural district of Suriçi was forced to expand beyond the city walls in 1940 due to the 'housing crisis'. Outside the walled core, building activity initially produced military facilities. These were followed by administrative structures. Examples of civilian architecture were finally built (Fig. 2).

Figure 2.

Aerial photographs of Diyarbakir, 1939 and 1950 (Explanatory Report for the Conservation Master Plan Amendment for Hançepék Square and its Environs within the Urban Conservation Area of the Suriçi Region, Sur District, Diyarbakir Province, 2020).



In the twentieth century, migration from the walled core (Suriçi) accelerated. This outward spillover accelerated

construction beyond the fortifications. This was particularly the case in the Yenişehir district. In the early Republican period, Yenişehir exhibited an orderly development pattern characterised by houses with gardens and public buildings; however, parallel to the rise of commercial activity, notable changes emerged in housing typologies and building heights (Yalçın, 2021).

Figure 3.

Diyarbakir in the 1950s (Ant Diyarbakir, 2018),



Figure 4.

Yenişehir, Diyarbakır, 1969, reprinted from Old Turkey Photographs Archive.



1950 is a particularly significant year. It is significant in the history of urbanization. After the Second World War, more and more people moved to cities all over the world. The rapid population movements that took place in Turkey after 1950 resulted in a situation where the housing stock was unable to keep up with the influx of people.

This led to the emergence of areas where people built makeshift dwellings, known as “gecekondu”, to house those who were arriving in the country. The unplanned growth of the population caused various problems, particularly in terms of infrastructure and transportation (Fig. 3).

The same dynamics were at play in the city of Diyarbakır. After 1950, the intensification of out-migration beyond

city walls led to unhealthy urbanization patterns and the emergence of blighted areas (Dağlı & Çağlayan, 2020). Mapping is based on the city's 1939 and 1952 orthophotos. These are documented by Dağlı and Çağlayan. The mapping shows the spread of residential zones. It indicates that the housing fabric began to expand irregularly. This expansion took place along the main arteries. The most notable of these are İstasyon Caddesi and Elâzığ Caddesi (Fig. 4, Fig. 5).

Figure 5.

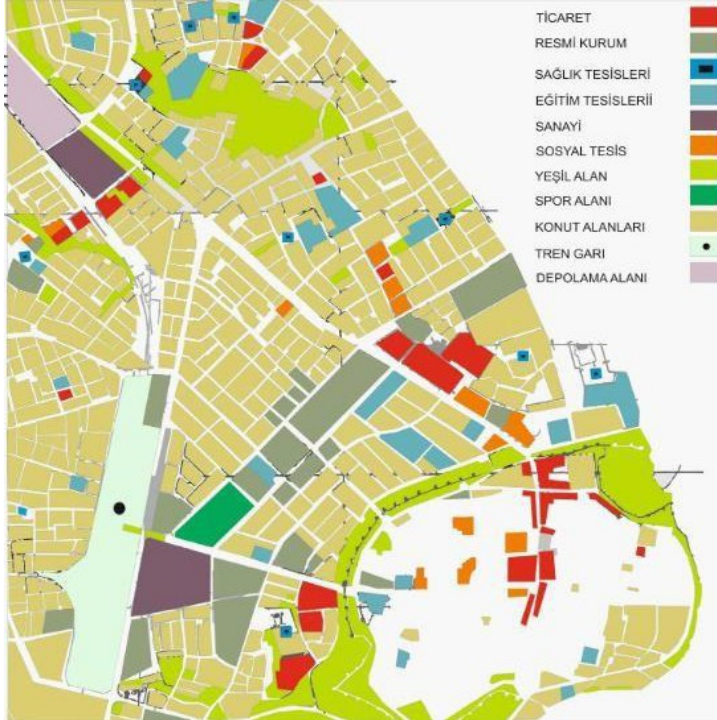
Urban Development in Diyarbakır Based on the Earliest Orthophotographs (Dağlı & Çağlayan, 2020)



A significant step was taken in the regulatory framework for planned development in 1965. In that year, a 1:1000-scale implementation (detailed) zoning plan was prepared, encompassing construction both within the walled core (Suriçi) and in the extramural areas.

Figure 6.

1965 Diyarbakır zoning plan (Diyarbakır Metropolitan Municipality, 2023).



The zoning plan prepared in 1965 includes decisions that disrupted the historic Suriçi fabric's low-rise character and its ethos of respect for local materials. By permitting reinforced-concrete structural systems, the regulation also extended to extramural areas, stipulating building-height parameters and legal provisions governing residential construction (Fig 6).

Figure 7.

Building activity in Yenişehir in the 1960s (Diyarbakir Provincial Yearbook, 1967)



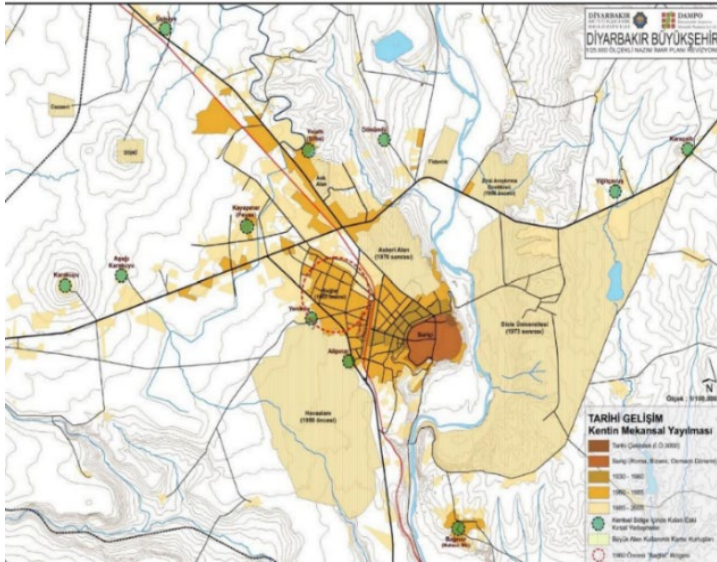
Figure 8.

Yenişehir, 1975 (Old Turkey Photographs Archive).



Figure 9.

Historical development of the city (spatial scale) (Diyarbakir Metropolitan Municipality Archive, 2016).



The first extramural growth occurred in the Yenişehir district, encompassing the Kooperatifler and Şehitlik neighborhoods (Arslan, 1999; Beysanoğlu, 2001; Özer, 2010). Arslan (1999) characterizes the years 1963–1973 as the period during which Yenişehir’s detached garden houses were demolished and replaced by multi-storey apartment blocks (Fig. 9).

The 1980s marked a pivotal decade politically and economically for Turkey. With the transition to mechanized agriculture, rural populations increasingly viewed cities as more attractive places of residence, triggering waves of migration. Residential land covered 293.24 hectares in 1960, rising to 1,277.23 hectares by the 1980s; by 2005, it had tripled relative to the 1980s, reaching 3,078.27 hectares (Gölçük, 2010; Biçen & Vural, 2023).

In the 2000s, Kayapınar was designated as the city's new growth area, while populations with middle- and lower-income levels tended to prefer the residential districts of Yenişehir and Suriçi (Yalçın, 2021) (Fig. 10).

Figure 10.

Urban expansion of the city of Diyarbakır between 2002 and 2020.



Note. Screenshot from Google Maps (2025).

According to Figure 8, the city has expanded from the Suriçi core toward the Kayapınar district, and the principal axis of urban growth has progressed in this direction. In addition, it is widely acknowledged that—particularly after the 2000s, when the pace of modern urbanization accelerated—Kayapınar's housing fabric has been more orderly and planned than that of other parts of the city (Karagöz, 2015).

Since the 2000s, Kayapınar has become recognised as one of the city's leading consumption hubs. It features new-generation cafés, recreational areas, parks, and shopping malls. Kayapınar is a residential unit that is a key reference point in the city, characterised by a predominance of housing and major arterial roads. Two main boulevards stand out. These are the 50-meter and 75-meter rights-of-way. They are known as the Mesopotamia and Mahabad Boulevards.

These run parallel to each other. They also connect directly to the Elazığ and Urfa Boulevards. These formed during the city's early settlement period.

In 2013, rural villages in the area were reclassified as urban neighbourhoods by the metropolitan municipality, thereby resulting in the expansion of the district's extent and jurisdiction. The population increased from 342,977 in 2018 to 362,407 in 2019 and to 425,143 in 2023. Approximately 90% of the district's residents live in the urban center.

There are particularly high concentrations in Firat and Medya neighborhoods. In this context, the rural settlement fabric within the district has progressively diminished over time to the point of being nearly negligible (Kayapınar Municipality, 2024) (Fig. 11).

Figure 11.

Central Neighborhoods Map of Kayapınar District (Kayapınar Municipality, 2024).



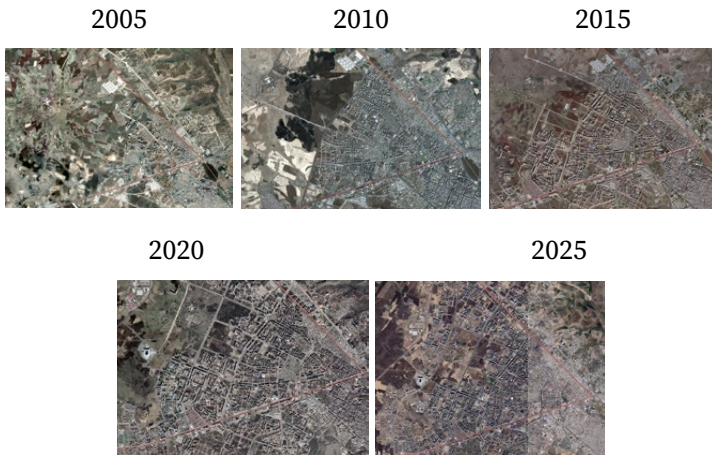
Evaluation and Conclusion

Growth in Kayapınar district has continued along a specific axis to the present day. Examination of the relevant maps reveals that growth has developed along two main axes on the Mesopotamia and Mahabad boulevards.

Furthermore, the satellite images and land use maps examined show that the conversion of rural areas into residential areas has hindered agricultural activities. This corridor-based growth has made the housing fabric in Kayapınar more orderly and planned compared with other parts of the city, but it has also made land use change in the rural area around it happen more quickly (Table 1).

Table 1.

Status of urbanization in Kayapınar, 2005–2025.



Note. Screenshot from Google Maps (2025).

The expansion of administrative boundaries was due to the reclassification of villages as urban neighbourhoods in 2013. From 2018 to 2023, the population increased from 342,977 to 425,143, leading to an escalation in density in central districts – notably Fırat and Medya. This densification has made issues of social and spatial cohesion more apparent across the rural–urban transition belt.

In conclusion, Kayapınar exhibits an urban growth pattern in which consumption and recreation nodes (such as shopping malls, cafés, and parks) have strengthened, with development anchored to backbone boulevards and a relatively orderly, plan-led housing fabric that rapidly converts surrounding rural land into urban functions. While this pattern compresses rural production areas and disrupts rural social structures, it also exerts increasing pressure to provide urban services efficiently.

References

- Ant Diyarbakır [@ant_diyarbakir]. (2018, August 13). *[Post on X]*. X. https://x.com/ant_diyarbakir/status/1028619776535547904https://x.com/ant_diyarbakir/status/1028619776535547904
- Biçen, A., & Vural, S. (2023). Kent ve konut üzerine betimsel analiz: Diyarbakır örneği. *Kent Akademisi*, 16(3), 1639–1665. <https://doi.org/10.35674/kent.1269970>
- Dağlı, D., & Çağlıyan, A. (2021). Kentsel gelişim ve dönüşüm sürecinin belirlenmesi: Diyarbakır örneği. *International Journal of Geography and Geography Education*, 43, 212–234. <https://doi.org/10.32003/igge.819481>
- Diyarbakır Metropolitan Municipality. (2023). *1965 Diyarbakır zoning plan*.

- Google. (2025). *Yenişehir, Diyarbakır* [Map]. Google Maps. URL - https://earth.google.com/web/search/Kayap%c4%b1nar%2fDiyarbak%c4%b1r/@37.96822812,40.0813519,756.32629776a,3024.40359162d,35y,360h,0t,0r/data=CiwiJgokCZQB4vZ7AUNAEX9b5U_M80JAGV2QcVAEJkRAIfZLeGVyAURAQgIIAToDCgEwQgIIAEoICIANyBEDEAA
- Gölcük, A. (2010). Kentsel planlama sürecinde kent formundaki değişimlerin Diyarbakır kenti örneğinde araştırılması (Yüksek lisans tezi). Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, Adana.
- Harvey, D. (2008). The right to the city. *New Left Review*, 53, 23–40.
- İlik, M. (2020). Diyarbakır kentinin mekânsal gelişim süreci bağlamında çarpık kentleşme ve gecekondulaşma sorunu (Lisans tezi). Dicle Üniversitesi, Eğitim Fakültesi, Diyarbakır.
- Jiang, Y., Duan, J., & Zhang, Y. (2025). The spontaneous spatial restructuring of traditional village based on an analysis of social relationship: A case in Fuling, Fujian China. *Habitat International*. <https://doi.org/10.1016/j.habitatint.2025.103309>
- Karagöz, N. (2015). Diyarbakır–Bismil çevre düzeni planı (pp. 2–47). <https://docplayer.biz.tr/6057470-10-5-diyarbakir-in-mekansal-kentsel-gelisimi-ve-imar-planlari-karsilastirmasi-10-6-1-1992-diyarbakir-bismil-cevre-duzeni-plan.html>
- Kasula, P., Dedekorkut-Howes, A., Shearer, H., & Baum, S. (2026). Social inclusion of urban villages: A systematic review of global urban planning practices. *Cities*, 169, 106509. <https://doi.org/10.1016/j.cities.2025.106509>
- Kayapınar Municipality. (2024). *Urban development projects*.
- Keleş, R. (2015). Kentleşme politikası (14. baskı). İmge Kitabevi.
- Sassen, S. (2001). *The global city: New York, London, Tokyo* (2. baskı). Princeton University Press.
- Tekeli, İ. (1994). Türkiye’de kentleşme yazıları. Tarih Vakfı Yurt Yayınları.
- United Nations. (2018). *World urbanization prospects: The 2018 revision*. United Nations, Department of Economic and Social Affairs, Population Division. <https://population.un.org/wup>

- UN-Habitat. (2020). World cities report 2020: The value of sustainable urbanization. United Nations Human Settlements Programme. <https://unhabitat.org/World-Cities-Report-2020>
- Yalçın, E. (2021). *Diyarbakır'da konut gelişme alanları ve konut tercihleri* (Yüksek lisans tezi). Çanakkale Onsekiz Mart Üniversitesi.
- Old Turkey Photographs Archive. (1969). *Yenişehir, Diyarbakır* [Photograph].
- Zhang, L., & Liu, H. (2026). Embracing urban life from the heart: The role of social networks in urban identity. *Cities*, 170, 106615.

The Individual Traces in Public Space: An Evaluation of Place Attachment and Personalization Practices

Ece Kaya

Gebze Technical University
ORCID: 0009-0003-3360-1152

Eren Kürkçüoğlu

Istanbul Technical University
ORCID: 0009-0003-3360-1152

Abstract

Public open spaces are places where cities make their presence visible through everyday interventions and leave their physical traces in various ways. These areas, where individuals express themselves in the spatial context in their life practices, contribute to the reproduction of social and spatial identities. Individual and physical interventions carried out by the urbanites in daily life are evaluated as “tracing practices” and are considered as forms of producing spatial belonging, which are indicators of the presence of individuals. Tracing practices, unlike frequently observed acts of vandalism in public open spaces, are signs of presence far from being destructive and can occur as personalisation behaviours in urban space. This study focuses on the question of how tracing practices contribute to place attachment

within the framework of personalization, affordances, and person-environment fit concepts. Interactions between the concepts analysed through a systematic literature review were found to be fragmented in the existing literature, which could not explain the practices of leaving traces from a holistic view. The affordances discussed in this study are the potential for personalization in the urban environment; this potential brings with it the formation of traces. The trace layer formed in the urban space is located in the memory when it is included in the active environment of the individual, and this gives a different layer to the person's connection with the space. As a result of these processes, the concept of PE Fit is involved in the cycle as a triggering mechanism. A theoretical model is proposed within the research to measure the impact of traces on place attachment. This model explains the affordances and supplies offered by the environment and the way the needs of the individual are met through the "traces layer". From a methodological point of view, systematic verification of the gap in the literature constitutes the justification for the proposed conceptual model. The developed model brings together concepts that are scattered in the literature on a common ground and proposes a new conceptual tool for urban design and planning research

Keywords: Place Attachment, Personalization, Public Open Space, Urban Traces

Introduction

Public open spaces are not only physical voids in the city but also places where urbanites make their presence felt through daily practices. These spaces, where individuals express themselves, serve as the interface between the urban environment and social life. Casual, non-destructive, individual interventions in public spaces are called ‘tracing practices’ in this study. Unlike vandalism, which is destructive, tracing allows individuals to personalise the space, gain visual visibility, and engage through casual touches. Thus, traces form a new urban layer and acquire new meanings, potentially signaling belonging or contributing to collective memory. Based on this assumption, the following questions are discussed within the scope of this study:

1. How do individual traces in public spaces play a role in reproducing spatial belonging, place attachment, and personal memory?
2. How do practices of leaving traces transform the perception and interpretation of public space?
3. How does the spatial distribution and visibility of traces affect the operational and symbolic layers of public space?

Under the light of the research questions, the aim is to address the concepts of affordances, personalisation, place attachment, and person-environment fit within a holistic framework and to formulate a conceptual model through the ‘layer of traces’. This study is not based on any fieldwork and is structured as a conceptual and theoretical proposal. In this respect, the conceptualisation of individual traces in the

context of public space contributes not only to the literature on place attachment but also to higher-level discussions on the production, appropriation, and management of public space.

Theoretical Framework

The potentials for behaviour that the environment offers to individuals are defined by Gibson (1979) as affordances. According to this approach, the environment provides affordances that have the potential to be beneficial or detrimental to the organism. Based on this definition, affordances are the totality of potentials offered to an entity capable of perceiving and utilising the environment, and they derive from the objective characteristics of the environment. Chemero (2013) states that the objective affordances offered by the environment to the subjects gain meaning through relational opportunities that enable behaviour, and that they exist in relationships rather than in individual components. In this perspective, the tracing practices examined within the scope of this study are evaluated as a result of the affordances offered by the urban environment to its inhabitants. The urban environment provides individuals with transformable and traceable spatial interfaces; whether or not to engage in tracing practices depends on the individual's own choice and the relationship they establish with the urban space. The traces that exist within the urban environment not only convey individuals' personal expressions to the space, but also make visible the possibilities that the environment offers to the individual. Within the built environment, urban spaces can

be adapted to enable desired behaviours, meaning that the affordances they provide are modifiable (Lang, 1994). Within this perspective, the totality of affordances provided to the individual constitutes the potential environment. While people create the set of potential environments for their activities and aesthetic preferences, the environment that filters through this set and gains meaning for the individual forms the active environment (Lang, 1987). Within the context of this research, while the entire urban environment is considered the potential environment for individuals, the assessment of whether the trace layer, the main subject of the study, is part of the active environment for individuals provides an answer to the research questions.

Affordances of the environment cover the physical dimension of tracing practices. From a personal context, tracing practices can be considered as a particular form of personalisation. Kuksa and Fisher (2017, as cited in Mace, 2024) approach personalisation in two ways. 'Personalisation for' encompasses individual interventions in the design and management of the environment to provide people with high-quality experiences. 'Personalisation by' addresses the unique and individual contributions that individuals make to the environment through their direct interventions. Mace (2020) considers both dimensions of personalisation as a whole and defines personalisation in public spaces as the impact it has on an individual's ability to shape their experiences and define their personal spaces. Thus, the affordances for leaving traces offered by the urban environment reveal the individual's potential to personalise the environment, while at the same time, the resulting layer of traces transforms the way the space is perceived

by other users, the possibilities for interpretation, and the understandings attached to it.

The discussion on the interrelationship between space and place supports the theoretical validity of tracing practises. Tuan (1987, as cited in Chylińska & Kosmala, 2023) states that for space to become a place, the individual has to attach personal, social, and cultural meanings to it. Lewicka (2010), meanwhile, links attachment to space to three main factors: physical, social, and socio-demographic. In this context, Chylińska & Kosmala (2023) state that when the aforementioned meanings and factors take on a material dimension, individuals express this meaning externally by leaving different traces and symbols in the areas they accept as a place. However, traces are no longer merely a physical layer in the urban environment; instead, they are reproduced through individuals' relationships of belonging and identity, acquiring new meanings. Therefore, traces can be considered the spatial reflection of an individual's relationship with the urban environment. At this point, it is necessary to refer to environmental behavior theories to understand the role of traces in the environment-human interaction.

The person-in-environment theory examines the relationships individuals establish with their environments and argues that behaviours arise from the combined influence of personal characteristics (P) and environmental characteristics (E). Lewin (1934) analyses the effect of the person and environment dimensions on behaviour using the formula $[B = f(P, E)]$. The Person-Environment Fit Theory, one of the various theories developed based on this approach,

Figure 1.

Example of tracing practices in urban public space: The Gum Wall, Seattle (Delso, 2017)



builds upon Lewin's (1934) formula and discusses the role of the environment in providing for the needs of the person and the effects of the fit between the person and the environment on behaviour. Caplan (1983) argues that person-environment fit has a stronger effect on motivation, behaviour, and health than personal characteristics. He also states that for P and E to be conceptually related to one another in an explicit manner, these components must be considered within commensurate dimensions.

Within the Person-Environment Fit Theory, the concept of fit is addressed in two branches. Demands-abilities addresses whether the person possesses the abilities appropriate to the demands of the environment. The demand dimension reflects the characteristics of the environment, while the

ability dimension reflects the characteristics of the person. Needs-supplies addresses person-environment adjustment through the supplies provided by the environment to meet the person's needs (Caplan, 1983). In early studies addressing Person-Environment Fit Theory, adjustment was generally addressed through demands-abilities and associated with environmental stress. Carp and Carp (1984) and Kahana (1982) developed Lewin's (1934) formula as $f[B = f(P, E, PcE)]$ to emphasize the positive outcomes of the supplies provided by the environment in terms of meeting personal needs and strengthening adaptation. Within this framework, the PcE component expresses the alignment of personal needs with the support offered by the environment and finds its place on the needs-supply alignment spectrum. In this context, environmental elements are considered not only as a foundation that directs individuals' behaviour but also as a support layer that meets their needs and shapes their relationships of belonging. Carp and others' development of this 'congruence model' subsequently formed the basis for expanding the person-environment fit theory in the context of the built environment (Zhang et al., 2025).

The fit between the person and the environment is also discussed in two dimensions: subjective and objective fit. Subjective fit refers to the fit perceived by the person concerned, while objective fit refers to the fit independent of human perception's bias. Objective fit may include realities about the person and the environment that are not perceived by the individual. The question of what constitutes the objective measure is both philosophical and pragmatic (Caplan, 1987). A distinction between objectivity and subjectivity could be identified in both personal

and environmental factors. When personal factors are considered, the objective dimension (Po) encompasses the individual's physical and demographic characteristics, while the subjective dimension (Ps) consists of the individual's own perceptions. Zhang et al. (2025) summarise these subjective perceptions as follows: 'For example: I feel that I can move freely, I feel that I am healthy, I do not feel that I am prone to depression.' From the built environment context, objectively existing components (Eo) can be defined as the type, scale, and location of objects, while the subjective environmental dimension (Es) represents the individual's perception of their built environment.

The discussions on fit presented so far outline the fundamental dimensions of the person-environment relationship. Person-environment fit shapes behaviour in two main forms: complementary fit and supplementary fit. Complementary fit occurs when the environment meets an individual's needs, while supplementary fit reflects shared values and characteristics between the individual and their environment. Through complementary fit, individuals satisfy their needs via environmental opportunities, and the environment supports this fit by responding to those needs. Although multiple dimensions exist in the literature, these two forms provide a basic framework for understanding fit, especially in spatial contexts (Zhang et al., 2025). Complementary fit aligns with Gibson's (1979) concept of affordances and the fit models by Carp and Carp (1984) and Kahana (1982). In this sense, the better the environment meets an individual's needs, the greater the person-environment fit.

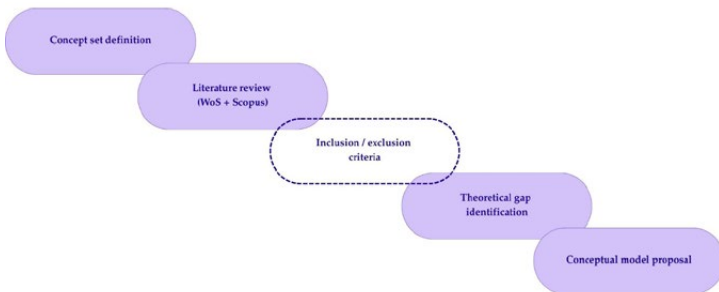
Complementary fit, affordances, and the congruence model provide a critical framework for relating traces to place attachment and territorial belonging. Altman and Low (1992) define one of an individual's fundamental needs in relation to their environment as connecting with the surroundings and feeling a sense of belonging. When considered within the framework of space and place discussions, they state that the fundamental goal for the urban environment, i.e., space, to become a place for the individual is the emotional bond that people establish with their environmental surroundings. De Backer (2022) considers the emotional-affective relationship between the individual and place in attachment to be entirely positive. Place attachment expresses both the emotional and behavioural reflections of the bonds a person forms with their environment. In the context of person-environment fit, the environment providing supplies that meet the individual's need for belonging and place attachment strengthens the individual's attachment to this environment. Edwards (2008) emphasises that a robust theory must explain not only positive/negative relationships but also the mechanisms of these relationships. In this study, the "layer of traces" that emerges through the affordances provided by the urban environment is considered a concrete expression of environmental supplies; the individual's sense of belonging is seen as a fundamental need that corresponds to these supplies. Therefore, traces are not only individual spatial expressions but also complementary supports offered by the environment to the individual. Within this framework, the person-environment fit theory provides the conceptual means to explain the role of traces in place attachment and belonging.

Methodology

A systematic literature review protocol has been developed to identify the intersections between tracing practices and theories of personalisation, place attachment, and person-environment fit. The protocol includes the criteria for selecting the literature to be reviewed, the databases to be used, and the relevant search terminology.

Figure 2.

Methodological Framework



In the literature review, key terms are identified based on the theoretical framework. These concepts form the theoretical components of the trace–personalisation–attachment relationship. The review aims to explore how these concepts intersect and to identify studies addressing tracing practices and their connection to place attachment. Web of Science (WoS) and Scopus databases are preferred within the scope of the research because these two databases are among the most comprehensive indexes in the fields of social sciences, urban studies, architecture, and environmental studies, and are complementary in these areas. Only open-access articles published in English and Turkish were evaluated

from the publications obtained. Subsequently, the fields of study were limited to Urban Studies, Architecture, Social Sciences, Environmental Sciences, Psychology, and Arts & Humanities in WoS and Scopus. The key terms used are listed in Table 1.

Table 1.

Literature review: Conceptual groups and variations

Concept	Key Terms	Search Format
Place attachment	place attachment	“place attachment”
Personalization	personalization, appropriation, “claiming space”, “territorial mark”*, “urban inscription”, graffiti, sticker	personalization OR appropriation OR “claiming space” OR “territorial mark*” OR “urban inscription*” OR graffiti OR sticker*
Affordance	affordance	affordance*
Person-Environment Fit	“person–environment fit”, “P–E fit”	“person–environment fit” hyphenated / non-hyphenated forms
Urban context (limitation)	urban, “public space”, “built environment”	urban OR “public space” OR “built environment”

The quantitative distribution of literature reviewed from the WoS and Scopus databases is presented in Table 2. For conceptual reviews in an urban context, the reason Scopus data produced higher numerical results compared to WoS is that, unlike WoS, it is not possible to directly limit searches to the fields of Urban Studies and Architecture in Scopus.

Table 2.

Quantitative distribution of the literature review

	Web of Science	Scopus
Place attachment + urban context	395	757
Personalization + urban context	294	654
Affordance + urban context	142	231
PE Fit + urban context	7	17
Place attachment \cap Personalization	5	2
PE Fit \cap Affordance	2	5
Personalization \cap Affordance	5	4
Personalization \cap PE Fit	0	1
Place attachment \cap Affordance	10	9
Place attachment \cap PE Fit	9	8

Place attachment and personalisation have been extensively examined in urban contexts. In contrast, research on person–environment fit has primarily focused on older adults and residential settings within gerontology, with limited attention to public spaces and belonging. Personalisation and “urban traces” are typically discussed in terms of aesthetics, vandalism, or regional ownership, without considering their relationship to place attachment.

Consequently, place attachment, personalisation, affordances, and person–environment fit are largely examined in isolation, and not through the lens of tracing practices. The intersections among these concepts, particularly the overlap between place attachment, personalisation, and tracing, are underexplored. Affordances are generally discussed in terms of urban behavioural patterns, while person–environment

fit remains confined to ageing. This reveals a significant gap: there is no comprehensive theoretical framework integrating tracing practices with personalisation, place attachment, and person–environment fit. The literature’s fragmented nature underscores the need for an integrated conceptual approach.

In light of the findings, the research’s main contribution is the development of a conceptual model. The model is constructed by drawing on Gibson’s (1979) concept of affordance, the adaptation formula developed by Carp and Carp (1984), and the place attachment literature (Altman & Low, 1992; Tuan, 1987, as cited in Chylińska & Kosmala, 2023). This approach aims to explain the relationship between the affordances offered by the environment and the way in which an individual’s needs are met through the ‘trace layer’. Methodologically, the systematic validation of the gap in the literature forms the justification for the proposed conceptual model.

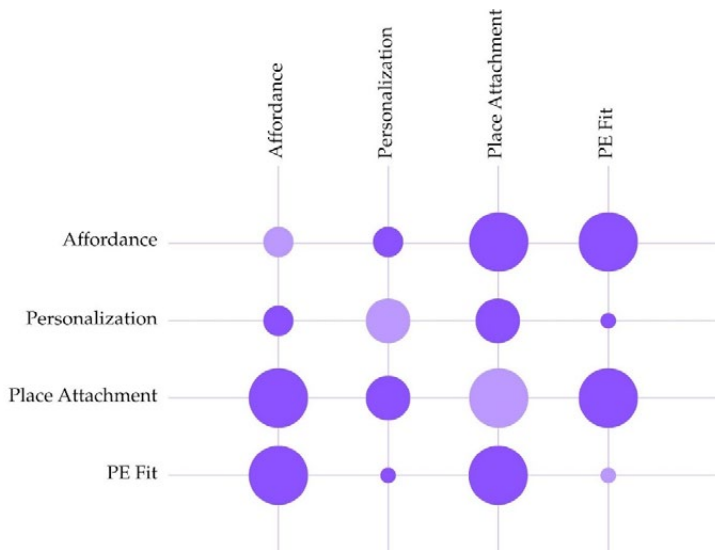
Findings

The literature review conducted has shown that while the concepts of place attachment and personalisation are widely discussed in the context of urban and public spaces, the concepts of affordances and person-environment fit are relatively more limited in the urban context. Figure 1 visualises the intersections of the concepts addressed in the study. It can be seen that person-environment fit theory has been studied quite limitedly in the context of urban and built environments, and that within these limited studies, the

theory's most restricted intersection is with personalisation. Another limited intersection is the intersection between the concepts of affordance and personalisation. Although the other intersection groups obtained are broader than these intersections, they remain quite limited compared to the overall literature. This situation indicates that conceptual integrity is lacking in the literature and that the theoretical explanation of 'tracing practices' as well as the accompanying individual reflections is addressed in a fragmented manner.

Figure 3.

Conceptual intersections



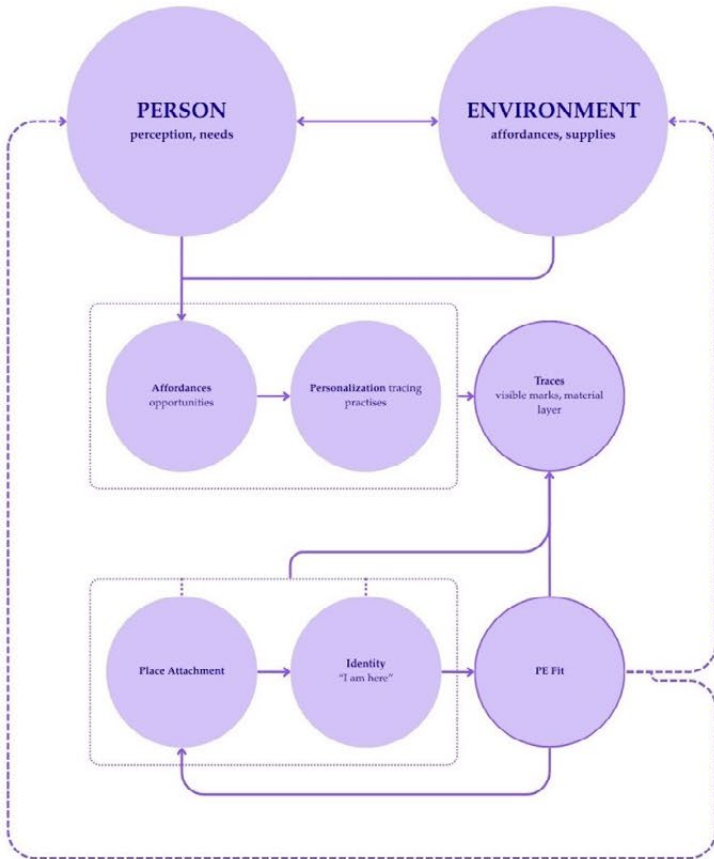
The systematic validation of the literature gap highlights the need to address the theoretical explanation of traces in person–environment relationships within a holistic model. In this context, the relationships established between the concepts of person, environment, affordances,

personalisation, tracing practices, traces, place attachment, and person–environment fit are presented in Figure 2. Conceptually, these relationships appear to operate in a more circular than linear manner. The relationship between the person and the environment is shaped by the affordances offered by the environment to the person and the person’s utilisation of these affordances. The affordances addressed in this study are the personalisation potential in the urban environment, which leads to the creation of traces. When the trace layer formed in the urban space becomes part of the individual’s active environment, it is stored in their memory, adding a different layer to the individual’s connection with the space. As a result of all these processes, the Person-Environment Fit Theory acts as a triggering mechanism in the cycle. The conceptual ties discussed in the theoretical section of the paper form the groundwork for the model developed within the scope of the research.

The model developed to measure the effect of traces on place attachment is proposed within the framework of a set of parameters. These parameters reveal that traces are not merely individual expressions, but also specific outputs of the affordances offered by the environment and the manner in which the individual’s needs are met. The adaptation formula developed by Carp and Carp (1984) has been developed within the scope of this study, taking into account both objective and subjective variables. The PcE component added by Carp and Carp (1984) to Lewin’s formula expresses the extent to which personal needs are met by environmental support. The “Personal Fit Score” proposed in this study is designed in line with a set of

Figure 4.

Conceptual ties



parameters that operationalise the aforementioned PcE component.

$$(1) B = f(P, E, PcE)$$

B= Individual's place attachment

$$P = P_o + P_s$$

P_o: The individual's objective and unambiguous, measurable data (demographic information, time spent in the field, etc.)

P_s: A person's general perception, personal memories

$$E = E_o + E_s$$

E_o: Objective and unambiguous, measurable data of the traces (physical condition, size, type, visibility, etc.)

E_s: The reflection of traces in an individual, formed by their perception

PcE= The individual perceiving traces and assigning meaning to them implies incorporating them into the active environment.

Table 3.

Parameter set

Block	Parameter	Explanation
Traces (E _o)	Type	Identification and classification of trace types
	Permanence	Classification based on the permanence of marks in the urban environment. (Temporary marks such as chalk, permanent marks such as carving and engraving)
	Scale	Small-medium-large scales

Traces (Eo)	Location	Identification of locations where traces are found, such as residential facades, commercial facades, urban furniture, etc.
	Density	Determining the degree of clustering of traces based on the size of the working area
	Visibility	Whether the traces are within the person's field of vision, close to or far from pedestrian movement
	Clustering/ Layering	The formation of traces in the same location being single, separate or overlapping
	Intervention (Conflict)	Whether corporate/individual intervention has been made in the traces
B. Perceptual Mediation (Ps ↔ Eo intersection)	Awareness	The participant sees/perceives the traces Noticed it spontaneously – noticed it when reminded
	Readability	Can the participant understand what consent is?
	Aesthetic Appreciation	Is this trace attractive to the individual?
	Memory	Is there a corresponding entry in the individual's personal memory?
	Character	Does the individual believe that the traces define the space?
	Bonding	Is the individual forming connections with traces?
	Normative/ Legitimate Perception	Does the individual legitimize traces?

C. Attachment (Ps)	Place Attachment	The participant's degree of attachment to the space in question
	Memory	Traces triggering personal/local memory
	Community	Collective ownership statements such as "our street/neighbourhood"
D. Territoriality (Ps + Es)	Community Identity	Is there a scenario where traces create a community identity?
	Belonging	Is the preservation, ownership and normative evaluation of traces visible?
	Identity Bond	Are the traces integrated with the identity of the area?

Personal Fit Score has been developed to measure individuals' interaction with traces and the effect of this interaction on place attachment within the framework of the congruence model and defined parameters. This scoring system corresponds to PcE in Carp and Carp's (1984) model. Within the framework of the Personal Fit Score, the physical and environmental presence of traces is first defined as the Supplies Score (S). The basic parameters in this scoring system are located in the Traces (Eo) block. Although different scoring systems may be developed for each parameter, the same scale should be used for scoring to ensure the overall validity of the result. Secondly, the Mediation Score (M) addresses the relationship between the individual and the environment through the Perceptual Mediation (Ps ↔ Eo) parameters. Due to the highly subjective nature of the parameters, the quality of the interviews conducted with participants is crucial for the calculation of

this score. Thirdly, the Belonging-Territoriality Score (AT) measures the degree to which traces lead to place attachment and ownership. In the parameter set, blocks C and D (Ps and Ps+Es) are designed to reveal belonging, memory layers, and community bonds. Similar to the mediation score, the quality of the interviews conducted with participants is important in calculating this score.

As a result of the Personal Fit Score, there is the potential to generate a 'place attachment layer' on the mapping for each participant. The fact that the 'trace layer' and the 'place attachment layer' either overlap or diverge on the mapping visualises the effect of the traces on the individual's sense of place attachment. This model explains the compatibility between the person's needs and environmental supplies through the traces layer. Thus, concepts that have been addressed in a fragmented manner in the literature are brought together within a holistic theoretical framework. The proposed model offers an applicable research framework for the field and contributes to the conceptualisation of urban traces in the context of personalisation and place attachment.

Discussion and Evaluation

This conceptual model, which allows for the simultaneous consideration of place attachment and traces, brings together concepts that have been discussed in a fragmented manner in the literature within a holistic approach. Wapner and Demick (2002) consider the acceptance of person-in-environment systems as an analytical unit encompassing a person's interactions, experiences, and actions with their

environment as a fundamental assumption consistent with holistic approaches. In this context, linking the trace layer to place attachment provides a theoretical basis for personalisation practices in the context of human-place interactions. Low and Altman (1992) state that the fundamental assumption of spatial belonging and place attachment analyses is that this is a complex phenomenon encompassing various aspects of the human-place bond. This implies that place attachment has many inseparable, complementary, and mutually defining characteristics, qualities, or features; it adds that it is not composed of separate or independent parts, components, dimensions, or factors. In this respect, the developed model fulfils an important conceptual gap in the literature.

This model brings together the concepts of place attachment, personalisation, affordances, and person-environment fit within a common framework. The developed model overcomes the fragmented and disconnected structure between the aforementioned concepts, organising the relationships within a systematic framework and proposing a new theoretical position. Approaches developed in the existing literature focus primarily on measuring individual behavioural outputs, whereas the model developed in this research re-examines the interactions between the person and the environment in a multi-layered manner. By addressing Gibson's (1979) theory of affordances through the concepts of potential and active environment introduced to the literature by Lang (1994), it presents the affordances offered by the urban built environment to the individual, the individual's interventions in the environment through personalisation practices, and the way individual needs

are met through place attachment on the same ground. Within this framework, the person-environment fit theory is conceptualised not only in terms of individual abilities or environmental demands, but also through the formation of traces and processes of attachment. This conceptual framework highlights the model's contribution to theory in two ways:

1. By bringing together concepts scattered throughout the literature on a common ground, it offers a holistic explanation.
2. By focusing on the visibility of concepts considered alongside traces at the spatial scale, it proposes a new conceptual tool for urban design and planning research.

Although the developed model fills a particular gap in the literature, it has certain limitations. The Personal Fit Score included in the model is based on subjective perceptions, which may lead to variability in the results obtained from different sample groups or different spatial contexts. This situation indicates that researchers need to be cautious in their selection of samples rather than reducing the applicability of the model. Considering Lewicka's (2010) place attachment factors, demographic diversity, spatial experience history, and cultural context emerge as factors that can directly influence personal perceptions and, consequently, the layers of belonging produced.

Another limitation is that the model has only been developed at a conceptual level. However, this limitation can be overcome by testing the model's validity through fieldwork in different urban contexts. Fieldwork of the model would contribute to a much broader understanding

of place attachment and tracing practices. As a result of its field application, this model has the potential to form the basis for interdisciplinary research at both conceptual and operational levels.

Conclusion

This study aims to theoretically discuss the concepts of place attachment and personalisation through the layer of individual traces in public spaces and to bring together concepts that have been addressed in a fragmented literature into a holistic and measurable model. The starting point of the research is the idea that the coherence between the person and the environment, the system of needs and supplies, becomes visible at the spatial level through traces.

This research methodologically confirms conceptual gaps in the literature through a systematic review and analysis method, subsequently developing a conceptual model designed to fill these gaps. The developed model combines the concepts of affordance, personalisation, and place attachment within the framework of the person-environment fit theory, explaining how individual practices become visible in urban space and how this visibility reflects back on the individual. This approach offers an original theoretical contribution by establishing a new bridge between concepts that have been studied independently in the literature.

The proposed model, once tested through field research, will contribute to a broader understanding of the role of traces in place attachment. The model developed in this context has the potential to go beyond conceptualisation and lay

the groundwork for interdisciplinary research in the fields of urban design, environmental psychology, and planning. Furthermore, in terms of conceptualising the visibility of individual traces in public spaces, this model offers a new perspective to research discussing how urban policies are shaped through public spaces and urban environments.

References

- Caplan, R. D. (1983). "Person-environment fit: Past, present and future." In *Stress Research*, edited by C. Cooper. London: Wiley.
- Caplan, R. D. (1987). Person-environment FIT theory and organizations: Commensurate dimensions, Time Perspectives, and Mechanisms. *Journal of Vocational Behavior*, 31(3), 248–267. [https://doi.org/10.1016/0001-8791\(87\)90042-x](https://doi.org/10.1016/0001-8791(87)90042-x)
- Carp, F. M., & A. Carp. (1984). "A Complementary/Congruence Model of Well-Being or Mental Health for the Community Elderly." In *Elderly People and the Environment. Human Behavior and Environment*, edited by I. Altman, M. P. Lawton, and J. F. Wohlwill, Vol. 7. Boston, MA: Springer. https://doi.org/10.1007/978-1-4899-2171-0_9.
- Chemero, A. (2003). An Outline of a Theory of Affordances. *Ecological Psychology*. 15. [10.1207/S15326969ECO1502_5](https://doi.org/10.1207/S15326969ECO1502_5).
- Chylińska, D., & Kosmala, G. (2023). The 'I was here' syndrome in tourism: The case of Poland. *Quaestiones Geographicae*, 42(2), 53–68. <https://doi.org/10.14746/quageo-2023-0015>
- De Backer, M. (2022). Between place and territory: Young people's emotional geographies of security and insecurity in Brussels' deprived areas. *Emotion, Space and Society*, 45. <https://doi.org/10.1016/j.emospa.2022.100911>
- Edwards, J. R. (2008). "Person–Environment Fit in Organizations: An Assessment of Theoretical Progress." *The Academy of Management Annals* 2 (1): 167–230. <https://doi.org/10.5465/19416520802211503>.
- Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.

- Kahana, E. (1982). "A Congruence Model of Person-Environment Interaction." In *Aging and the Environment: Theoretical Approaches*, edited by M. P. Lawton, P. G. Windley, and T. O. Byerts, 97–121. New York: Springer.
- Lang, J. (1987). *Creating Architectural Theory; the Role of the Behavioral Sciences in Environmental Design*. Van Nostrand Reinhold. New York.
- Lang, J. (1994). *Urban design: the American experience*. USA: John Wiley & Sons, Inc.
- Lewicka, M. (2010). What makes neighborhood different from home and city? effects of place scale on place attachment. *Journal of Environmental Psychology*, 30(1), 35–51. <https://doi.org/10.1016/j.jenvp.2009.05.004>
- Lewin, K. (1943). "Defining the 'Field at a Given Time.'" *Psychological Review* 50 (3): 292–310. <https://doi.org/10.1037/h0051703>
- Low, S. M., & Altman, I. (1992). Place Attachment. In: Altman, I., Low, S.M. (eds) *Place Attachment. Human Behavior and Environment*, vol 12. Springer, Boston, MA. https://doi.org/10.1007/978-1-4684-8753-4_1
- Mace, V. (2020). *Inhabiting the Public Interior. An Exploration into the Critical Role of Personalisation in Imparting Quality to Public Life*. AMPS Proceedings Series 18.2. *Experiential Design – Rethinking Relations between People, Objects and Environments*, 18 (2).
- Wapner, S., & Demick, J. (2002). 1. In *The Increasing Contexts of Context in the Study of Environment Behavior Relations* (pp. 3–14). essay, John Wiley & Sons, Inc.
- Zhang, Z., Zhang, W., Zhang, S., Chen, Y., Wang, X., Fujii, Y., & Furuya, N. (2024). Person-environment FIT theory in built environment: A scoping review. *Journal of Asian Architecture and Building Engineering*, 24(4), 2447–2463. <https://doi.org/10.1080/13467581.2024.2373824>
- Delso, J. (2017). *The Gum Wall, Seattle*. [Photograph]. Wikimedia Commons. [https://commons.wikimedia.org/wiki/File:The_Gum_Wall_\(Seattle\).jpg](https://commons.wikimedia.org/wiki/File:The_Gum_Wall_(Seattle).jpg)

PART 3

Smart Urbanisms,
Governance, and Spatial
Innovation

Transport Authorities and Innovation: Understanding Barriers for MaaS Implementation in Turkey

Berna alıřkan

Republic of Turkey Ministry of Transport and Infrastructure

ORCID: 0000-0001-9625-3237

Abstract

Mobility-as-a-service (MaaS) is an emerging concept that is gaining global attention. Preliminary research and field tests in developed cities indicate that MaaS has the potential to transform mobility patterns and foster more sustainable transportation networks. However, due to variations in institutional structures, transportation infrastructure, and user preferences, many emerging cities possess unique characteristics that limit the direct transferability of certain services. Consequently, critical questions arise regarding the implementation of MaaS in developing countries, the primary challenges involved, and the appropriate leadership for such initiatives. This study examines public sector involvement and identifies potential barriers that transportation authorities may face. The barriers to MaaS

implementation are categorized as institutional, social, financial, and operational. Selected projects are analyzed based on the challenges encountered during MaaS service implementation. Furthermore, the most significant obstacles are identified in alignment with Turkey's national transport development objectives. The article also reviews key applications, emphasizing governance issues and the role of transport authorities, and provides a roadmap for the adoption of MaaS and related transportation technologies in developing cities.

The MaaS concept offers the potential to provide residents of developing metropolitan areas, such as Istanbul, with convenient, cost-effective, environmentally sustainable, and efficient transportation options. Successful MaaS implementation depends on effective collaboration among government entities, authorities, and industry stakeholders. Despite its advantages, several obstacles may hinder widespread adoption. Key factors identified to mitigate the risk of MaaS system failure during initial implementation phases include data standardization, data sharing and cooperation, payment services and infrastructure, customer acceptance, business models, regulatory frameworks, and financial resources.

Keywords: mobility-as-a-service, mobility, transport development, understanding barriers

Introduction

Mobility-as-a-Service (MaaS) has been extensively studied by academics and practitioners since its emergence as a new transportation concept, and it is regarded as one of the most innovative and disruptive ideas to have developed in the transportation sector over the past decade. MaaS can be considered as a complex ecosystem in which multiple stakeholders with diverse goals collaborate and compete to provide clients with seamless multi-modal packages via a subscription-based digital platform (Cisterna et al., 2023). MaaS is a developing technology, hence it is required to study this phenomenon by combining several approaches from various settings (technology, user behavior) and scientific disciplines (engineering, psychology, economy, etc.) (Rindone and Vitetta, 2024).

Although the term “MaaS” was first used over ten years ago, there is currently no agreed-upon definition of the term. This is in spite of several attempts to define MaaS and its differences, as well as a few commercial MaaS trials and offers in the developed world. Nonetheless, common components of conventional MaaS definitions characterize it as a multimodal user-centric mobility management system in which an integrator consolidates various travel options into a single digital platform that incorporates tickets, payment, booking, and trip planning. According to the authors, MaaS is more than just a digital trip planner; it can work at many spatial scales (local, metropolitan, and regional) and supports sustainable transportation policy objectives (Ho and Tirachini, 2024).

In terms of sustainable development, the United Nations' sustainable development goals emphasize the significance of providing socially sustainable mobility services to all people. Mobility as a Service (MaaS), a new smart mobility concept, can help achieve this objective. Researchers, practitioners, and policymakers continue to struggle with measuring the impact of MaaS on vulnerable social groups including as the elderly, disabled, and low-income individuals (Dadashzadeh et al., 2024).

Filipe and Heath (2023) cited the benefits of MaaS applications in urban areas as follows: Increase the modal share of more ecologically friendly and efficient transportation solutions, Reducing private car use/ownership, improving accessibility, influencing users' travel behavior, social inclusion and equity. Improve citizens' air quality and health. New business models are being introduced, as well as the integration of multimodal transportation into a single platform.

The remainder of this paper is organized as follows. The connection between sustainable urban mobility and Mobility as a Service (MaaS) is explained in Section 2. The obstacles to MaaS implementation are explained in Section 3 and substantial data privacy problems. Section 4 contains the development of MaaS applications in Turkey and suggests an efficient MaaS implementation among public transport authorities, and we addressed the key points and certain important concerns of this topic in Section 5 and final comments are given in Section 6.

Mobility as a Service (MaaS) and Sustainable Urban Mobility

Mobility as a Service (MaaS) has the potential to contribute to sustainable urban mobility in cities. Transport data, such as infrastructure, individual travel patterns, and transport services, is essential for operators and providers of transport services to enhance and modify their offerings in response to consumer demands. However, regulations and processes pertaining to the gathering and sharing of transportation data (making it publicly available and anonymized) should apply to central governments, local governments, and other stakeholders. For instance, one of the key ways that MaaS varies from traditional journey planning platforms is that it gives users access to more information, which can help them make decisions that will ensure their trips go efficiently. One of the primary mechanisms that MaaS differs from conventional travel planning platforms is that it provides users with additional information to assist them make decisions that will guarantee the success of their journeys. MaaS platforms should be able to provide real-time information about events, delays, and congestion that impact the road, public transport, and micro-mobility networks (Dadashzadeh et al., 2024).

Smart mobility, which emphasizes the use of transportation systems to support urban traffic and sustainable mobility, is one of the core principles of the smart city. It is expected that Mobility as a Service (MaaS) would offer a new mobility paradigm that promotes more sustainable and smarter urban futures as this facet develops. Table 1 below summarizes the attributes of smart mobility (Calvo-Mora et al., 2023).

Table 1.*Smart Mobility Attributes*

Attributes	Definition
Flexibility	provides a navigation system that enables customers to select from a variety of transportation options that meet their needs.
Efficiency	offers cost-effective mobility choices with less interruption and short journey times.
Integration	ensures end-to-end route designs for all transportation modalities.
Sustainability	encourages activities that emit fewer carbon gases and are cleaner and more sustainable.
Safety and Protection	enhances the safety of the roads
Social Benefits	provides equitable access to public transportation for all citizens.
Automation	makes it easier to automate every operation.
Connectivity	creates a network of interconnected objects
Accessibility	Is affordable to everyone
User Experience	improves the user experience

Mobility

Mobility, in its simplest form, is the ease and comfort with which people and objects can move. Mobility refers to journeys and the act of making these journeys in pursuit of a goal or desire. Several forms of transportation, including cars, pedestrians, and public transportation, can be used for these trips. Mobility is influenced by the variety of transportation options, the accessibility of high-speed transportation, and the growth of transportation

infrastructure (2023, Çetiner). Any modern civilization must embrace urban mobility. This sector is anticipated to change due to the rise of digital platforms, specialized mobile applications, and new business models based on the sharing economy and access over ownership (shared mobility and Mobility as a Service). From the perspective of multimodal mobility management, it will hasten and encourage the adoption of more efficient and ecologically friendly forms of transportation (Savastano et al., 2023).

Transportation and Sustainability

When considering the characteristics defined for sustainable transportation, it is possible to say that all urban components must be considered as a whole of urban relations. Within this whole of urban relations, transportation plays a crucial role in its impacts such as land use, its radical impact on the spatial environment, and the use of natural resources. Thus, it is now essential to develop strategies and policies for governments in order to develop sustainable transportation systems and to take action, intervening in production, planning, transportation, urbanization, and related issues (Çetiner, 2023).

Mobility as a Service (MaaS)

Many problems arising and stemming from existing transportation habits in cities have necessitated the development of various solutions around the concept of sustainable transportation. One potential solution is the concept of “Mobility as a Service (MaaS). This concept is a current approach whose impact and scope are still

being examined in many cities around the world. However, its potential impact is important for implementing the necessary “paradigm shift” actions required to achieve a more sustainable transportation system in cities (Çetiner, 2023).

The definition of MaaS is as follows: “systems [that] offer consumers access to multiple transport modes and services, owned and operated by different mobility service providers, through an integrated digital platform for planning, booking, and payment.” (Vij et al., 2020). By promoting sustainable travel practices, MaaS, an inventive business model that integrates a variety of different technologies, has the potential to significantly alter the mobility environment. There is still disagreement around the essential components of MaaS platforms for supply and demand actors, despite ongoing initiatives and efforts toward MaaS solutions. The key components of MaaS platforms are examined by Athanasopoulou et al. (2022) from the supply-side perspective of mobility service providers (MSPs) and the demand-side perspective of travelers.

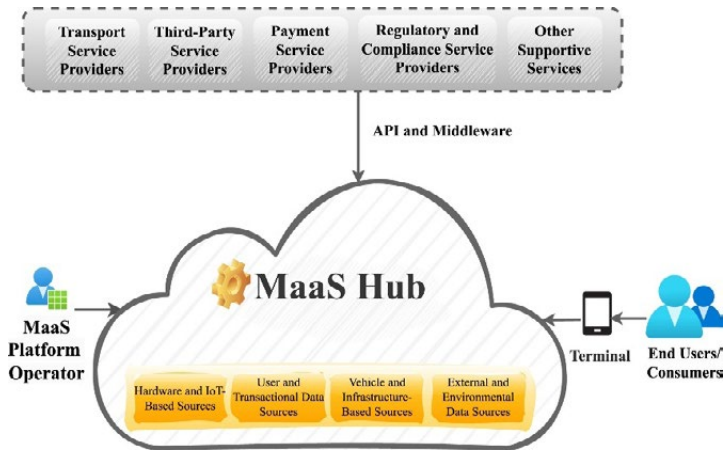
The MaaS Platform Operator is in charge of coordinating the integration of services, data sources, and stakeholders in the MaaS Hub, as seen in Figure 1, which depicts the flow of interactions within a MaaS ecosystem.

The primary entity responsible for service management, data source integration, and stakeholder coordination is the MaaS Platform Operator. The operator makes sure the ecosystem functions properly and offers users a consistent experience.

Public transportation companies, ride-sharing and ride-hailing companies, and micromobility services like bike sharing are examples of transport service providers. Through the MaaS platform, they offer a range of mobility options.

Figure 1.

MaaS Hub



Some features of MaaS that improve the intelligence of transportation are as follows: Bokolo (2023) Multimodal, seamless, customized, single interface, intermodal, data-driven, on-demand, user-centered, simple to use, integration of payments. Jittrapirom et al. (2017) used a literature review to define the fundamental features of the MaaS. There are nine fundamental traits. 1. Integration of transit modes is one of its subtitles. 2. The option of tariffs 3. A single platform 4. Several actors 5. Technology Utilization 6. A focus on demand 7. The need to register 8. Customization 9. Personalization.

Chinbat et al. (2023) outlined the 'Scale', 'Authority and role', 'Data sharing', 'Funding' and 'Current problems' by

distinctions between the central and local administrations. It is crucial to explain how they contribute to the realization of MaaS's advantages.

Piras et al. (2024) conducted a workshop and an online survey with Cagliari mobility service providers, public and private transportation companies, and local public officials. The results of the workshop show a range of viewpoints on Mobility as a Service (MaaS), depending on the type and background of stakeholders. Public administrations employ MaaS to promote intermodality and reduce reliance on automobiles.

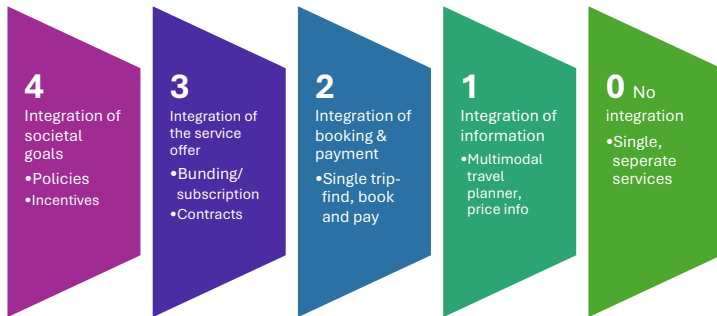
In metropolitan regions, Mobility as a Service (MaaS) allows users to use an app or online service to choose the most efficient method of transportation to reach their location. This eliminates the need for private car ownership while providing seamless charging, reservation, route planning, and time efficiency. Although this is the optimal way for urban transportation in the future, problems such as stakeholder division, data and communication technology, and business model sustainability are hindering full-scale implementation (Slavulj et al. 2023).

According to Smith and Hensher (2020), MaaS is a service that enables users to schedule, reserve, and pay for a variety of mobility services over a common digital channel. Using a MaaS case study, Sochor et al. (2018) integrated MaaS levels, characterizing it as a "integration" level since MaaS combines several modes of transportation into a single service package. See Fig. 2. 'Integration of Societal Goals' was the highest level, 4. The contribution of Level 4 can be summed up as follows: "the added value is reduced private car ownership and use, a more accessible, livable

city, and so on.” The extent to which local, regional, and/or national policies and objectives are integrated into the MaaS service (or individual services, because a Level 4 approach can be integrated at any level) demonstrates the application of incentives. A shift to MaaS could be deemed sustainable if it helps achieve societal objectives, including the need for improved accessibility, less traffic, innovation, and decarbonization of the transportation system. Stated differently, it might be deemed viable to move to MaaS services that incorporate social aims.

Figure 2.

MaaS levels Sochor et al. (2018)



Understanding the Barriers for the Implementation of MaaS

MaaS is a user-focused service model that offers door-to-door mobility choices. This innovative idea has been thoroughly studied and has the potential to change urban travel in a way that is more sustainable. However, there are numerous outstanding challenges and impediments hindering its full implementation.

In countries where public funding for transportation is scarce or nonexistent, MaaS could act as a catalyst for a thorough environmental and equity-seeking reform of transportation pricing. The public sector would have to actively participate in this change, both financially and through regulation. The disorganized, underfunded, and fragmented transportation market found in many developing cities presents MaaS with both potential and challenges. By integrating several services into a single, user-friendly platform that simplifies, expedites, and lowers the cost of daily travel, MaaS offers a chance to generate value for both customers and service providers. Increasing public transit accessibility and utilization with MaaS requires an integrated transportation network that offers passengers an appealing transportation alternative in terms of cost, journey duration, dependability, convenience, and comfort. Most stakeholders, particularly those in developing countries, appear to recognize that one of MaaS's objectives should be to create an integrated transportation network (Ho & Tirachini, 2024).

Kayıkcı and Kabadurmus (2022) defined the barriers (B1, B2, B3, B4, B5, B6, B7) based on a thorough literature review as shown in Table 2. Furthermore, we added 'Data Privacy' barrier to the main list, which is studied by Garroussi et al. (2025).

Table 2.*Identification and definition of barriers*

Barriers	Definition
Unwillingness of transportation operators to collaborate and share data (B1)	Due to competition between partners and insufficient technical conditions, collaboration and data sharing problems may arise between the parties involved. This creates a significant barrier, especially for the private and public sectors in the MaaS ecosystem.
Data standardization (B2)	The different data types and formats received from different sources by different partners and API feeds pose a barrier to seamless integration and simultaneous interoperability.
Labor shortage (B3)	The insufficient trained human resources to be occupied in the MaaS ecosystem
Financial resources (B4)	The limited financial resources (insufficient investment and financial subsidies).
Infrastructure and payment services (B5)	The lack of infrastructures and payment services required for successful MaaS services, such as ICT infrastructure, for data operations and transactions.
Business model (B6)	The lack of a business model for MaaS leads to operational problems and uncertainty in the distribution of roles and profits (or losses).

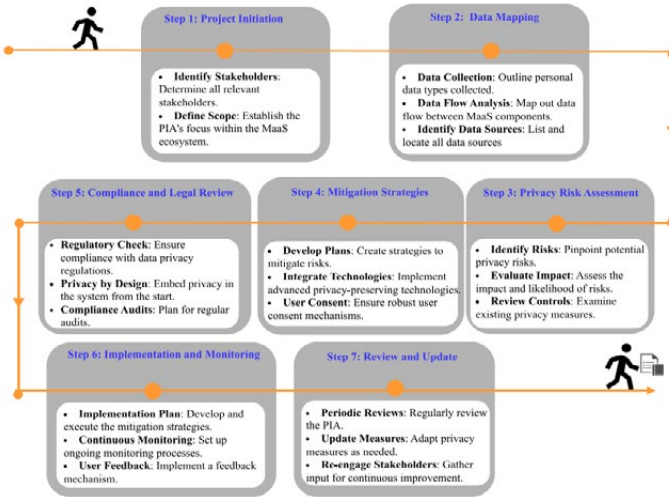
Barriers	Definition
Regulatory framework (Laws, Regulations, and Guidelines) (B7)	The laws, regulations, and guidelines can be a barrier to successful MaaS adoption, such as ticket sales by third parties, subsidization of traffic, the uncertainty of the role of partners, competition laws, etc. In addition, MaaS should be legally supported on issues such as open data standards and security.
Data privacy (B8)	Privacy protection is a critical responsibility for all stakeholders in urban mobility, including users and transportation authorities, to ensure the success and sustainability of MaaS systems.

Three criteria were used by Hasselwander and Bigotte (2021) to identify impediments. These fall into three categories: environmental, organizational, and technological barriers. Lack of experience and uncertainty about roles and responsibilities among the actors in a new, emerging ecosystem; the entrenched structures of transport authorities, their slow decision-making processes, and their lack of creative strategies and integrated planning approaches; a lack of financial resources and funding; complex, non-transparent, and/or non-competitive public procurement practices; the degree of centralization of the transport authority (and subordinated agencies); high economic risks, high marketing costs, and a long time to return on investment; and a lack of ICT expertise are some of these obstacles.

Combining passenger and freight transit under MaaS could enhance its appeal while minimizing negative affects on transportation. Le Pira et al. (2025) investigated the viability of MaaS for Passengers and Freight (MaaS4PaF). The MaaS4PaF concept is a conceptual framework is needed to systematically explore passenger and freight integration in MaaS. MaaS4PaF barriers are 'Behaviour and culture', 'Business model', 'Data management', 'Lack of regulation', 'MaaS-related barriers', 'Privacy concerns', 'Security concerns', 'Service quality', 'Stakeholder roles', 'System complexity', 'Technical feasibility', and 'Technology gap' based on expert answers.

Data Privacy in MaaS

MaaS presents significant data privacy issues in addition to the obstacles discussed in the preceding section. Large volumes of personal data, such as real-time location, travel habits, and preferences, are collected and managed by MaaS platforms. For MaaS systems to be successful and long-lasting, privacy protection is a crucial duty for all parties involved in urban mobility, including users and transportation authorities. One important issue that has not yet received enough attention is striking a balance between preserving user privacy and enhancing service operations through data exchange. Even while privacy-preserving technologies have advanced, research on how to integrate them with managerial, legal, and economic frameworks for an interdisciplinary approach is still lacking. Implementing Privacy Impact Assessments (PIAs) throughout the lifecycle of MaaS systems can assist in detecting and mitigating privacy concerns (see Fig. 3 for a systematic approach) (Garroussi et al., 2025).

Figure 3.*Assessment Steps for data privacy in MaaS*

Modern transportation systems, on the other hand, rely on robust data sources acquired from a wide range of providers and used for a variety of purposes in order for the network to run properly and best serve the interests of its users. The classification of data can be listed as: Data, Private data, Data Exhaust (or passive data), Self-Quantification Data (Cottrill, 2020).

MaaS Applications in Turkey

The Ministry of Transport and Infrastructure developed several decisions and policies to make transportation more sustainable in its publication titled “National Intelligent Transportation Systems Strategy Document and 2020-2023 Action Plan,” prepared in 2020. According to this document,

the mission is to “create a smart transportation network that integrates all modes of transportation, utilizes current technologies, utilizes domestic and national resources, transportation systems should be efficient, safe, effective, innovative, dynamic, sustainable, environmentally friendly and should provide added value” In this regard, five strategic objectives have been identified: “Developing the ITS infrastructure, ensuring sustainable smart mobility, ensuring road and driving safety, creating a livable environment and a conscious society, and ensuring data sharing and security”. Accordingly, various technology-focused solutions have been identified within the scope of smart transportation systems as long-term goals. Some of these include:

- Ensuring that all forms of transportation are integrated in compliance with the standards and the developed ITS architecture.
- Increasing the usage of information and communication technology within cars
- Creating completely autonomous automobiles and extending them to other forms of transportation.
- Carrying out the infrastructure and system work required to transform rail systems’ kinetic energy into green energy.
- Working on legislation pertaining to micromobility, ride-sharing, and other alternative last-mile transportation applications.
- Increasing the application of blockchain technology in freight and logistics services, MaaS, data sharing, and related fields.

- Building an Internet of Things network using ITS components, storing the information gathered from these components in a big data environment, and preparing it for analysis.
- Making use of cutting-edge technology in communications, deep learning, artificial intelligence, and related domains to optimize transportation infrastructure.
- Anonymizing transportation data that has been gathered and utilizing it for study and creative application development.

At the national level, issues such as institutional, physical, and digital integration in transportation, savings, efficiency, utilization of smart transportation systems, use of new technologies, implementation of new solutions, reducing the share of highways in transportation, and developing and promoting environmentally friendly energy-consuming transportation modes are considered important.

Despite the lack of a practical implementation, working groups in Turkey are already creating business models related to MaaS. The Istanbul Metropolitan Municipality is creating a MaaS living laboratory. The Ministry of Transport and Infrastructure in Turkey is working with the Union of Municipalities of Turkey and Intelligent Transportation Systems Turkey (ITS Turkey) to train potential public and private mobility service providers, spread MaaS knowledge, and increase public awareness. Every year, the International Intelligent Transportation Systems Summit (ITS Summit) increases public awareness and advances MaaS knowledge (Kayıkcı & Kabadurmus, 2022).

TRota, which is planned to be Turkey's first domestic and national Level 2 MaaS application; offers users various transportation modes, including intercity and urban public transportation, shared bicycles and e-scooters, and car rental, in a single application. TRota provides real-time data access to transportation data, enabling the MaaS platform to provide users with accurate and up-to-date information about available services, schedules, and locations (İncemehmetoğlu et al., 2024).

In Istanbul, a MaaS application has not yet been created. Nonetheless, some applications for mobile transportation are regularly utilized. To complete different information, payment, reservation, and ticket sales in various modes of transportation, travelers must utilize multiple mobile applications. Table 3 shows the mobile transportation applications used in Istanbul (Çetiner, 2023).

Table 3. Mobile transportation applications used in Istanbul

Trip Planning		Payment		Active Transportation	
Yandex Maps	View trip planning, current or future estimated travel time, transfer options, traffic information, public transport stops, and route information for car, public transport, walking, and e-scooter.	İstanbulkart	Information about your İstanbulkart(s) and data regarding previous trips can be viewed. The application provides balance loading, subscription package purchases, and visa transactions. The application developer is İBB BELBİM.	İSBİKE	You can view the number of bicycles at the bike stops, their location, and purchase digital minutes or annual subscriptions. The app developer is İBB İSPARK
Google Maps	View trip planning, current or future estimated travel time, transfer options, traffic information, and public transport stop and route information for car, public transport, walking, and bicycle.	İstanbulSenin	The "İstanbul Senin" application includes transportation applications such as "İstanbulkart," "Where is My Bus?," "Metro İstanbul," "City Lines," "İspark," "City Map," and "Pocket Traffic." The "Where is My Bus?" application is used through the İstanbul Senin HGS payment	Yürübe	The app developer is İBB Spor İstanbul.
Moovit	View trip planning, current or future estimated travel time, transfer options, traffic information, and public transport stop and route information for public transport, minibus, shared taxi, bicycle, and walking.	HGS	transactions are processed. The application owner is		
Citymapper	View trip planning, current or future estimated travel time, and transfer options for public transport, minibus, shared taxi, Uber, bicycle, and walking.	İSPARK	PTT Parking lot location and occupancy information can be viewed, and debt payments can be made through the app. The app developer is IMM İSPARK.		

<p>Trip Planning</p>		<p>Payment</p>		<p>Active Transportation</p>		
<p>IMM Traffic</p>	<p>View real-time traffic</p>					
<p>IMM City Map</p>	<p>information. Travel planning, current, or future estimated travel times, and transfer options are available for public transportation, minibuses, shared taxis, bicycles, and walking. Bike paths, metro lines, important landmarks, and stops can be viewed on the map.</p>					

Public Transportation		Taxi		Car Rental & Sharing		E-scooters etc.	
				Rentiva	This is a car sharing app. Car sharing can be done hourly or daily, depending on the selected data range and pick-up location.	Palm	
				Bla Bla Car	This is a ride sharing app. Suitable rides can be searched for based on the selected data range and route.	Hey	
				Mart TAG		Rocket Scooter, Scooby, Tazi, Tornet, Volly, Atta Git	

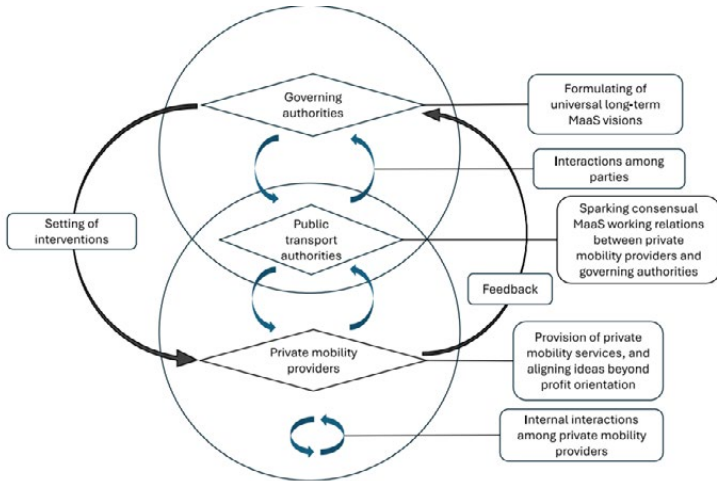
Towards an Efficient MaaS Implementation Among Public Transport Authorities

According to this report, government agencies, private mobility stakeholders, and public transportation authorities must work together for MaaS to be implemented successfully. Figure 4 illustrates the cycle of relationships that Mubiru (2025) proposed between the three main participants in the MaaS implementation process. Public transportation authorities play a key role in fostering MaaS working relationships amongst the other two parties in this framework. The relative obligations of these actors are also outlined. It is recommended that governing bodies develop long-term MaaS initiatives and visions. It is advised that private mobility providers collaborate closely with public transportation authorities to offer mobility services and to allow them to offer input, as this is crucial for integrating their suggestions into the long-term plans developed by governing bodies.

MaaS is a user-centric concept that encompasses various modes of transportation and necessitates physical, digital, and institutional integration. Understanding travel demand, the current transportation structure, and the responsible institutions/actors in transportation is critical for implementing MaaS applications. In developing countries, analyzing journeys and passenger profiles within the transportation system, determining willingness to pay and use potential MaaS applications, and assessing barriers and potential in the context of local characteristics are critical for developing MaaS-related foresight/insight.

Figure 4.

A suggested framework outlining the relationships and duties between MaaS regulating bodies, private mobility stakeholders, and public transportation agencies



Discussion and Evaluation

We perform a descriptive study of the literature, taking into account the following three factors:

(i) the state of the art for Mobility as a Service (MaaS) and Sustainable Urban Mobility; (ii) Understanding Implementation Barriers and MaaS Applications in Turkey; and (iii) a proposed framework outlining the roles and responsibilities of private mobility stakeholders, public transportation authorities, and governing authorities in MaaS.

We primarily concentrate on implementation challenges for the adoption of the mobility-as-a-service concept based

on the literature review. Eight categories—Collaboration and Data Sharing, Data Standardization, Labor Shortage, Financial Sources, Infrastructure and Payment Services, Business Model, Laws, Regulations and Guidelines, and Data Privacy—are used to categorize barriers.

Several working groups are in place to create business models connected to MaaS, despite the fact that there isn't a true MaaS application in Turkey at the moment. In the Istanbul Metropolitan Municipality, a living laboratory for MaaS is now under construction. In the previous section, mobile transportation applications were introduced for trip planning, transportation, car rental & sharing, etc., in Istanbul. In addition, the Ministry of Transportation and Infrastructure of Turkey runs a number of initiatives in partnership with the Union of Municipalities of Turkey and Intelligent Transportation Systems Turkey (ITS Turkey) to educate future public and private mobility service providers, increase public awareness, and disseminate MaaS knowledge.

One of the main points of contention in transportation and mobility studies is the integration of mobility services. The goal of integrating mobility forms is to provide smooth connections between future mobility services and conventional means of transportation. By giving consumers the freedom to select their preferred form of transportation and reimburse their travel costs within a single spectrum, this mobility paradigm seeks to decrease the use of private vehicles in transportation (Mubiru, 2025).

The requirement for secure, computationally efficient, and privacy-preserving solutions is growing as MaaS

platforms get more complicated. Future studies should concentrate on developing algorithms that offer robust privacy protection at the lowest possible computing cost. This is particularly crucial for cloud computing since existing privacy-preserving methods might have a detrimental effect on system performance, including real-time responsiveness and matching accuracy (Garroussi et al., 2025).

Conclusion

Several facets of integrating transportation networks during the transition process have been addressed by transport authorities. To pinpoint the precise MaaS imprints that these authorities left behind throughout their shift, research is still necessary. The purpose of this study is to evaluate transport authorities' participation in MaaS development and suggest ways to increase their involvement in the planning process. MaaS is a sustainable solution that considers economic, social, and environmental aspects. It is expected to change urban transportation systems in this way in the future. However, MaaS implementation is not easy, and it may be less successful for a variety of reasons.

In its publication titled “National Intelligent Transportation Systems Strategy Document and 2020-2023 Action Plan,” the Ministry of Transport and Infrastructure produced a number of decisions and policies to improve the sustainability of transportation. This strategy identifies technology-focused solutions as long-term objectives within the context of smart transportation systems. Expanding the application of blockchain technologies in MaaS, data sharing, freight and

logistics services, and related fields is one of the identified scopes. Çetiner (2023) evaluates the concept of mobility as a service within the scope of sustainable transport, and this thesis states that a MaaS application has not yet been created in Istanbul. Nonetheless, some applications for mobile transportation are regularly utilized. According to Kayıkcı and Kabadurmus (2022), several working groups are in place to create business models connected to MaaS, despite the fact that there isn't a true MaaS application in Turkey at the moment.

The framework of laws and policies is a crucial component in directing the creation and incorporation of cutting-edge services and technologies in urban settings. It includes important factors, including data exchange and standardization, collaborative innovation, and border limitation. To enable a successful MaaS adoption, laws, rules, and guidelines should support MaaS. However, the absence of laws governing data security, open data standards, third-party ticket sales, or traffic subsidies impedes MaaS initiatives in many nations. The national and local legislative framework should be determined, and governmental authorities must actively encourage and fund MaaS projects and pilot initiatives in order to uncover the potential benefits of MaaS growth.

Turkey has made significant efforts to lay the groundwork for the adoption of more sustainable transportation solutions. It is believed that national transportation regulations and mobility strategies in metropolitan cities should be modified in order to deploy innovative sustainable solutions such as MaaS.

References

- Athanasopoulou, A., Deijkers, T., Ozkan, B., & Turetken, O. (2022). MaaS platform features: An exploration of their relationship and importance from supply and demand perspective, *Journal of Urban Mobility*, Volume 2, <https://doi.org/10.1016/j.urbmob.2022.100028>.
- Bokolo, A.J. (2023). Examining the Adoption of Sustainable eMobility-Sharing in Smart Communities: Diffusion of Innovation Theory Perspective. *Smart Cities*, 6, 2057–2080. <https://doi.org/10.3390/smartcities6040095>
- Chinbat, T., Nakamura, F. Matsuyuki, M., & Tanaka, S. (2025). Development and implementation of equity: implication for Mobility-as-a-Service in Japan, *Transportation Research Procedia*, Volume 82, Pages 1436-1451, <https://doi.org/10.1016/j.trpro.2024.12.134>.
- Cisterna, C., Madani, N., Bandiera, C., Viti, F., & Cools, M. (2023). MaaS modelling: a review of factors, customers' profiles, choices and business models. *Eur. Transp. Res. Rev.* 15, 37 <https://doi.org/10.1186/s12544-023-00597-y>
- Cottrill, C. D. (2020). MaaS surveillance: Privacy considerations in mobility as a service, *Transportation Research Part A*, <https://doi.org/10.1016/j.tra.2019.09.026>
- Çetiner, V. (2023). Sürdürülebilir Ulaşım Bağlamında Hizmet olarak Hareketlilik (Mobility as a Service-MaaS): İstanbul. <https://polen.itu.edu.tr:8443/server/api/core/bitstreams/1f4a655f-9453-409e-ad59-ba7bbae0bf16/content>
- Dadashzadeh, N., Sucu, S., Pangbourne, K., & Ouelhadj, D. (2024). Socially Sustainable Mobility as a Service (MaaS): A practical MCDM framework to evaluate accessibility and inclusivity with application, *Cities*, Volume 154, <https://doi.org/10.1016/j.cities.2024.105360>.
- Filipe, R. P., & Heath, A. (2023). Impacts of Implementing Mobility as a Service in Urban Areas – A Systematic Literature Review, *Transportation Research Procedia*, Volume 72, Pages 179-186, <https://doi.org/10.1016/j.trpro.2023.11.392>.

- Garroussi, Z., Legrain, A., Gambs, S., Gautrais, V., & Sansò, B. (2025). A systematic review of data privacy in Mobility as a Service (MaaS), *Transportation Research Interdisciplinary Perspectives*, Volume 31, <https://doi.org/10.1016/j.trip.2024.101254>.
- Hasselwander, M., & Bigotte, J. F. (2022). Transport Authorities and Innovation: Understanding Barriers for MaaS Implementation in the Global South, *Transportation Research Procedia*, Volume 62, Pages 475-482, <https://doi.org/10.1016/j.trpro.2022.02.059>.
- Hasselwander, M., & Bigotte, J.F. (2021). Transport Authorities and Innovation: Understanding Barriers for MaaS Implementation in the Global South, *Transportation Research Procedia*, https://www.researchgate.net/publication/359181273_Transport_Authorities_and_Innovation_Understanding_Barriers_for_MaaS_Implementation_in_the_Global_South
- Ho, C. Q. & Tirachini, A. (2024). Mobility-as-a-Service and the role of multimodality in the sustainability of urban mobility in developing and developed countries, *Transport Policy*, Volume 145, Pages 161-176, <https://doi.org/10.1016/j.tranpol.2023.10.013>.
- <https://doi.org/10.1016/j.tranpol.2022.10.015>.
- İncemehmetoğlu, K. N., Tuğlu, K., Çoşkun, Ö., İrdam, Ö. M., Avcı, İ., & Kınacı, B.F. (2024). Türkiye'nin MAAS Platformu İçin Veri ve Ödeme Yöntemi Standardizasyonu. *Akıllı Ulaşım Sistemleri Ve Uygulamaları Dergisi*, 7(2), 286-303. <https://doi.org/10.51513/jitsa.1520992>
- Jittrapirom, P., Caiati, V., Feneri, A., Ebrahimigharehbaghi, S., Alonso-González, M., & Narayan, J. (2017). Mobility as a Service: A Critical Review of Definitions, Assessments of Schemes, and Key Challenges, *Urban Planning*, Vol 2, No 2 (2017): Smart Cities – Infrastructure and Information, <https://www.cogitatiopress.com/urbanplanning/article/view/931>
- Kayıkci, Y., & Kabadurmus, O. (2022). Barriers to the adoption of the mobility-as-a-service concept: The case of Istanbul, a large emerging metropolis, *Transport Policy*, Volume 129, Pages 219-236,
- Le Pira, M., Giuffrida, N., Tapia, R., Tavasszy, L., Correia, G., Pilla, F., Ignaccolo, M., & Inturri, G. (2025). Exploring the feasibility

- of Mobility as a Service (MaaS) for integrated passenger and freight transport through a Delphi survey, *Transportation Research Procedia*, Volume 90, Pages 559-566, <https://doi.org/10.1016/j.trpro.2025.06.107>.
- Mubiru, I. (2025). Investigating the involvement of public transport authorities in MaaS developments, *Transportation Research Interdisciplinary Perspectives*, Volume 29, <https://doi.org/10.1016/j.trip.2025.101337>.
- National Intelligent Transportation Systems Strategy Document and 2020-2023 Action Plan, <https://www.uab.gov.tr/uploads/pages/bakanlik-yayinlari/ulusal-akilli-ulas-im-sistemleri-strateji-belgesive-2020-2023-eylem-plani-eng.pdf>
- Piras, F., Scalas, A., Sottile, E., & Meloni, I. (2025). Drivers and barriers of Mobility-as-a-Service: insights from stakeholders of a middle-size Italian city, *Transportation Research Procedia*, Volume 90, Pages 959-966, <https://doi.org/10.1016/j.trpro.2025.06.017>.
- Rey-Moreno, M., Perriñez-Cristóbal, R., & Calvo-Mora, A. (2023). Reflections on Sustainable Urban Mobility, Mobility as a Service(MaaS) and Adoption Models. *Int. J. Environ. Res. Public Health* 2023, 20,274. <https://doi.org/10.3390/ijerph20010274>
- Rindone, C., & Vitetta, A. (2025). Mobility as a Service towards sustainability: pilot experiments and user choice analysis, *Transportation Research Procedia*, Volume 90, Pages 1007-1014, <https://doi.org/10.1016/j.trpro.2025.06.011>.
- Savastano, M., Suciú, M., Gorelova, I., & Stativa, G. (2023). How smart is mobility in smart cities? An analysis of citizens' value perceptions through ICT applications, *Cities*, Volume 132, <https://doi.org/10.1016/j.cities.2022.104071>.
- Slavulj, M., Šojat, D., Prskalo, H., & Vidan, L. (2023). An Overview of the Current State of Mobility as a Service, *Transportation Research Procedia*, Volume 73, Pages 212-219, <https://doi.org/10.1016/j.trpro.2023.11.910>.
- Smith, G., & Hensher D. A. (2020). Towards a framework for Mobility-as-a-Service policies, *Transport Policy*, Volume 89, Pages 54-65, <https://doi.org/10.1016/j.tranpol.2020.02.004>.

- Sochor, J. Arby, H., Karlsson, I.C. M., & Sarasini, S. (2018). A topological approach to Mobility as a Service: A proposed tool for understanding requirements and effects, and for aiding the integration of societal goals, *Research in Transportation Business & Management*, Volume 27, Pages 3-14, <https://doi.org/10.1016/j.rtbm.2018.12.003>.
- Vij, A., Ryan, S., Sampson, S., & Harris, S. (2020). Consumer preferences for Mobility-as-a-Service (MaaS) in Australia, *Transportation Research Part C: Emerging Technologies*, Volume 117, <https://doi.org/10.1016/j.trc.2020.102699>.

Reimagining the Role of Skopje Aqueduct in Contemporary Urban Life

Mimoza Klekovska

Municipality of Karpos, Skopje, North Macedonia
ORCID: 0009-0009-1916-7808

Jasna Grujoska-Kuneska

International Balkan University, Skopje, North Macedonia
ORCID: 0009-0007-7875-8136

Arbresha Ibrahim

International Balkan University, Skopje, North Macedonia
ORCID: 0009-0008-3502-6901

Abstract

The Skopje aqueduct is a remarkable artistic and architectural achievement, believed to have been constructed during the first half of the 6th century. It represents the unique example of its kind in the Republic of North Macedonia, and one of the few in the Balkan region. As a well-designed and appropriately positioned structure, it played a key role in the water supply and functioning of the city for several centuries. Today, the aqueduct is a significant part of the cultural heritage in the country, standing as a physical link to the past civilizations and reflecting their advanced engineering skills and capacity to meet the urban needs over time. Despite its substantial architectural, cultural, and historical significance, the aqueduct is not treated appropriately, and the current condition is not enviable,

remaining partly separated from the urban life of Skopje. Through the years, the surrounding area of the Skopje aqueduct has undergone certain developmental changes. Located in the Vizbegovo area, the aqueduct is now gradually integrated into the city's urban landscape and faces the growing urban pressure, which can be seen as both a threat and an opportunity for positive transformation of the site. According to the Directorate for the Protection of Cultural Heritage, this monument has its place in the Register of documented immovable cultural heritage, and in accordance with the General Urban Plan of the City of Skopje, a document named Protective and conservation foundations has been elaborated for it, developed by the National Conservation Center - Skopje. This paper investigates the potential of the Skopje aqueduct to be effectively integrated into the urban fabric of the city, as an important component of its identity. It proposes a balanced approach that respects the significance of the site and developmental needs, highlighting the importance of careful planning, effective zoning, and adaptive reuse. Through different case studies, it showcases the role of heritage sites in fostering sustainable urban development.

Keywords: Skopje aqueduct, cultural heritage, urban integration, sustainable development, heritage preservation

Introduction

Urban heritage plays an important role in contemporary societies. It creates a tangible connection to our past, provides a sense of social identity, and can be seen as a resource for sustainable and economic development. Historic structures such as aqueducts, viaducts, bridges, etc. are living witnesses of the engineering and architectural achievements of our ancestors, revealing the knowledge and skill of past societies. When properly conserved and treated, they have the potential to become significant elements and enhance the character of modern urban environments.

The Skopje Aqueduct is a remarkable cultural monument in North Macedonia, commonly believed to date from the 6th century. (Institute for protection of cultural monuments of N. Macedonia, 2021). It is the unique example of its kind in the country and one of the few preserved in the region. Once representing a vital water-supplying system, the aqueduct, for a long time, has been disconnected from the social life of the city, located in a semi-urban zone. Following successful precedencies such as the aqueduct Pont du Gard in France or Bennerley viaduct in the UK, this paper aims to explore the possibilities for the Skopje aqueduct to be reimagined within the urban fabric of the city. By exploring its historical context, zoning framework, current condition, and significance, it identifies the opportunities and challenges of this approach, establishing a connection between the preservation needs and use.

Historical Context and Heritage Value

The Skopje Aqueduct is a remarkable example of ancient engineering achievements. It's a monumental structure of the 'single-story above-ground aqueduct' type, preserved along its entire length of 385.80m, fig. 1. It consists of 54 arches constructed using a combination of stone blocks and bricks and supported by sturdy piers, two ramps (north and south) and the water channel structure, (Institute for protection of cultural monuments of N. Macedonia, 2021). Its construction date still remains widely debated and links to three possible periods: Roman (1st or 2nd century), Byzantine (527-565), or Ottoman period (16th century). Carefully planned and positioned, the aqueduct was designed to transport water from a distant source to the ancient city of Scupi, playing a vital role in the functioning of the city over several centuries. Throughout history, the aqueduct underwent significant changes. Its primary function continued during the Ottoman period, serving as a vital water supply for the numerous baths. Over time, as the city expanded and new water systems emerged, the use of the aqueduct gradually diminished and remained in use until 1915, after which it fell into neglect (History Tools, 2024).

Figure 1.

Skopje Aqueduct



It seems the aqueduct was forgotten until the mid-20th century, when it began to attract attention again. In 1952, the aqueduct became protected property by the decision issued by the Republic Institute for the Protection of Cultural Monuments, Skopje, and this status was confirmed in 1967 by the Institute for the Protection of Cultural Monuments of the city of Skopje (Institute for protection of cultural monuments of N. Macedonia, 2021). During the second half of the past century, the aqueduct sustained some damage (fig. 2) – collapse of three arches and two pillars, which were repaired soon afterwards (Volcev et al., 2023).

Figure 2.

Historical damages to the aqueduct, (MARX, 2016)



Today, the aqueduct is recognized as a vital part of the cultural heritage in North Macedonia. Acknowledging its exceptional values and unique character, in 2019, the aqueduct attracted special attention and several field surveys, and studies were conducted by the expert teams, revealing its existing condition (NI Conservation Center - Skopje,

2023). Damages were observed along the entire length of the aqueduct, in the form of cracks, material degradation, absence of wooden ties in some columns, presence of vegetation, etc. These damages are attributed to three main factors: changes in the stress–strain state of the structure, atmospheric influences, and human neglect (Volcev et al., 2023). Consequently, conservation and restoration activities began in 2021, initially involving drainage of the site and directing the water (atmospheric and infiltrated groundwater) beyond the boundaries of the marked zones, and reinforcement and stabilization of the inclined and damaged pillars (NI Conservation Center - Skopje, 2023). In the same year, upon the proposal of the Office for Protection of Cultural Heritage and the opinion of the National Council for Cultural Heritage in 2021, the aqueduct was declared as a cultural heritage monument of exceptional importance, subcategory of outstanding significance, which ensures its permanent preservation (Institute for Protection of Cultural Monuments of N. Macedonia, 2021).

The aqueduct embodies a wide range of values that cover much more than its initial purpose. The aqueduct has been preserved along its entire length, with a high level of *authenticity* in its structural and other elements. Representing the traditions and social practices of the community, the aqueduct carries important *cultural* values. Its impressive architecture is a synthesis of functionality and aesthetics. The inclined route of the aqueduct is particularly interesting, as it required additional skills from the builders to ensure an uninterrupted flow of water, which highlights both its *architectural and engineering* value. The *historical* value derives from its age, providing insight into the engineering

and urban planning skills of past societies, which also strengthens its *educational* value. As a valuable *landscape* asset that enriches the character of the surroundings, the aqueduct can be seen as a spatial framework for cultural gatherings, which can potentially increase its *social* value.

Comparative Case-Studies

Bennerley Viaduct in the UK

Bennerley viaduct is an iconic industrial heritage located in the East Midlands, UK, and one of the two of its kind preserved in the county. It's a 442m long iron structure, opened to trains in 1878 as part of the old Nottingham to Derby 'Friargate' railway line. The viaduct was in use until 1968 and then was out of use for more than 50 years, until 2022, when it was reopened for walking and cycling. The restoration of the viaduct, which followed a detailed field survey, involved: repairing ironwork, piers, and parapets, construction of a new ramp on the western end, and installation of a new deck. Beneath the viaduct, volunteers had created a wildlife corridor, a place for people to spend more time in nature, (Bridge Design and Engineering, 2020). The adaptive reuse of the viaduct (fig. 3) transformed the structure into a vibrant public space and surpassed the gap between heritage preservation and sustainable development.

Diocletian Aqueduct in Croatia

The Croatian aqueduct near Split (fig. 4) was built at the same time as Diocletian's Palace, in the late 3rd century, early 4th century. It is 9 km long, and it was in use for 2-3 centuries. After that period, the aqueduct was inactive for 13 centuries before being restored for use during the Austro-Hungarian period. A characteristic of this aqueduct is that one part of it is in underground arches (tunnels) carved directly into the rocks. Due to a typhus epidemic in 1948, the use of that water stopped (ceased). Nowadays, the City water supply company uses some tunnels to throw excess water into them. The City of Split's plans are to include this aqueduct in the city's tourist offer (Crolove.pl, 2022).

Figure 4.

Underground part of the Diocletian aqueduct near Split, Croatia, (Crolove.pl, 2022)

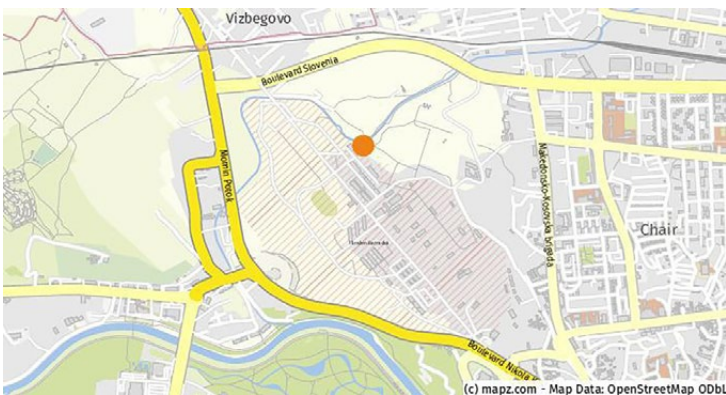


Positioning the Skopje Aqueduct Within the Urban Fabric of the City

The Skopje aqueduct is woven into the urban fabric of the city, a few kilometers far away from its center in the urban district SSI 03, defined by the traffic routes: to the north - city highway – Boulevard Slovenia, - to the east - city highway Macedonia Kosovo Brigade Boulevard, - to the south and west it is tangential to the transit highway Nikola Karev Boulevard, fig. 5. The largest part of the area covered by the subject quarter SSI 03 is located in the municipality of Karposh, while some parts belong to the municipalities of Butel and Chair. The distance from the center of the city of Skopje is about 3.5 km in a northwestern direction, and the altitude ranges from 261.22 to 276.14 m. The entire quarter covers an area of 2553340,38 m², gathered in a perimeter of 6754,2072 m², and the more limited area of the aqueduct is 867,37 m² (0,08 ha).

Figure 5.

Location of the Skopje Aqueduct (Mapz, 2025)



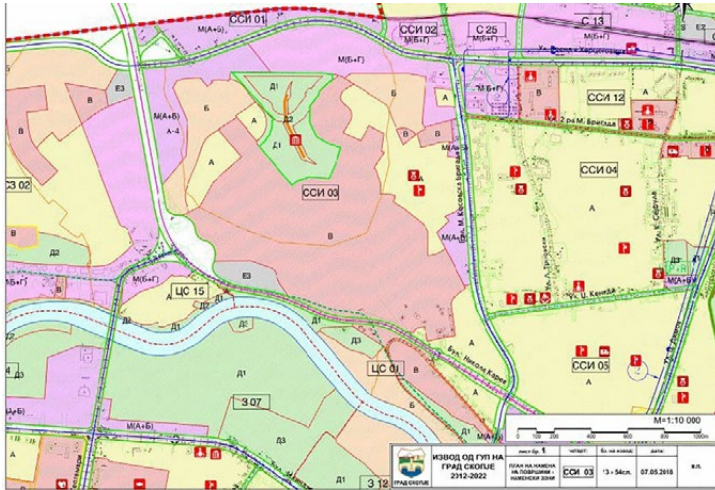
As an immovable cultural heritage of the highest rank, according to the Law on Spatial and Urban Planning, different planning standards and recommendations have been established to protect cultural monuments, as well as guidelines for determining the regime for their protection. To develop these measures, the Directorate for the Protection of Cultural Heritage was consulted, in accordance with the General Urban Plan (GUP) of the City of Skopje, which incorporates the Basic Protective-Conservation Principles (No. 07-80/41 dated 31.08.2012) prepared by the National Conservation Center – Skopje, and approved by the Directorate with a Decision (UP No. 17-753 dated 13.09.2012) (Built Urban LLC, 2020).

For the cultural monument – the Aqueduct, the strict boundary line of the good is defined, together with its contact zone, category, protection regime of the monument itself, and the protection regime of its contact zone. In the designated quarter SSI 03, the following main classes of purposes are represented (fig. 6):

- V4 - State institutions, specifically complexes and facilities of the Ministry of Defense – Ilinden barracks,
- V1 - Education and science, and
- V3 - Culture. The representation of engaged area under the main class of purpose Class V4 (State institutions) in the quarter SSI 03 occupies an area of approximately 172.18 ha or 67% of the total area of the urban scope of the quarter. Within the Regulatory Plan of the GUP of the City of Skopje 2012-2022 for quarter SSI 03, there is also a higher education facility, specifically the facility of the International Balkan University (Agency for Spatial Planning, 2019).

Figure 6.

Plan for purpose-specific zones for quarter SSI 03, 2012-2022 (Agency for Spatial Planning, 2019)



The Regulatory plan of the GUP of the City of Skopje 2012-2022 for the SSI 03 quarter has been developed in order to enable spatial development, regulation, and protection of the territory of the City of Skopje, providing the necessary spatial conditions for its rational planning, and the possibility for its operationalization through lower-level planning documentation. This type of plan should achieve a physical, functional, economic, aesthetic, and coherent whole (platform) that will stimulate the humanization of living and working conditions; set a high standard for intercepting (satisfying) cultural needs and the needs for rest, recreation, and a healthy environment, and organize a quarter that will facilitate balanced development of the municipality to which it belongs as well as of the City of

Skopje based on criteria grounded in the principles of sustainable development (Agency for Spatial Planning, 2019).

In the entire urban district - SSI 03 and the city as a whole, the Aqueduct stands as a transcendence, a reminiscence of the past in the present urban living, and evokes life-giving, reincarnation into another urban function. If, according to ancient, primal criteria, the value of an object is evaluated based on fact whether it meets the three Vitruvian criteria, the triad of construction, function, and aesthetics (*venustas*, *utilitas*, and *firmitas* - represents central goals and normative values of architecture), it can be said that the Skopje aqueduct has confirmed this triad over the centuries. The aqueduct still has the potential to meet the urban criteria of a successful place described in the book *Responsive Environment* (McGlynn et al., 2013). These are: permeability, variety or range of use, legibility or recognizability, and robustness. It also has the capacity to meet other qualities such as visual appropriateness, richness or generosity in appearance, and personalization. It is our human (moral) duty and social responsibility of every conscientious state to put effort into achieving/maintaining these targets.

Probably one of the reasons for the urban indifferent treatment of the Skopje aqueduct is the complex property-legal conditions in its placement. As a public good of the highest order, the main goal is to be equally accessible to all. Therefore, the residential zone should be at a 'reasonable' distance, with an emphasis on public functions and well-maintained urban greenery, which is the most relaxing available function. It is recommended to use non-invasive methods of landscaping and to improve accessibility for pedestrians.

Vision and Urban Reintegration Concept

Despite its importance, the aqueduct has long been disconnected from the social urban life of the city. This study explores the possibilities for reintegrating the aqueduct into the urban fabric of the city, re-envisioning it from an isolated monument into a significant landscape asset. This concept employs international precedents such as Pont du Gard in France, Bennerley Viaduct in the UK, and Diocletian Viaduct in Croatia and applies them within the cultural and spatial context of the city of Skopje. The aqueduct was studied through a time-based perspective: its historical context, current meaning, and future potential for adaptive reuse and long-term urban integration.

The concept is based on a multi-layered approach that includes enhancing the public accessibility, environmental integration, and community engagement of the aqueduct, fig. 7. It suggests walking paths along the aqueduct, placed at a safe distance from the structure that connects the monument with the surrounding urban complex. Along with the designed spots for rest, these paths provide continuous visibility of the structure and make it an integral part of daily life. At distances of 30-40m, there are extensions on these paths supplied with urban equipment (resting points), where visitors can sit and peacefully observe. The extensions are on both sides of the pedestrian paths, but alternately (zig-zag) placed so as not to obstruct each other's view. The view, framed in each arch of the aqueduct in the form of a vista, reaches into the distance and creates beautiful visual experiences.

Replacing the damaged greenery with native vegetation can potentially create inviting spaces as picnic or garden

spots, framed by the arches of the aqueduct, creating shaded areas for social interaction. Moreover, the aqueduct can be seen as a spatial framework for cultural gatherings, such as seasonal festivals, allowing the people to enjoy the events while appreciating the monument's significance. By using the nearby open spaces and minimal urban installations that respect the site, the aqueduct can be transformed into a valuable landscape asset.

Figure 7.

Skopje aqueduct project elements



This concept aims to reintegrate the aqueduct within the city context as an important heritage landmark that reflects memories from the past and makes a reconnection with people and nature, while respecting its values and meaning. Thus, this space will be tailored to accommodate the different ages and temperaments of visitors, where everyone will find their own distance of communication, just as Jan Gehl states in his book 'Cities for People', (Gehl,

2010) “A place that can be simultaneously close to people and distant from them”.

Conclusion

Urban elements in cities are created to function and to endure. They often outlast individual architectural structures. The Skopje Aqueduct has functioned and lasted for centuries. Its prominence lies in the fact that it is among the very few aqueducts that do not follow a straight line, but have a deviation in their path. It used to function in times when water was supplied to the ancient settlement of Scupi and later when the city was relocated to Kale. If today it stands only as a monument, its revitalization and repurposing into a recreational zone would represent its third reincarnation. The aqueduct may not be the most prominent landmark of the city, as the Stone Bridge takes precedence, but it is certainly like a Phoenix, capable of long-lasting function and always reviving within the urban fabric of the city. Thus, it satisfies and confirms even the most stringent architectural and urban planning criteria for a monument of the highest rank.

References

- Agency for Spatial Planning. (2019). *Regulatory Plan of the General Urban Plan (GUP) of the City of Skopje 2012–2022 for Quarter SSI 03, Planning Period 2018–2022*.
- Bridge Design and Engineering. (2020). *Iron Giant*. Bridge Design and Engineering. Retrieved August 24, 2025, from <https://www.bridgeweb.com/Iron-giant/7414>
- Built Urban LLC. (2020). *Detailed Urban Plan (DUP) for City Quarter SSI 03, Block SSI 03.02, Municipality of Karpoš and Municipality of Butel, Skopje (Planning Period 2020–2025)*.
- Crolove.pl. (2022). *Underground part of the Diocletian's Roman aqueduct in Split*. Retrieved August 28, 2025, from <https://crolove.pl/underground-part-of-the-diocletians-roman-aqueduct-in-split/>
- Gehl, J. (2010). *Cities for people*. Island Press.
- History Tools. (2024). *The Skopje Aqueduct: A Testament to Ancient Engineering in Macedonia*. Retrieved August 22, 2025, from <https://www.historytools.org/stories/the-skopje-aqueduct-a-testament-to-ancient-engineering-in-macedonia>
- Institute for protection of cultural monuments of N. Macedonia. (2021). *The Aqueduct Monument in Skopje has been declared cultural heritage of particular importance, subcategory: of exceptional significance*. Retrieved August 22, 2025, from <http://uzkn.gov.mk/аквадуктот-во-Скопје-е-прогн/>
- Mapz. (2025). Mapz Visualization Platform. Retrieved August 28, 2025 from <https://www.mapz.com/>
- MARX. (2016). *Skopje aqueduct/6th century*. Retrieved August 27, 2025 from <https://marh.mk/skopskiot-akvadukt/>
- McGlynn, S., Smith, G., Alcock, A. & Murrain, P. (2013). *Responsive Environments* (I. Bentley (Ed.)). Routledge. <https://doi.org/10.4324/978080080516172>
- NI Conservation Center - Skopje. (2023). *Projects*. Retrieved August 23, 2025, from <https://www.nukcs.mk/category/проекти/>
- Pont du Gard. (n.d.). *Preserving the landscapes of the Pont du Gard*. Retrieved August 25, 2025, from <https://pontdugard.fr/en/preserve?utm>

UNESCO World Heritage Center. (n.d.). *Pont du Gard (Roman Aqueduct)*.

Retrieved August 25, 2025, from <https://whc.unesco.org/en/list/344/>

Volcev, R., Postolov, N., Todorov, K. & Lazarov, L. (2023). Overview of the damages to the Aqueduct in Skopje, original: Преглед на оштетувањата на аквадуктот во Скопје. *20th International Symposium, MASE*.

Williamson, D. (2019). *Viaduct set to reopen for the first time in 50 years*. The Friends of Bennerley Viaduct. Retrieved August 24, 2025, from <https://www.bennerleyviaduct.org.uk/viaduct-set-to-reopen-for-the-first-time-in-50-years/>

Digital Governance and Urban Space Production: Smart City Applications on the Examples of Istanbul, Barcelona, and Amsterdam

Hatice Savaş Demir

Istanbul Beykent University, Engineering-Architecture Faculty,
Interior Architecture Department
ORCID: 0000-0003-0189-3544

Abstract

Digitalized cities offer new opportunities not only in terms of governance models but also in terms of spatial decision-making and design processes. Open data systems, geographic information platforms, and digital participation tools include new actors in planning, urban design, and architectural project design processes, while creating alternative models that increase transparency and participation in the production of space. This study aims to reveal the effects of data-driven smart city applications on the production, design, and use of urban space, not only in governance processes, but also in how digitalization transforms participatory urban design processes. In this study, the effects of data-driven smart city applications on architecture and urban design are comparatively examined through

the examples of Istanbul, Barcelona, and Amsterdam. The extent to which and how citizens can be involved in spatial decision-making processes through digital platforms, open data portals and geographic information systems used in all three cities are analyzed; the reflections of data-driven governance on the physical environment are discussed. In addition, how digital technologies enable the visualization, discussion and redesign of spatial scenarios at the urban scale is evaluated. This study argues that well-designed digital governance models in the context of architecture and urban planning can implement democratic, accountable, and inclusive policies, empowering citizens to have a say in shaping the future of the cities they live in. However, having digital governance models alone does not guarantee the implementation of participatory policies in the architectural and urban design processes of a city.

Keywords: smart city, digital governance, participatory design

Introduction

In recent years, with the digitalization of public services and the development of smart city applications, urban and spatial decision-making processes have also begun to be digitized. Web-based platforms and mobile applications have been developed that support citizen participation in spatial decision-making processes in their cities. While some of these platforms and applications are projects developed by private companies, there are also systems developed by local governments.

This study comparatively examines the impact of smart city systems developed and implemented by local governments in Barcelona, Amsterdam, and Istanbul on architecture, urban design, and citizen participation. In all three cities, the extent to which citizens can participate in spatial decision-making processes and the information they can access through web-based digital platforms and mobile applications is analyzed and compared. The study argues that the presence of digital participation tools alone does not ensure participatory design. The accessibility of digital participation tools, which actors are included, and which decisions they can influence, all influence the success of digital participation tools.

Conceptual Framework: Digital City, Data, and Participation

The impact of digitalization on urban management is currently being evaluated within the framework of the smart city concept. The smart city approach not only equips cities with advanced technological equipment but also features concepts such as data-driven decision-making, citizen participation, community engagement, transparency, and accountability in urban governance. The smart city concept aims to improve urban services by relying on intensive digital data collection and analysis, aims for sustainable development and quality of life, and focuses on the needs of citizens (Helbing et al., 2024).

A data-driven design approach in digital city governance generates a data-guided process at every phase, from

defining urban problems to advancing solutions. Data collected through smart city technologies can transmit the real-time status, needs, and requests of the city and its residents to architects and urban planners. This data allows architects and urban planners to develop more accurate design solutions according to the needs of the city and its residents. Digital replicas of urban spaces can be created using Geographic Information Systems, 3D city models, and digital twin technologies. Digital city models ease the visualization of design alternatives by architects and urban planners and create a common platform where actors from different fields, such as citizens and experts, can speak the same language. Publicly accessible digital twins and geographic information systems increase inclusiveness by providing access to urban data across diverse actors. This allows for more participatory, transparent, and data-driven processes in architectural and urban design projects (De Filippi & Cocina, 2022).

Citizen participation in urban planning has been on the agenda both in theory and practice since the mid-1900s. Arnstein's ladder of participation theory (1969) defines citizen participation as the redistribution of power and the inclusion of disadvantaged groups in decision-making processes (Arnstein, 1969). While traditional participatory design approaches involve participants in decision-making processes through various surveys, meetings, workshops, and face-to-face meetings, digital platforms, referred to in the literature as e-participation or e-design, allow for greater reach and facilitate participatory decision-making processes (Hodson et al., 2020). Thanks to online platforms and mobile applications, citizen participation in spatial

decision-making processes in their cities has become more accessible, inclusive, and accountable (Silva, 2015). Digital participation tools have the potential to increase citizen participation, encourage collaboration, empower disadvantaged groups to be heard, and act as facilitators to prevent conflicts of interest. Digital participation tools can be used to prioritize projects or determine budget expenditures in line with citizens' needs and desires (Babelon et al., 2021). However, the existence of smart city applications and digital participation instruments does not always ensure meaningful participation. Digital participation instruments must be well-designed and accessible to everyone. Issues such as a lack of technological literacy can present new challenges. Properly designed, accessible, and inclusive digital participation tools facilitate interactive and participatory methods in spatial decision-making processes in cities (Falco & Kleinhans, 2019).

In summary, smart cities and digital participation instruments strengthen the culture of collaboration by bringing together varied actors in urban spatial decision-making processes and creating a participatory decision-making ecosystem. Accurately created and carried out digital participation models provide for improving the quality of urban life by easing citizens' participation in shaping their cities and making decisions about the cities' future.

Methodology

This study employed a comparative analysis method. Barcelona, Amsterdam, and Istanbul apply digital tools

to varying scopes in spatial decision-making practices. Therefore, these three cities were selected for comparative analysis.

Publicly available, open-source data and urban planning platforms were examined in the context of architecture and urban planning in Barcelona, Amsterdam, and Istanbul. The study used openly accessible geographic information systems, digital twin models, 3D urban models, and participatory digital platforms integrated into the planning process as primary data sources.

Three main criteria form the basis of the analysis:

- **Integration of open access data into the design process:** The format in which open access data portals are publicly available and how these data are used in design and planning decisions were examined.
- **The impact of participatory digital platforms on spatial decision-making:** All three local governments have participatory digital platforms, but how the actors participate in the decision-making process on these platforms, and their impact on the decision-making process were examined.
- **Use of visual and digital tools:** The role of 3D models, simulation tools, and digital twin applications in urban space design and decision-making processes was examined.

Findings: Urban Studies on Digital Governance in Design

Barcelona

Barcelona is a pioneer in implementing smart city strategies in participatory design. Significant work has been underway on digital democracy and governance. Since 2015, urban governance has been digitalized as part of the Digital City Plan project. As part of this project, the Decidim.Barcelona platform has been developed. Through the Decidim.Barcelona platform, citizens can participate in a wide range of issues, from zoning plans to the city budget. The “Repensem el 22@” project used the Decidim.Barcelona platform to engage thousands of citizens in design processes. Tens of thousands of citizens (more than 27,000 users as of 2022) can participate in urban decisions on the Decidim.Barcelona platform (Decidim Barcelona, n.d.). The success of the Decidim.Barcelona platform confirms that, when designed correctly, digital participation platforms can facilitate citizen participation and facilitate public engagement.

Within the scope of the “Superilles” project, data-driven digital participation platforms were used in design decisions at the neighborhood level. The superblock concept is based on limiting vehicle traffic on the inner streets of nine urban blocks, pedestrianizing these areas, and integrating them into public life. The municipality has acted on the principles of maximum citizen participation and shared responsibility in implementing the superblock projects. Before developing design proposals for each superblock, meetings, surveys, and

online forums were held with residents; open geographical data on street use (pedestrian counts, noise measurements, etc.) and GIS analyses were shared. The proposed design alternatives were put to a vote through the Decidim platform or collaboratively developed in in-person workshops. This enabled residents' suggestions in pilot superblocs to be reflected in the final interventions, resulting in much higher acceptance of the projects (Ajuntament de Barcelona, n.d.).

In terms of digital infrastructure, Barcelona is also developing tools that will enable data-driven urban design decisions. The city began work on creating a Local Digital Twin platform in the early 2020s. This digital twin aims to integrate layers of urban systems, such as air quality, noise, traffic, logistics, and population, based on a 3D map of the city's physical reality, including its buildings and infrastructure. This platform aims to simulate the impact of changes to the city on various systems in advance and provide an objective basis for prioritizing public space design (Eurocities, 2023).

Amsterdam

The Amsterdam Smart City initiative, launched in 2016, brought together diverse stakeholders to find solutions to urban problems (Amsterdam Smart City, n.d.). As a key component of this initiative, a 3D digital city model and digital twin infrastructure were created. A 3D city model project called "3D Amsterdam" has been established. The Amsterdam Local Digital Twin also enables analyses of the city and its architecture. For instance, the visibility of solar panels set on the roofs of historic buildings was analyzed

using the Amsterdam Digital Twin application. The local government plans to use digital twins in several phases of urban planning periods, including evaluation, design, zoning, and implementation. The digital twin application can also be used to quantify the physical environmental impacts of new buildings in major urban renewal projects (Twin4Resilience, 2022).

Amsterdam stands out with its user experience-focused approaches to digital governance. For example, a planning tool developed by the Amsterdam Transport Innovation Unit plans personalized routes for wheelchair users (Amsterdam Smart City, 2025). In this project, data scientists went into the field with several volunteer users and individually noted experienced issues such as curb heights, ramp slopes, and road obstacles. This data was mapped and fed into the digital application. The resulting prototype route planner can recommend the most appropriate urban route for any user, taking into account their disabilities and preferences (Pinhão et al., 2024). This study emphasized the importance of collecting data from users' personal experiences rather than solely from technical sources, thus enhancing the human-centricity of the design.

Istanbul

While the Istanbul Metropolitan Municipality (IMM) has been taking steps in digital governance in recent years, its tangible impact on architecture and urban design is still limited. The IMM Open Data Portal, launched in 2019, is an initiative aimed at sharing city-related data with the public. However, the number and diversity of datasets offered on

the portal are limited. A large portion of the dataset on the portal is in the mobility category (Istanbul Metropolitan Municipality, 2020). IMM's geographic information systems infrastructure is primarily limited to internal use. This hinders the direct use of urban planning data and maps by civic stakeholders. However, IMM has made some digital mapping applications available to the public. For example, Harita Istanbul, as a city guide application, provides citizens with access to basic city information and maps. However, these tools fall short of actively engaging citizens in design decisions (Istanbul Metropolitan Municipality, 2024).

A participatory budget platform called “Bütçem İstanbul” (My Budget Istanbul) was developed. Through this platform, developed in 2022, Istanbulites were able to propose project ideas, vote on them, and include some projects in the municipal budget (Istanbul Metropolitan Municipality, 2023). Additionally, there is a digital participation platform called “İstanbul Senin” (Istanbul is Yours), which has both a web-based and a mobile application. Through this platform, citizens can participate in city-related surveys. In 2020, a competition was held for the redesign of Taksim, Bakırköy, and Salacak squares. Citizens were able to vote online through the “İstanbul Senin” platform to select the projects selected by the jury and made it to the finals. However, the selected projects were not implemented.

A 3D city model was developed in 2023. Published under the name “3D Istanbul,” this model covers the Historic Peninsula and its surroundings. The “3D Istanbul” application allows for digital city tours or simulations using weather conditions (Istanbul Metropolitan Municipality, n.d.).

The Istanbul Metropolitan Municipality Department of Information Technologies developed the Disaster-Focused Digital Twin Project. A virtual model of Istanbul was created, and environmental, transportation, security, and energy data were integrated into this virtual model. The Disaster-Focused Digital Twin Project utilizes 3D simulations and artificial intelligence analyses for potential disaster scenarios such as earthquakes, as well as for risk reduction, efficient resource use, and coordinated response during crisis periods. The Disaster-Focused Digital Twin Project received the Council of Europe Development Bank Social Cohesion Award in 2025 (Istanbul Metropolitan Municipality, 2024).

Discussion and Conclusion

The examples of Istanbul, Barcelona, and Amsterdam demonstrate both diversity and significant differences in the impact of digital management applications on architecture and overall design. All three cities have increased open data and ministry information systems within the scope of smart city modules, begun integrating digital participation tools into planning components, 3D Departments have begun utilizing digital twin and heating technologies, and various initiatives are underway in the data sections of public spaces. However, each city's robust structure and potential for improvement differ in these dimensions. The table below provides a comparative analysis of the findings from the previous section with three cent applications in each dimension (Table 1).

Table 1.*Comparison of the findings obtained for three cities.*

Dimension	Barcelona	Amsterdam	İstanbul
Use of Open Data and GIS	<p>Open Data Portal</p> <p>GIS integrated into all planning processes; innovative analyses with open map data</p> <p>Focus: Using data for strategic decision support and innovation</p>	<p>Open Data Policy</p> <p>GIS and 3D data are rich with national resources; data analysis is prevalent in planning.</p> <p>Focus: In addition to sharing data, ethical use and crowdsourcing are key ideas.</p>	<p>Open Data Portal</p> <p>GIS is used by municipal departments (e.g., transportation, zoning), but data sharing with the public is limited.</p> <p>Focus: Transparency of core city data and data collection on priority issues such as disasters and transportation.</p>

<p style="text-align: center;">Digital Participation (e-participation)</p>	<p>The Decidim platform provides institutionalized participation; the city's budget is allocated to projects based on public vote.</p> <p>A culture of online consultation, proposal submission, and discussion is well-established; tens of thousands of users are active.</p> <p>Strengths: The vision of digital democracy is integrated into the municipality, allowing urban decisions to be made through broad consensus.</p>	<p>Participation is encouraged at the neighborhood level through tools like OpenCity/OpenBorough, where citizens collaboratively shape local decisions.</p> <p>Young people and NGOs are embracing digital platforms, but overall participation is moderate (a culture of in-person participation is also strong).</p> <p>Strengths: Inclusivity and data privacy are prioritized in participation processes.</p>	<p>Istanbul Senin app, with its survey and voting opportunities, is engaging the public on multiple digital platforms.</p> <p>Presenting the competition project to the citizens' vote at the final stage facilitated participation in urban space design.</p>
--	---	---	--

3D Modeling & Digital Twin	The Digital Twin Platform is currently under development; accessibility analyses are being conducted. Extensive simulation and 3D analysis have been used on projects like the Superilles (traffic, noise, and pollution impacts are calculated in advance).	Early adopter; one of the first to use city digital twins. The 3D City Model was generated with open data; design parameters for new development areas were derived from existing city data.	The Disaster-Focused Digital Twin project combines city data into an integrated model to simulate earthquake scenarios. Planning units are using drones and 3D modeling for current situation analysis, and visualization is used to foster stakeholder engagement.
----------------------------	--	---	---

To conclude, all three municipals have ventures that address community-based participatory design approaches within the digital governance ecosystem. However, their practices processes vary. Barcelona is one of the precursor city in digital governance over the Decidim.Barcelona application. Amsterdam applies digital governance from a human-centered attitude. Istanbul has applications concentrated on crucial issues like disasters. While digital governance approaches present in all three cities, their impression on community participation in spatial planning and design decisions are different from each other. Barcelona and Amsterdam, which had operative community participation policies before carrying out digital governance, seem to be employing smart city applications more influential. This conclusion determines that the use of smart city applications alone does not provide community engagement and citizen participation. Primarily, governments should

improve community engagement policies and then smart city applications should serve as facilitators around the policies.

References

- Ajuntament de Barcelona. (n.d.). Superilles. Barcelona City Council. Retrieved August 31, 2025, from <https://ajuntament.barcelona.cat/superilles/en>
- Amsterdam Smart City / Amsterdam for All Initiative. (2025, June 19). Data Dilemmas: Data and AI for an accessible Amsterdam. Retrieved August 31, 2025, from <https://amsterdamsmartcity.com/updates/event/data-dilemmas-data-and-ai-for-an-accessible-amsterdam>
- Amsterdam Smart City. (n.d.). Amsterdam Smart City. Retrieved August 31, 2025, from <https://amsterdamsmartcity.com/>
- Arnstein, S. R. (1969). A ladder of citizen participation. *Journal of the American Institute of planners*, 35(4), 216-224.
- Babelon, I., Pánek, J., Falco, E., Kleinhans, R., & Charlton, J. (2021). Between consultation and collaboration: self-reported objectives for 25 web-based geoparticipation projects in urban planning. *ISPRS International Journal of Geo-Information*, 10(11), 783.
- Bollier, D. (2016). *The city as platform: How digital networks are changing urban life and governance*. Washington, DC: The Aspen Institute.
- De Filippi, F., & Cocina, G.G. (2022). Digital Technologies to Encourage e-Participation in Urban Regeneration. In: *Urban Regeneration and Community Empowerment Through ICTs. Local and Urban Governance*. Springer, Cham. https://doi.org/10.1007/978-3-030-97755-9_2
- Decidim Barcelona. (n.d.). Decidim Barcelona. Retrieved August 31, 2025, from <https://www.decidim.barcelona/>
- Eurocities. (2023, May 3). Barcelona shapes the future of city planning. Retrieved August 31, 2025, from <https://eurocities.eu/stories/barcelona-shapes-the-future-of-city-planning/>
- Falco, E., & Kleinhans, R. (2019). Digital participatory platforms for co-production in urban development: A systematic review. *Crowdsourcing: Concepts, methodologies, tools, and applications*, 663-690.

- Helbing, D., Mahajan, S., Carpentras, D., Menendez, M., Pournaras, E., Thurner, S., Verma, T., Arcaute, E., Batty, M., & Bettencourt, L. M. A. (2024). Co-creating the future: Participatory cities and digital governance. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 382(2285), Article 20240113. <https://doi.org/10.1098/rsta.2024.0113>
- Hodson, M., Kasmire, J., McMeekin, A., Stehlin, J. G., & Ward, K. (2020). *Urban Platforms and the Future City*. Routledge.
- İstanbul Büyükşehir Belediyesi (2020). İBB Açık Veri Portalı. Retrieved August 31, 2025, from <https://data.ibb.gov.tr/>
- İstanbul Büyükşehir Belediyesi. (2020). İstanbul Senin [Mobile app]. Retrieved August 31, 2025, from <https://istanbulSenin.istanbul/>
- İstanbul Büyükşehir Belediyesi. (2023). Bütçe Senin Portalı. Retrieved August 31, 2025, from <https://butcesenin.istanbul/>
- İstanbul Büyükşehir Belediyesi. (2024). Afet Odaklı Dijital İkiz Platformu. Retrieved August 31, 2025, from <https://frd.ibb.istanbul/afet-odakli-dijital-ikiz-platformu/>
- İstanbul Büyükşehir Belediyesi. (2024). İstanbul Harita Portalı [Online map]. Retrieved August 31, 2025, from <https://harita.istanbul/2d?@=28.95551,41.01431,16.06064&p=45.00000&b=0.00000&suk=&ruk=!&ms=!b281!c&o=!o2&ct=0&duk=&dwk=>
- İstanbul Büyükşehir Belediyesi. (n.d.). 3b İstanbul [Online map]. Retrieved August 31, 2025, from <https://3bistanbul.ibb.gov.tr/#>
- Pinhão, C., van Uden, E., & Brilleman, S. (2024, June 30). Accessible Route Planner. OpenResearch Amsterdam. Retrieved August 31, 2025, from <https://openresearch.amsterdam/en/page/121230/accessible-route-planner>
- Silva, C. N. (2015). Open source urban governance: Crowdsourcing, neogeography, VGI, and citizen science. In *Open Source Technology: Concepts, Methodologies, Tools, and Applications* (pp. 209-226). IGI Global.
- Twin4Resilience (T4R). (2022). Transforming territorial planning with Local Digital Twins. Retrieved August 31, 2025, from <https://t4r.nweurope.eu/>

Urban Diplomacy and Toponymic Gift-Giving in Çanakkale

Canan Zehra Çavuş

Çanakkale Onsekiz Mart University,
Faculty of Humanities and Social Sciences, Department of Geography
ORCID: 0000-0002-9544-4901

Sevim Kocabaş

Çanakkale Onsekiz Mart University, School of Graduate Studies,
M.Sc. Program in Geography
ORCID: 0009-0005-9740-1349

Abstract

Urban toponymy is a field that looks at the names of places in cities, such as neighbourhoods, boulevards, streets, squares, and institutions. These names have specific meanings and help people remember certain places or events. Saying the name of a place also brings to mind what it means. This act of remembering goes both ways: remembering one thing may mean not remembering other things on purpose. Toponymy plays a role in both remembering and forgetting in urban memory, and it also affects diplomatic relations. This study investigates urban toponyms serving a diplomatic role (toponymic diplomacy) within sister city relationships, emphasizing the toponymic exchanges between sister cities in Çanakkale (Turkey). The research concentrates on the historical administrative hubs of Çanakkale province,

particularly the central district, Gelibolu, and the urban centres of Biga. City transportation maps, records from the General Directorate of Population and Citizenship Affairs' address change notification panel, relevant municipal websites, and Google Earth are all sources of data. Data were verified to guarantee reliability and content validity. After that, the results of the content analysis with Maxqda and the spatial analysis with ArcGIS 10.8 were looked at. The research juxtaposes cities functioning as administrative hubs during the Ottoman era (Biga and Gelibolu Sanjaks) with the Merkez district in the Republican era. We found urban toponyms with diplomatic meanings and used them to explain diplomatic relations in terms of soft power, cultural representation, and the processes of remembering and forgetting. More research into cities with different political, cultural, and geographic identities may help us understand how toponyms work in urban diplomacy. They might talk about memory and amnesia, how cultural heritage is passed down, and how geography is important from different academic points of view to help build good relationships.

Keywords: toponymic diplomacy; toponymic gift-giving; urban toponymy; Relations between sister cities

Introduction

In urban areas, place names are more than just useful for finding your way around; they are also important for building social memory and identity. The names of neighborhoods, boulevards, avenues, streets, squares, parks, and gardens have historical, cultural, and political implications that help

define the collective memory of cities. Urban toponymy is a multidisciplinary field that studies these place names. In this context, the names of neighborhoods, boulevards, avenues, streets, squares, and institutions constitute the core subject of research in urban toponymy. The branch of urban toponymy that focuses on the names of boulevards, avenues, streets, and roads (hodonymy), together with the names of parks and gardens, forms the subject of this study (Yavuz & Şenel, 2013).

The study, conducted in 7 urban neighborhoods in the central district of Çanakkale, 3 urban neighborhoods in the township of Kepez, 5 urban neighborhoods in the district of Gelibolu, and 10 urban neighborhoods in the district of Biga, examined the names of boulevards, avenues, streets, squares, parks, and gardens with a focus on the theme of diplomacy. The selection of the study area was influenced by the fact that both the districts and the central district have historically served as administrative centers of Çanakkale.

Çanakkale is a city that is trying to build brand value around the idea of being a “City of Peace.” This is obvious in the names of its neighborhoods. In this sense, the study has been structured around the issue of diplomacy. We looked at diplomatic ideas, people who work in diplomacy, and names of settlements that are relevant to this theme. We also looked at how these ideas are connected to sister city ties and the practice of giving toponyms as gifts. This process is important because it shows how local governments interact with each other on a cultural and symbolic level in the international arena and in the urban realm. Toponymic gift-giving is significant in the realm of international presence,

as it involves a reciprocal interaction (Düzgün, 2024; Sysiö et al., 2023).

To date, toponymic gift-giving and urban diplomacy—rarely addressed in toponymy studies—have not, to our knowledge, been examined in the context of sister cities. However, conducting research in the framework of cultural interaction and international relations will further enhance interaction between places. These naming practices are carried out by the dominant authority, namely, local governments. This process also reflects a decision-making mechanism regarding who is to be commemorated, remembered, and honored symbolically through urban names.

The next section of this study reviews previous work on diplomacy and toponymic gift-giving, followed by a description of the methodology. In the findings section, content analysis and spatial analysis of street, avenue, square, park, and garden names are carried out in line with themes related to diplomacy. The discussion and evaluation section interprets the findings in the context of sister cities. Concluding with results and recommendations, this study is significant as it reveals how the naming practices of local governments enhance their visibility at the international level and how they reinforce sister city relations and toponymic gift-giving practices through the symbolic and diplomatic references employed in naming.

Literature Review

Place names are multifaceted tools that serve different purposes in different contexts, going beyond merely

describing and defining places. They construct social memory, guide practices of remembrance and forgetting, and, in this sense, play a strategic role in international relations. For example, when claiming ownership of a place, they are used in efforts to dominate the space (David, 2011; Njoh & Chie, 2019; Short & Dubots, 2022) to express solidarity, retaliation, punishment, and shaming (Gnatiuk & Basik, 2023), to develop constructive relations (Sysiö et al., 2023), for place recognition and tourism purposes (Ji, 2018), and for income-generating functions (Brunila et al., 2023; Willer, 2022). These characteristics—the functions of fostering good relations, solidarity, retaliation, punishment, and shaming—enable the use of toponyms in diplomatic relations. In this context, Gnatiuk and Basik (2023) examined the toponymic solidarity function using the example of Ukraine. The authors examine a performative action against the Russia-Ukraine War that began in 2022, focusing on the “Ukraine Street” campaign launched by the One Philosophy consulting group in collaboration with the Ukrainian Ministry of Foreign Affairs as part of a broader initiative called “Stand with Ukraine.” As a result of the widely supported campaign, within the first nine months, 20 place names in 19 cities across 16 countries (14 in Europe and 2 in North America) were officially and permanently renamed in support of Ukraine. Temporary renamings were also carried out. Toponymic solidarity, as a symbolic performance representing solidarity with Ukraine, includes the symbolic renaming of streets and squares by countries in reference to Ukraine. This toponymic process has three sides: the toponyms of countries supporting Ukraine that commemorate Ukraine (toponymic solidarity), the toponyms

of Ukraine that commemorate these countries based on reciprocity (toponymic gratitude), and the commemorative toponyms of Russia aimed at countering this performance (toponymic retaliation). Special ceremonies carry out these renamings, highlighting the performative and diplomatic aspects of the process. Place names in this geopolitical environment reveal both cooperative and conflicting power relations (Gnatiuk & Basik, 2023).

Ankara, the capital of Türkiye, has been examined in two studies that evaluate toponyms in the context of diplomatic gift-giving and retaliation (Düzgün, 2024; Sysiö et al., 2023). In this context, street names with diplomatic representation and associations with embassies were analyzed, and it was noted that the names of 11 embassies are directly linked to street names. In a more detailed analysis of two examples, the renaming of *Kader Sokak* to *Beyaz Zambaklar Sokak* (Finland) was evaluated in terms of toponymic gift-giving. Another example relates to toponymic retaliation: *Nevzat Tandoğan Caddesi* was renamed *Zeytin Dalı Caddesi* in reference to the “Olive Branch Operation,” and subsequently, the street where the new U.S. Embassy building is located was renamed *Malcolm X Caddesi* (Sysiö et al., 2023).

Düzgün (2024) notes that the renaming of *Nevzat Tandoğan Caddesi*, where the U.S. Embassy in Ankara is located, to *Zeytin Dalı Caddesi* in February 2018 could be interpreted in different ways by local residents: either as an act directed against the U.S. or as a reference to the meaning of the previous street name. Additionally, in October 2018, the Ankara Metropolitan Municipality Council decided to rename *Cumhuriyet Caddesi*, where the new U.S. Embassy

building is located, as *Malcolm X Caddesi*. In March 2011, *Öveçler 4. Cadde*, where many Afghans reside, was renamed *Kabil Caddesi*. Similarly, the naming of a street near the Montenegrin Embassy in Ankara as *Podgorica Caddesi*, the announcement that a street in Podgorica would be named *Ankara Caddesi*, and the reciprocal naming of *Budapeşte Caddesi* in Ankara and *Ankara Caddesi* in Budapest are further examples of toponymic diplomacy.

Alongside these efforts at the level of states and capitals, toponymic gift-giving and diplomacy are also observed in cities of different scales that do not have administrative functions, with the aim of fostering charitable relations and establishing sister city relationships. Such information can be found under the subheading “names related to friendship and brotherhood” in typological studies conducted on this subject. However, to the best of our knowledge, no study has focused specifically on this topic.

Aliğaoğlu and Uzun (2011) conducted a study on 25 settlements to develop a typology of urban toponymy, identifying 197 “Friendship–Brotherhood Streets.” In this context, examples include the streets named Filibe, Selanik, Tırnova, Drama, Rodop, and Deliorman in Kırklareli; Buhara and Taşkent Streets in Sivas; and Kerkük, Kudüs, and Bosna Hersek Streets in Konya. The authors note that Ankara is particularly rich in this regard due to its status as the capital (Aliğaoğlu & Uzun, 2011). Moreover, research conducted in Balıkesir on Azerbaijan Street (Aliğaoğlu & Yiğit, 2013), in Bandırma on Korea and Cyprus Streets (Yılmaz Çildam, 2018), and on Hakkı Turaylıç Street in Erzincan (Orhan & Dönmez, 2023) offers additional instances of streets designated to

promote positive relations. People think of these names as symbols of international friendships, historical ties, and messages of support for each other in the city.

Methodology

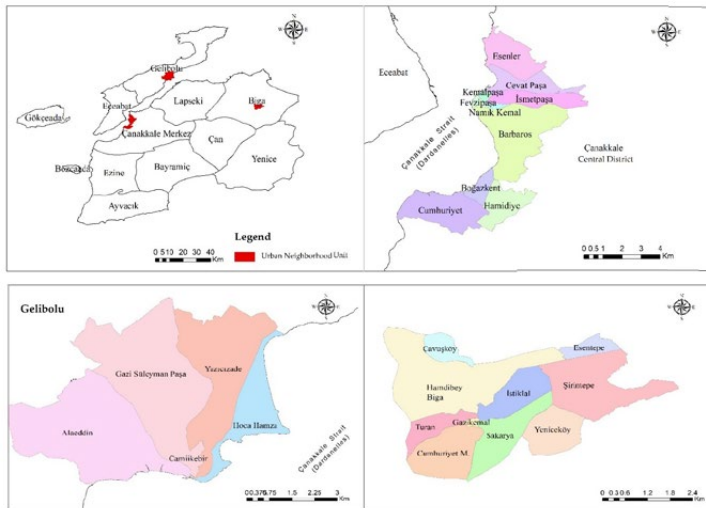
This study examines diplomacy-themed urban names in Çanakkale, a city that is in the process of building its brand value under the slogan “City of Peace.” In this context, the names of boulevards, streets, avenues, squares, parks, and gardens are analyzed. Sister city relationships, which serve the mission of fostering good relations, are also examined within the framework of urban diplomacy and toponymic gift-giving. The aim of this research is to analyze diplomacy-themed place names in Çanakkale—a city not directly at the center of diplomatic relations—through the lens of symbolic strategies employed in international relations (e.g., remembrance/forgetting, fostering good relations, solidarity, retaliation, gratitude, shaming, and punishment).

The research area of this study has been defined as the administrative centers of Çanakkale province throughout its historical development. Accordingly, the city centers of the Central, Gelibolu, and Biga districts were selected as the research sites. In the Central district, there are seven neighborhoods: Barbaros, Cevatpaşa, Esenler, Fevzipaşa, İsmetpaşa, Kemalpaşa, and Namık Kemal. Due to the process of urban expansion, the city center has merged with the township of Kepez, located immediately to its south, forming a single urban entity. Therefore, the neighborhoods of Boğazkent, Cumhuriyet, and Hamidiye, which belong to

Kepez, have also been included in the study. For the purposes of this research, the term “Çanakkale Central District” refers to these ten neighborhoods. The city center of Gelibolu comprises five neighborhoods: Alaeddin, Camiikebir, Gazi Süleyman Paşa, Hoca Hamza, and Yazıcızade. The city center of Biga includes ten neighborhoods: Cumhuriyet, Çavuşköy, Esentepe, Gazikemal, Hamdibey, İstiklal, Sakarya, Şirintepe, Turan, and Yeniceköy, all of which were also considered in the analysis (Figure 1).

Figure 1.

Study Area Location Map



The data sources for this study include city transportation maps, data accessed from the address change notification panel of the General Directorate of Population and Citizenship Affairs (2025), the websites of the relevant municipalities (Biga Belediyesi, 2025; Gelibolu Belediyesi,

2025; Çanakkale Belediyesi, 2025a), and the Google Earth platform (Google, 2025). These data were cross-checked to ensure reliability and content validity. The MAXQDA qualitative analysis program was employed in the content analysis phase to identify toponyms related to diplomacy from the data obtained through maps and institutions. The ArcGIS 10.8 software package was used to prepare maps for the spatial analysis of the content-analyzed data. In the subsequent phase, the findings derived from comparing the data of the three cities were evaluated.

Findings

According to data obtained from the General Directorate of Population and Citizenship Affairs, there are a total of 2,779 place names (boulevards, avenues, streets, and roads) in Çanakkale (1,264), Gelibolu (679), and Biga (836) (Table 1). The accessible place names were analyzed according to the following diplomatic themes: diplomatic concepts (DC), persons related to diplomacy (PD), international agreements (IA), urban settlement names (US), national settlement names (NS), international settlement names (IS), other names (O), and the total number of streets (T). The analysis identified 34 hodonyms associated with diplomatic concepts, 4 hodonyms related to diplomatic figures, 2 hodonyms connected to international agreements, 34 hodonyms pertaining to urban settlement names, 30 hodonyms linked to national settlement names, and 2 hodonyms associated with international settlement names.

Table 1.

Frequency of Hodonyms in Çanakkale Central District (CD), Gelibolu, and Biga Districts According to Diplomatic Themes

District	Neighborhood	DC	PD	IA	US	NS	IS	O	T
Çanakkale/CD	Barbaros	2	0	1	1	7	1	273	285
Çanakkale/CD	Cevatpaşa	2	0	0	8	2	0	118	130
Çanakkale/CD	Esenler	5	2	0	0	1	0	141	149
Çanakkale/CD	Fevzipaşa	0	0	0	0	0	0	32	32
Çanakkale/CD	İsmetpaşa	3	1	0	5	3	0	182	194
Çanakkale/CD	Kemalpaşa	0	0	0	0	0	0	33	33
Çanakkale/CD	Namık Kemal	0	0	0	0	0	0	23	23
Çanakkale/CD	Boğazkent	0	0	0	1	0	0	100	101
Çanakkale/CD	Cumhuriyet	1	0	0	6	2	0	249	258
Çanakkale/CD	Hamidiye	3	1	0	2	0	0	53	59
Gelibolu	Alaeddin	10	0	0	4	1	0	109	124
Gelibolu	Camiikebir	0	0	0	1	7	0	85	93
Gelibolu	Gazi Süleyman Paşa	1	0	1	4	0	0	119	125
Gelibolu	Hoca Hamza	0	0	0	0	0	0	198	198
Gelibolu	Yazıcızade	0	0	0	1	4	0	134	139
Biga	Cumhuriyet	0	0	0	0	0	0	70	70
Biga	Çavuşköy	0	0	0	0	0	0	27	27
Biga	Esentepe	0	0	0	0	0	0	60	60
Biga	Gazikemal	0	0	0	0	0	0	17	17
Biga	Hamdibey	0	0	0	0	1	0	159	160
Biga	İstiklal	1	0	0	0	0	0	75	76
Biga	Sakarya	2	0	0	1	0	0	103	106
Biga	Şirintepe	3	0	0	0	1	1	209	214
Biga	Turan	0	0	0	0	0	0	25	25
Biga	Yeniceköy	1	0	0	0	1	0	79	81
Total		34	4	2	34	30	2	2674	2779

Sixteen diplomatic concepts—peace, unity, solidarity, democracy, friendship, trust, nation, homeland, and freedom—were identified in the district of Çanakkale Central. The district of Gelibolu identified eleven diplomatic concepts, including peace, friendship, Korean heroes, and respect. Seven diplomatic concepts—peace, friend, trust, Cyprus martyrs, and respect—were identified in the district of Biga. When the districts are evaluated according to their place names, the representation of diplomatic concepts is 1.26% in Çanakkale Central, 1.31% in Gelibolu, and 1.03% in Biga. Excluding repeated hodonyms, the Çanakkale Central district contains the highest number of diplomatic concepts (Table 1, Table 2). However, in Çanakkale, the neighborhoods of Fevzipaşa, Kemalpaşa, Namık Kemal, Boğazkent, and Hamidiye; in Gelibolu, Camiikebir, Hoca Hamza, and Yazıcızade; and in Biga, Cumhuriyet, Çavuşköy, Esentepe, Gazikemal, Hamdibey, and Turan—making a total of 14 neighborhoods—do not contain place names derived from diplomatic concepts.

Table 2.

Diplomatic concepts in the place names of Çanakkale Central District (CD)

No	District	Neighborhood	Hodonyms
1	Çanakkale/CD	Barbaros	Dayanışma Sokak
2	Çanakkale/CD	Barbaros	Güven Sokak
3	Çanakkale/ CD	Cevatpaşa	Demokrasi Caddesi
4	Çanakkale/ CD	Cevatpaşa	Özgürlük Caddesi
5	Çanakkale/ CD	Cumhuriyet	Birlik Sokak
6	Çanakkale/ CD	Esenler	Barış 1. Sokak
7	Çanakkale/ CD	Esenler	Barış Caddesi

8	Çanakkale/ CD	Esenler	Barişkent Çıkmazı Sokak
9	Çanakkale/ CD	Esenler	Demokrasi Cadde
10	Çanakkale/ CD	Esenler	Özgürlük Cadde
11	Çanakkale/CD	Hamidiye	Bariş Sokak
12	Çanakkale/CD	Hamidiye	Ulus Sokak
13	Çanakkale/ CD	Hamidiye	Vatan Sokak
14	Çanakkale/ CD	İsmetpaşa	Birlik Sokak
15	Çanakkale/ CD	İsmetpaşa	Dostluk Sokak
16	Çanakkale/ CD	İsmetpaşa	Vatan Sokak
17	Gelibolu	Alaeddin	Bariş Sokak
18	Gelibolu	Alaeddin	Dostlar Sokak
19	Gelibolu	Alaeddin	Kore Kahramanlar Caddesi
20	Gelibolu	Alaeddin	Kore Kahramanlar Çıkmazı Sokak
21	Gelibolu	Alaeddin	Kore Kahramanlar 1 Sokak
22	Gelibolu	Alaeddin	Kore Kahramanlar 2 Sokak
23	Gelibolu	Alaeddin	Kore Kahramanlar 2. Geçit Sokak
24	Gelibolu	Alaeddin	Kore Kahramanlar 3 Sokak
25	Gelibolu	Alaeddin	Kore Kahramanlar 4 Sokak
26	Gelibolu	Alaeddin	Kore Kahramanlar 5 Sokak
27	Gelibolu	Gazi Süleyman Paşa	Saygılı Sokak
28	Biga	İstiklal	Kıbrıs Şehitleri Caddesi
29	Biga	Sakarya	Bariş Caddesi
30	Biga	Sakarya	Kıbrıs Şehitleri Caddesi
31	Biga	Şirintepe	Dost Sokak
32	Biga	Şirintepe	Kıbrıs Şehitleri Caddesi
33	Biga	Şirintepe	Saygı Sokak
34	Biga	Yeniceköy	Güven Sokak

There are four street names related to diplomacy: President Fip Street (Esenler), Yılmaz Akyürek Street (Esenler), Rauf Denктаş Street (Hamidiye), and Emile Vitalis Street (İsmetpaşa). Hans Jürgen Fip, the former mayor of Osnabrück who played a key role in establishing the sister city relationship between Çanakkale and Osnabrück, is commemorated in Çanakkale with a street named after him, reflecting both sister city relations and the promotion of constructive relations. Additionally, Yılmaz Akyürek, who worked on the integration of foreign citizens in Osnabrück and passed away in 2007, is also recognized in the context of diplomatic figures (Çanakkale Belediyesi, 2025b). Rauf Denктаş, founder and first president of the Turkish Republic of Northern Cyprus (Presidency of the Turkish Republic of Northern Cyprus, 2025), and Emile Vitalis, an Italian attaché known for his contributions to the city, are commemorated through urban names as figures associated with diplomacy.

Table 3.

Persons Associated with Diplomatic Relations

District	Neighborhood	Hodonyms
Çanakkale/CD	Esenler	Başkan Fip Caddesi
Çanakkale/CD	Esenler	Yılmaz Akyürek Sokak
Çanakkale/ CD	Hamidiye	Rauf Denктаş Caddesi
Çanakkale/ CD	İsmetpaşa	Emile Vitalis Sokak

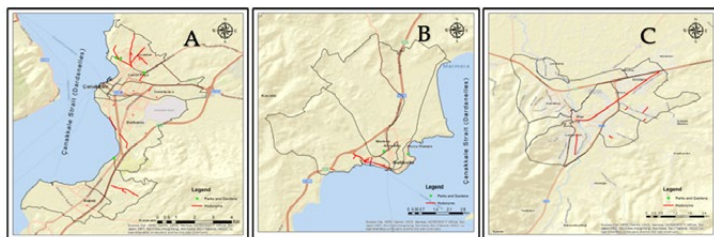
Under the theme of international agreements, the name Lozan, which holds an important place in the history of the Republic of Turkey, is commemorated through the urban toponyms Lozan Street (Barbaros Mah.) and Lozan Square (Gazi Süleyman Paşa). The memory of Lozan is thus

preserved in the districts of Çanakkale Central District and Gelibolu.

The settlement names found in the place names were analyzed under three categories. Accordingly, 34 urban settlement names, 30 national settlement names, and 2 international settlement names were identified. Urban settlements were not analyzed in the context of diplomacy or sister city relations. Under the theme of national settlement names, examples include settlements outside Çanakkale province, such as İzmir, Bursa, Burdur, Karaman, Sakarya, Kocatepe, Gölcük, and Sur. International settlement names were found in two neighborhoods: Cyprus Street (TRNC) in Barbaros Neighborhood (Central District) and Mostar Street (Bosnia and Herzegovina) in Şirintepe Neighborhood (Biga).

Figure 2.

Diplomatic Concepts of Parks and Gardens and Hodonyms in the Study Area, Reprinted from OpenStreetMap



We looked at the names of 197 parks and gardens, including 86 in Çanakkale Central, 18 in Gelibolu, and 93 in Biga. The study found that most parks and gardens with names based on diplomatic ideas are in Çanakkale Central. Gelibolu has only one park like this (Hamzaköy Sevgi Park), while Biga doesn't have any parks or gardens named after diplomatic

ideas (Table 4). Three parks are also named after international settlements: Morabbin Park in Australia, Osnabrück Park in Germany, and Tapolca Park in Hungary.

Table 4.

Diplomatic Concepts in Parks, Gardens, and Squares

District	Park Names
Çanakkale/CD	Barış Kordonu
Çanakkale/CD	Barışkent Parkı
Çanakkale/CD	Hoşgörü Parkı
Çanakkale/CD	IIPT Kepez Zeytin Barış Parkı ve Zeytin Barış Yolu
Çanakkale/CD	Özgürlük Parkı
Gelibolu	Hamzaköy Sevgi Parkı

Discussion and Evaluation

This research examines boulevard, avenue, street, and road names associated with diplomacy in 10 neighborhoods of Çanakkale Center, 5 neighborhoods of Gelibolu, and 10 neighborhoods of Biga, within the framework of urban toponymy. We looked at 2.779 hodonyms in these 25 urban neighborhoods to see if they had anything to do with diplomacy. In Çanakkale Center, the representation rate of diplomatic conceptions was 1,26%. In Gelibolu, it was 1,31%, while in Biga, it was 1,03%. Notably, some concepts appear in more than one hodonym, or a street or avenue may extend across multiple neighborhoods. From this perspective, even though the repetition of concepts affects the rates, they represent fewer distinct diplomatic concepts

in terms of usage and recognition. When these repetitions are disregarded, it is observed that the highest number of diplomatic concepts is found among the hodonyms of Çanakkale Center. This highlights the effectiveness of Çanakkale Municipality's process of building brand value under the slogan "City of Peace" and its emphasis on these concepts. It has been decided that the name of a neighborhood in Çanakkale Center, which has not yet been reflected in place names but for which establishment initiatives have been launched, will be "Barış Mahallesi" (Peace Neighbourhood) (Ton Tv, 2025).

There are four place names related to diplomacy. Among these, Başkan Fip Street (Esenler) and Yılmaz Akyürek Street (Esenler) are associated with the Çanakkale–Osnabrück sister city cooperation. This observation demonstrates that the sister city relationship with Osnabrück is reflected in urban toponyms. In fact, Osnabrück has named Akyürek Square in his honor. In this context, the practice of toponymic gift-giving and reciprocity (Düzgün, 2024; Sysiö et al., 2023) can be observed in the sister city relationship between Çanakkale and Osnabrück. In addition to these representations in hodonyms, a park in Çanakkale Center also references the city of Osnabrück (Çanakkale Belediyesi, 2025b).

Tapolca Park (Hungary) is also named after an international settlement in connection with its sister city relationship. During the park's opening ceremony, Tapolca Mayor Dobo Zoltan announced that a "Çanakkale Park" would also be established in Tapolca. This practice of toponymic gift exchange, along with the associated opening ceremonies, underscores the role of urban diplomacy and the promotion of positive relations. (Çanakkale Belediyesi, 2025c)

Morabbin Park (Australia) It is homophonous with the name of a settlement in Australia. However, to our knowledge, there is no explicit statement regarding this. Place names have reflected the name Rauf Denктаş (TRNC) in the context of friendship and brotherhood relations. The name Emile Vitalis, on the other hand, appears in urban names due to his contributions to the city throughout history and his role as Italian ambassador. These names indicate that diplomatic ties are strong even in a city that does not have an administrative function or, more explicitly, is not a capital city.

The presence of the theme of peace in the names of parks and gardens in Çanakkale Central (Barış Kordonu, Barışkent Park, Hoşgörü Park, IIPT Kepez Olive Peace Park and Olive Peace Road, and Freedom Park) indicates that naming conventions aligning with the city's "City of Peace" theme have been adopted. With the exception of Hamzaköy Love Park, there are no parks or gardens in the districts named after the theme of diplomacy.

Although there are 30 hodonyms classified under national settlement names, only one has been identified as connected to a sister city relationship. Among these hodonyms, "Sur Street" appears to be associated with the sister city Sur (Diyarbakır).

Conclusion

This study investigates place names with diplomatic themes in Çanakkale, a city that is not directly at the center of diplomatic relations. In this context, the city of Çanakkale constitutes the research area as it builds brand value under the slogan "City of Peace." The study covers the urban

neighborhoods of Çanakkale's Central District and Kepez Township, as well as 10 neighborhoods in the districts of Biga and Gelibolu, which have historically served as administrative centers of the sanjak. Accordingly, a total of 2,779 hodonyms and 197 park and garden names across these three urban areas were examined. Data from city transportation maps, the address change notification panel of the General Directorate of Population and Citizenship Affairs, the websites of the relevant municipalities, and the Google Earth platform were analyzed using Maxqda software for content analysis and ArcGIS 10.8 for spatial analysis.

Names with a diplomatic theme were evaluated under the sub-themes of diplomatic concepts, individuals associated with diplomacy, international agreements, urban settlement names, national settlement names, international settlement names, and other categories. The study results include 34 hodonyms named after diplomatic concepts and 6 park and garden names. When looking at the representation rates in the districts of Çanakkale Central, Biga, and Gelibolu, they are all around the same. But if you take out repeating concepts, hodonyms in the Central District show more concepts. So, from the point of view of people who use urban names, names with a diplomacy theme are part of the city's communal memory. But adding more of them would probably make the community's recall even better.

Sub-themes such as sister city ties and toponymic gift-giving practices illustrate the persons engaged in diplomacy. Osnabrück and Tapolca, which are Çanakkale's two sister cities, stand out in this setting. Urban naming does not include other sister cities that have agreements with the municipalities of Çanakkale, Kepez, Gelibolu, and Biga.

But sister cities work together on a lot of projects. Giving toponymic gifts to these places could make the city more visible and well-known. This is because the reciprocity that comes with these kinds of gifts would make sure that ideas associated to Çanakkale are symbolically represented in the partner cities' metropolitan areas.

The diplomatic aspects seen in the urban nomenclature of Çanakkale are predominantly manifested in naming conventions associated with soft power, cultural representation, commemoration, and the fostering of advantageous ties. Urban names are more likely to stand for ideas that are related to sibling cities. Names that allude to Bosnia and Herzegovina and the Turkish Republic of Northern Cyprus are also signs of friendship and historical relations. It is significant that urban names linked to the Turkic Republics are likewise uncommon. In the future, this element should be taken into account when making sister city agreements, granting toponymic gifts, and naming cities.

The study also found that city names recognize people who have been given honorary citizenship certificates. Because honorary citizenship is given to people who have made a difference in the city and, in a way, achieved distinction, this topic is important to study in urban toponymy. Future research should also examine this feature of toponyms, as it significantly contributes to the visibility of individuals who have impacted the city within collective memory.

References

- Aliğaoglu, A., & Uzun, A. (2011). Şehirsel toponimi (hodonimi) Türkiye için bir tipoloji denemesi. *Coğrafi Bilimler Dergisi*, 9(2), 123–133. <https://doi.org/10.2139/ssrn.3394477>
- Aliğaoglu, A., & Yiğit, Y. (2013). Balıkesir’de şehirsel toponimi: cadde adları. *Doğu Coğrafya Dergisi*, 18(30), 311–330.
- Biga Belediyesi. (2025). *Kent envanter ve otomasyon sistemi (KEOS)*. <https://keos.biga.bel.tr/keos/> (Retrieved August 22, 2025)
- Brunila, M., LaViolette, J., Ch-Wang, S., Verma, P., Féré, C., & McKenzie, G. (2023). Toward a Critical Toponymy Framework for Named Entity Recognition: A Case Study of Airbnb in New York City. *EMNLP 2023 - 2023 Conference on Empirical Methods in Natural Language Processing, Proceedings*, 4676–4695. <https://doi.org/10.18653/v1/2023.emnlp-main.284>
- Çanakkale Belediyesi. (2025a). *Web coğrafi bilgi sistemi (WebGIS)*. <https://webgis.canakkale.bel.tr> (Retrieved August 22, 2025)
- Çanakkale Belediyesi. (2025b). [Single-page informational document] https://www.canakkale.bel.tr/file/144/_vV.pdf (Retrieved August 22, 2025)
- Çanakkale Belediyesi. (2025c). [Single-page informational document] <https://www.canakkale.bel.tr/tr/sayfa/1140-haberler/5826-hayrettin-karaca-ve-tapolca-parki-torenle-acildi> (Retrieved August 27, 2025)
- David, J. (2011). Commemorative place names - Their specificity and problems. *Names*, 59(4), 214–228. <https://doi.org/10.1179/002777311X13082331190074>
- Düzgün, D. (2024). Toponymic diplomacy: A new conceptual framework for understanding the geopolitics of place names. *Geopolitics*, 29(4), 1356–1379. <https://doi.org/10.1080/14650045.2023.2252349>
- Google. (2025). <https://earth.google.com/> (Retrieved August 22, 2025)
- Gelibolu Belediyesi.(2025). *Kent envanter ve otomasyon sistemi (KEOS)*. <https://keos.gelibolu.bel.tr/keos/> (Retrieved August 22, 2025)
- General Directorate of Population and Citizenship Affairs. (2025). *e-application*. <https://www.turkiye.gov.tr/adres-degisikligi-bildirimi?adres=beyan%C4%B1> (Retrieved August 1, 2025)

- Gnatiuk, O., & Basik, S. (2023). Performing geopolitics of toponymic solidarity: The case of Ukraine. *Norsk Geografisk Tidsskrift*, 77(2), 63–77. <https://doi.org/10.1080/00291951.2023.2170827>
- Ji, X. (2018). City-renaming and its effects in China. *GeoJournal*, 83(2), 381–397. <https://doi.org/10.1007/s10708-017-9772-0>
- Njoh, A. J., & Chie, E. P. (2019). Vocabularies of Spatiality in French Colonial Urbanism: Some Covert Rationales of Street Names in Colonial Dakar, West Africa and Saigon, Indochina. *Journal of Asian and African Studies*, 54(8), 1109–1127. <https://doi.org/10.1177/0021909619860248>
- OpenStreetMap Contributors. (2025). *OpenStreetMap*. <https://www.openstreetmap.org> (Retrieved August 1, 2025)
- Orhan, F., & Dönmez, H. İ. (2023). Erzincan'ın şehirselleşme süreci ve şehir kimliği üzerindeki etkisi. *Van Yüzyüncü Yıl Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, Cumhuriyet Özel Sayısı*, 230–246.
- Presidency of the Turkish Republic of Northern Cyprus. (2025). [Biography - Founding President Rauf Raif Denktaş] (Retrieved August 22, 2025)
- Short, J. R., & Dubots, L. (2022). Contesting Place Names: the East Sea/ Sea of Japan Naming Issue. *Geographical Review*, 112(2), 187–206. <https://doi.org/10.1080/00167428.2020.1827936>
- Sysö, T., Ülker, O., & Tokgöz, N. (2023). Assembling a critical toponymy of diplomacy: The case of Ankara, Turkey. *Geopolitics*, 28(1), 416–438. <https://doi.org/10.1080/14650045.2021.1912022>
- Ton Tv. (2025, July 31). *İsmi belli gözler onayda: Barış Mahallesi muhtarını seçecek*. Ton TV. <https://www.tontv.com.tr/haber/25842419/ismi-belli-gozler-onayda-baris-mahallesi-muhtarini-sececek>
- Willer, C. J. (2022). Rebranding place “to build community”: neighborhood branding in Buffalo, NY. *Urban Geography*, 43(9), 1350–1371. <https://doi.org/10.1080/02723638.2021.1927323>
- Yavuz, S., & Şenel, M. (2013). Yer adları (toponim) terimleri sözlüğü. *Turkish Studies - International Periodical For The Languages, Literature and History of Turkish or Turkic*, 8(8), 2239–2254.
- Yılmaz Çıldam, S. (2018). Şehirselleşme süreci: Cadde adları, Bandırma örneği. *Atatürk Üniversitesi Edebiyat Fakültesi Dergisi*, 61, 1–25.

Public Toilets in Istanbul: A Spatial and Socio-Cultural Assessment

Ali Yılmaz

Istanbul Technical University, Faculty of Architecture, Department of Urban and
Regional Planning, Istanbul, Türkiye
ORCID: 0000-0003-2203-8416

Cihan Mert Sabah

Istanbul Technical University, Faculty of Architecture, Department of Urban and
Regional Planning, Istanbul, Türkiye
ORCID: 0000-0001-8994-5112

Abstract

Urban public toilets reflect many aspects of urban environment, such as livability, inclusiveness, and public health. This study addresses urban public toilet as an important issue for urban health, social and environmental justice; focusing on the spatial distribution and sociocultural base of public toilets in Istanbul. Instead of viewing toilets only as a service, this study examines location, density, accessibility, and daily demand of the public toilets. In addition, it explores *who* uses toilets, *how* patterns vary among demographic groups, and *how* cultural norms affect accessibility. Research method employs an approach that applies spatial analysis city-wide and including qualitative data. The findings show important differences in both the availability and usage of public toilets across Istanbul.

Specifically, access is limited and irregular in some neighborhoods that reveals spatial inequality pattern. Disadvantaged groups such as particularly elderly residents feel those inequalities directly. Therefore, as of urban inclusion, this research proposes a data-driven framework to support equitable urban policy and toilet planning by focusing infrastructural patterns and socio-spatial inconsistencies behind. Results aim to encourage the policy makers, urban planners and experts in public health to develop inclusive and sustainable strategies for toilets. This paper attempts to make an empirical and comprehensive contribution to the literature on the role of public sanitation, which is an often-overlooked but very basic building block of daily urban life in Turkey in shaping inclusive, healthy, and equitable cities.

Keywords: public toilets, spatial justice, accessibility, İstanbul

Introduction

Access to toilets in public places is an essential but overlooked area in urban infrastructure. Whether the facility is available or not will demonstrate a city's overall strategy on matters related to public health, social justice, equity, and people-centric planning. As an issue associated with fundamental humanity and an aspect linked with people's dignity and well-being, and as a result, an issue associated with the right to sanitation and access to basic services within publics, toilets are an area that falls within infrastructure but remain unmentioned and overlooked. Within recent years, there has been an increased recognition within academic

literature with regard to the relevance and importance of public toilets. Researchers emphasise the necessity of integrating public toilets into spatial planning frameworks (Greed, 2006) and highlight the impact of these facilities on safety, gender equality, accessibility, and public health (Barcan, 2005; Ellisa & Luana, 2022). International studies reveal how demographic variables, cultural norms, and governance models shape the design and spatial distribution of sanitation facilities (Fan & Zhang, 2023; Purkayastha & Raheja, 2024). Those challenges are particularly included in densely populated metropolises like Istanbul, where weak infrastructure and changing social, political, and daily urban demands are of great concern. Furthermore, the city's complex spatial structure, cultural and social diversity, and continuity of toilet practices stemming from Ottoman and Islamic bases continue to affect daily life through the investigation of public toilets. Although Istanbul is a global metropolis, access to public restrooms is largely unequal across its urban distribution. One primary reason for this is the concentration of existing city restrooms in tourist areas and major transportation hubs, while low-income neighborhoods, informal settlements, and surrounding areas are inadequate (Afacan & Gürel, 2015). In this context, access and usage characteristics are further shaped by social factors such as gender roles, socioeconomic status, and disability. Therefore, these factors play a decisive role in determining who can use clean and safe sanitation facilities and under what conditions. In this context, the main objective of this research is to examine in detail the spatial and socio-cultural factors shaping the existence and location of public toilets in Istanbul.

Literature Review

Public toilets are becoming more and more important for urban areas in cities and towns, and they have a direct effect on many other things as well. Globally, many academics and urban planners emphasise the need for comprehensive and strategic approaches to the distribution, design, and management of these facilities (Greed, 2006; Penner, 2013; Molotch & Noren, 2010). This literature review synthesises international perspectives on the spatial and socio-cultural dimensions of public toilets, then focuses on Turkey, and Istanbul in particular, to highlight the problems and conclusions encountered in providing inclusive and contextually sensitive public toilets.

The spatial distribution of public toilets should be guided by multi-scale planning approaches. Greed (2006) states that public toilets should be integrated as a mainstream component of national and local urban policies, and that accessibility can be ensured through a hierarchical model covering the city as a whole (macro), district (meso), and neighbourhood (micro) scales. Accordingly, as per Jeffery (2021), sanitation in public domain regions represents an essential measure for determining sustainability, and it becomes absolutely imperative to use data-driven measures and address geographical disparities. Research conducted by Fan and Zhang (2023) on tourist toilets and demographic distribution within rural China determined that transport, geography, structure, and demographic density are critical factors. Their work shows that significant mismatches between demand and supply lead to hygiene and accessibility problems. Similarly, the spatial distribution of public

toilets in Istanbul shows marked inequality; infrastructure is largely concentrated in tourist areas, transport hubs, and commercial centres, while many residential areas, peripheral districts, and informal settlements receive inadequate services (Afacan & Gurel, 2015; IMM, 2024).

The design of public toilets should incorporate dimensions of safety, usability, and integration into the urban context. Ellisa and Luana (2022) demonstrated that women's perceived safety in Jakarta is closely related to the spatial context, emphasising that well-lit, pedestrian-integrated, visible toilets reduce the risk of crime. These findings are also consistent with Jacobs' (1961) principle of "eyes on the street". Purkayastha and Raheja have emphasized inclusivity and explained that "design needs to factor in cultural values, physical needs, and user needs at an emotional level. It requires a participatory design method, and more so because India has very strong taboos against sanitation as a subject." Although there are some best practices within Istanbul (e.g., the underground toilets in Kadıköy; IMM, 1997), there is a lack of standardised and inclusive design guidelines across the city.

Public toilets are spaces where gender norms, social hierarchies, and cultural values are reproduced. Barcan (2005) described male toilets as places 'where hegemonic masculine norms are performed and regulated', and Del Río Almagro and Rodríguez (2016) demonstrated that gendered toileting practice enforces binary and exclusive norms. This discussion also aligns with the work of Moreira et al. (2021) on inclusive toilet policies. In India, the lack of clean, safe, and accessible toilets limits women's participation in public

life and affects their labour force participation rates (Gokhale et al., 2023). A similar situation is observed in Turkey; the use of paid toilets, gender-based mobility constraints, and perceptions of privacy create access barriers for women (Afacan & Gurel, 2015).

Inadequate access to toilets poses serious public health risks and disproportionately affects women, children, the elderly, and people with disabilities. Sahoo et al. (2015) demonstrated that sanitation-related stress leads to both psychological and physical adverse outcomes in women. Hygienic design, regular maintenance, clean water supply, and privacy elements are critical for protecting human dignity. Inclusive sanitation also encompasses menstrual hygiene support, child-friendly features, accessibility for persons with disabilities, and gender-neutral toilet options.

Principles emphasized in national and international literature imply that universal design should and needs to be contextualized. The prevalence of squat toilets in Istanbul, paid toilets, and the inadequacy of maintenance services are some indicators that traditional norms and market exclusivity still exist. Actually, they should be understood in the framework of local culture. Thus, squatting toilets and money toilets, which first appeared in Istanbul, indicate the persistence of traditional culture. Nevertheless, there coexists a rising demand for gender-neutral toilets, and there should be an emphasis on free and culturally acceptable toilets, especially within densely populated regions and transport interchanges (Afacan & Gurel, 2015; IMM, 2024). The comparative presentation of international best practices and the Istanbul-focused assessment in this text reveal

significant spatial, social, and cultural differences in the provision of public toilets that are more than technical facilities that deliver a basic service. While there are some positive examples in Istanbul, prevailing practices appear fragmented and insufficient in comprehensively meeting the needs of different user groups in the city.

Universal design offers a framework that needs to be reinterpreted in accordance with local conditions and cultural practices, rather than providing standardized solutions. In the context of Istanbul, the prevalence of traditional Turkish toilets and the continuation of paid usage models demonstrate the persistence of traditional habits and economically based exclusionary mechanisms. The need for gender-inclusive, free, and culturally contextually sensitive public restrooms is increasing, particularly in densely populated areas and transportation hubs (Afacan & Gürel, 2015). In this context, in order to reveal the spatial, social, and cultural differences in the provision of public toilets, international best practices and approaches specific to Istanbul are discussed comparatively in Table 1.

Table 1.

Comparison of international vs. Istanbul public toilet approaches.

Dimension	International Practices	Istanbul Practices
Spatial Planning	Strategic, multi-scalar (Greed, 2006; Fan & Zhang, 2023)	Fragmented, tourism-focused (Afacan & Gürel, 2015)
Gender Inclusivity	Gender-neutral options (Gokhale et al., 2023)	Gender-segregated, limited female access (Afacan & Gürel, 2015)

Cultural Sensitivity	Prayer spaces, symbolic interventions (Ellisa & Luana, 2022)	Mixed practices, traditionalist design (IMM, 1997)
Maintenance & Access	Public-funded, free entry in some countries	Mostly paid, limited free options
Universal Design	Participation-based adaptation (Purkayastha & Raheja, 2024)	Not systematically applied

Public restrooms cannot be considered solely as technical infrastructure elements; they are critically important for ensuring justice in the city, creating healthy living conditions, and promoting gender equality. International studies show that spatial characteristics and cultural dynamics should be considered together in the planning of public restrooms. In Istanbul, current approaches to planning and managing public restrooms remain uneven and only partially effective. While there are a few positive examples, they tend to function in isolation.

Methodology

This study, in light of the introduction and literature review above, spatially examines the distribution and daily use of public restrooms in Istanbul. Research methodology is designed using a combination of qualitative and quantitative (socio-spatial) analyses. First, temporal observations were made, and then statistical/data-driven applications were created to determine the key variables that shape toilet usage patterns. Thus, public restrooms are considered holistically and layered, not only in terms of their location,

but also when, by whom, and in what kind of urban context they are used.

Data Acquisition and Preparation

This research design combines three different datasets examined through spatial analysis and compares the relationships between these datasets. The primary dataset comprises anonymized user information from 2020 to 2024 regarding public restrooms in Istanbul. It has information like when it was used, what gender it was used by, and what age group it was used by. Trend and demographic analyses are based on the years 2022–2024 in order to lessen the pandemic's huge effects on how people use public spaces. The Istanbul Metropolitan Municipality Open Data Portal (2024) says that seasonal analyses show that summer lasts from May to October and winter lasts from November to April.

The first secondary dataset is called Points of Interest (POI). It uses a detailed GIS map that shows points of interest (POIs) for businesses, banks, restaurants, transportation, corporations, culture, and facilities/recreational services (OpenStreetMap, 2024). The second secondary dataset has information about the demographics of people living in homes, such as population density, the ratio of females, age composition (0–15, 15–64, 65+), and average years of education. This data was applied to a grid system provided by the Turkish Statistical Institute (TURKSTAT, 2024). To minimize the modifiable area unit problem (MAUP), a grid system covering a 100-ha (1km x 1km) area was created. This approach allowed for the overlapping of information

on the frequency of use of public toilets, points of interest (POIs) in the grid, and demographic factors, resulting in a consistent dataset for sociospatial and sociostatistical approaches.

Analytical Framework

This study includes a three-step analysis process designed to provide a detailed investigation of the sociospatial pattern. The first step focused on citywide usage trends, public use data to identify temporal patterns, including daily circulations, seasonal changes, and long-term differences. In this step, age and gender parameters are examined to clarify the composition of the user base and observe how the structure changes over time. Second, spatial maps are created for important indicators such as usage intensity, summer-winter rates, female rate, and average age. Those spatial representations play a critical role in identifying clusters of high and low access public toilets and varied demographic and seasonal patterns. Third, the study attempts to uncover *why* these spatial patterns emerge and which factors most affect those patterns. Finally, a correlation matrix is developed to examine the statistical relationships between public toilet usage indicators and a number of urban contextual variables. In doing so, the impact of urban functions was evaluated by examining the correlations between usage indicators and the density of different Point of Interest (POI) categories. In addition, the role of the resident population was assessed using demographic data from the Turkish Statistical Institute (2024). Thus, the different effects of the functional population (those who are in an area during the day) and the resident

population (those who live there at night) on the overall sanitation demand in the city were highlighted.

Findings

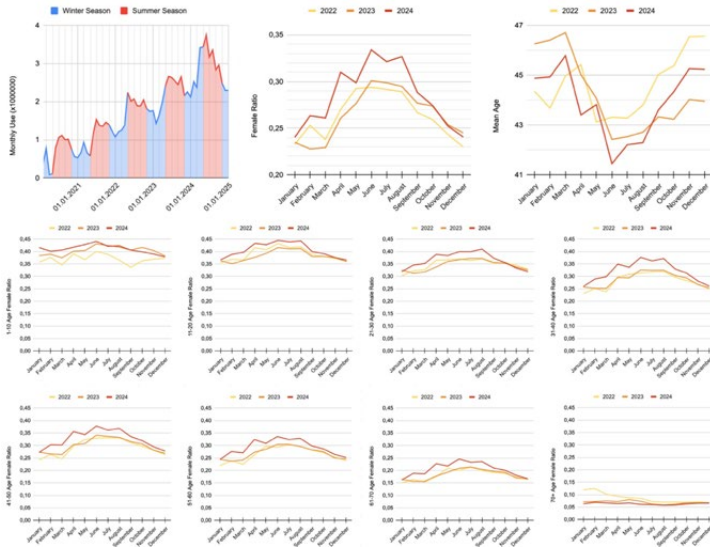
The use of public toilets in Istanbul has been examined separately in terms of socio-spatial and socio-demographic perspectives. Accordingly, the findings explain temporal diversity, demographic factors, and how neighborhoods in Istanbul differ spatially from one another.

General Usage Dynamics

From a general usage dynamics perspective, the study first presents data on public toilet use in Istanbul between 2020 and 2024. This focuses on trends relevant to discussions of socio-spatial justice and demographic equality in public sanitation. It explains how the overall use of city toilets changes over time, across seasons, and among different demographic groups. Figure 1 shows an increasing trend in the use of public toilets along with a seasonal cycle. The increasing number of public toilet users indicates the expansion of public sanitation in the whole city. In addition, public toilet use has straightforward peaks seasonally during the summer. This reflects Istanbul's seasonal dynamic spatial movement, where public life increases; such as outdoor activities increase, and demand for common space increases.

Figure 1.

Public toilet usage data. Total monthly use (top-left), total female ratio (top-center), mean age (top-right) and age-gender synthesis (bottom).



The difference between male and female users appears decreasing, but the imbalance stays important. Closer investigation shows that number of female users has increased over time peaking in 2024 but did not reached equality with with male statistics. Rate of women using public restrooms generally remains between 20-35%. Therefore, that situation shows that structural, cultural, and design barriers of accessibility. Furthermore, temporal variation makes this inequality even more visible, as the rate of women using public restrooms increases in the summer months and decreases in the winter months. Thus, it can be said that women's presence in public spaces are more dependent on temporal conditions in compared to men's.

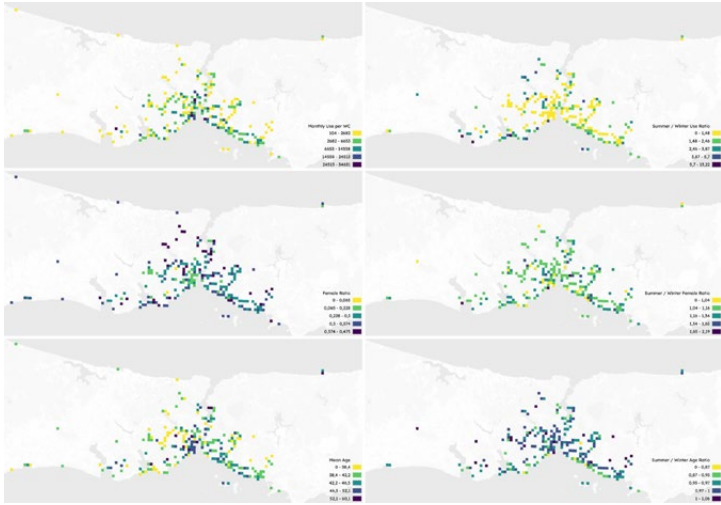
For age dynamics, a strong seasonal variation can be easily observed. The average age of users reach top in summer and rises in winter. That change may show increased presence of students or young professionals like white collar workers, and tourists in public areas in summer; while winter usage is more associated with the daily pattern of local population. In this context, considering age and gender together, it shows a systematic decrease in the rate of female users as age increases. While gender balance is relatively better in younger and middle-aged groups, this trend stagnates and in some cases reverses in older groups. Furthermore, users aged 70 and over stand out as the most excluded group, with the lowest proportion of female users within this group. In light of these findings, it is understood that older women have limited access to public spaces and sanitation infrastructure in terms of spatial justice.

Spatial Patterns and Inequities

A spatial analysis based on a 100-hectare grid system was conducted, depending on the average use of public toilets throughout the city. Within this scope, Figure 2 shows that the distribution and use of public toilets in Istanbul are far from homogeneous, and an irregular concentration logic is observed in terms of spatial fairness.

Figure 2.

Distribution and usage patterns of public toilets in Istanbul (Monthly use, female ratio, mean age -left- and their summer/winter use change ratio -right-).



The locations of public restrooms are mostly determined by how close they are to the city's main transportation routes and areas with a lot of people moving around. The densest clusters can be found along the Marmara and Bosphorus coasts, as well as along rail lines and in large urban parks. The density of use is a direct result of this supply-driven spatial structure. Central business districts, multimodal transportation hubs, and popular coastal areas are some of the places with the most demand. When comparing seasons, it's clear that the city's daily and year-round routines are very different in different parts of the city. For example, areas around business centers and metro lines are used fairly consistently throughout the year, while recreation and coastal areas are quieter in the winter and

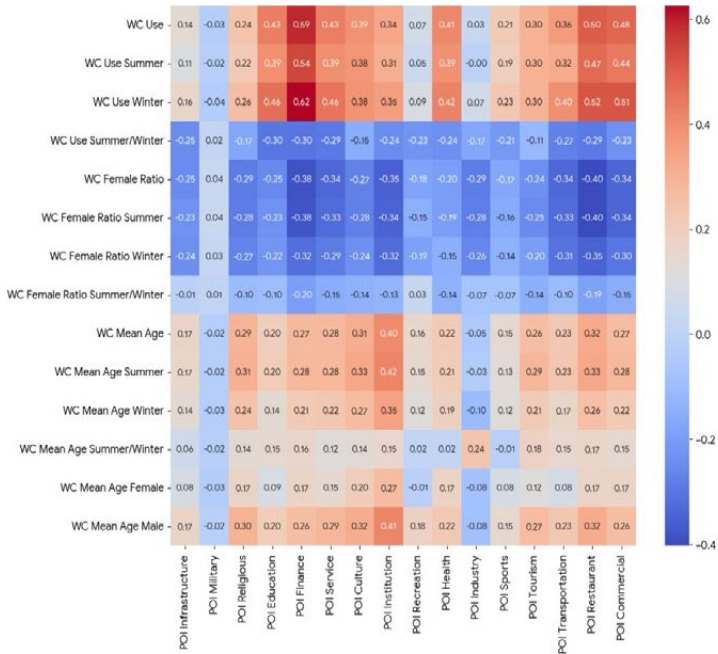
become very busy in the summer. In some parts of the city, public restrooms serve a function that supports the daily movements of workers and passengers. In other areas, however, they become more active during recreational or tourist seasons. Therefore, this spatial difference is reflected in the demographic profiles of users. The ratio of female toilet users is low in central business districts (CBDs) and main transportation axes and higher in recreational spaces such as parks or coastal areas. Furthermore, age patterns differ densely across Istanbul. Elderly users are common in transportation hubs and historical center areas. On the other hand, youth users are concentrated in the south and recreational areas, especially in summer. When the patterns are considered together, it becomes clear that public space in Istanbul is not static, but dynamic.

Urban and Demographic Factors

To understand the reasons behind spatiotemporal toilet usage patterns, data on public toilet use correlated with two main types of information. The first consists of Points of Interest (POI) data, which reflects the functional spatial distribution of urban patterns. The second layer comprises demographic data from the Turkish Statistical Institute (TÜİK), reflecting the composition of the resident population. The correlation analysis shown in Figure 3 and Figure 4 lead to a clear and important conclusion about what cause people to need public toilets: Demand does not arise from the demographic characteristics of the resident population in a specific area; rather, it is influenced by the urban functions of that area and the transient (daytime) population it draws during the day.

Figure 3.

The correlation analysis of public toilet use and POI (e.g. daytime)



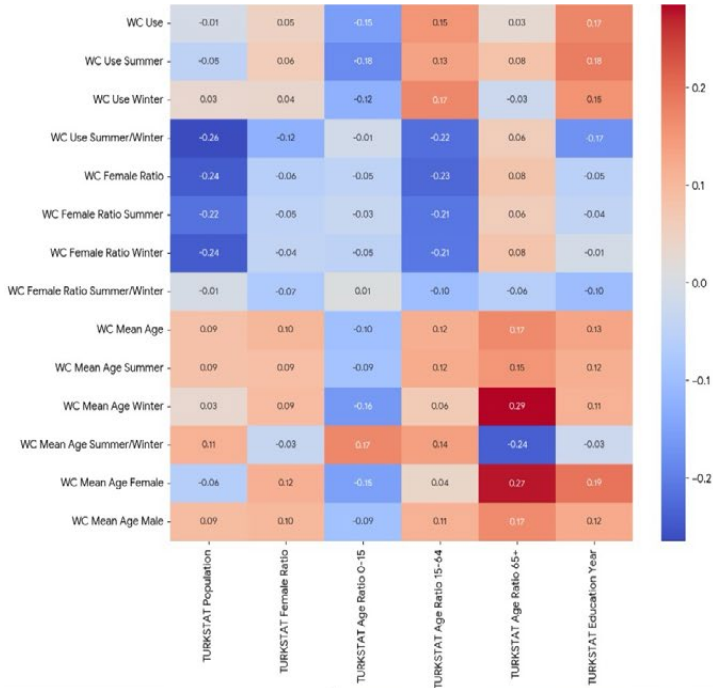
The general usage level shows a strong and statistically significant positive correlation with categories with high POI density, such as finance, commerce, restaurants, and transport. This finding confirms that the highest demand is concentrated in economic and social activity centres where people work, shop, socialise and travel. However, within this general picture, gender analysis reveals a significant contradiction that points to socio-spatial injustice: the proportion of female users shows a negative correlation with precisely these high-density commercial and financial centres. This situation indicates that these areas, which

form the economic heart of the city, have a functional and possibly culturally male-dominated character, and that this structure is directly reflected in women's rates of public infrastructure use. On the other hand, the positive correlation between the average age of users and the density of institutional, cultural, and religious spaces indicates that different urban functions attract different demographic groups and that each type of space creates its own unique user profile. In the second phase of the analysis, correlating usage data with resident population data from 2024 further sharpened the findings and led to an important conclusion for urban planning practice: there is almost no significant relationship between the nighttime population density of an area and the density of public toilet use. This finding clearly demonstrates how misleading traditionally used settlement-based population data can be in public service planning. Demand stems more from users who come to the area during daytime hours than from residents.

The only significant exception to this general trend concerns the population aged 65 and over. In neighborhoods with a high proportion of elderly people, the average age of public toilet users was also observed to be higher. This indicates that elderly individuals with more limited mobility predominantly use public infrastructure in their immediate surroundings; therefore, it points to the importance of local-scale service provision for this group. Similarly, the lack of a significant relationship between the proportion of resident women in neighborhoods and the proportion of female users in public toilets once again confirms that the user profile is determined by the functional character of the area rather than the population structure. Accordingly,

Figure 4.

The correlation analysis of public toilet use and residential demographics(e.g.night-time).



the two-stage correlation analysis provides a holistic and complementary picture. POI analysis reveals the source of demand (urban functions and land use), while population analysis shows what does not cause demand (demographic structure of the resident population). From the perspective of urban and regional planning, those findings indicate the need for planning of urban public services.

Discussion and Evaluation

This research showed that use of public toilets in Istanbul is deeply associated with the city's social and spatial structure and, more importantly, with social inequalities. First, it can be stated that public toilet usage in Istanbul is mainly shaped by the functional characteristics of the urban fabric. Therefore, the need for planning approaches that take into account the dynamics of people in urban areas is very significant. Strong correlations are found between the intensity of toilet use and urban functions such as finance, commerce, food and beverage, and transportation. Demand for public toilets is densely clustered in areas with high economic and social activity. These results, as Fan & Zhang (2023) stated, show the importance of population mobility of related infrastructure. Secondly, this research contributes to discussions about spatial justice from a gender perspective. In this context, it is observed that the rate of women's use of public spaces is quite low in densely populated commercial and financial districts. Therefore, it is seen that these areas remain predominantly male-dominated, both symbolically and functionally. At this point, it is understood that our findings are consistent with previous studies on women's perceptions of safety (Ellisa & Luana, 2022) and freedom of movement (Gokhale et al., 2023). In contrast, the increasing presence of women in recreational and coastal areas suggests that women's use of public spaces is shaped by urban safety. Finally, the low rate of use of city toilets among elderly women supports accessibility-focused research (Afacan & Gürel, 2015) and shows that they face exclusion from safety concerns, health, and mobility.

Conclusion

This study uncovers the need for equitable and inclusive approaches for public toilet infrastructure in Istanbul and makes a contribution to urban planning literature and practice. Traditional urban configurations and planning methods are insufficient in addressing real and practical daily needs. Instead of relying on static and pure data-centric approaches, the planning discipline must adopt dynamic, activity-oriented, and mobility-based strategies. Identifying disadvantaged population groups and implementing varied actions for areas where these groups live is necessary. Finally, decision-makers should develop inclusive approaches that prioritize accessibility, safety, and cultural focus in urban policies and integrate those aspects into the planning and management of public toilet infrastructure.

References

- Afacan, Y., & Gurel, M. O. (2015). Public toilets as a matter of accessibility: a study on users with disabilities in Turkey. *METU Journal of the Faculty of Architecture*, 32(2), 143–162.
- Barcan, R. (2005). Dirty spaces: Communication and contamination in men's public toilets. *Journal of International Women's Studies*, 6(2), 7–23.
- Del Río Almagro, A., & Rodríguez, O. C. (2016). Public toilets and sex-gender fictions: A research from artistic practice. *Opción*, 32(9), 658–684.
- Ellisa, E., & Luana, L. (2022). Female restrooms in tourist destinations: how the socio-spatial conditions of public toilets influence women's perception of safety. *Journal of Asian Architecture and Building Engineering*, 21(3), 789–802.

- Fan, W.-Y., & Zhang, Y.-X. (2023). Spatial distribution of tourist toilets and the driving factors in rural destinations. In *2023 11th International Conference on Agro-Geoinformatics* (pp. 1–6).
- Gokhale, V. A., Joshi, D., & Acharya, A. (2023). Women's contested mobility and equity in Indian urban environment: case of public toilets in Pune, Maharashtra. *Cities & Health*, 7(1), 67–78.
- Greed, C. (2006). A strategic spatial planning approach to public toilet provision in Britain. In *Contemporary Ergonomics* (pp. 307–312).
- Istanbul Metropolitan Municipality (IMM). (1997). *Kadıköy underground toilet architectural report*. IMM Archive.
- Istanbul Metropolitan Municipality (IMM). (2024). Open Data Portal. <https://data.ibb.gov.tr>
- Jacobs, J. (1961). Jane Jacobs. *The Death and Life of Great American Cities*, 21(1), 13-25.
- Molotch, H., & Noren, L. (Eds.). (2010). *Toilet: Public restrooms and the politics of sharing* (Vol. 1). NYU Press.
- Moreira, F. D., Rezende, S., & Passos, F. (2021). On-street toilets for sanitation access in urban public spaces: A systematic review. *Utilities Policy*, 70, 101186.
- OpenStreetMap (OSM) (2024). *Planet dump*. <https://www.openstreetmap.org>
- Penner, B. (2013). *Bathroom*. Reaktion Books.
- Purkayastha, D., & Raheja, G. (2024). Inclusive public toilets: A universal design enquiry for the Indian context. *Studies in Health Technology and Informatics*, 308, 183–193.
- Sahoo, K. C., Hulland, K. R. S., Caruso, B. A., Swain, R., Freeman, M. C., Panigrahi, P., & Dreibelbis, R. (2015). Sanitation-related psychosocial stress: A grounded theory study of women across the life-course in Odisha, India. *Social Science & Medicine*, 139, 80–89.
- Turkish Statistical Institute (TURKSTAT). (2024). Geographical Statistics Portal. <https://data.tuik.gov.tr>
- WHO. (2021). *Guidelines on inclusive sanitation*. <https://www.who.int/news-room/fact-sheets/detail/sanitation>

CIP - Каталогизација во публикација

Национална и универзитетска библиотека “Св. Климент Охридски”, Скопје

711.4:72.012(082)

RESILIENT, inclusive, and smart cities [Електронски извор] : contemporary perspectives on urban development / edited by Marija Miloshevska Janakieska. - Skopje : Balkan University Press, 2026. - (Architecture & Design ; 3)

Начин на пристапување (URL):

<https://ibupress.com/Pages/Book/Details?id=VQAAAA>. - Текст во ПДФ формат, содржи X, 251 стр., илустр. - Наслов преземен од екранот. - Опис

на изворот на ден 06.03.2026. - About the Editor: стр. [8-9]. - About the Authors: стр. [11-19]. - Foreword: стр. XXI-XXIII. - Библиографија кон трудовите

ISBN 978-608-4868-70-5

а) Урбан развој -- Градови -- Архитектура -- Просторно планирање
--
Зборници

COBISS.MK-ID 68348933