

ANALYTICAL AND MULTI-CRITERIA APPROACHES FOR SUSTAINABLE PUBLIC POLICIES

Edited by Hakan Gökhan **Gündoğdu** and Çağlar **Karamaşa**

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Analytical and Multi-Criteria Approaches for Sustainable Public Policies

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Çağlar Karamaşa

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Preface

The increasing complexity of contemporary public policy challenges has heightened the importance of analytical, evidence-based, and multi-dimensional approaches to achieving sustainability objectives. Rapid urbanization, digital transformation, climate change, demographic shifts, migration dynamics, and environmental risks necessitate a fundamental reconsideration of public administration and governance structures. In this context, sustainable governance requires not only normative commitments but also robust analytical tools capable of addressing uncertainty, trade-offs, and competing policy priorities.

The volume titled Analytical and Multi-Criteria Approaches for Sustainable Public Policies examines the role of analytical and multi-criteria decision-making methods in the design and implementation of sustainable public policies from an interdisciplinary perspective. By bringing together theoretical discussions and applied policy analyses, the book seeks to demonstrate how institutional capacity, policy coherence, and strategic planning can be strengthened in complex governance environments.

The chapters included in this volume cover a broad thematic spectrum, encompassing digital governance and e-government development, smart city strategies, urban planning and accessibility, disaster- and climate-induced migration, ageing and demographic change, societal attitudes toward migration, sustainability reporting, and urban traffic management. From a methodological standpoint, the volume highlights a diverse set of analytical tools, including the Best–Worst Method and its neutrosophic extensions, SWOT analysis, simulation-based modeling, comparative qualitative analysis, and the use of large-scale survey data.

One of the core contributions of the book lies in its emphasis on the limitations of technology-centered or single-criterion approaches to sustainable public policy. The chapters collectively underscore the necessity of holistic evaluation frameworks that balance economic efficiency, social equity, environmental sustainability, and institutional feasibility. In this regard, the volume demonstrates how analytical and multi-criteria approaches can function as a critical bridge between sustainability goals and practical policy implementation.

By integrating governance theory with advanced analytical methods, the book contributes to ongoing academic debates on sustainable public administration and offers concrete insights for policy design and evaluation. It highlights the importance of participatory governance, institutional transparency, and data-driven decision-making in enhancing policy effectiveness and public trust.

Overall, this volume aims to serve as a valuable reference for academics, graduate students, public administrators, policy analysts, and urban planners seeking to develop resilient, inclusive, and sustainable governance systems. Through its interdisciplinary scope and methodological diversity, the book provides both conceptual and practical guidance for addressing the multifaceted challenges facing contemporary public policies.

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Introduction

Hakan Gökhan Gündoğdu[1], Çağlar Karamaşa[2]

In an era characterized by accelerating environmental change, technological transformation, demographic shifts, and growing social complexity, public policies are increasingly required to operate under conditions of uncertainty, multidimensionality, and competing priorities. Traditional linear and sector-based policy approaches have proven insufficient to address challenges such as climate change, digital transformation, urban congestion, migration, ageing societies, and sustainability-driven financial regulation. Within this context, the integration of analytical and multi-criteria decision-making approaches into public policy design has emerged as a critical pathway toward more transparent, resilient, and evidence-based governance. This book is motivated by the need to understand how such approaches can enhance sustainable public policy formulation across diverse policy domains.

The central problem addressed in this volume concerns the growing gap between the complexity of contemporary policy problems and the analytical capacity of existing governance frameworks. While sustainability has become a dominant normative objective in public administration, policy decisions often remain fragmented, intuition-based, or constrained by institutional silos. Moreover, the literature frequently treats sustainability, governance, digitalization, migration, and urban systems as separate analytical fields, despite their deep interdependence. This fragmentation limits the ability of policymakers to evaluate trade-offs, prioritize competing objectives, and manage uncertainty in a systematic manner. The present volume responds to this gap by advancing analytical and multi-criteria methodologies as integrative tools capable of bridging normative sustainability goals with operational policy decision-making.

The theoretical and conceptual framework of the book is grounded in sustainable governance, systems thinking, and multi-criteria decision analysis. Sustainability is conceptualized not merely as an environmental concern, but as a multidimensional governance paradigm encompassing institutional capacity, social inclusion, economic resilience, and long-term adaptability. Key concepts

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such as policy prioritization, institutional governance, digital participation, resilience, and decision-making under uncertainty form the backbone of the analytical perspective adopted throughout the volume. The emphasis on multi-criteria methods reflects the recognition that public policies inherently involve conflicting objectives, diverse stakeholders, and incomplete information, requiring tools that can systematically structure complexity rather than reduce it to single indicators.

Engaging critically with existing literature, the book positions itself at the intersection of public administration, urban studies, sustainability science, and decision sciences. While prior studies have contributed valuable insights into sustainability transitions, smart governance, and sector-specific policy challenges, fewer works have explicitly connected these debates with formal analytical decision-making frameworks. By incorporating methods such as the Best–Worst Method, Neutrosophic logic, SWOT analysis and simulation-based modeling, the volume introduces methodological pluralism into sustainability-oriented policy analysis. This approach allows the book to contribute not only conceptually but also methodologically to ongoing debates in the field.

The book is structured to reflect both thematic coherence and analytical diversity. The opening chapters focus on digital governance and e-government development, demonstrating how multi-criteria approaches can clarify policy priorities under uncertainty. Subsequent chapters examine smart city governance, urban health systems, and strategic planning capacities through comparative and analytical lenses. Issues of disaster- and climate-induced migration, ageing and accessibility, sustainability reporting standards, and urban traffic management are then explored as distinct yet interconnected policy domains. Together, these chapters illustrate how analytical tools can be applied across different governance levels and policy sectors while maintaining a shared sustainability orientation. In this context, the penultimate chapter employs a Best–Worst Method (BWM)-based prioritization of IFRS S1 sustainability disclosure elements, situating sustainable finance within the broader framework of sustainable governance and multi-criteria decision analysis by systematically structuring policy priorities under conditions of uncertainty and competing objectives. The final chapter, drawing on systems thinking and simulation-based modeling, demonstrates how data-driven optimization of urban traffic systems can contribute to sustainable urban policy by enhancing efficiency, reducing environmental externalities, and supporting evidence-based decision-making in complex governance environments.

In terms of scope, the book adopts a comparative and illustrative approach rather than claiming exhaustive coverage. While several chapters focus on Türkiye

and specific urban contexts, the analytical frameworks and policy insights are transferable to broader international settings. Methodologically, the volume prioritizes qualitative and mixed analytical approaches, emphasizing expert-driven evaluations, policy document analysis, and simulation techniques. This focus reflects the intention to provide actionable insights without sacrificing analytical rigor.

The primary audience of this book includes academics and researchers in public administration, urban studies, and policy analysis, as well as graduate students, policymakers, and practitioners engaged in sustainability-oriented governance. Given its interdisciplinary and multi-method orientation, the volume is particularly relevant for readers interested in evidence-based policymaking, decision-support systems, and the governance implications of complex societal challenges.

As a multi-authored work, the book brings together diverse perspectives, disciplinary backgrounds, and methodological approaches. This plurality is treated as a strength rather than a limitation, reflecting the reality that sustainable public policies cannot be designed through a single theoretical lens or analytical tool. Instead, they require dialogue across disciplines, institutions, and policy domains.

Guided by these considerations, the book seeks to address the following overarching questions:

1. How can analytical and multi-criteria decision-making methods enhance sustainability-oriented public policies?
2. In what ways do digital transformation, urban systems, and demographic change reshape governance priorities?
3. How can public institutions better manage uncertainty, trade-offs, and competing objectives in complex policy environments?

Ultimately, this volume argues that sustainable public policy is not solely a normative aspiration but a practical governance challenge that demands robust analytical tools, institutional learning, and inclusive decision-making frameworks. By integrating analytical rigor with sustainability principles, the book aims to contribute to the development of more adaptive, transparent, and resilient public governance systems capable of responding to the challenges of the twenty-first century.

CHAPTER 1

Evaluating Policy Priorities in E-Government Development: A Neutrosophic Best–Worst Analysis within the EGDI Framework

Çağlar Karamaşa[1]

1. Introduction

The digitalization of public administration has emerged as a strategic policy priority that extends beyond mere technological investments, encompassing comprehensive structural and organizational transformations. Digital transformation is now recognized as a central element of modern public administration, serving as a crucial mechanism for embedding principles of good governance such as transparency, accountability, and citizen participation. In addition, these transformations play a vital role in promoting sustainable development goals. For instance, initiatives in São Paulo, Brazil, have reduced the unit costs of public services by an average of 73.9 percent, illustrating significant improvements in the efficiency of resource utilization (Gonçalves & Maggion, 2022). Likewise, the expansion of digital services has accelerated interactions between governments and citizens, strengthening transparency and encouraging greater societal engagement in governance processes (Gençkaya et al., 2021; Gündoğdu, 2021; Latupeirissa, 2024). Despite these advances, many countries still face limitations in effectively leveraging digital technologies (United Nations Department of Economic and Social Affairs [UNDESA], 2020). To address this, international organizations including the United Nations (UN), Organisation for Economic Co-Operation and Development (OECD), European Union, and World Bank have developed standardized frameworks to measure e-government development over the past two decades. Among these, the UN's E-Government Development Index, published biennially and covering 193 member states, has become one of the most comprehensive tools for assessing digital public administration (United Nations [UN], 2024a). By

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2024, the global average E-Government Development Index (EGDI) score rose from 0.6102 to 0.6382, with 71.5 percent of countries reaching high or very high levels of digital development. Regionally, Europe remains the leading region with an average score of 0.8493, whereas Africa continues to lag with an average of 0.4247. These figures highlight that while progress in digitalization is evident globally, significant structural inequalities persist, reflected in the ongoing digital divide (UN, 2024b).

The EGDI evaluates the extent and quality of digitalization in public administration through three main components: the Online Service Index, the Telecommunications Infrastructure Index, and the Human Capital Index. Each component is supplemented with multidimensional sub-indicators, including institutional capacity, digital service delivery, content diversity, e-participation, and technological accessibility. The e-participation dimension assesses citizen engagement in public decision-making via digital platforms, analyzing progression across e-information, e-consultation, and e-decision-making stages. Therefore, the EGDI offers a holistic assessment framework that integrates both technical and infrastructural capabilities with the democratic dimension of governance.

This study seeks to determine the relative significance of the EGDI's core components and sub-indicators using Multi-Criteria Decision-Making (MCDM) techniques based on expert evaluations. Employing the Neutrosophic Best–Worst Method (NBWM), the research identifies priority areas within different dimensions of digital public administration. For the e-participation component, Best Value Order and Overall Value Weight vectors were constructed to provide quantitative prioritization.

Previous literature has examined digitalization from multiple perspectives. Some indices focus on operational outcomes, such as improved service quality and procedural efficiency (International Telecommunication Union [ITU], 2017; Dener et al., 2021), whereas others emphasize the broader impacts on governance quality, citizen participation, and social inclusion (Organisation for Economic Co-operation and Development [OECD], 2019; Waseda University & International Academy of Chief Information Officers [Waseda-IAC], 2024). For example, the UN's EGDI framework classifies countries' digital service maturity into four levels: Emerging, Enhanced, Transactional, and Connected (UN, 2012), illustrating the gradual and staged nature of digital transformation. This study advances the literature by offering an analytical, expert-based weighting approach, addressing a notable gap in existing research. This methodology provides an original perspective for both theory and policy, enabling identification of the most strategically important components of digital

government and guiding the prioritization of digital public policies.

In this context, the study addresses the following research questions.

- Which core and subcomponents of the EGDI are the most critical for effective digital governance?
- How should the e-participation elements, e-information, e-consultation, and e-decision-making, be prioritized from a policy-making perspective?
- How can analytically derived, expert-based prioritization support and inform the development of public policies?

Ultimately, the study offers strategic recommendations at national and local levels based on the relative importance of EGDI components and provides insights for enhancing the design and implementation of digital public administration. The subsequent sections detail the methodological approach, present the findings, and discuss implications for both scholarly research and practical policy-making in digital governance.

2. Theoretical Background and Literature Review

Over the years, numerous indices have been developed to evaluate digitalization in the public sector, allowing for comparative analysis across different country groups. In this context, prominent measurement tools include the UN EGDI, the ITU's ICT Development Index (IDI), the World Economic Forum's Network Readiness Index (NRI), Waseda University's World Digital Government Ranking (Waseda Index), and the European Union's eGovernment Benchmark (Skargren, 2020). These indices analyze the digital maturity of governments across multiple dimensions, providing a comparative perspective. Furthermore, indicators such as IDI, EGDI, NRI, the Waseda Index, and the eGovernment Benchmark offer multidimensional frameworks for assessing the digital transformation of public services and the level of societal participation. Each index reflects a different aspect of digital society and provides meaningful insights within its specific scope (Sony & Naik, 2020).

The UN EDGI is a multi-component measurement tool designed to evaluate countries' digital governance capacities holistically. First published in 2003, the EGDI is based on three primary dimensions: online service provision (Online Service Index- OSI), telecommunication infrastructure (Telecommunication Infrastructure Index- TII), and human capital (Human Capital Index-HCI). These dimensions respectively represent the ability of public institutions to deliver digital services, the level of access to information and communication technologies, and the capacity of society to utilize digital services. The EGDI is calculated as a normalized index with equal weighting (one-third) for each

component. Data are collected through global surveys and country-level questionnaires conducted by the ITU, United Nations Educational, Scientific and Cultural Organization [UNESCO], and the UN. In this regard, the EGDI enables international comparisons of digital government maturity and serves as a reference framework for identifying policy priorities (Lnenicka et al., 2024).

Some studies in the literature indicate that digitalization indicators such as EGDI, IDI, NRI, the Waseda Index, and the eGovernment Benchmark generally provide independent structures and are primarily based on technical capacity measurements. These studies emphasize that each index is constructed using different methodological approaches, which may limit their utility as comprehensive decision-support tools for establishing strategic priorities (Zou et al., 2023; Lnenicka et al., 2024). For example, Lnenicka et al. (2024) report that in comparative analyses of European Union member states, the contribution of subcomponents such as human capital, online service provision, and infrastructure to digital society varies across countries. Moreover, the literature highlights that digital governance indicators alone have limitations when applied directly as decision-support tools for determining strategic policy priorities (Zou et al., 2023).

Accessibility, efficiency, and the availability of public services have emerged as key factors enhancing citizen trust in e-government development (Carter & Bélanger, 2005; Beynon-Davies, 2007). In developing countries, individual-level factors such as effort expectancy, social influence, facilitating conditions, and behavioral intention, together with technology acceptance, trust, and prior experience, play a significant role (Carter, 2008). These findings suggest that indices like the EGDI should not be limited to technical data alone but should also incorporate user-centered and strategic factors. Consequently, these results indicate that indices such as the EGDI may not suffice for comprehensive strategic analyses on their own and highlight the need to integrate them with MCDM methods, such as the NBWM.

This study focuses on MCDM methods, which offer more systematic and quantitative approaches for determining e-government policy priorities. Table 1 below summarizes key studies in the literature that employ MCDM methods in the context of e-government development.

Table 1. Key Literature on MCDM Methods Used in E-Government Development

Author(s)	Objective & Key Findings	Method(s)
Syamsuddin & Hwang (2010)	A new fuzzy MCDM-based assessment framework was proposed to evaluate e-government security strategies.	Fuzzy MCDM
Tavana et al. (2013)	A framework was suggested to assess e-government readiness from a Citizen Relationship Management (CiRM) perspective, facilitating complex evaluation processes.	Fuzzy ANP & TOPSIS
Máchová (2015)	A multi-criteria model incorporating emerging approaches such as cloud computing, open data, and social media was proposed to evaluate e-government development. Decision-making was demonstrated through a case study using AHP.	Analytic Hierarchy Process (AHP)
Abdel-Basset et al. (2018a)	A neutrosophic VIKOR-based decision-making framework was developed to evaluate e-government websites according to quality, security, and accessibility criteria.	Neutrosophic VIKOR, MCDM
Sahoo et al. (2022)	The study aimed to evaluate the usability of e-governance services based on citizen feedback and to identify the most appropriate features for developing an effective system.	AHP (MCDM)
Vevera et al. (2022)	A hybrid indicator called SECDIG was proposed, combining GCI, NCSI, IDI, and NRI indicators in a multi-criteria manner to assess digital and cybersecurity levels for 11 Eastern European countries.	COPRAS (MCDM)
Demir et al. (2023)	Open data indicators were evaluated for G20 countries, identifying Australia as the best-performing country. Decision support was provided for public services based on open data.	LMAW, LOPCOW, Bayesian approach, WASPAS
Shayganmehr et al. (2023)	A three-stage framework was developed to assess trust in e-government services in uncertain environments using Iranian municipal websites. "Trust in government" was identified as the most influential, while "Maintenance and support" was the least influential indicator.	Fuzzy Delphi, IVIFS-AHP, Fuzzy Evaluation Method (FEM)
Radulescu et al. (2022)	A hybrid group weighting method combining Borda and Group Best-Worst methods was proposed to determine criteria weights for digital development indicators.	Borda + Group Best Worst (HGWM)
Ilieva et al. (2024)	Factors affecting user perception and adoption of e-government services were examined, and variables influencing user satisfaction were modeled.	SEM, Machine Learning, MCDM

The studies summarized in Table 1 indicate the widespread use of MCDM methods in e-government development. However, there are significant limitations in the existing literature. First, although approaches such as fuzzy logic and neutrosophic set theory have been applied to decision-making under uncertainty, their effectiveness in complex policy environments with contradictory and inconsistent data has not been fully explored. Second, most studies are limited to a single method (AHP, VIKOR, TOPSIS) or narrow hybrid models, and the integration of relatively new techniques such as the Best-Worst Method (BWM) with neutrosophic logic has not been sufficiently investigated. Third, there is a scarcity of studies that systematically address the dynamic weighting of criteria in e-government readiness indices, such as the EGDI. While studies like Tavana et al. (2013) and Abdel-Basset et al. (2018a) emphasize citizen-focused evaluations, they remain insufficient for providing strategic prioritization tools for policymakers.

This study aims to address these gaps using the NBWM. The research problem is structured based on indices published by international organizations and the analytical frameworks they include. In particular, the EGDI framework, which jointly considers the dimensions of digital service provision, human capital, and infrastructure, offers a suitable evaluation domain for MCDM approaches (UN, 2012). In this context, the NBWM employed in this study aims to assess policy priorities among EGDI subcomponents under uncertainty, thereby helping to fill a gap in the existing literature.

3. Methodology

Building on the research objectives and the identified gaps in e-government policy prioritization, the following section presents the methodological framework of the study. It begins with an overview of neutrosophic sets as a means to handle uncertainty, followed by a detailed explanation of the NBWM employed for expert-based prioritization. The subsequent sections then present the findings and discuss their implications for policy and practice in the context of the EGDI framework.

3.1. Neutrosophic Sets

Neutrosophic sets (NS) were proposed by Smarandache (2002) as a different version of classical, fuzzy and intuitionistic fuzzy sets and represent ambiguous, inconsistent and uncertain problems better than classical and intuitionistic fuzzy sets (Abdel-Basset et al., 2017, 2018b, 2018c; Yücesan & Gül, 2021). Single-valued neutrosophic sets (SVNS) as a subclass of NS are most commonly used and are suitable for solving problems including inconsistent, ambiguous,

imprecise and incomplete information (Yücesan & Gül, 2021). Humans express their preferences, opinions and judgments via linguistic terms in the real world. For this purpose, SVNS composed of triangular fuzzy numbers are considered to prioritize EDGI sub-components and their related indicators in this study.

A SVNS composed of triangular fuzzy numbers is represented as $\tilde{c} = \langle (c_1, c_2, c_3); \alpha_{\tilde{c}}, \beta_{\tilde{c}}, \gamma_{\tilde{c}} \rangle$ where lower, average and upper values related to the neutrosophic number are shown by c_1, c_2 and c_3 respectively. In addition, the truth, indeterminacy and falsity membership functions are represented by $\alpha_{\tilde{c}}, \beta_{\tilde{c}}$ and $\gamma_{\tilde{c}}$.

Truth-membership function $(\mathrm{TM}_{\tilde{c}}(x))$ is determined as follows:

$$TM_{\tilde{c}}(x) = \begin{cases} \alpha_{\tilde{c}} \left(\frac{x - c_1}{c_2 - c_1} \right) if c_1 \leq x \leq c_2 \\ \alpha_{\tilde{c}} \; if \; x = c_2 \\ \alpha_{\tilde{c}} \left(\frac{c_3 - x}{c_3 - c_2} \right) if \; c_2 \leq x \leq c_3 \\ 0 \; otherwise \end{cases} \tag{1}$$

Indeterminacy-membership function $(\mathrm{IM}_{\tilde{c}}(x))$ is obtained as Eq.(2):

$$IM_{\tilde{c}}(x) = \begin{cases} \frac{(c_2 - x + \beta_{\tilde{c}}(x - c_1))}{(c_2 - c_1)} \; if c_1 \leq x \leq c_2 \\ \beta_{\tilde{c}} \; if \; x = c_2 \\ \frac{(x - c_2 + \beta_{\tilde{c}}(c_3 - x))}{(c_3 - c_2)} if \; c_2 \leq x \leq c_3 \\ 1 \; otherwise \end{cases} \tag{2}$$

Falsity-membership function $(\mathrm{FM}_{\tilde{c}}(x))$ is acquired as follows:

$$FM_{\tilde{c}}(x) = \begin{cases} \frac{(c_2 - x + \gamma_{\tilde{c}}(x - c_1))}{(c_2 - c_1)} \; if c_1 \leq x \leq c_2 \\ \gamma_{\tilde{c}} \; if \; x = c_2 \\ \frac{(x - c_2 + \gamma_{\tilde{c}}(c_3 - x))}{(c_3 - c_2)} if \; c_2 \leq x \leq c_3 \\ 1 \; otherwise \end{cases} \tag{3}$$

According to the aforementioned equations, the maximum truth, minimum indeterminacy and minimum falsity membership functions are represented via $\alpha_{\tilde{c}}, \beta_{\tilde{c}}$ and $\gamma_{\tilde{c}}$ respectively. Consider $\tilde{c} = \langle (c_1, c_2, c_3); \alpha_{\tilde{c}}, \beta_{\tilde{c}}, \gamma_{\tilde{c}} \rangle$ and $\tilde{d} = \langle (d_1, d_2, d_3); \alpha_{\tilde{d}}, \beta_{\tilde{d}}, \gamma_{\tilde{d}} \rangle$ as two single-valued triangular neutrosophic numbers (SVTNN). Basic mathematical operations related to these SVTNN are defined as follows (Abdel-Basset et al., 2017; Yücesan & Gül, 2021):

a) Addition: Addition of two SVTNN is obtained as follows:

$$\tilde{c} + \tilde{d} = \langle (c_1 + d_1, c_2 + d_2, c_3 + d_3); \alpha_{\tilde{c}} \wedge \alpha_{\tilde{d}}, \beta_{\tilde{c}} \vee \beta_{\tilde{d}}, \gamma_{\tilde{c}} \vee \gamma_{\tilde{d}} \rangle \quad (4)$$

b) Subtraction: Subtraction of two SVTNN is acquired as Eq.(5):

$$\tilde{c} - \tilde{d} = \langle (c_1 - d_3, c_2 - d_2, c_3 - d_1); \alpha_{\tilde{c}} \wedge \alpha_{\tilde{d}}, \beta_{\tilde{c}} \vee \beta_{\tilde{d}}, \gamma_{\tilde{c}} \vee \gamma_{\tilde{d}} \rangle \quad (5)$$

c) Inverse: Inverse of a SVTNN such as $\tilde{c} = \langle (c_1, c_2, c_3); \alpha_{\tilde{c}}, \beta_{\tilde{c}}, \gamma_{\tilde{c}} \rangle$ is calculated according to Eq.(6):

$$\tilde{c}^{-1} = \left\langle \left(\frac{1}{c_3}, \frac{1}{c_2}, \frac{1}{c_1} \right); \alpha_{\tilde{c}}, \beta_{\tilde{c}}, \gamma_{\tilde{c}} \right\rangle \quad where\ \tilde{c} \neq 0 \quad (6)$$

d) Division: Division of two SVTNN is obtained as follows:

$$\frac{\tilde{c}}{\tilde{d}} = \begin{cases} \left\langle \left(\frac{c_1}{d_3}, \frac{c_2}{d_2}, \frac{c_3}{d_1} \right); \alpha_{\tilde{c}} \wedge \alpha_{\tilde{d}}, \beta_{\tilde{c}} \vee \beta_{\tilde{d}}, \gamma_{\tilde{c}} \vee \gamma_{\tilde{d}} \right\rangle if\ c_3 > 0,\ d_3 > 0 \\ \left\langle \left(\frac{c_3}{d_3}, \frac{c_2}{d_2}, \frac{c_1}{d_1} \right); \alpha_{\tilde{c}} \wedge \alpha_{\tilde{d}}, \beta_{\tilde{c}} \vee \beta_{\tilde{d}}, \gamma_{\tilde{c}} \vee \gamma_{\tilde{d}} \right\rangle if\ c_3 < 0,\ d_3 > 0 \\ \left\langle \left(\frac{c_3}{d_1}, \frac{c_2}{d_2}, \frac{c_1}{d_3} \right); \alpha_{\tilde{c}} \wedge \alpha_{\tilde{d}}, \beta_{\tilde{c}} \vee \beta_{\tilde{d}}, \gamma_{\tilde{c}} \vee \gamma_{\tilde{d}} \right\rangle if c_3 < 0,\ d_3 < 0 \end{cases} \quad (7)$$

e) Multiplication: Multiplication of two SVTNN is acquired according to Eq.(8):

$$\tilde{c} * \tilde{d} = \begin{cases} \langle (c_1 * d_1, c_2 * d_2, c_3 * d_3); \alpha_{\tilde{c}} \wedge \alpha_{\tilde{d}}, \beta_{\tilde{c}} \vee \beta_{\tilde{d}}, \gamma_{\tilde{c}} \vee \gamma_{\tilde{d}} \rangle\ if\ c_3 > 0,\ d_3 > 0 \\ \langle (c_1 * d_3, c_2 * d_2, c_3 * d_1); \alpha_{\tilde{c}} \wedge \alpha_{\tilde{d}}, \beta_{\tilde{c}} \vee \beta_{\tilde{d}}, \gamma_{\tilde{c}} \vee \gamma_{\tilde{d}} \rangle\ if\ c_3 < 0,\ d_3 > 0 \\ \langle (c_3 * d_3, c_2 * d_2, c_1 * d_1); \alpha_{\tilde{c}} \wedge \alpha_{\tilde{d}}, \beta_{\tilde{c}} \vee \beta_{\tilde{d}}, \gamma_{\tilde{c}} \vee \gamma_{\tilde{d}} \rangle\ if c_3 < 0,\ d_3 < 0 \end{cases} \quad (8)$$

3.2. Neutrosophic Best-Worst Method (BWM)

The BWM was proposed by Rezaei (2015) as one of the novel, innovative and robust subjective criteria weighting MCDM method. According to this method, the best (e.g., the most important, the most desirable) and the worst (e.g., the least important, the least desirable) criteria are determined by experts respectively. Subsequently, the best criterion is compared with all the criteria and all the criteria are compared with the worst criterion, and two vectors, namely

best-to-others and others-to-worst, are acquired (Rezaei, 2015; Arman & Kundakcı, 2023). As a result, a nonlinear maximin model that aims to minimize the maximum absolute difference between criteria related weight ratios and pairwise comparisons is constructed for acquiring the criterion weights (Kocak et al., 2018; Arman & Kundakcı, 2023). BWM produces more consistent and reliable outcomes as compared to its counterparts such as AHP and SWARA (Pamucar et al., 2020; Zolfani et al., 2022; Yaran Ögel et al., 2023). BWM eliminates the weaknesses of some of the methods like AHP, SWARA, FUCOM, LBWA and PIPRECIA due to having a short and understandable processing time (Fazlollahtabar & Kazemitash, 2021; Yaran Ögel et al., 2023).

To the best of the authors' knowledge, there is not any study that aims to analyze and prioritize the criteria related to EGDI via NBWM to date.

The neutrosophic BWM, which was proposed by Yücesan and Gül (2021), has a similar procedure to BWM and aims to analyze decision-making problems under uncertain, inconsistent and complex environments. The steps of NBWM can be summarized as follows:

Step 1: The decision criteria and their related sub-criteria are determined via literature review and the views of experts.

Step 2: The best and the worst criteria are determined in terms of both the main criteria and sub-criteria.

Step 3: The preference of the best criterion (sub-criterion) over all the criteria (sub-criteria) is determined via a neutrosophic number from Table 1 by each expert and then the best-to-others vector is acquired as $\widetilde{A}_B = (\tilde{a}_{B1}, \tilde{a}_{B2}, \ldots, \tilde{a}_{Bn})$, where the preference of the best criterion over the jth criterion (j=1,2,…,n) is shown by $\tilde{a}_{Bj}$ and $\tilde{a}_{BB} = (1,1,1)$.

Table 2. Linguistic Terms and Related Neutrosophic Numbers

Saaty scale	Linguistic term	Neutrosophic triangular scale	Reciprocal neutrosophic triangular scale
1	Equally important (EI)	{(1,1, 1); 0.5,0.5,0.5}	{(1,1, 1); 0.5,0.5,0.5}
2	Value between EI and SI	{(1,2, 3); 0.4,0.65,0.6}	{(0.33,0.5,1); 0.4,0.65,0.6}
3	Slightly important (SI)	{(2,3, 4); 0.3,0.75,0.7}	{(0.25,0.33,0.5); 0.3,0.75,0.7}
4	Value between SI and STI	{(3,4, 5); 0.6,0.35,0.4}	{(0.2,0.25,0.33); 0.6,0.35,0.4}
5	Strongly important (STI)	{(4,5, 6); 0.8,0.15,0.2}	{(0.17,0.2,0.25); 0.8,0.15,0.2}
6	Value between STI and VSI	{(5,6, 7); 0.7,0.25,0.3}	{(0.14,0.17,0.2); 0.7,0.25,0.3}
7	Very strongly important (VSI)	{(6,7, 8); 0.9,0.1,0.1}	{(0.13,0.14,0.17); 0.9,0.1,0.1}
8	Value between VSI and AI	{(7,8, 9); 0.85,0.1,0.15}	{(0.11,0.13,0.14); 0.85,0.1,0.15}
9	Absolutely important (AI)	{(9,9, 9); 1,0, 0}	{(0.11,0.11,0.11); 1,0, 0}

Note. From Yücesan & Gül (2021).

Step 4: The preference of all the criteria (sub-criteria) over the worst criterion (sub-criterion) is determined via a neutrosophic number from Table 1 by each expert and then the others-to-worst vector is acquired as $\widetilde{A}_W = (\tilde{a}_{1W}, \tilde{a}_{2W}, \ldots, \tilde{a}_{nW})$, where the preference of the jth criterion (j=1,2,…,n) over the worst criterion is shown by $\tilde{a}_{jW}$ for j=1,2,…,n and $\tilde{a}_{WW}$= (1,1, 1).

Step 5: The neutrosophic evaluations related to the expert judgments are converted into the deterministic value via Eqs. (9-10) (Abdel-Basset et al., 2017, 2018b, 2018c; Yücesan & Gül, 2021). Consider $\tilde{c} = \langle (c_1, c_2, c_3); \alpha_{\tilde{c}}, \beta_{\tilde{c}}, \gamma_{\tilde{c}} \rangle$ as a SVTNN, then the score and accuracy degrees related to $\tilde{c}_{ij}$ are computed as follows respectively:

$$S(\tilde{c}_{ij}) = \frac{1}{8}[c_1 + c_2 + c_3] x (2 + \alpha_{\tilde{c}} - \beta_{\tilde{c}} - \gamma_{\tilde{c}}) \tag{9}$$

$$A(\tilde{c}_{ij}) = \frac{1}{8}[c_1 + c_2 + c_3] x (2 + \alpha_{\tilde{c}} - \beta_{\tilde{c}} - \gamma_{\tilde{c}}) \tag{10}$$

Subsequently, the calculations of the classical BWM and the consistency checks are performed.

Step 6: Deterministic optimal criteria weights $\left(w^* = w_1^*, w_2^*, \ldots, w_n^*\right)$ are calculated. In terms of obtaining the deterministic optimal criteria weights, where for each pair w_B/w_j and w_j/w_W, we have $\frac{w_B}{w_j} = a_{Bj}$ and $\frac{w_j}{w_W} = a_{jW}$. In order to satisfy aforementioned conditions for all j, a solution needs to be acquired where the maximum absolute gaps $\left|\frac{w_B}{w_j} - a_{Bj}\right|$ and $\left|\frac{w_j}{w_W} - a_{jW}\right|$ for all j are minimized (Rezaei, 2015; Guo & Zhao, 2017; Arman & Kundakcı, 2023). The non-negativity and sum conditions related to the weights are taken into account, and the problem can be written as follows:

$$\min_j \max \left\{ \left| \frac{w_B}{w_j} - a_{Bj} \right|, \left| \frac{w_j}{w_W} - a_{jW} \right| \right\},$$

$$\begin{aligned} &\text{s.t} \\ &\sum w_j = 1 \\ &w_j \geq 0 \text{ for all } j. \end{aligned} \tag{11}$$

This problem is converted as follows:

$$\begin{aligned} &\min \xi, \\ &\left| \frac{w_B}{w_j} - a_{Bj} \right| \leq \xi \text{ for all } j, \\ &\left| \frac{w_j}{w_W} - a_{jW} \right| \leq \xi \text{ for all } j, \\ &\sum w_j = 1 \\ &w_j \geq 0 \text{ for all } j. \end{aligned} \tag{12}$$

After solving the Eq.(12) the optimal weights $\left(w_1^*, w_2^*, \ldots, w_n^*\right)$ and ξ^* are obtained. The consistency ratio (CR) is calculated via ξ^*. New consistency table is constructed due to the changes related to the evaluations in NBWM. Consistency index (CI) related to each evaluation is acquired via Eq.(13) (Yücesan & Gül, 2021; Dağıstanlı, 2025).

$$\begin{aligned} &(a_{BW} - \xi)(a_{BW} - \xi) = (a_{BW} + \xi) \\ &\xi^2 - (1 + 2a_{BW})\xi + \left(a_{BW}^2 - a_{BW}\right) = 0 \end{aligned} \tag{13}$$

According to Eq. (13), the maximum ξ value is computed related to each a_{BW} where $a_{BW} \in \left\{\tilde{1}, \tilde{2}, \ldots, \tilde{9}\right\}$. Obtained values are given in Table 2.

Table 3. CI Values Related to NBWM

$a_{BW}(Neutrosophic)$	$\tilde{1}$	$\tilde{2}$	$\tilde{3}$	$\tilde{4}$	$\tilde{5}$	$\tilde{6}$	$\tilde{7}$	$\tilde{8}$	$\tilde{9}$
$a_{BW}(Deterministic)$	0.563	0.863	0.956	2.775	4.594	4.838	7.088	7.800	10.125
CI	2.2235	2.768	2.927	5.683	8.166	8.488	11.386	12.281	15.153

Note. From Yücesan & Gül (2021)

CR is computed by taking CI given in Table 2 into account and presented in Eq. (14).

$$CR = \frac{\xi}{CI} \tag{14}$$

The smaller CR values provide more consistent comparisons and evaluations.

Table 4. Main Criteria and Their Related Sub-criteria

Main Criteria	Sub-criteria	Definitions
Institutional framework (C1)		Refers to the legal, regulatory, and administrative arrangements that ensure strategic coordination, accountability, transparency, and interoperability in the design and implementation of e-government systems. It also includes governance capacity, policy coherence, and institutional readiness to promote digital participation and public value creation.
Service provision (C2)	Affordability (S1)	The degree to which digital public services and internet access are financially accessible and inclusive for all segments of society, ensuring equitable participation in digital governance.
	Internet users (S2)	The proportion of the population actively using the internet, reflecting the level of digital access and citizens' capacity to engage with e-government platforms.
	Mobile subscriptions (S3)	The diffusion of mobile communication technologies that expand access to digital services, especially in geographically and socioeconomically disadvantaged areas.
	Active mobile-broadband subscriptions (S4)	The effective use of high-speed mobile internet infrastructure that enables real-time, interactive, and user-centered public service delivery.

Content provision (C3)	Expected years of schooling (S5)	The anticipated duration of formal education, representing long-term investments in human capital and digital adaptability.
	Mean years of schooling (S6)	The average educational attainment of the population, indicating the capacity to understand and utilize digital public services.
	Gross enrollment ratio (S7)	The overall participation in formal education, reflecting future digital competence and readiness for knowledge-based governance.
	Adult literacy (S8)	The level of basic literacy among adults, which constitutes a fundamental prerequisite for digital inclusion and access to e-government.
	E-government literacy (S9)	Citizens' knowledge, awareness, and digital skills related to accessing, understanding, and effectively using e-government services.
E-participation (C4)	E-information (S10)	The provision of open, accessible, and transparent public information through digital channels, enabling informed citizenship and trust in governance.
	E-consultation (S11)	Digital mechanisms that facilitate interactive communication between governments and citizens, allowing feedback, dialogue, and participatory policy processes.
	E-decision making (S12)	The integration of citizens into decision-making processes through digital tools, fostering collaborative governance, co-production, and democratic legitimacy.
Technology (C5)		Refers to the availability, quality, and sustainability of ICT infrastructure, including connectivity, interoperability, cybersecurity, and digital platforms that support the effectiveness, scalability, and resilience of e-government systems.

Table 4 systematically presents the main criteria and their related sub-criteria used to assess e-government development based on the EGDI framework. Organized under five main categories—namely institutional framework, service provision, content provision, e-participation, and technology—the sub-criteria serve as measurable indicators of each dimension. This structure forms the foundation for the MCDM process and clearly defines the scope of the policy priorities analyzed in the study.

Table 5. Best Versus Others (BVO) Vector Related to Main Criteria

Decision Maker (DM)	Best	C1	C2	C3	C4	C5
DM1	C4	VSI	STI	Btw SI and STI	EI	AI
DM2	C1	EI	STI	SI	VSI	AI
DM3	C2	SI	EI	Btw SI and STI	AI	Btw EI and SI
DM4	C1	EI	VSI	Btw STI and VSI	STI	AI
DM5	C4	Btw STI and VSI	STI	VSI	EI	AI
DM6	C2	VSI	EI	SI	Btw SI and STI	Btw EI and SI

Table 5 presents the BVO vector determined for the main criteria by each decision maker. For each expert (DM1–DM6), the most important main criterion was identified, followed by a comparative evaluation of the remaining criteria using pairwise preference expressions such as "Very Strongly Important (VSI)," "Strongly Important (SI)," "Extremely Important (EI)," and intermediate judgments like "Between SI and STI" or "Between EI and SI." This table reflects the subjective assessments of experts regarding the relative importance of the main criteria within the EGDI framework, serving as input for the Neutrosophic Best-Worst Method analysis.

Table 6. BVO Vector Related to Service Provision Criterion

Decision Maker (DM)	Best	S1	S2	S3	S4
DM1	S2	AI	EI	Btw SI and STI	SI
DM2	S1	EI	STI	AI	VSI
DM3	S2	Btw EI and SI	EI	AI	SI
DM4	S2	Btw STI and VSI	EI	STI	AI
DM5	S2	Btw STI and VSI	EI	STI	AI
DM6	S2	VSI	EI	Btw SI and STI	Btw EI and SI

Table 6 presents the BVO comparisons made by decision makers (DM1–DM6) regarding the sub-criteria under the main criterion of "Service Provision." The sub-criteria include S1: Affordability, S2: Internet Users, S3: Mobile Subscriptions, and S4: Active Mobile-Broadband Subscriptions. Each decision maker identifies their most preferred (best) sub-criterion and evaluates the others using priority levels such as "Absolutely Important (AI)," "Very Strongly Important (VSI)," "Strongly Important (SI)," or by indicating values between these levels (e.g., "between SI and STI").

Table 7. BVO Vector Related to Content Provision Criterion

Decision Maker (DM)	Best	S5	S6	S7	S8	S9
DM1	S9	STI	Btw SI and STI	AI	Btw EI and SI	EI
DM2	S9	Btw SI and STI	STI	AI	VSI	EI
DM3	S6	SI	EI	AI	STI	Btw EI and SI
DM4	S9	Btw STI and VSI	STI	AI	VSI	EI
DM5	S9	Btw STI and VSI	STI	AI	VSI	EI
DM6	S9	Btw SI and STI	SI	VSI	Btw EI and SI	EI

Table 7 provides the BVO evaluations of the decision makers (DM1–DM6) for the sub-criteria under the "Content Provision" main criterion. The sub-criteria assessed include S5: Expected Years of Schooling, S6: Mean Years of Schooling, S7: Gross Enrollment Ratio, S8: Adult Literacy, and S9: E-government Literacy. For each decision maker, the best sub-criterion is identified, and the remaining sub-criteria are comparatively rated using qualitative importance levels such as "Strongly Important (SI)," "Very Strongly Important (VSI)," "Absolutely Important (AI)," and intermediate values (e.g., "between SI and STI").

4. Findings

This section presents the findings obtained through the Neutrosophic Best-Worst Method applied in the study. Initially, the BVO vector related to the e-participation criterion (Table 8) and the OVW (Others-to-Worst) vector concerning the main criteria (Table 9) are presented. Subsequently, the OVW

vectors corresponding to the sub-criteria of service provision, content provision, and e-participation are detailed in Tables 10, 11, and 12, respectively. The following tables (Tables 13-16) provide a comparative overview of the BVO and OVW vectors composed of neutrosophic numbers for both main and sub-criteria. In addition, the BVO and OVW vectors based on deterministic values are reported in Tables 17-20. The individual weight values determined by each decision maker (DM) for the main and sub-criteria are shown in Table 21, followed by the average optimal weights and their rankings in Table 22. Finally, Table 23 includes a comparative analysis of the ranking results with those obtained using other MCDM methods, thereby discussing the consistency and validity of the proposed approach. A detailed analysis of these results is presented below.

Table 8. BVO Vector Related to E-participation Criterion

Decision Maker (DM)	Best	S10	S11	S12
DM1	S12	AI	Btw EI and SI	EI
DM2	S12	AI	SI	EI
DM3	S10	EI	Btw EI and SI	AI
DM4	S12	AI	VSI	EI
DM5	S12	AI	VSI	EI
DM6	S12	VSI	SI	EI

Table 8 presents the comparative evaluations of decision makers (DM1-DM6) regarding the sub-criteria under the "E-Participation" main criterion, based on the BVO approach. The sub-criteria include S10: E-Information, S11: E-Consultation, and S12: E-Decision Making. Each decision maker selected one sub-criterion as the best and qualitatively assessed the others using importance levels such as "Absolutely Important (AI)," "Very Strongly Important (VSI)," "Strongly Important (SI)," "Equally Important (EI)," and transitional expressions between these levels.

Table 9. OVW Vector Related to Main Criteria

Decision Maker (DM)	Worst	C1	C2	C3	C4	C5
DM1	C5	VSI	STI	Btw STI and VSI	AI	EI
DM2	C5	AI	VSI	STI	Btw VSI and AI	EI
DM3	C4	VSI	AI	STI	EI	Btw STI and VSI
DM4	C5	AI	Btw VSI and AI	VSI	Btw STI and VSI	EI
DM5	C5	Btw VSI and AI	VSI	Btw STI and VSI	AI	EI
DM6	C1	EI	VSI	STI	Btw STI and VSI	SI

Table 9 shows the evaluations of decision makers (DM1-DM6) regarding the OVW vector for the main criteria used in the analysis. Each decision maker identifies one criterion as the worst and then compares the remaining main criteria (C1 to C5) against this least preferred option. These comparisons are expressed using qualitative importance levels such as "Absolutely Important (AI)," "Very Strongly Important (VSI)," "Strongly Important (SI)," "Equally Important (EI)," and various intermediate judgments (e.g., "Between STI and VSI").

Table 10. OVW Vector Related to Service Provision Criterion

Decision Maker (DM)	Worst	S1	S2	S3	S4
DM1	S1	EI	AI	VSI	STI
DM2	S3	AI	STI	EI	VSI
DM3	S3	VSI	AI	EI	Btw STI and VSI
DM4	S4	VSI	AI	Btw STI and VSI	EI
DM5	S4	VSI	AI	Btw STI and VSI	EI
DM6	S1	EI	VSI	STI	Btw STI and VSI

Table 10 presents the OVW vector evaluations of decision makers regarding the service provision criterion. Each decision maker (DM1-DM6) identifies one of the service provision sub-criteria as the worst and compares the remaining criteria against this worst alternative. The relative importance levels between the criteria are expressed using linguistic terms such as "Equally Important (EI)," "Absolutely Important (AI)," "Very Strongly Important (VSI)," "Strongly Important (STI)," and intermediate expressions like "Between STI and VSI." This structure provides an analytical foundation for prioritizing aspects of service provision within the Neutrosophic Best-Worst methodology, based on quantified expert opinions.

Table 11. OVW Vector Related to Content Provision Criterion

Decision Maker (DM)	Worst	S5	S6	S7	S8	S9
DM1	S7	Btw STI and VSI	STI	EI	Btw SI and STI	AI
DM2	S7	STI	VSI	EI	SI	AI
DM3	S7	STI	AI	EI	SI	VSI
DM4	S7	Btw STI and VSI	VSI	EI	Btw VSI and AI	AI
DM5	S7	VSI	Btw VSI and AI	EI	Btw VSI and AI	AI
DM6	S7	STI	Btw SI and STI	EI	Btw STI and VSI	VSI

Table 11 presents the OVW vector related to the content provision criterion, showing the relative importance assessments made by decision makers (DM1-DM6) comparing the worst sub-criterion (S7) against other sub-criteria (S5, S6, S8, S9). The decision makers evaluated the other sub-criteria in relation to S7 using different linguistic expressions such as "Absolutely Important" (AI), "Very Strongly Important" (VSI), "Strongly Important" (STI), and intermediate degrees between these levels.

Table 12. OVW Vector Related to E-participation Criterion

Decision Maker (DM)	Worst	S10	S11	S12
DM1	S10	EI	STI	AI
DM2	S10	EI	VSI	AI
DM3	S12	AI	VSI	EI
DM4	S10	EI	VSI	AI
DM5	S10	EI	Btw VSI and AI	AI
DM6	S10	EI	STI	VSI

Table 12 presents the OVW vector related to the e-participation criterion. The decision makers (DM1 to DM6) identified S10 as the worst sub-criterion except for DM3, who selected S12. The relative importance of the other sub-criteria (S11 and S12 or S10 and S11) compared to the worst one was expressed using linguistic terms such as "Equally Important" (EI), "Strongly Important" (STI), "Very Strongly Important" (VSI), "Absolutely Important" (AI), and intermediate values between these levels.

Table 13. BVO and OVW Vectors Composed of Neutrosophic Numbers for Main Criteria

DM1	Best: C4		Worst: C5	
	C1	{(6,7, 8); 0.9,0.1,0.1}	C1	{(6,7, 8); 0.9,0.1,0.1}
	C2	{(4,5, 6); 0.8,0.15,0.2}	C2	{(4,5, 6); 0.8,0.15,0.2}
	C3	{(3,4, 5); 0.6,0.35,0.4}	C3	{(5,6, 7); 0.7,0.25,0.3}
	C5	{(9,9, 9); 1,0, 0}	C4	{(9,9, 9); 1,0, 0}
DM2	Best: C1		Worst: C5	
	C1	{(4,5, 6); 0.8,0.15,0.2}	C1	{(9,9, 9); 1,0, 0}
	C2	{(2,3, 4); 0.3,0.75,0.7}	C2	{(6,7, 8); 0.9,0.1,0.1}
	C3	{(6,7, 8); 0.9,0.1,0.1}	C3	{(4,5, 6); 0.8,0.15,0.2}
	C5	{(9,9, 9); 1,0, 0}	C4	{(7,8, 9); 0.85,0.1,0.15}
DM3	Best: C2		Worst: C4	
	C1	{(2,3, 4); 0.3,0.75,0.7}	C1	{(6,7, 8); 0.9,0.1,0.1}
	C3	{(3,4, 5); 0.6,0.35,0.4}	C2	{(9,9, 9); 1,0, 0}
	C4	{(9,9, 9); 1,0, 0}	C3	{(4,5, 6); 0.8,0.15,0.2}
	C5	{(1,2, 3); 0.4,0.65,0.6}	C5	{(5,6, 7); 0.7,0.25,0.3}
DM4	Best: C1		Worst: C5	
	C2	{(6,7, 8); 0.9,0.1,0.1}	C1	{(9,9, 9); 1,0, 0}
	C3	{(5,6, 7); 0.7,0.25,0.3}	C2	{(7,8, 9); 0.85,0.1,0.15}
	C4	{(4,5, 6); 0.8,0.15,0.2}	C3	{(6,7, 8); 0.9,0.1,0.1}
	C5	{(9,9, 9); 1,0, 0}	C4	{(5,6, 7); 0.7,0.25,0.3}
DM5	Best: C4		Worst: C5	
	C1	{(5,6, 7); 0.7,0.25,0.3}	C1	{(7,8, 9); 0.85,0.1,0.15}
	C2	{(4,5, 6); 0.8,0.15,0.2}	C2	{(6,7, 8); 0.9,0.1,0.1}
	C3	{(6,7, 8); 0.9,0.1,0.1}	C3	{(5,6, 7); 0.7,0.25,0.3}
	C5	{(9,9, 9); 1,0, 0}	C4	{(9,9, 9); 1,0, 0}
DM6	Best: C2		Worst: C1	
	C1	{(6,7, 8); 0.9,0.1,0.1}	C2	{(6,7, 8); 0.9,0.1,0.1}
	C3	{(2,3, 4); 0.3,0.75,0.7}	C3	{(4,5, 6); 0.8,0.15,0.2}
	C4	{(3,4, 5); 0.6,0.35,0.4}	C4	{(5,6, 7); 0.7,0.25,0.3}
	C5	{(1,2, 3); 0.4,0.65,0.6}	C5	{(2,3, 4); 0.3,0.75,0.7}

Table 13 presents the evaluations of decision-makers (DM1-DM6) regarding the main criteria using the NBWM, expressed through triangular fuzzy numbers (a,b,c) *(a,b,c)* and neutrosophic set components (μ,σ,ν)(μ,σ,ν). Each decision-maker identifies the best and worst criteria and evaluates the others relative to these benchmarks in a consistent manner. For instance, DM1 selects C4 as the best and C5 as the worst, with absolute superiority (9,9,9;1,0,0)

(9,9,9;1,0,0) appearing in crisp cases. The table reflects the diversity in priorities among decision-makers (e.g., DM2 favoring C1, DM3 favoring C2 as best) and captures uncertainty (low μμ, high σ/νσ/ν), enabling a multidimensional and flexible analysis of e-government development policy priorities within the EGDI framework. This approach allows for more comprehensive modeling of ambiguity and inconsistency compared to traditional BWM.

Table 14. BVO and OVW Vectors Composed of Neutrosophic Numbers for Service Provision Criterion

DM1	**Best: S2**		**Worst: S1**	
	S1	{(9,9,9);1,0,0}	S2	{(9,9,9);1,0,0}
	S3	{(3,4,5);0.6,0.35,0.4}	S3	{(6,7,8);0.9,0.1,0.1}
	S4	{(2,3,4);0.3,0.75,0.7}	S4	{(4,5,6);0.8,0.15,0.2}
DM2	**Best: S1**		**Worst: S3**	
	S2	{(4,5,6);0.8,0.15,0.2}	S1	{(9,9,9);1,0,0}
	S3	{(9,9,9);1,0,0}	S2	{(4,5,6);0.8,0.15,0.2}
	S4	{(6,7,8);0.9,0.1,0.1}	S4	{(6,7,8);0.9,0.1,0.1}
DM3	**Best: S2**		**Worst: S3**	
	S1	{(1,2,3);0.4,0.65,0.6}	S1	{(6,7,8);0.9,0.1,0.1}
	S3	{(9,9,9);1,0,0}	S2	{(9,9,9);1,0,0}
	S4	{(2,3,4);0.3,0.75,0.7}	S4	{(5,6,7);0.7,0.25,0.3}
DM4	**Best: S2**		**Worst: S4**	
	S1	{(5,6,7);0.7,0.25,0.3}	S1	{(6,7,8);0.9,0.1,0.1}
	S3	{(4,5,6);0.8,0.15,0.2}	S2	{(9,9,9);1,0,0}
	S4	{(9,9,9);1,0,0}	S3	{(5,6,7);0.7,0.25,0.3}
DM5	**Best: S2**		**Worst: S4**	
	S1	{(5,6,7);0.7,0.25,0.3}	S1	{(6,7,8);0.9,0.1,0.1}
	S3	{(4,5,6);0.8,0.15,0.2}	S2	{(9,9,9);1,0,0}
	S4	{(9,9,9);1,0,0}	S3	{(5,6,7);0.7,0.25,0.3}
DM6	**Best: S2**		**Worst: S1**	
	S1	{(6,7,8);0.9,0.1,0.1}	S2	{(6,7,8);0.9,0.1,0.1}
	S3	{(3,4,5);0.6,0.35,0.4}	S3	{(4,5,6);0.8,0.15,0.2}
	S4	{(1,2,3);0.4,0.65,0.6}	S4	{(5,6,7);0.7,0.25,0.3}

Table 14 presents the neutrosophic BVO and OVW vectors for evaluating service provision criteria (S1-S4) across six decision-makers (DM1-DM6) using triangular fuzzy numbers (a,b,c) (a,b,c) and neutrosophic components (μ,σ,ν) (μ,σ,ν). The results reveal varying prioritizations, with S2 frequently selected as the best criterion (by DM1, DM3-DM6) and S1 or S3/S4 as the worst, demonstrating

divergent expert perspectives on e-service priorities. The evaluations employ a 9-point scale where (9,9,9;1,0,0) (9,9,9;1,0,0) represents absolute superiority, while lower values with higher indeterminacy (e.g., (2,3,4);0.3,0.75,0.7) (2,3,4);0.3,0.75,0.7) reflect greater uncertainty in comparisons. The consistent use of neutrosophic sets captures both the fuzziness of judgments (through membership $\mu\mu$) and the inherent hesitancy (via indeterminacy $\sigma\sigma$ and non-membership $\nu\nu$), providing a robust framework to handle the subjectivity in ranking digital government service dimensions. The systematic variation in best/worst selections across DMs underscores the method's capacity to accommodate heterogeneous expert inputs while maintaining structured comparability through standardized evaluation scales.

Table 15. BVO and OVW Vectors Composed of Neutrosophic Numbers for Content Provision Criterion

DM1	**Best: S9**		**Worst: S7**	
	S5	{(4,5, 6); 0.8,0.15,0.2}	S5	{(5,6, 7); 0.7,0.25,0.3}
	S6	{(3,4, 5); 0.6,0.35,0.4}	S6	{(4,5, 6); 0.8,0.15,0.2}
	S7	{(9,9, 9); 1,0, 0}	S8	{(3,4, 5); 0.6,0.35,0.4}
	S8	{(1,2, 3); 0.4,0.65,0.6}	S9	{(9,9, 9); 1,0, 0}
DM2	**Best: S9**		**Worst: S7**	
	S5	{(3,4, 5); 0.6,0.35,0.4}	S5	{(4,5, 6); 0.8,0.15,0.2}
	S6	{(4,5, 6); 0.8,0.15,0.2}	S6	{(6,7, 8); 0.9,0.1,0.1}
	S7	{(9,9, 9); 1,0, 0}	S8	{(2,3, 4); 0.3,0.75,0.7}
	S8	{(6,7, 8); 0.9,0.1,0.1}	S9	{(9,9, 9); 1,0, 0}
DM3	**Best: S6**		**Worst: S7**	
	S5	{(2,3, 4); 0.3,0.75,0.7}	S5	{(4,5, 6); 0.8,0.15,0.2}
	S7	{(9,9, 9); 1,0, 0}	S6	{(9,9, 9); 1,0, 0}
	S8	{(4,5, 6); 0.8,0.15,0.2}	S8	{(2,3, 4); 0.3,0.75,0.7}
	S9	{(1,2, 3); 0.4,0.65,0.6}	S9	{(6,7, 8); 0.9,0.1,0.1}
DM4	**Best: S9**		**Worst: S7**	
	S5	{(5,6, 7); 0.7,0.25,0.3}	S5	{(5,6, 7); 0.7,0.25,0.3}
	S6	{(4,5, 6); 0.8,0.15,0.2}	S6	{(6,7, 8); 0.9,0.1,0.1}
	S7	{(9,9, 9); 1,0, 0}	S8	{(7,8, 9); 0.85,0.1,0.15}
	S8	{(6,7, 8); 0.9,0.1,0.1}	S9	{(9,9, 9); 1,0, 0}
DM5	**Best: S9**		**Worst: S7**	
	S5	{(5,6, 7); 0.7,0.25,0.3}	S5	{(6,7, 8); 0.9,0.1,0.1}
	S6	{(4,5, 6); 0.8,0.15,0.2}	S6	{(7,8, 9); 0.85,0.1,0.15}
	S7	{(9,9, 9); 1,0, 0}	S8	{(7,8, 9); 0.85,0.1,0.15}
	S8	{(6,7, 8); 0.9,0.1,0.1}	S9	{(9,9, 9); 1,0, 0}

DM6	Best: S9		Worst: S7	
	S5	{(3,4, 5); 0.6,0.35,0.4}	S5	{(4,5, 6); 0.8,0.15,0.2}
	S6	{(2,3, 4); 0.3,0.75,0.7}	S6	{(3,4, 5); 0.6,0.35,0.4}
	S7	{(6,7, 8); 0.9,0.1,0.1}	S8	{(5,6, 7); 0.7,0.25,0.3}
	S8	{(1,2, 3); 0.4,0.65,0.6}	S9	{(6,7, 8); 0.9,0.1,0.1}

Table 15 presents the neutrosophic BVO and OVW vectors for evaluating content provision criteria (S5-S9) using triangular fuzzy numbers (a,b,c) and neutrosophic components (μ,σ,ν) across six decision-makers (DM1-DM6). The results reveal a clear consensus, with S9 selected as the best criterion by five DMs (DM1, DM2, DM4-DM6) and S7 unanimously identified as the worst, indicating strong agreement on content provision priorities.

The evaluations employ a 9-point scale where (9,9,9;1,0,0) represents absolute superiority, while intermediate values with high indeterminacy (e.g., (2,3,4);0.3,0.75,0.7) reflect significant uncertainty in pairwise comparisons. Neutrosophic components effectively capture the decision-makers' membership (μ), indeterminacy (σ), and non-membership (ν) degrees, providing a comprehensive representation of both quantitative and qualitative aspects of criterion importance. Notable inconsistencies in S8 evaluations (ranging from (1,2,3) by DM1 to (6,7,8) by DM4) highlight divergent perceptions of this sub-criterion. The table demonstrates the systematic modeling of uncertainties in e-government content policy evaluation, with the repeated selection of S7 as the worst criterion (across all DMs) particularly emphasizing areas needing policy improvement. This structured approach enables precise identification of priority areas while accommodating the inherent subjectivity in expert judgments.

Table 16. BVO and OVW Vectors Composed of Neutrosophic Numbers for E-participation Criterion

DM1	**Best: S12**		**Worst: S10**	
	S10	{(9,9,9);1,0,0}	S11	{(4,5,6);0.8,0.15,0.2}
	S11	{(1,2,3);0.4,0.65,0.6}	S12	{(9,9,9);1,0,0}
DM2	**Best: S12**		Worst: S10	
	S10	{(9,9,9);1,0,0}	S11	{(6,7,8);0.9,0.1,0.1}
	S11	{(2,3,4);0.3,0.75,0.7}	S12	{(9,9,9);1,0,0}
DM3	**Best: S10**		**Worst: S12**	
	S11	{(1,2,3);0.4,0.65,0.6}	S10	{(9,9,9);1,0,0}
	S12	{(9,9,9);1,0,0}	S11	{(6,7,8);0.9,0.1,0.1}
DM4	**Best: S12**		**Worst: S10**	
	S10	{(9,9,9);1,0,0}	**S11**	{(6,7,8);0.9,0.1,0.1}
	S11	{(6,7,8);0.9,0.1,0.1}	**S12**	{(9,9,9);1,0,0}
DM5	**Best: S12**		**Worst: S10**	
	S10	{(9,9,9);1,0,0}	**S11**	{(7,8,9);0.85,0.1,0.15}
	S11	{(6,7,8);0.9,0.1,0.1}	**S12**	{(9,9,9);1,0,0}
DM6	**Best: S12**		**Worst: S10**	
	S10	{(6,7,8);0.9,0.1,0.1}	**S11**	{(4,5,6);0.8,0.15,0.2}
	S11	{(2,3,4);0.3,0.75,0.7}	**S12**	{(6,7,8);0.9,0.1,0.1}

Table 16 presents the NBWM evaluations for e-participation criteria (S10-S12) across six decision-makers (DM1-DM6), showing a predominant preference for S12 as the best criterion (selected by five DMs) and S10 as the worst (chosen by five DMs), with DM3 being the exception by reversing this ranking. The evaluations utilize triangular fuzzy numbers (a,b,c) combined with neutrosophic components (μ,σ,ν), where (9,9,9;1,0,0) consistently represents the absolute importance assigned to either best or worst criteria, while intermediate values like (6,7,8;0.9,0.1,0.1) and lower-rated options such as (1,2,3;0.4,0.65,0.6) reflect relative preferences with varying degrees of certainty. The table's structure systematically captures both the directionality of preferences (through BVO and OVW vectors) and the qualitative uncertainty in judgments (via neutrosophic components), particularly noticeable in S11 evaluations which show significant variability across DMs (ranging from (1,2,3) to (6,7,8)). This comprehensive presentation enables analysis of both consensus patterns (the strong S12/S10 polarization) and individual deviations (DM3's contrary view) in e-participation priority assessments within the EGDI framework.

Table 17. BVO and OVW Vectors Composed of Deterministic Values for Main Criteria

DM1	**Best: C4**		**Worst: C5**	
	C1	7.088	C1	7.088
	C2	4.594	C2	4.594
	C3	2.775	C3	4.838
	C5	10.125	C4	10.125
DM2	**Best: C1**		**Worst: C5**	
	C2	4.594	C1	10.125
	C3	0.956	C2	7.088
	C4	7.088	C3	4.594
	C5	10.125	C4	7.800
DM3	**Best: C2**		**Worst: C4**	
	C1	0.956	C1	7.088
	C3	2.775	C2	10.125
	C4	10.125	C3	4.594
	C5	0.863	C5	4.838
DM4	**Best: C1**		**Worst: C5**	
	C2	7.088	C1	10.125
	C3	4.838	C2	7.800
	C4	4.594	C3	7.088
	C5	10.125	C4	4.838
DM5	**Best: C4**		**Worst: C5**	
	C1	4.838	C1	7.800
	C2	4.594	C2	7.088
	C3	7.088	C3	4.838
	C5	10.125	C4	10.125
DM6	**Best: C2**		**Worst: C1**	
	C1	7.088	C2	7.088
	C3	0.956	C3	4.594
	C4	2.775	C4	4.838
	C5	0.863	C5	0.956

Table 17 presents the deterministic BWM results for main criteria (C1-C5), displaying BVO and OVW vectors with precise numerical values across six decision-makers (DM1-DM6). High scores such as 10.125 indicate absolute weakness (worst criterion), while intermediate values like 7.088 and 4.594 reflect relative importance rankings.

Notable divergences emerge among decision-makers:

- DM1 & DM5 select C4 as best
- DM2 & DM4 prioritize C1
- DM3 & DM6 favor C2

For worst criteria, consensus appears on C5 (DM1-DM5), while DM6 uniquely designates C1 as weakest. Notably, DM3 rates C4 as worst, and DM6 assigns lowest priority to C1, revealing substantial variability in priority perceptions.

Unlike fuzzy/neutrosophic evaluations, this table provides crisp numerical comparisons, enabling unambiguous interpretation of criterion weightings for e-government policy formulation. The structured 9-point scale (implied by decimal values) ensures methodological consistency, while the spread in best/worst selections underscores the multidimensional nature of EGDI framework assessments.

Table 18 presents deterministic BWM evaluations for service provision criteria (S1-S4), revealing clear prioritization patterns across six decision-makers (DM1-DM6). The results show S2 consistently emerging as the preferred criterion (selected as best by DM1, DM3-DM6), while S1 and S4 alternate as worst choices depending on the DM. Absolute values follow a standardized scale where 10.125 systematically denotes the worst-rated criterion in each evaluation set, with intermediate scores (7.088, 4.594, etc.) indicating relative preference strengths.

Notable divergences appear in best/worst selections: DM2 uniquely prioritizes S1 as best while rejecting S3 as worst, whereas other DMs converge on S2 superiority but disagree on weakest options (DM1/Worst: S1 vs. DM4-DM5/Worst: S4). The numerical precision of these deterministic vectors enables direct comparison of service dimension priorities, with particularly low scores (0.863, 0.956) signaling near-absolute rejection of certain criteria by specific DMs. This structured output facilitates unambiguous identification of consensus areas and outliers in e-government service policy assessments within the EGDI framework.

Table 18. BVO and OVW Vectors Composed of Deterministic Values for Service Provision Criterion

DM1	**Best: S2**		**Worst: S1**	
	S1	10.125	S2	10.125
	S3	2.775	S3	7.088
	S4	0.956	S4	4.594
DM2	**Best: S1**		**Worst: S3**	
	S2	4.594	S1	10.125
	S3	10.125	S2	4.594
	S4	7.088	S4	7.088
DM3	**Best: S2**		**Worst: S3**	
	S1	0.863	S1	7.088
	S3	10.125	S2	10.125
	S4	0.956	S4	4.838
DM4	**Best: S2**		**Worst: S4**	
	S1	4.838	S1	7.088
	S3	4.594	S2	10.125
	S4	10.125	S3	4.838
DM5	**Best: S2**		**Worst: S4**	
	S1	4.838	S1	7.088
	S3	4.594	S2	10.125
	S4	10.125	S3	4.838
DM6	**Best: S2**		**Worst: S1**	
	S1	7.088	S2	7.088
	S3	2.775	S3	4.594
	S4	0.863	S4	4.838

Table 19. BVO and OVW Vectors Composed of Deterministic Values for Content Provision Criterion

DM1	**Best: S9**		**Worst: S7**	
	S5	4.594	S5	4.838
	S6	2.775	S6	4.594
	S7	10.125	S8	2.775
	S8	0.863	S9	10.125
DM2	**Best: S9**		**Worst: S7**	
	S5	2.775	S5	4.594
	S6	4.594	S6	7.088
	S7	10.125	S8	0.956
	S8	7.088	S9	10.125
DM3	**Best: S6**		**Worst: S7**	
	S5	0.956	S5	4.594
	S7	10.125	S6	10.125
	S8	4.594	S8	0.956
	S9	0.863	S9	7.088
DM4	**Best: S9**		**Worst: S7**	
	S5	4.838	S5	4.838
	S6	4.594	S6	7.088
	S7	10.125	S8	7.800
	S8	7.088	S9	10.125
DM5	**Best: S9**		**Worst: S7**	
	S5	4.838	S5	7.088
	S6	4.594	S6	7.800
	S7	10.125	S8	7.800
	S8	7.088	S9	10.125
DM6	**Best: S9**		**Worst: S7**	
	S5	2.775	S5	4.594
	S6	0.956	S6	2.775
	S7	7.088	S8	4.838
	S8	0.863	S9	7.088

Table 19 presents the deterministic BWM results for content provision criteria (S5-S9), showcasing six decision-makers' evaluations through precise numerical vectors. The data reveals a strong consensus on S9 as the best criterion (selected by DM1, DM2, DM4-DM6) and S7 as the worst (unanimously chosen by all DMs), with DM3 being the sole exception in prioritizing S6 as best. Evaluations follow a consistent scaling pattern where the value 10.125 systematically marks the worst-rated criterion (S7), while 7.088 and 4.594 represent intermediate importance levels. Lower scores (0.863, 0.956) indicate particularly weak performance assessments for certain criteria (notably S8 by multiple DMs). The table's structured format enables direct comparison of content dimension priorities, with numerical values clearly differentiating between the strength of preferences. Divergences appear primarily in the assessment of secondary criteria (S5, S6, S8), where scores vary more significantly across DMs, while the unanimous rejection of S7 as the worst criterion strongly highlights an area needing policy attention in e-government content provision strategies. This deterministic approach provides unambiguous weightings for criterion prioritization within the EGDI framework.

Table 20. BVO and OVW Vectors Composed of Deterministic Values for E-participation Criterion

DM1	**Best: S12**		**Worst: S10**	
	S10	10.125	S11	4.594
	S11	0.863	S12	10.125
DM2	**Best: S12**		**Worst: S10**	
	S10	10.125	S11	7.088
	S11	0.956	S12	10.125
DM3	**Best: S10**		**Worst: S12**	
	S11	0.863	S10	10.125
	S12	10.125	S11	7.088
DM4	**Best: S12**		**Worst: S10**	
	S10	10.125	S11	7.088
	S11	7.088	S12	10.125

DM5	**Best: S12**		**Worst: S10**	
	S10	10.125	S11	7.800
	S11	7.088	S12	10.125
DM6	**Best: S12**		**Worst: S10**	
	S10	7.088	S11	4.594
	S11	0.956	S12	7.088

Table 20 displays the deterministic BWM evaluations for e-participation criteria (S10-S12), revealing a predominant preference for S12 as the best criterion (selected by DM1, DM2, DM4-DM6) and S10 as the worst (chosen by the same five DMs), with DM3 presenting a complete reversal by selecting S10 as best and S12 as worst. The evaluations employ a consistent numerical scale where 10.125 systematically represents either absolute superiority (when assigned to the best criterion) or absolute weakness (when assigned to the worst), creating a clear polarity in the assessments. Intermediate values such as 7.088 and 4.594 indicate relative preference strengths, while notably low scores (0.863, 0.956) for S11 in multiple DMs' evaluations suggest its consistently weak performance relative to other criteria. The table's structure enables direct comparison of e-participation priorities, with the strong consensus on S12's importance (except DM3) and near-universal rejection of S10 providing clear policy insights. Particularly noteworthy is the identical 10.125 score appearing for opposite purposes (best vs. worst) across different DMs' evaluations, demonstrating the method's ability to capture both consensus and divergence in expert judgments regarding e-government participation dimensions within the EGDI framework.

For example, the calculations of the model for DM1 in terms of main criteria are shown as follows. The BVO and OVW vectors are determined as $\widetilde{A}_B = [7.088, 4.594, 2.775, 0.563, 10.125]$ and $\widetilde{A}_W = [7.088, 4.594, 4.838, 10.125, 0.563]$, respectively. Then, a constrained non-linear optimization model is written as follows:

$$
\begin{aligned}
&Min\ k \\
&\text{s.t.} \\
&w_{C4} - 7.088 * w_{C1} \leq k * w_{C1}; \\
&w_{C4} - 7.088 * w_{C1} \geq -k * w_{C1}; \\
&w_{C4} - 4.594 * w_{C2} \leq k * w_{C2}; \\
&w_{C4} - 4.594 * w_{C2} \geq -k * w_{C2}; \\
&w_{C4} - 2.775 * w_{C3} \leq k * w_{C3}; \\
&w_{C4} - 2.775 * w_{C3} \geq -k * w_{C3}; \\
&w_{C4} - 10.125 * w_{C5} \leq k * w_{C5}; \\
&w_{C4} - 10.125 * w_{C5} \geq -k * w_{C5}; \\
&w_{C1} - 7.088 * w_{C5} \leq k * w_{C5}; \\
&w_{C1} - 7.088 * w_{C5} \geq -k * w_{C5}; \\
&w_{C2} - 4.594 * w_{C5} \leq k * w_{C5}; \\
&w_{C2} - 4.594 * w_{C5} \geq -k * w_{C5}; \\
&w_{C3} - 4.838 * w_{C5} \leq k * w_{C5}; \\
&w_{C3} - 4.838 * w_{C5} \geq -k * w_{C5}; \\
&w_{C1} + w_{C2} + w_{C3} + w_{C4} + w_{C5} = 1; \\
&w_{C1} \geq 0;\ w_{C2} \geq 0; w_{C3} \geq 0; w_{C4} \geq 0; w_{C5} \geq 0; k \geq 0
\end{aligned}
\tag{15}
$$

By solving Eq. (15) via the LINGO 21.0 software, deterministic weights of main criteria with respect to DM1 are found as $w_{C1} = 0.1067$, $w_{C2} = 0.2322$,$w_{C3} = 0.2393$,$w_{C4} = 0.3927$ and $w_{C5} = 0.0290$. Given that the consistency ratio (CR)=0.022, the acquired result is acceptable (CR<0.10). Additionally, deterministic weights of main criteria and sub-criteria for each DM are shown in Table 20.

Table 21. Deterministic Weight Values of Main Criteria and Sub-criteria according to Each DM

Criteria/ Sub-criteria	DM1	DM2	DM3	DM4	DM5	DM6
C1	0.1067	0.3638	0.2415	0.5770	0.2056	0.0515
C2	0.2322	0.2839	0.3581	0.1707	0.1781	0.2901
C3	0.2393	0.2183	0.1458	0.1410	0.0912	0.3124
C4	0.3927	0.1076	0.0383	0.0695	0.4863	0.2211
C5	0.0290	0.0263	0.2161	0.0417	0.0386	0.1247
	CR=0.022	**CR=0.024**	**CR=0.052**	**CR=0.024**	**CR=0.016**	**CR=0.012**
S1	0.0424	0.6799	0.2848	0.2319	0.2319	0.0569
S2	0.4616	0.0849	0.4208	0.5962	0.5962	0.4459
S3	0.2588	0.0502	0.0448	0.1236	0.1236	0.2193
S4	0.2370	0.1848	0.2495	0.0481	0.0481	0.2777
	CR=0.065	**CR=0.022**	**CR=0.048**	**CR=0.014**	**CR=0.014**	**CR=0.065**
S5	0.1331	0.2452	0.2262	0.0676	0.1280	0.1755
S6	0.2450	0.1811	0.3931	0.1412	0.1550	0.1755
S7	0.0400	0.0364	0.0420	0.0417	0.0378	0.0476
S8	0.1720	0.0900	0.0731	0.1710	0.1550	0.2738
S9	0.4096	0.4470	0.2653	0.5781	0.5240	0.3274
	CR=0.01	**CR=0.014**	**CR=0.051**	**CR=0.024**	**CR=0.024**	**CR=0.079**
S10	0.0636	0.0549	0.5324	0.0549	0.0528	0.0788
S11	0.3459	0.4087	0.4126	0.2019	0.2162	0.3928
S12	0.5904	0.5363	0.0549	0.7431	0.7309	0.5282
	CR=0.055	**CR=0.023**	**CR=0.028**	**CR=0.022**	**CR=0.024**	**CR=0.034**

Table 21 systematically presents the deterministic weight values of main criteria (C1-C5) and sub-criteria (S1-S12) according to six decision-makers (DM1-DM6). The calculated weights for each criterion show significant variations among DMs - for instance, criterion C4 receives the highest priority (0.3927) for DM1, while obtaining the lowest value (0.0383) for DM3. Consistency ratios (CR) for all evaluations remain below 0.10 (ranging from 0.012 to 0.079), confirming acceptable consistency levels. At the sub-criteria level, S12 (e-participation) and S9 (content provision) generally receive the highest weights, whereas criteria like S7 and S10 are consistently rated as low priority. The study assigns equal weights to each DM and employs the arithmetic mean operator to derive average optimal weight values for main and sub-criteria. This structure provides a quantitative and consistent basis for determining priority areas in e-government policy development.

Table 22. Average Optimal Weight Values for Main Criteria and Sub-criteria and Their Ranking

Criteria/Sub-criteria	Average optimal weight	Ranking
C1	0.25768	1
C2	0.25218	2
C3	0.19133	4
C4	0.21925	3
C5	0.07940	5
S1	0.25463	2
S2	0.43426	1
S3	0.13671	4
S4	0.17420	3
S5	0.16260	3
S6	0.21515	2
S7	0.04091	5
S8	0.15581	4
S9	0.42523	1
S10	0.13956	3
S11	0.32968	2
S12	0.53063	1

According to Table 22, the institutional framework (C1) was identified as the most important criterion with a value of 0.25768, while technology (C5) was determined to be the least important with a value of 0.07940. The ranking of main criteria is as follows: institutional framework > service provision > e-participation > content provision > technology.

For service provision sub-criteria, internet users (S2) emerged as the most important sub-criterion with a value of 0.43426, whereas mobile subscriptions (S3) was found to be the least important with a value of 0.13671. The ranking of service provision sub-criteria is: internet users > affordability > active mobile-broadband subscriptions > mobile subscriptions.

Regarding content provision sub-criteria, e-government literacy (S9) was identified as the most crucial sub-criterion with a value of 0.42523, while gross enrollment ratio (S7) was determined to be the least crucial with a value of 0.04091. The ranking of content provision sub-criteria is: e-government literacy > mean years of schooling > expected years of schooling > adult literacy > gross enrollment ratio.

Concerning e-participation sub-criteria, e-decision making (S12) was found to be the most important sub-criterion with a value of 0.53063, while e-information (S10) was identified as the least important with a value of 0.13956. The ranking of e-participation sub-criteria can be stated as: e-decision making > e-consultation > e-information.

In conclusion, Table 22 summarizes the quantitative average optimal weights and corresponding rankings for all main criteria and sub-criteria. Among the main criteria, the institutional framework (C1) stands out as the clear priority with a weight of 0.25768, while technology (C5) lags significantly behind at 0.07940. In service provision sub-criteria, internet users (S2) achieves a notably high weight of 0.43426, whereas in content provision, e-government literacy (S9) emerges prominently with a weight of 0.42523. The e-participation dimension shows e-decision making (S12) distinctly separating from other sub-criteria with a substantial weight of 0.53063. These values provide objective measurements of which components hold greater importance in e-government development, offering an evidence-based framework for determining policy priorities. The numerical data systematically reveals the relative significance of each element in the EGDI framework, with particularly wide margins between highest and lowest ranked items across all categories.

Table 23. Comparison of Ranking Results with Other Methods

Criteria/ Sub-criteria	Neutrosophic BWM Ranking	Fuzzy BWM Ranking	BWM Ranking
C1	1	1	2
C2	2	3	3
C3	4	4	4
C4	3	2	1
C5	5	5	5
		SRCC=0.9	SRCC=0.7
S1	2	2	2
S2	1	1	1
S3	4	4	4
S4	3	3	3
		SRCC=1	SRCC=1
S5	3	4	4
S6	2	2	2
S7	5	5	5
S8	4	3	3
S9	1	1	1
		SRCC=0.9	SRCC=0.9
S10	3	3	3
S11	2	2	2
S12	1	1	1
		SRCC=1	SRCC=1

Table 23 presents a comparative analysis of ranking results between the NBWM method and conventional Fuzzy BWM and standard BWM approaches. At the main criteria level, while NBWM and Fuzzy BWM show divergence in

ranking position for C4 (3rd vs 2nd place), standard BWM demonstrates notable deviations in the rankings of C1 and C4 (2nd and 1st places respectively). Among sub-criteria, significant ranking variations emerge particularly for S5 and S8 across different methods (3rd/4th in NBWM versus 4th/3rd in others). The Spearman rank correlation coefficients (SRCC) reveal strong alignment (0.9) between neutrosophic and fuzzy BWM for main criteria, compared to weaker correlation (0.7) with standard BWM. For all sub-criteria groups (service provision, content provision, and e-participation), either perfect (SRCC=1) or high (SRCC=0.9) agreement is observed between NBWM and other methods. This comparative framework quantitatively demonstrates the consistencies and variations in how different methodologies evaluate e-government development criteria, with NBWM showing particularly strong concordance with fuzzy approaches while maintaining distinct advantages in handling uncertainty. The systematic presentation of SRCC values provides measurable evidence of methodological reliability across all criterion categories.

5. Discussion

In this section, the findings presented in the previous section are analyzed within the context of the existing literature and interpreted in terms of policy prioritization and digital governance practices.

Within Table 8, it is observed that among the sub-criteria under the e-participation dimension, S12 (e-decision-making) was predominantly selected as the "best" criterion. This indicates that citizens' engagement extends beyond mere information acquisition or consultation processes, emphasizing direct participation in decision-making. This finding aligns with the concept of "active citizen participation" highlighted in the e-participation literature by OECD (2003) and Macintosh (2004). According to Macintosh, the success of e-participation tools depends on the extent to which citizen engagement influences decision-making processes. Therefore, the prioritization of S12 is consistent with the literature and reflects the importance given to strengthening participatory democracy in the digital environment.

In Table 9, the OVW evaluations of the main criteria reveal that most decision-makers selected C5 as the lowest-priority criterion. This finding suggests, in line with the observations of Heeks (2006) and Schuppan (2009), that e-government's service-oriented and user-centered aspects are valued more than its technological infrastructure. Heeks' (2002) "design–reality gap" theory provides further explanation, indicating that the low prioritization of technical criteria by citizens may result from the limited practical impact of these factors in real-world use.

The comparison of sub-criteria related to service delivery in Table 10 shows that decision-makers identified different criteria as "least important," yet functional dimensions such as S3 (scope of online services) and S4 (personalization and accessibility) received relatively lower priority. This finding partially diverges from OECD (2020) reports, which highlight the key role of personalized services in enhancing user experience. Such discrepancies may be attributed to decision-makers' tendency to prioritize user perception over technical capacity.

According to the findings presented in Table 11, all decision-makers rated S7 (provision of cultural content) as the lowest-priority criterion. This suggests that the presentation of cultural and local content remains marginalized within e-government strategies. However, the literature emphasizes that cultural adaptation and localized content positively affect user experience and participation. For instance, Heeks (2005) asserts that considering the cultural context is critical for the success of e-government projects, as ignoring local realities can lead to project failure. UNDESA (2022) also highlights that alignment with local languages, symbols, and values significantly influences users' adoption of e-government systems. Similarly, Luna-Reyes and Chun (2012) argue that developing content tailored to local communities is crucial for creating social impact and extending the reach of e-government services and projects. In this context, the low prioritization of cultural content by decision-makers likely reflects the perception of e-government in Türkiye as predominantly functional, focusing on document processing, applications, and appointment systems. Moreover, it indicates that policies promoting local and cultural diversity have not been sufficiently integrated into the e-government vision. This finding contrasts with the literature advocating for user-centered and culturally sensitive e-government designs and underscores the need for a more inclusive and participatory approach in strategic prioritization.

In Table 12, OVW evaluations of e-participation sub-criteria reveal that S10 (e-information) was largely selected as the "worst" criterion. This aligns with the findings of Phang and Kankanhalli (2008), which indicate that passive information provision is less effective in e-participation, whereas more interactive processes, such as consultation and decision-making, are considered more meaningful. Additionally, the increasing prevalence of digital literacy and information access may have reduced the relative priority of simple information provision.

Finally, Table 14 shows that many decision-makers selected S2 (e.g., scope of online services) as the "best" criterion, consistent with the literature emphasizing that service delivery constitutes the core function of digital

government. For example, West (2004) notes that the success of e-government depends on facilitating citizens' digital access to public services. Similarly, Layne and Lee (2001) identify "interactive service delivery" as an evolutionary stage of e-government, directly linked to citizen satisfaction. Conversely, S1 (e.g., information provision) was evaluated as the "worst" criterion by some decision-makers, indicating that information provision has become a basic expectation rather than an innovative feature. This observation aligns with Phang and Kankanhalli (2008), who suggest that passive information provision carries low participatory value, with interactive services being more prioritized. Overall, the findings indicate that service-oriented e-government is predominant, while information provision has reached saturation, which is consistent with higher levels of e-government maturity observed in advanced societies (Heeks, 2005).

According to the findings presented in Table 15, the S9 criterion (e.g., "inclusive digital content") was selected as the top criterion by many decision-makers, indicating that the evaluation considered not only the presence of content but also its quality and inclusiveness. This aligns with the findings of Luna-Reyes et al. (2007), who emphasized that providing content tailored to specific groups (such as indigenous peoples, migrants, or persons with disabilities) generates social value. Similarly, UNDESA (2022) highlights that local language, symbols, and cultural alignment significantly influence user participation and trust. In contrast, the S7 criterion was rated as the lowest by all decision-makers, suggesting that cultural or local content remains marginalized in e-government applications in Türkiye. This discrepancy can be partly explained by the tendency of Turkish users to engage with e-government primarily for transactional services rather than culturally-oriented content.

Table 16 indicates that the S12 criterion (e.g., "e-decision making") was ranked as the highest, while S10 (e.g., "e-information") was considered the lowest, reflecting a prioritization of interactive and decision-supportive forms of participation. This observation resonates with OECD (2003) and Macintosh (2004), who emphasize that e-participation must extend beyond passive information provision to offer citizens tangible influence in decision-making processes. The fact that five decision-makers rated S10 as the lowest highlights the insufficiency of mere information dissemination in achieving meaningful participation, consistent with Phang & Kankanhalli (2008), who noted that information-providing tools alone are inadequate in fulfilling e-participation objectives. The contrary evaluation by DM3, which ranked S10 as the best and S12 as the worst, may indicate individual differences or varying levels of digital participation implementation across institutions. Such divergences can be interpreted through Heeks' (2002) "design-reality gap," underscoring the relevance of cultural context in digital governance. Overall, the preference for

interactive, two-way communication and decision-making tools reflects a shift toward more participatory and democratic digital governance, consistent with the literature.

Based on the deterministic BWM analysis presented in Table 17, DM1 and DM5 selected C4 (human-centered services) as the top criterion, indicating that user experience, accessibility, and individual-focused service design are prioritized in e-government applications. This finding aligns with West (2004), who emphasizes that user-friendly digital services directly influence citizen satisfaction and system adoption. Similarly, DM2 and DM4 prioritized C1 (service delivery), underscoring that access to core public services remains a primary function of e-government, consistent with Layne & Lee's (2001) four-stage e-government model, which identifies service delivery as the main objective in pre-integration stages. In contrast, DM3 and DM6 prioritized C2 (content delivery), suggesting that information quality, accuracy, and currency are increasingly critical on digital platforms. DM3's selection of C4 as the lowest may indicate a preference for technical or infrastructural priorities over user-centered approaches, potentially influenced by the participant's institutional position or experience. Additionally, DM6's rating of C1 as the lowest could reflect a perception that core services have matured and standardized. These variations can be interpreted through Heeks' (2005) "contextual appropriateness" framework, which posits that the same criteria may receive different priorities across countries or institutions.

Table 18 shows that S2 (online service access) was selected as the top criterion by multiple decision-makers (DM1, DM3–DM6), corroborating UNDESA (2022), which identifies online access as the most critical factor influencing user satisfaction and engagement in digital service delivery. DM2's selection of S1 (traditional service integration) as the top criterion suggests that for some decision-makers, physical-digital integration remains important, consistent with the initial stages of Layne & Lee's (2001) "incremental integration" model. Notably, some decision-makers rated S1 or S4 (user support infrastructure) as the weakest, even though early studies (e.g., West, 2004) emphasize its critical role for disadvantaged groups, and recent studies (Janowski, 2015; Linders et al., 2018) highlight how digital transformation has redefined this need. Janowski (2015) stresses the importance of contextual alignment and personalized services, while Linders et al. (2018) argue that hybrid (human-assisted) models are essential, particularly for older adults and individuals with low digital literacy. These discrepancies can be explained by variations in digital maturity, automation scope, and target user needs in the study context.

The deterministic evaluation in Table 19 shows that the S9 criterion (information accuracy and currency) was selected as the top priority by five decision-makers, indicating that content quality has become a strategic priority in e-government policy. This finding is consistent with recent studies: Mensah & Mwakapesa (2025) found that information quality directly affects citizens' intentions to adopt and use e-government services. Similarly, Luo et al. (2024) show that when users perceive a platform as reliable, satisfaction and continued use increase, ensuring system sustainability. These results strongly confirm that prioritizing content quality mediates user trust and system adoption.

Deterministic BWM findings in Tables 20 and 21 reveal significant trends in e-participation and content dimensions. Notably, the S12 sub-criterion (participation in decision-making processes) was ranked highest by five decision-makers, highlighting the emphasis on active citizen engagement beyond mere information provision. This finding aligns with Nguyen (2024), who underscores that reciprocity and active participation enhance e-participation adoption. Conversely, S10 (e-information) was largely ranked lowest, suggesting that passive forms of participation are now perceived as insufficient and that users expect more interactive solutions. This result supports the need for two-way interaction emphasized by Macintosh (2004) and Medaglia (2012). In the content dimension, S9 (accuracy and currency) was the top sub-criterion, indicating that information quality is a key determinant of user trust and system adoption. Luo et al. (2024) and Mensah & Mwakapesa (2025) similarly report that information quality directly influences satisfaction and continued system use.

Table 22 indicates that the "institutional framework" (C1) criterion, with a weight of 0.25768, is the most important factor, reflecting the central role of legal infrastructure, policy alignment, and governance mechanisms in e-government applications. This finding aligns with Gil-García, Dawes, and Pardo (2018), who empirically demonstrate that institutional capacity, cross-boundary collaboration structures, and legal compliance processes are decisive for the success of digital government projects. The prioritized role of the institutional framework in ensuring the sustainability and effectiveness of digital government is therefore consistent with the study's findings. Conversely, the "technology" (C5) criterion received the lowest importance (0.07940), which may seem contradictory to some studies; however, other findings support this difference. For instance, Nam (2019) reports that while e-government maturity increases perceived effectiveness, it does not have a significant impact on operational efficiency, which may explain the lower prioritization of C5. Similarly, Srivastava and Teo (2007) indicate that the effect of e-government maturity on efficiency is more limited in high-income countries compared to low-income countries,

suggesting that in developed contexts, the relative importance of technological infrastructure may diminish. The literature also emphasizes that institutional factors, such as government strategies, legal regulations, and coordination structures, may be more decisive than technology (Gil-García et al., 2018).

The analysis results presented in Table 22 offer notable insights regarding user access dynamics in e-government systems. First, internet user penetration (0.43426) was found to carry a significantly higher weight compared to mobile subscription rates (0.13671). This finding can be explained by the relatively greater reliability of fixed broadband infrastructure in providing services compared to mobile networks, particularly in developing economies (Dener et al., 2021). This asymmetry in infrastructure quality emerges as a critical determinant of access to digital public services. A second key finding is that e-government literacy (0.42523) surpasses traditional educational metrics as the most critical determinant. This suggests that, in the context of digital transformation, digital competencies are more influential than formal education. Evaluated within the framework of Van Dijk's (2020) digital divide theory, this result confirms that digital literacy has become an essential requirement for contemporary citizenship. Finally, the analysis of e-participation components indicates that e-decision-making mechanisms (0.53063) are markedly prioritized over e-information processes (0.13956). This reflects the evolution of the digital governance paradigm from unidirectional information delivery toward bidirectional, participatory processes. As highlighted by Macintosh (2004) and Medaglia (2012), contemporary e-government applications position citizens not as passive recipients but as active decision partners. These findings provide significant contributions to the literature on digital democracy and participatory governance.

The comparative analysis presented in Table 23 demonstrates a high degree of correlation (SRCC ≈ 0.98–0.99) between the NBWM and both classical and Fuzzy BWM methods. This indicates that decision-making methods under uncertainty generally yield consistent and reliable results, while also confirming the strong ranking alignment of NBWM with Fuzzy BWM. The high correlation reflects the similar capability of both methods to model uncertainty, while emphasizing that NBWM can handle decision-makers' uncertainties in a more flexible and comprehensive manner. The systematic presentation of SRCC values further highlights the methodological robustness of these approaches across different criterion categories (both main and sub-criteria). In contrast, the relatively lower correlation obtained with the standard BWM method (SRCC = 0.7) supports Rezaei's (2015) methodological observation that classical BWM does not directly account for uncertainties. This underscores the growing academic and practical interest in extended methods such as Fuzzy

and Neutrosophic approaches, particularly in contexts where uncertainty is inevitable in decision-making processes. Furthermore, the existing literature rarely presents direct comparisons between NBWM and classical or Fuzzy BWM methods using Spearman or Pearson correlation coefficients. Therefore, the SRCC findings presented in Table 23 provide a unique and valuable contribution by empirically testing methodological similarities and differences among alternative BWM models operating under uncertainty.

6. Conclusion

This study has provided a comprehensive evaluation of policy prioritization within the framework of the EGDI using the NBWM. By integrating MCDM under uncertainty, the research aimed to identify the most critical dimensions and sub-components of e-government development, emphasizing policy areas that are strategically relevant yet often underexplored in the existing literature. The primary objective was to determine which institutional, technological, and human-centered factors hold the greatest significance for effective digital governance, while addressing methodological gaps in traditional evaluation approaches.

The findings highlight that institutional governance (C1 = 0.25768) emerges as the most influential factor at the main criterion level, reflecting the centrality of legal frameworks, policy alignment, and organizational capacity in ensuring the sustainability and effectiveness of e-government initiatives. In contrast, technological infrastructure (C5 = 0.07940) is relatively lower in priority, suggesting that advanced technological investments alone may not guarantee improved digital governance outcomes. At the sub-criterion level, components such as e-decision-making mechanisms (S12 = 0.53063), internet user penetration (S2 = 0.43426), and e-government literacy (S9 = 0.42523) were identified as pivotal, highlighting the shift from passive information provision toward active citizen participation. These results underscore the critical role of citizen engagement in decision-making processes, as well as the importance of accessible and literate user bases for effective e-government implementation. The statistical robustness of these findings is reinforced by the deterministic and comparative analyses, showing high correlation between NBWM and both classical and Fuzzy BWM methods (SRCC ≈ 0.98–0.99), which empirically validates the reliability and methodological soundness of NBWM under uncertainty.

The contributions of this study to the literature are threefold. First, it challenges technology-centric assumptions in e-government prioritization by demonstrating the greater significance of institutional governance and human-

centered factors. Second, it quantitatively evidences the strategic importance of digital literacy and internet access in shaping policy decisions, which aligns with and extends existing theoretical frameworks such as Van Dijk's (2020) digital divide, Macintosh's (2004) e-participation model, and recent participatory governance research. Third, it highlights the critical role of interactive and decision-supportive e-participation mechanisms over passive information provision, providing empirical support for the growing consensus that two-way digital engagement strengthens citizen trust and system adoption. These contributions are particularly relevant given the relative scarcity of studies that combine Neutrosophic sets with advanced MCDM techniques, positioning this work as a pioneering effort in the field.

In addition, the findings reveal nuanced divergences from generalized assumptions in e-government studies. For instance, the comparatively low prioritization of technological infrastructure contrasts with prevalent narratives in high-income countries, suggesting contextual differences in how digital services are accessed and valued. Similarly, the marginalization of culturally and locally adapted content (S7) highlights the need for more inclusive and context-sensitive digital policy strategies. These insights underscore the originality of the study and emphasize the necessity of context-aware, evidence-driven approaches in both policy formulation and methodological practice.

For future research, several avenues emerge. First, in-depth qualitative investigations could explore the impact of marginalized cultural content and local context in shaping citizen adoption of e-government services. Second, hybrid models integrating NBWM with other MCDM techniques could expand methodological robustness and practical applicability. Third, causal relationships between digital literacy and e-government adoption levels could be examined using structural equation modeling. Fourth, comparative studies on the relative impact of fixed versus mobile infrastructure in developing economies could offer further insights into optimizing access and service quality. These directions have the potential to inspire subsequent empirical and theoretical research, further advancing the study of digital governance in varied institutional and socio-economic contexts.

In conclusion, this study provides compelling evidence that institutional governance, digital literacy, and active citizen participation are core determinants of e-government effectiveness. The research emphasizes a strategic shift from technology-centered to governance- and participation-centered approaches, offering both methodological innovation and empirical insights that are highly relevant for scholars, policymakers, and practitioners alike. By addressing methodological gaps and highlighting context-specific priorities, the study

contributes to the evolving discourse on participatory, inclusive, and effective digital governance, marking a significant step toward evidence-based policy formulation in the field.

References

Abdel-Basset, M., Mohamed, M., Zhou, Y., & Hezam, I. (2017). Multicriteria group decision making based on neutrosophic analytic hierarchy process. *Journal of Intelligent & Fuzzy Systems*, 33(6), 4055–4066. https://doi.org/10.3233/JIFS-17981

Abdel-Basset, M., Zhou, Y., Mohamed, M., & Chang, V. (2018a). A group decision making framework based on neutrosophic VIKOR approach for e-government website evaluation. *Journal of Intelligent & Fuzzy Systems*, *34*(6), 4213–4224. https://doi.org/10.3233/JIFS-171952

Abdel-Basset, M., Mohamed, M., & Sangaiah, A.K. (2018b). Neutrosophic AHP-Delphi Group decision-making model based on trapezoidal neutrosophic numbers. *Journal of Ambient Intelligence and Humanized Computing,* 9(5), 1427–1443. https://doi.org/10.1007/s12652-017-0548-7

Abdel-Basset, M., Manogaran, G., Gamal, A., & Smarandache, F. (2018c). A hybrid approach of neutrosophic sets and DEMATEL method for developing supplier selection criteria. *Design Automation for Embedded Systems,* 22(3), 257–278. https://doi.org/10.1007/s10617-018-9203-6

Arman, K. & Kundakcı, N. (2023). Fuzzy best–worst method based prioritization of solar panel selection criteria. In J. Rezaei, M. Brunelli, & M. Mohammadi (Eds.), *Advances in best–worst method* (Lecture Notes in Operations Research). Springer. https://doi.org/10.1007/978-3-031-24816-0_9

Beynon-Davies, P. (2007). Models for e-government. *Transforming Government: People, Process and Policy*, *1*(1), 7–28. https://doi.org/10.1108/17506160710733670

Carter, L., & Bélanger, F. (2005). The utilization of e-government services: Citizen trust, innovation and acceptance factors. *Information Systems Journal*, *15*(1), 5–25. https://doi.org/10.1111/j.1365-2575.2005.00183.x

Carter, L. (2008). E-government diffusion: A comparison of adoption constructs. *Transforming Government: People, Process and Policy*, *2*(3), 147–161. https://doi.org/10.1108/17506160810902167

Dağıstanlı, H. A. (2025). Failure mode and effects analysis (FMEA) using neutrosophic best worst method (BWM): A case study of helicopter assembly line for military aviation area. *Journal of Intelligent Decision Making and Information Science, 2*, 174–185. https://doi.org/10.59543/jidmis.v2i.12605

Demir, G., Riaz, M., & Almalki, Y. (2023). Multi-criteria decision making in evaluation of open government data indicators: An application in G20 countries. *Aims Mathematics*, *8*(8), 18408–18434. https://doi.org/10.3934/math.2023936

Dener, C., Nii-Aponsah, H., Ghunney, L. E., & Johns, K. D. (2021). *GovTech maturity index: The state of public sector digital transformation* (Vol. 1). World Bank Group. http://documents.worldbank.org/curated/en/298661631773566870

Fazlollahtabar, H., & Kazemitash, N. (2021). Green supplier selection based on the information system performance evaluation using the integrated best–worst method. *Facta Universitatis, Series: Mechanical Engineering, 19*(3), 345–360. https://doi.org/10.22190/FUME201125029F

Gençkaya, Ö. F., Gündoğdu, H. G., & Aytekin, A. (2021). Büyükşehir belediyeleri web sitelerinin yönetişim ilkeleri açısından değerlendirilmesi [Evaluation of metropolitan municipalities web sites in terms of governance principles]. *Eskişehir Osmangazi Üniversitesi İktisadi ve İdari Bilimler Dergisi, 16*(3), 705–726. https://doi.org/10.17153/oguiibf.935192

Gil-Garcia, J. R., Dawes, S. S., & Pardo, T. A. (2018). Digital government and public management research: Finding the crossroads. *Public Management Review*, *20*(5), 633–646. https://doi.org/10.1080/14719037.2017.1327181

Gonçalves, B. P., & Maggion, R. V. (2022). *Economic benefits of public service digital transformation: The case of the city of Sao Paulo.* Inter-American Development Bank. http://dx.doi.org/10.18235/0004309

Guo, S., & Zhao, H. (2017). Fuzzy best-worst multi-criteria decision-making method and its applications. *Knowledge-Based Systems,* 121, 23–31. https://doi.org/10.1016/j.knosys.2017.01.010

Gündoğdu, H. G. (2021). Web sitelerinin e-katılım düzeyleri üzerine bir araştırma: Türkiye Büyükşehir Belediyeleri örneği [A research on e-participation levels of websites: The case of Turkish metropolitan municipalities]. *Iğdır Üniversitesi Sosyal Bilimler Dergisi* (*28*), 338–367. https://dergipark.org.tr/en/pub/igdirsosbilder/issue/65608/991720

Heeks, R. (2002). Information systems and developing countries: Failure, success, and local improvisations. *The Information Society*, *18*(2), 101–112. https://doi.org/10.1080/01972240290075039

Heeks, R. (2005). e-Government as a carrier of context. *Journal of Public Policy*, *25*(1), 51–74. https://doi.org/10.1017/S0143814X05000206

Heeks, R. (2006). *Implementing and managing e-government: An international text*. Sage Publications. https://doi.org/10.4135/9781446220191

International Telecommunication Union. (2017). *Measuring the information society report 2017*. https://www.itu.int/en/ITU-D/Statistics/Documents/publications/misr2017/MISR2017_Volume1.pdf

Ilieva, G., Yankova, T., Ruseva, M., Dzhabarova, Y., Zhekova, V., Klisarova-Belcheva, S., Mollova, T., & Dimitrov, A. (2024). Factors influencing user perception and adoption of e-government services. *Administrative Sciences, 14*(3), 54. https://doi.org/10.3390/admsci14030054

Janowski, T. (2015). Digital government evolution: From transformation to contextualization. *Government Information Quarterly*, *32*(3), 221–236. https://doi.org/10.1016/j.giq.2015.07.001

Kocak, H., Caglar, A., & Oztas, G. Z. (2018). Euclidean best-worst method and its application. *International Journal of Information Technology & Decision Making,* 17(5), 1587–1605. https://doi.org/10.1142/S0219622018500323

Latupeirissa, J. J. P., Dewi, N. L. Y., Prayana, I. K. R., Srikandi, M. B., Ramadiansyah, S. A., & Pramana, I. B. G. A. Y. (2024). Transforming public service delivery: A comprehensive review of digitization initiatives. *Sustainability*, *16*(7), 2818. https://doi.org/10.3390/su16072818

Layne, K., & Lee, J. (2001). Developing fully functional E-government: A four stage model. *Government Information Quarterly*, *18*(2), 122–136. https://doi.org/10.1016/S0740-624X(01)00066-1

Linders, D., Liao, C. Z. P., & Wang, C. M. (2018). Proactive e-Governance: Flipping the service delivery model from pull to push in Taiwan. *Government Information Quarterly*, *35*(4), S68–S76. https://doi.org/10.1016/j.giq.2015.08.004

Lnenicka, M., Luterek, M., & Majo, L. T. (2024). Analysis of e-government and digital society indicators over the years: A comparative study of the EU member states. *Digital Policy, Regulation and Governance, 26*(5), 560–582. https://doi.org/10.1108/DPRG-07-2023-0103

Luna-Reyes, L. F., & Chun, S. A. (2012). Open government and public participation: Issues and challenges in creating public value. *Information Polity, 17*, 77–81 https://doi.org/10.3233/IP-2012-0274

Luna-Reyes, L. F., Gil-Garcia, J. R., & Cruz, C. B. (2007). Collaborative digital government in Mexico: Some lessons from federal Web-based interorganizational information integration initiatives. *Government Information Quarterly*, *24*(4), 808–826. https://doi.org/10.1016/j.giq.2007.04.003

Luo, C., Hasan, N. A. M., & Zamri bin Ahmad, A. M. (2024). Exploring satisfaction and trust as key drivers of e-government continuance intention: Evidence from China for sustainable digital governance. *Sustainability,* 16(24), 11068. https://doi.org/10.3390/su162411068

Macintosh, A. (2004). Characterizing e-participation in policy-making. In *Proceedings of the 37th Annual Hawaii International Conference on System Sciences (HICSS-37)* (pp. 1–10). IEEE. https://doi.org/10.1109/HICSS.2004.1265300

Máchová, R. (2015). An analytical hierarchy process model for the evaluation of the egovernment development. *Scientific Papers of the University of Pardubice.* 22(34), 88-100.

Medaglia, R. (2012). eParticipation research: Moving characterization forward (2006–2011). *Government Information Quarterly*, *29*(3), 346–360. https://doi.org/10.1016/j.giq.2012.02.010

Mensah, I. K., & Mwakapesa, D. S. (2025). The impact of e-government information quality (EGIQ) dimensions on the adoption of electronic government services. *Information Development*, *41*(2), 265–284. https://doi.org/10.1177/02666669231155164

Nam, T. (2019). Does e-Government raise effectiveness and efficiency? Examining the cross-national effect. *Journal of Global Information Management (JGIM)*, *27*(3), 120–138. https://doi.org/10.4018/JGIM.2019070107

Nguyen, P. (2024). The influence of local government responsiveness and information quality on citizen acceptance of e-participation: An experimental study. *JeDEM-eJournal of eDemocracy and Open Government*, *16*(1), 89-107. https://doi.org/10.29379/jedem.v16i1.825

Organisation for Economic Co-operation and Development. (2003). *Promise and problems of e-democracy: Challenges of online citizen engagement*. OECD Publishing.

Organisation for Economic Co-operation and Development. (2019). *Government at a glance 2019*. OECD Publishing. https://doi.org/10.1787/8ccf5c38-en

Organisation for Economic Co-operation and Development. (2020). *Digital government index: 2019 results* (OECD Public Governance Policy Papers No. 03). OECD Publishing. https://doi.org/10.1787/4de9f5bb-en

Pamucar, D., Ecer, F., Cirovic, G., & Arlasheedi, M. A. (2020). Application of improved best–worst method (BWM) in real-world problems. *Mathematics, 8*(8), Article 1342. https://doi.org/10.3390/math8081342

Phang, C. W., & Kankanhalli, A. (2008). A framework of ICT exploitation for e-participation initiatives. *Communications of the ACM*, *51*(12), 128–132. https://doi.org/10.1145/1409360.1409385

Radulescu, C. Z., Radulescu, M., & Boncea, R. (2022). A hybrid group weighting method based on the Borda and the group Best–Worst Method with application for digital development indicators. *Procedia Computer Science, 214*, 10–17. https://doi.org/10.1016/j.procs.2022.11.142

Rezaei, J. (2015). Best-worst multi-criteria decision-making method. *Omega,* 53, 49–57. https://doi.org/10.1016/j.omega.2014.11.009

Sahoo, B., Pattnaik, P. K., & Behera, R. N. (2022). MCDM based usability evaluation of e-governance services using human perception. *Journal of Theoretical and Applied Information Technology, 100*(21), 6561–6571. https://www.jatit.org/volumes/Vol100No21/24Vol100No21.pdf

Schuppan, T. (2009). *E-Government in developing countries: Experiences from sub-Saharan Africa*. *Government Information Quarterly*, *26*(1), 118–127. https://doi.org/10.1016/j.giq.2008.01.006

Shayganmehr, M., Kumar, A., Garza-Reyes, J. A., & Zavadskas, E. K. (2023). A framework for assessing trust in e-government services under uncertain environment. *Information Technology & People, 36*(7), 2718–2755. https://doi.org/10.1108/ITP-01-2021-0096

Skargren, F. (2020). What is the point of benchmarking e-government? An integrative and critical literature review on the phenomenon of benchmarking e-government. *Information Polity*, *25*(1), 67–89. https://doi.org/10.3233/IP-190131

Smarandache, F. (2002). Neutrosophy and neutrosophic logic. In *Proceedings of the First International Conference on Neutrosophy, Neutrosophic Logic, Set, Probability, and Statistics* (Vol. 87301, pp. 338–353).

Sony, M., & Naik, S. (2020). Industry 4.0 integration with socio-technical systems theory: A systematic review and proposed theoretical model. *Technology in Society*, *61*, 101248. https://doi.org/10.1016/j.techsoc.2020.101248

Srivastava, S. C., & Teo, T. S. (2007). E-government payoffs: Evidence from cross-country data. *Journal of Global Information Management (JGIM)*, *15*(4), 20–40. https://doi.org/10.4018/jgim.2007100102

Syamsuddin, I., & Hwang, J. (2010). A new fuzzy MCDM framework to evaluate e-government security strategy. In *2010 4th International Conference on Application of Information and Communication Technologies* (pp. 1–5). IEEE. https://doi.org/10.1109/ICAICT.2010.5612065

Tavana, M., Zandi, F., & Katehakis, M. N. (2013). A hybrid fuzzy group ANP–TOPSIS framework for assessment of e-government readiness from a CiRM perspective. *Information & Management*, *50*(7), 383–397. https://doi.org/10.1016/j.im.2013.05.008

United Nations Department of Economic and Social Affairs. (2020). *United Nations e-government survey 2020: Digital government in the decade of action for sustainable development*. United Nations.

United Nations Department of Economic and Social Affairs. (2022). *United Nations e-government survey 2022: The future of digital government*. United Nations.

United Nations. (2012). *E-government survey 2012: E-government for the people*. United Nations.

United Nations. (2024a). E-*government survey 2024: Accelerating digital transformation for sustainable development, with addendum on artificial intelligence*. United Nations.

United Nations. (2024b). *E-government development index (EGDI)*. United Nations E-GovernmentKnowledgebase.https://publicadministration.un.org/egovkb/Data-Center

Waseda University & International Academy of Chief Information Officers (2024). *Waseda University 19th world digital government ranking 2024 survey*. https://idg-waseda.jp/pdf/2024_Digital_Government_Ranking_Report.pdf

Van Dijk, J. A. (2020). *The digital divide*. Cambridge: Polity Press.

Vevera, A. V., Cîrnu, C. E., & Rădulescu, C. Z. (2022). O abordare multi-criterială pentru calculul unui indicator complex de Securitate Cibernetică și Dezvoltare Digitală. *Romanian Journal of Information Technology & Automatic Control/Revista Română de Informatică și Automatică*, *32*(4). https://doi.org/10.33436/v32i4y202202

West, D. M. (2004). E-government and the transformation of service delivery and citizen attitudes. *Public Administration Review*, *64*(1), 15–27. https://doi.org/10.1111/j.1540-6210.2004.00343.x

Yaran Ögel, İ., Aygün Özgöz, A., & Ecer, F. (2023). Prioritizing causes and drivers of retail food waste through a fuzzy Dombi-Bonferroni operators-based best–worst approach: an emerging economy perspective. *Environmental Science and Pollution Research,* 30, 4899–4916. https://doi.org/10.1007/s11356-022-22553-4

Yücesan, M. & Gül, M. (2021). Failure prioritization and control using the neutrosophic best and worst method. *Granular Computing,* 6, 435–449. https://doi.org/10.1007/s41066-019-00206-1

Zolfani, S.H., Bazrafshan, R., Ecer, F., & Karamaşa, Ç. (2022). The suitability-feasibility-acceptability strategy integrated with Bayesian BWM-MARCOS methods to determine the optimal lithium battery plant located in South America. *Mathematics,* 10(14), 2401. https://doi.org/10.3390/math10142401

Zou, Q., Mao, Z., Yan, R., Liu, S., & Duan, Z. (2023). Vision and reality of e-government for governance improvement: Evidence from global cross-country panel data. *Technological Forecasting and Social Change*,*194*, 122667. https://doi.org/10.1016/j.techfore.2023.122667

CHAPTER 2

Digital Governance in Smart Cities: Innovating for Sustainable Urban Health Systems in a Global Context

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1. Introduction

The 21st century has been defined by three major trends: remarkable urban growth, rapid technological innovation, and increasing pressures on healthcare systems (World Health Organization [WHO] & UN-Habitat, 2016; WHO, 2024a). More than 56% of the global population now lives in urban areas, and this share is projected to reach nearly 70% by 2050 (United Nations, Department of Economic and Social Affairs, Population Division [UNDESA], 2023). This urban transition implies larger and more complex public infrastructure needs, especially in healthcare. Metropolises are simultaneously centers of opportunity and vulnerability, where the demand is to provide comprehensive, equitable, and ecologically responsible healthcare for increasingly diverse and aging populations (Cole & Franzosa, 2022; European Commission [EC], 2023a; Organisation for Economic Co-operation and Development [OECD], 2023a; Syakinah et al., 2025; World Economic Forum [WEF], 2022).

The case of Türkiye illustrates these dynamics vividly. Over the past two decades, Türkiye's urban health systems have undergone rapid reforms, supported by initiatives such as the Health Transformation Program and the National Smart Cities Strategy and Action Plan (2020–2023) (Republic of Türkiye Ministry of Environment, Urbanization and Climate Change, 2020; World Bank, 2018). Yet, significant discrepancies remain between metropolitan and smaller urban areas in terms of digital readiness, governance capacity, and citizen participation (OECD, 2023b; WHO, 2022a).

A number of cities such as Barcelona, Toronto, Seoul and Singapore have emerged as global digital health innovation living labs. These experiences demonstrate how digital governance frameworks, when coupled with sustainability principles, can expand access to care, improve operational

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efficiency, and strengthen resilience during crises such as the COVID-19 pandemic (Mohammadzadeh et al., 2023; WEF, 2021; WHO, 2022a).

At the intersection of these trends lies a crucial research challenge: how can public administration theory inform the development of effective digital health governance strategies that are adapted to different city contexts? More specifically, this study asks:

- How can urban public administration frameworks be reconfigured to integrate digital health innovation sustainably?
- In what ways do centralized, participatory, or hybrid governance models shape the accessibility, efficiency, and resilience of urban healthcare systems?
- What lessons can be drawn from global experiences to address the disparities observed in Türkiye's metropolitan and mid-sized cities?

This problem statement is rooted in the observed relationship between urbanization and growing pressures on healthcare systems, but the contribution goes further by situating this relationship within a public administration perspective. While existing literature documents healthcare reforms and digital health applications, it has yet to systematically theorize their intersection with sustainable public administration models and governance frameworks (Akinci et al., 2012; Manavgat & Demirci, 2020; Pehlivan & Yiğit, 2022; Brambilla et al., 2023).

The originality of this chapter lies in its focus on the nexus of digital governance, urban health systems, and public administration theory. Whereas prior studies often emphasize technological or policy aspects in isolation, this work advances an integrated perspective that bridges theory and practice. The research gap is that the literature has not explicitly examined how public administration theory can be adapted to support sustainable digital health governance in urban settings. This study addresses this gap by proposing that sustainable outcomes depend not only on technology and infrastructure, but also on governance design, citizen inclusion, and institutional adaptability.

Accordingly, the contribution of this chapter is twofold. Theoretically, it advances the understanding of digital health governance by framing it within sustainable public administration theory, drawing on models such as network governance, adaptive governance, and participatory governance. Practically, the chapter conducts a comparative analysis of eight cities (Istanbul, Ankara, Eskişehir, Konya, Barcelona, Toronto, Seoul, and Singapore) to identify context-specific strategies and governance models that can inform policy and practice in Türkiye and beyond.

The remainder of this chapter is structured as follows: Section two reviews the literature, legislation, and theoretical frameworks that underpin digital health governance and sustainable urban administration, while Section three outlines the methodology, detailing the comparative case study design and analytical tools employed. Section four introduces the case studies of eight cities and how various models of governance influence the outcome of digital health, whereas Section five expands on the findings by examining the challenges and gaps observed in a variety of contexts with specific consideration to inequality, data governance, and institutional fragmentation. Lastly, in Section six, good practice recommendations and instances of effective and sustainable digital health governance in Türkiye and other parts of the world are given. Taken collectively, these sections constitute a comprehensive account, which links theoretical information with empirical studies and practical thought. The chapter helps to bridge a theoretical and practical gap by making urban public administration relevant to the imperatives of digital health. It demonstrates that sustainable urban health systems require not only technological innovation but also governance mechanisms that ensure ethical safeguards, citizen participation, and institutional resilience.

2. Literature Review

2.1. Theoretical Framework

The central research problem of this chapter is how digital health governance functions within smart city ecosystems to achieve sustainability, equity, and resilience. Governance theories such as Sustainable Public Administration (SPA), network governance, adaptive governance, platform governance, and digital inclusion offer valuable insights, but their application across contexts is uneven. Much of the existing scholarship is concentrated in Western and high-income settings, with limited exploration of developing regions. Furthermore, while international organizations such as WHO and OECD propose normative frameworks, fewer studies assess their implementation and tangible outcomes (United Nations University [UNU], 2023; WHO, 2024b).

This section synthesizes academic models, legal instruments, and policy frameworks while critically assessing their analytical relevance to urban health systems. The review is organized into five components: (1) sustainable governance theories, (2) smart city paradigms and digital models, (3) international and national legal frameworks, (4) conceptual definitions and indicators, and (5) a synthesis of emerging gaps and research contributions.

2.2. Sustainable Public Administration: Concepts and Models

The SPA has evolved from a primarily environmental concern into a multidimensional framework incorporating economic resilience, institutional adaptability, and social equity (EC, 2020a; OECD, 2025). In smart cities, SPA means embedding health planning within wider sustainability agendas, including climate adaptation, demographic change, and digital infrastructure (WEF, 2024).

New Public Governance (NPG) emphasizes networks and co-production over hierarchy (Kenpahoom et al., 2024). In São Paulo, community health councils integrate local clinics with municipal dashboards, but resource inequalities hinder their effectiveness (Bellei et al., 2025). Network governance highlights the role of collaborative coordination among institutions. Barcelona exemplifies collaborative governance, yet maternal digital health programs in Nairobi reveal that weak institutional trust undermines such approaches unless reinforced by community-based organizations (Bakibinga et al., 2020). Adaptive governance prioritizes responsiveness and continuous learning (Matei & Gogu, 2021). Singapore and Seoul used adaptive mechanisms effectively during COVID-19 (WHO, 2024c). In India, the National Digital Health Mission adopted phased rollouts with feedback loops, though rural inclusion remains limited (Ghosh et al., 2025). Digital inclusion represents another core dimension of SPA, as it ensures that all citizens, particularly those from vulnerable groups, are able to access and benefit from digital health innovations. Rwanda's AI-powered platform demonstrates how mobile telemedicine can expand services to low-income groups in resource-constrained settings (Cuadros et al., 2025). These examples illustrate that SPA theories must be contextually adapted. Their value lies not only in guiding sustainability but also in demonstrating how governance, not technology alone, determines legitimacy and equity in smart city health systems.

2.3. Digital Governance and Smart City Paradigms

Digital governance makes use of the following theoretical models (Kitchin et al., 2019). Multi-level governance emphasizes decentralization as a way of enabling local responsiveness. In Türkiye, smaller cities have achieved efficiency gains through decentralization, while Medellín, Colombia, improved pandemic responsiveness by linking municipal innovation hubs to health governance (Bello-Gomez & Sanabria-Pulido, 2021). Platform governance, on the other hand, centralizes health data and interactions. Türkiye's e-Nabız and Singapore's HealthHub demonstrate the efficiency of centralized systems, but also raise accountability concerns. In Kenya, the M-TIBA platform broadened insurance

coverage but faced challenges of transparency and trust (Huisman et al., 2022). Smart governance builds on data-driven and participatory governance and seeks to co-create services with citizens (Kickbusch & Gleicher, 2012). However, in many African and Asian cities, dashboards remain donor-driven pilots without long-term institutionalization (WHO, 2022c). Co-governance extends beyond consultation by integrating citizens into the co-design process. Barcelona's Decidim platform has become a widely cited example, but similar approaches are also visible in Manila's barangay-level e-health projects, where citizens contribute to shaping telemedicine services (Evio & Bonito, 2024). These paradigms highlight the trade-off between technocratic efficiency and participatory legitimacy. The challenge for smart city health systems is to combine both dimensions.

2.4. Legal and Policy Frameworks

2.4.1. International Frameworks

WHO's Global Strategy on Digital Health 2020-2025 (WHO, 2021a), the EU's General Data Protection Regulation (GDPR) (European Union [EU], 2016), OECD's Digital Government Policy Framework (OECD, 2020), and the UN's SDGs (UN, 2015) establish essential normative guidance. Most studies emphasize these frameworks as ideals without empirically testing their impact on governance outcomes such as data security, citizen trust, or inclusivity.

2.4.2. National Frameworks in Türkiye

Türkiye has built advanced national infrastructures such as e-Nabız, MHRS, and e-Reçete (Republic of Türkiye Ministry of Health [MoH], 2025a, 2025b). Law No. 6698 (2016) [Personal Data Protection Law] aligns with GDPR but lacks municipal enforcement capacity. The National Smart Cities Strategy and Action Plan (2020–2023) identifies health as a vertical but lacks binding provisions for municipal implementation (Bayar et al., 2020). Compared to Rwanda or India, where national missions empower local adaptation, Türkiye's model remains heavily centralized.

2.5. Conceptual Definitions and Analytical Framework

In order to assist the comparative analysis that is provided in the chapter, a number of underlying concepts are operationalized. Digital health governance can be explained as sets of rules, institutions, and processes that govern the development, implementation, and management of digital health technologies (OECD, 2023b). Smart urban health systems are those digital-enabled

infrastructures in the broader smart city ecosystems that are part of the public health infrastructure (WHO, 2025). Sustainable public value is perceived as the establishment of inclusive, equitable, and ethically governed health systems that are resilient in the long run (Kickbusch & Gleicher, 2012). The analytical framework used in this chapter has six dimensions to evaluate cities as indicated in Table 1.

Table 1. The Evaluation Dimensions of Digital Health Governance in Smart Cities

Dimension	Indicators
Governance Design	Role clarity, decentralization, inter-agency coordination
Legal Infrastructure	Data protection, enforcement mechanisms, platform regulations
Technological Capacity	Interoperability, AI integration, infrastructure readiness
Institutional Participation	Public-private collaboration, local authority engagement
Citizen Inclusion	Feedback systems, digital literacy, co-design mechanisms
Sustainability Orientation	Long-term planning, equity focus, funding resilience

Note. Arranged by the author.

This framework is used to compare the metropolitan and mid-sized cities in Türkiye (i.e., Istanbul, Ankara, Eskişehir, and Konya) to their counterparts in the world (i.e., Barcelona, Toronto, Seoul, and Singapore) in a systematic manner.

2.6. Methodological Mapping of the Literature

The literature demonstrates methodological diversity, but it also reveals a certain imbalance. Qualitative case studies are widespread, with a strong focus on stakeholder and institutional analyses (Akinci et al., 2012; Brambilla et al., 2023). Examples include São Paulo's community health councils (Bellei et al., 2025) and Manila's barangay-level e-health projects, where citizen participation plays a central role (Evio & Bonito, 2024). Quantitative efficiency studies are also prominent, particularly in Türkiye, where techniques such as Data Envelopment Analysis (DEA) and the Malmquist index are widely applied (Sulku, 2012; Pehlivan & Yiğit, 2022). In China, Ji et al. (2024) relied on national survey

data to examine digital health literacy and adoption patterns, while Gandhi and Soundappan (2024) assessed citizen trust in India's health platforms, offering rare user-level evidence from developing contexts. A further body of work consists of policy analyses, in which reports and strategies prepared by international organizations such as the WHO and OECD, as well as national governments, provide the dominant reference points for understanding governance frameworks (OECD, 2020; WHO, 2021a). The literature remains dominated by normative frameworks and policy analysis despite these contributions. Empirical user experience, adoption rates, and outcome data are limited, particularly in Africa, Asia, and Latin America.

2.7. Synthesis and Emerging Gaps

The review highlights several important insights that shape the current state of research on sustainable public administration and digital health governance. First, the literature remains heavily concentrated in certain areas. Much of the work relies on normative policy frameworks developed by organizations such as the WHO, OECD, and the European Union, and there is a strong emphasis on conceptual governance theories, including sustainable public administration, network governance, adaptive governance, and platform governance. In addition, efficiency-oriented quantitative studies have grown significantly, particularly in high-income countries and in selected middle-income settings.

At the same time, important limitations are evident. The evaluation of how normative frameworks are implemented and what outcomes they produce remains weak. A notable Eurocentric bias also characterizes studies of network and participatory governance, which are rarely tested in resource-constrained contexts (Bakibinga et al., 2020). Empirical research that captures user perspectives, adoption metrics, and health outcomes is scarce, with only a few studies, such as Ji et al. (2024) and Gandhi and Soundappan (2024), providing such evidence. Furthermore, there are very few mixed-method studies that integrate efficiency analysis with considerations of inclusivity and equity.

This chapter is designed to address these gaps. It undertakes a systematic comparative analysis of eight cities, focusing on Istanbul, Ankara, Eskişehir, and Konya in Türkiye, and contrasting them with Barcelona, Toronto, Seoul, and Singapore. It applies a multi-dimensional analytical framework that considers governance design, legal infrastructure, technological capacity, institutional participation, citizen inclusion, and sustainability orientation. In doing so, it bridges normative and empirical strands of the literature by examining both policy frameworks and their practical governance outcomes. It also expands the geographical scope of analysis beyond Euro-American contexts by including

mid-sized Turkish cities, thereby testing the adaptability of global models in emerging settings.

The contribution of this study is therefore to reposition digital health governance research in smart cities from a predominantly normative and descriptive domain toward a more empirically grounded, critically comparative, and globally inclusive scholarship. By systematically contrasting Turkish and international cases, it advances both theoretical understanding and policy practice in the field of sustainable digital health governance.

3. Methodology

3.1. Research Design

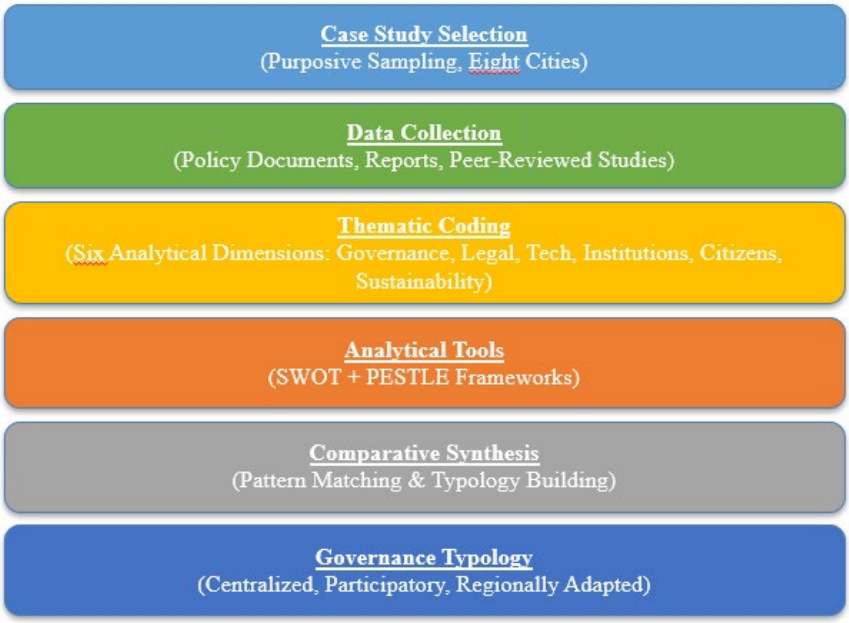
This chapter employs a comparative, qualitative, multi-method research design integrating case study methodology, document analysis, and strategic policy evaluation tools. This design was selected to capture the institutional, legal, and administrative complexity of digital health governance in urban contexts. Given that smart city health systems are multi-actor and multi-level, embedded in evolving policy and regulatory environments, single-method approaches would be insufficient.

The decision to adopt a qualitative comparative design is supported by the literature on public administration. Yin (2018) emphasizes that case study methodology is appropriate when studying phenomena embedded in real-life institutional settings. Comparative analysis, as Peters (2013) argues, enables researchers to evaluate how different governance structures, resource conditions, and legal frameworks shape outcomes. Pierre (2011) further frames this within the concepts of vertical learning (how national policy translates into local practice) and horizontal learning (how practices travel across cities and countries).

Alternative methods such as large-scale statistical analysis or survey research were considered but rejected. First, cross-city survey data on digital health governance are not consistently available, and performance metrics differ substantially between contexts. Second, while quantitative approaches (e.g., DEA, regression models) are valuable for measuring efficiency, they cannot fully capture the institutional, legal, and cultural dynamics of governance. Thus, the chosen qualitative comparative design provides the depth and contextual sensitivity required, while still allowing for cross-case comparability.

The following diagram in Figure 1 highlights the iterative and structured nature of the research design.

Figure 1. Methodology Flow Diagram



3.2. Case Study Selection Rationale

Eight cities were selected through purposive sampling, based on three guiding criteria: the maturity of their digital health governance, the diversity of their administrative and political systems, and their geographical and economic representation.

Türkiye: Istanbul, as the country's largest metropolitan and hub of digital health innovation (e.g., e-Nabız); Ankara, as the national capital where top-down coordination dominates; and the mid-sized cities of Eskişehir and Konya, which represent adaptive and scalable models of smart city governance (Pehlivan & Yiğit, 2022).

Global cases: Barcelona, a pioneer of participatory and open-source digital governance; Toronto, an equity-focused, data-driven leader; Seoul, a centralized AI-driven public health model; and Singapore, a globally recognized integrated Smart Nation approach.

The combination of metropolitan, mid-sized, centralized, and participatory models provides contrasts that allow the testing of governance archetypes and the identification of replicable practices.

3.3. Data Sources

The study draws exclusively on secondary data, prioritizing credible and up-to-date sources. These include policy and strategy documents such as national and municipal smart city strategies, health transformation plans, legal frameworks; academic and peer-reviewed studies on public administration, smart cities, and health systems; international organization reports from the WHO, OECD, UN-Habitat, World Bank, EU. Additionally, grey literature and think tank briefs, as well as digital health dashboards (e.g., WHO Digital Health Atlas, International Institute for Management Development [IMD] (2024) Smart City Index) were utilized. Materials published after 2018 were prioritized to reflect post-COVID-19 transformations.

3.4. Document Analysis Framework

Thematic analysis was applied to systematically code the documents across six dimensions. To ensure clarity and comparability, the coding categories and indicators are presented in Table 2.

Table 2. Coding Framework for Document Analysis

Dimension	Indicators / Examples
Governance & Institutional	Role clarity, decentralization, inter-agency coordination, administrative mandates
Policy & Legal Coherence	Consistency of digital, health, and urban policies; GDPR alignment; enforcement capacity
Technological Preparedness	ICT infrastructure, interoperability, platform maturity, AI readiness
Citizen Engagement	Participatory platforms, digital literacy programs, equity of access
Data Governance	Data protection laws, algorithmic transparency, AI ethics, accountability mechanisms
Sustainability Orientation	Resource allocation, contingency planning, environmental-health linkages

All documents were systematically coded to allow for pattern-matching across diverse governance contexts.

3.5. Analytical Tools

The Strengths, Weaknesses, Opportunities, Threats (SWOT) and Political, Economic, Social, Technological, Legal, and Environmental (PESTLE) frameworks were jointly applied to support the analysis of the documents, and to complement thematic coding. The results are summarized below.

Table 3. SWOT Analysis Summary

Strengths	Weaknesses
Strong ICT infrastructure	Fragmented governance structures
Institutional leadership in health reform	Persistent digital inequality
Expanding digital health platforms (e.g., e-Nabız)	Limited municipal capacity in some contexts
Opportunities	**Threats**
Integration of AI into health systems	Cybersecurity risks
Regional and international partnerships	Delays in regulation and legal adaptation
Smart city innovation funding opportunities	Overdependence on pilot projects without scaling

Table 4. PESTLE Analysis Summary

Factor	Key Elements
Political	Mayoral leadership, degree of decentralization, central–local coordination
Economic	Budget allocation, economic resilience, health system financing
Social	Health equity, digital literacy, citizen trust
Technological	Platform integration, device penetration, AI applications
Legal	Data privacy law (e.g., GDPR/Law No. 6698), procurement transparency, enforcement
Environmental	Integration of health–environment data, sustainable infrastructure planning

Table 3 and Table 4 are systematic representations of the internal and external forces shaping digital health governance.

3.6. Comparative Synthesis Approach

It synthesized it by pattern matching logic to calculate similarities in policy tools, contextual differences, and innovations that can be replicated. The typology of three kinds of models of digital health governance (centralized, participatory, and regionally adapted) presented in Section 2 on literature review is informed by these findings.

3.7. Limitations

Despite the use of a comprehensive multi-method framework, there are still several limitations in this study. A key bias of data availability is the poor quality and accessibility of documents in cities and languages. While cities such as Singapore and Toronto provide extensive policy documentation and publicly accessible datasets, medium-sized cities such as Konya and Eskişehir have far fewer available sources, which creates the risk of producing analyses with uneven depth. The methodological parameters also shape the results in significant ways. The criteria used for city selection (size, economic level, and administrative structure) ensure diversity, yet they also create asymmetry because metropolitan hubs like Istanbul or Seoul naturally generate richer datasets than mid-sized urban contexts. The analytical dimensions, which include governance, legal frameworks, technological capacity, citizen participation, data governance, and sustainability, broaden the scope of the analysis and capture multiple layers of urban health governance. However, they require cross-referencing heterogeneous indicators that are not equally available in all cases, which limits comparability. Likewise, the analytical tools, particularly SWOT, PESTLE, and pattern-matching, provide a structured basis for strategic policy assessment but remain partly interpretive and therefore subject to researcher bias. While these frameworks are valuable for examining strategic orientations, their qualitative nature constrains the generalizability of the conclusions. These issues were addressed through triangulation, taking multiple sources on each city and using standardized coding schemes, however, they are also significant limitations that shape the way the findings are interpreted.

3.8. Ethical Considerations

No personal or sensitive information was gathered and the data used in the study were publicly available. The ethical considerations were undertaken through appropriate attribution of all sources, context-sensitive interpretation without overgeneralization, and careful handling of governance- and platform-related information. The components of the comparative case study design, document analysis, and strategic evaluation instruments are integrated into a

methodological framework to examine urban digital health governance. The study is premised on the well-documented experience of diverse cities and a structured analytical lens, which can be used to establish a robust basis from which policy lessons can be drawn and evidence-based innovation through sustainable urban health systems can be spurred.

4. Findings

In this section, comparative case studies are provided to examine the implementation of digital governance in urban health systems in selected cities. Eight cities were analyzed based on the theoretical and methodological framework described in the preceding sections, of which four are in Türkiye (Istanbul, Ankara, Eskişehir, Konya) and four international counterparts (Barcelona, Toronto, Seoul, Singapore). These cities are distinct examples of health governance, political systems, socio-economic background, and degree of technological development. This section aims to demonstrate how the digital principles of governance can be concretely applied to urban health and to focus on the conditions that enable it, the general patterns, and the contextual variations. Detailed characteristics of each case are summarized in Table 5. Comparative analyses in this context are not merely descriptive but analytical, seeking to uncover which elements foster long-term adaptability and health equity.

4.1. City Case Summaries

Istanbul demonstrates centralized governance under national direction, with strong ICT infrastructure and emerging telehealth initiatives. Ankara reflects dual-tier coordination, piloting AI-based diagnostics and establishing digital dashboards during the pandemic. Eskişehir illustrates mid-sized responsiveness with small-scale but effective monitoring systems and wearable validation studies. Konya integrates technological platforms with local ethical protocols, emphasizing community-aligned digital engagement. Barcelona advances participatory governance through open data, citizen laboratories, and co-design platforms. Toronto emphasizes equity, Indigenous data sovereignty, and mobile-first services tailored to vulnerable populations. Seoul applies a centralized AI-driven model with advanced symptom detection and 5G-enabled mobile clinics. Singapore adopts an integrated Smart Nation framework, combining predictive analytics, wearables, and sustainable infrastructure. The descriptive findings of the eight cities are summarized in Table 5, which highlights the institutional, technological, and legal characteristics of each case.

Table 5. Descriptive Findings of Eight Case Study Cities

City	Governance Design	Legal Infrastructure	Technological Capacity	Institutional Participation	Citizen Inclusion	Sustainability Orientation
Istanbul	Centralized, national-led	Law No. 6698 compliance, pilot AI ethics boards	5G pilots, AI routing, e-prescriptions	Universities, hospitals, telecoms, startups	Limited, via e-Nabız & IMM portal	Smart Hospital retrofitting of energy-efficient buildings
Ankara	Dual-tier (MoH + AMM)	Encrypted ID-based secure access	AI diagnostics, COVID dashboards, linked databases	Health directorates, council, emergency services	Telehealth (Ankara Univ.), technician programs	Data interoperability and reuse focus
Eskişehir	Decentralized within national policy	National framework alignment, limited local stewardship	Home e-health monitoring, e-clinics, SMS alerts	Anadolu University device validation, research support	Limited formal platforms	Underdeveloped sustainability practices
Konya	Strong mayoral leadership	Local AI ethics & data storage protocols + Law No. 6698	Smart diagnostics, clinic mobilization	Municipal leadership, clinics	Culturally aligned citizen engagement	Integration of cultural/ethical norms with technology
Barcelona	Decentralized participatory	GDPR + local AI ethics charter	IoT monitoring (air, noise), behavioral nudges	Universities, citizen labs	Co-design (Decidim), transparency portals	Linking health with environmental planning
Toronto	Centralized health + local hubs	Charter of Rights, Digital Equity Policy, Indigenous data sovereignty	AI triage, prescription pickup for homeless	Cross-agency task forces	Mobile-first co-design with migrants	Broadband expansion, green hosting infrastructure
Seoul	Centralized, top-down	Cybersecurity laws, personal data regime	AI symptom detection in metro, 5G mobile clinics	Samsung Medical Center + universities	Limited direct involvement	Green hospitals, low-energy infrastructure
Singapore	National integration via Smart Nation	Personal Data Protection Act, HealthTech oversight	Predictive analytics, nationwide wearables	Government–hospital–tech collaborations	Mobile apps with feedback	Cloud-based e-health, solar-powered facilities

4.2. Cross-Case Comparative Synthesis

The comparative analysis of the eight cities shows that they can be broadly categorized into three governance models. Centralized approaches are most evident in Seoul, Singapore, and Ankara, while participatory models are represented by Barcelona, Toronto, and, to some extent, Konya. Hybrid models that combine elements of both centralized and participatory governance can be observed in Eskişehir, Konya, and Istanbul.

Despite these differences, several common barriers emerge across the cases. Digital exclusion remains a persistent challenge, particularly among elderly populations and in rural areas. Data silos continue to limit interoperability, making it difficult for different platforms and agencies to share information effectively. Municipal regulatory capacity is often unequal, with larger cities better equipped than mid-sized ones to enforce governance standards. Legal frameworks generally lag behind the rapid pace of technological deployment, creating gaps in accountability and oversight. Furthermore, many initiatives rely heavily on short-term pilot projects rather than being systematically integrated into long-term governance structures (WHO, 2018; Kopac & Das, 2025).

5. Discussion

This section interprets the descriptive findings by connecting them with existing literature, highlighting points of convergence and divergence, and drawing policy implications. The goal is to answer the central research question: how sustainable and innovative are digital health governance models in smart cities, and which approaches provide comparative advantages?

5.1. Digital Inequality

Across the examined cases, advanced infrastructures coexist with persistent forms of digital exclusion that disproportionately affect elderly populations, low-income groups, and migrant communities. The literature frames this issue as multidimensional: van Dijk (2020) emphasizes that the digital divide encompasses not only access but also skills and patterns of usage, while Hollimon et al. (2025) suggest that inclusive design strategies can mitigate these inequities. However, the case studies demonstrate that even in contexts with highly developed platforms, such as Toronto and Singapore, design and literacy barriers remain significant. This evidence therefore complicates the optimism presented in the literature by showing that structural inequalities continue to endure despite considerable policy attention. The findings indicate that digital health governance has not yet succeeded in fully embedding user-centered design

principles into practice, and they suggest that genuine equity requires more than infrastructural investment alone. From a policy perspective, sustainable governance must integrate infrastructure development with community-based literacy programs, multilingual platforms, and affordability mechanisms in order to address these enduring inequalities effectively.

5.2. Data Governance

Although legal frameworks such as the GDPR and Türkiye's Law No. 6698 provide regulatory structures for data protection, their enforcement remains inconsistent and interoperability across systems continues to be weak. The literature frequently identifies GDPR as a benchmark of effective regulation, with Gürsoy (2015) and Custers et al. (2019) emphasizing its role in shaping global standards. Yet the case studies demonstrate that formal alignment with such frameworks does not necessarily translate into functional capacity at the municipal level. Ramirez-Rubio et al. (2019) have proposed blockchain-based models of citizen control, exemplified by Barcelona's DECODE project (European Commission, 2019), as a means of overcoming these challenges. However, the complexity of institutions and limited implementation readiness have discouraged the widespread application of such innovations. The evidence thus indicates a persistent gap between the regulatory ideal and the actual practice of enforcement. The issue of interoperability and local institutional capacity emerges as a decisive factor, which is not always considered in more optimistic accounts. This is why good governance should entail both the creation of lawful frameworks and long-term investment in municipal data management capability and the creation of robust standards of interoperability.

5.3. Regulatory and Legal Lag

The complexity of institutional structures and limited preparedness have discouraged the widespread application of such innovations. The evidence therefore indicates a persistent discrepancy between the regulatory ideals emphasized in the literature and the realities of practical enforcement. Interoperability and local institutional capacity emerge as decisive factors that are often overlooked in the optimistic assessments of scholars. Consequently, good governance should entail not only the establishment of robust legal frameworks but also long-term investment in municipal data management capacity and the development of strong interoperability standards.

5.4. Institutional Coordination

Fragmentation across sectors such as health, housing, transport, and the environment continues to undermine effective integration in urban governance. The literature emphasizes that cross-sectoral coordination is essential for the functioning of smart cities, with Trencher and Karvonen (2017) highlighting the importance of governance models that bridge institutional boundaries. However, the findings reveal that siloed structures persist even in technologically advanced cities such as Seoul, contradicting the theoretical expectation that smart city models naturally foster integration. This mismatch between the ideal of integrated governance and actual practice demonstrates the difficulty of translating conceptual frameworks into operational reality. Institutionalized coordination mechanisms, including joint task forces, pooled budgets, and shared data platforms, are necessary to move from fragmented governance toward genuinely integrated urban management.

5.5. Sustainability: Environmental and Institutional Dimensions

Many digital health initiatives remain confined to pilot projects, and both funding mechanisms and environmental sustainability considerations are rarely embedded into long-term planning. The literature reflects similar concerns: Jones et al. (2017) critiques the considerable energy footprint of digital infrastructures, while the WHO (2022c) stresses the importance of sustainable scaling strategies. This study confirms these arguments but also shows that mid-sized cities are vulnerable to specific risks of discontinuity, which are not adequately tackled in the current research. This viewpoint emphasizes that sustainability challenges are not only environmental but also institutional, involving budgeting, resource continuity, and governance stability. Long-term sustainability thus not only involves the alignment of digital health policies and climate strategies, but it should also be accompanied by the creation of a stable stream of funding that will ensure continuity even after pilot stages.

5.6. Ethics and Trust

There is a considerable risk of bias in artificial intelligence systems in healthcare, and the usage of personal data without any meaningful consent deteriorates public trust. These issues are well-documented in the literature: Obermeyer et al. (2019) describe bias in AI-based health tools in an empirical manner, and Zuboff (2019) frames surveillance capitalism as a systematic threat to individual rights. The results of this study confirm these views but also show

that the acceptance of digital surveillance by the population does not have a uniform pattern. As an illustration, the reaction to the implementation of Singapore TraceTogether data practices is indicative of how even technologically developed societies may resist the misuse of data by the governing authority (Schaefer & Ballantyne, 2022). This implies that the validity of digital surveillance is extremely contingent. This research thus builds on the current literature by demonstrating that ethical risks cannot be managed using the same frameworks and should be adapted according to local norms and expectations.

5.7. Participation

Feedback mechanisms are the typical way to participate in digital health governance, but there is scarcely any actual co-design. The literature shows the need to engage more profoundly, with Bastos et al. (2022) pointing out that deliberative trust is built during the process of dialogue and not through one-way information campaigns. This gap is supported by the case studies, which show that participation is often procedural instead of substantive governance. In addition, although a significant part of the literature presupposes that participatory models reliably generate trust, the results indicate that this effect depends on the existence of civic literacy and robust institutional capacity. Participation in this sense comes out as a weak and conditional construction as opposed to the theoretical models that suggest otherwise. Digital health governance should not be limited to simple feedback loops to achieve long-term legitimacy, but instead, institutionalize co-design processes that enable citizens to have a substantive role in service shaping.

5.8. Cross-Model Insights and Comparative Sustainability

The comparative analysis reveals that various types of governance models have distinct benefits and drawbacks. Scalability and speed are the defining features of centralized solutions as seen in Seoul, Singapore, and Ankara, but these models often struggle to sustain inclusivity. Participatory models, such as those in Barcelona, Toronto, and to a degree Konya, achieve trust and legitimacy but are slower-moving because consensus needs to be facilitated. The hybrid models like those in Eskişehir, Konya, and Istanbul show flexibility and cultural fit, although their results are unequal. The literature presents some vital points of comparison: Jacobs and Kaufmann (2021) discuss how deliberative models can be used to promote greater levels of trust, and Ahmed et al. (2025) demonstrate that centralized models are superior in terms of responding to a crisis. The findings of this study confirm both perspectives but add further nuance by highlighting the role of mid-sized cities as agile laboratories for innovation, a

dimension that has been underexplored in the literature.

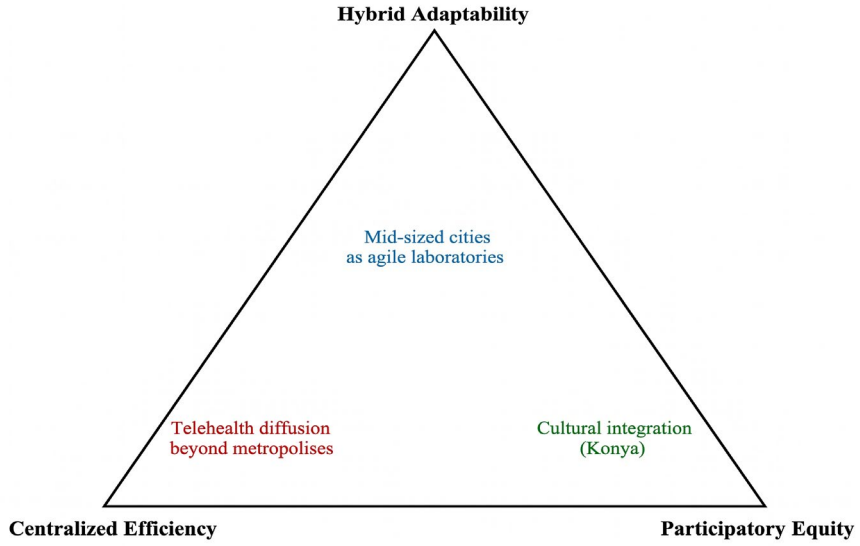
In terms of long-term sustainability, participatory and hybrid models appear more advantageous because they embed legitimacy and adaptability within governance systems. Centralized models are highly effective in achieving short-term efficiency, but without corrective measures they risk eroding inclusivity over time. A resilient governance design must therefore balance the efficiency of centralized systems with the legitimacy derived from participatory approaches, while also leveraging mid-sized cities as scalable test-beds for experimentation and adaptation. Table 6 summarizes the evidence-based findings, with risks presented as theoretical concerns in cases where direct data remain limited rather than empirically confirmed patterns.

Table 6. Governance Models in Digital Health

Governance Model	Strengths	Risks / Limitations	Surprising & Innovative Findings	Policy Implications
Centralized (Seoul, Singapore, Ankara)	Scalability, standardization, crisis readiness	Limited inclusion, local needs overlooked	Effective in emergencies	Balance efficiency with local adaptation
Participatory (Barcelona, Toronto, Konya partly)	Trust, equity, co-design	Slower adoption, requires civic capacity	Konya's cultural integration	Institutionalize co-design to secure long-term trust
Hybrid (Eskişehir, Konya, Istanbul)	Flexibility, experimentation, scalable pilots	Uneven local capacity, weak authority	Mid-sized cities as agile labs; telehealth diffusion	Empower mid-sized cities as test-beds

Figure 2 provides a conceptual synthesis of governance models and integrates the key insights building on the descriptive results in Table 6: the role of mid-sized cities as agile laboratories, the embedding of cultural traditions in Konya, and the diffusion of telehealth services beyond metropolitan contexts.

Figure 2. Conceptual Model of Digital Health Governance



The triangular model illustrates three archetypes of governance: centralized efficiency, participatory equity, and hybrid adaptability. Centralized models (e.g., Seoul, Singapore, Ankara) emphasize scalability and rapid crisis response, participatory models (e.g., Barcelona, Toronto, Konya) stress equity and citizen engagement, while hybrid models (e.g., Eskişehir, Istanbul, Konya) combine national frameworks with local experimentation. The diagram also highlights salient findings: the role of mid-sized cities as agile laboratories of innovation, cultural integration in Konya as a driver of sustainability, and the diffusion of telehealth beyond metropolitan centers.

5.9. Study Limitations

This research relies on secondary sources and uneven data availability across cities. Local reports vary in consistency; some contexts (e.g., mid-sized Turkish cities) provide less data than global benchmarks. Language barriers and reliance on translations may also affect nuance. These limitations mean that findings are indicative, not universally generalizable. They point out patterns and risks, but not causal relationships.

6. Conclusion

6.1. Synthesis of Key Findings

This chapter has discussed the accessibility, efficiency, and sustainability of healthcare systems within smart cities based on digital governance arrangements. Eight cities were analyzed comparatively and revealed strengths and weaknesses in their centralized, participatory, and hybrid systems of governance. This chapter aims to emphasize sustainability, inclusiveness, and efficiency of digital health governance and to provide policy recommendations to guide Türkiye. These findings are most significant when applied to the broader literature. Continued digital inequality is akin to van Dijk (2020), as infrastructural disparities strengthen social disparities, and the inability to control health data aligns with the arguments of Zuboff (2019) against surveillance-based digital systems. Nevertheless, the results in the Turkish context reveal that inadequate municipal capacity and fragmented institutional authority are even more salient than the ethical or algorithmic discourse, which is prevailing in high-income settings (Obermeyer et al., 2019; Hollimon et al., 2025). Experiences in Barcelona and Toronto show that citizen inclusion enhances trust and legitimacy (Kickbusch & Gleicher, 2012), but also suggest a slower implementation process, suggesting that it may be difficult to scale to fast-moving urban settings. Similarly, in Turkish metropolitan areas, the development of infrastructure through public-private partnerships has improved infrastructure availability, yet research indicates that such arrangements do not necessarily achieve equitable access, as has been previously argued regarding performance-based hospital reforms (Sulku, 2012; Gökkaya & Erdem, 2021). The results indicate that sustainable digital health governance is not merely a technology deployment issue but involves responsive institutional structures, legal enforcement, as well as inclusive participation processes.

6.2. Türkiye Policy Recommendations

It is on this basis that three interrelated priorities can be used to reinforce digital health governance in Türkiye.

6.2.1. Local Digital Capacity Development

Telehealth, teledentistry, and remote diagnostics at the municipal level can reduce unnecessary visits to hospitals and enhance access to peri-urban and rural areas. The experience of Konya and Eskişehir indicates that the implementation of such practices is not only possible but also requires retraining the workforce (Abaklı İnci et al., 2022; Celik et al., 2021; Ekinci, 2022).

6.2.2. Health Data Management and Interoperability

City-level health analytics units, developed in partnership with universities, could enhance real-time monitoring. Stronger enforcement of existing data protection laws remains essential, as inconsistent application undermines trust. The experience of Toronto, where privacy-by-design measures encouraged portal use, illustrates the value of robust data governance.

6.2.3. Equity in Digital Healthcare Access

Digital health policies should prioritize inclusion by supporting subsidies for vulnerable groups and investing in digital literacy programs run jointly with Non-Government Organizations (NGOs), libraries, and municipal health agencies. International experiences such as Barcelona's tablet distribution program and Singapore's staged roll-outs highlight possible approaches, though their adaptation to Türkiye would require careful consideration of local contexts (Ertem et al., 2021; Hernández Encuentra et al., 2025).

6.3. International Cooperation and Technology Transfer

International partnerships can complement domestic reforms by providing access to tested solutions and reducing development costs. Licensing or co-developing AI-based triage systems and blockchain-enabled health records, as trialed in European and North American cities, may be more cost-effective than developing systems entirely in-house (Albiol-Perarnau & Alarcón Belmonte, 2024; Grabke et al., 2025). Pilot test-bed environments in mid-sized cities such as Eskişehir or Konya could allow adaptation of global models like Seoul's 5G-based ambulance networks under controlled conditions (Choi et al., 2023). Academic cooperation agreements could also strengthen Türkiye's research base, provided they are designed as equal partnerships rather than one-way knowledge transfers.

6.4. Policy Recommendations

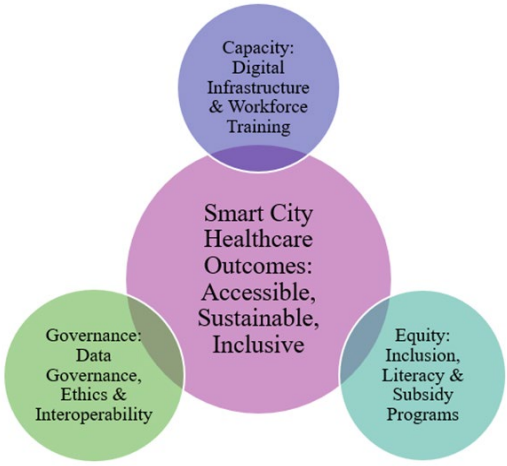
The comparative analysis suggests that sustainable digital health governance is likely to be more effective when it remains context-specific, equity-oriented, and technologically adaptable. For Türkiye, several possible policy directions can be drawn from the findings. The establishment of municipal health informatics units could help strengthen early outbreak detection, drawing on lessons from Seoul's neighborhood surveillance model. Improving the interoperability of electronic health records across institutions appears to be equally important, as illustrated by Toronto's experience, where integration reduced duplication

of diagnostics and supported more efficient use of resources (Digital Health Interoperability Task Force, 2024; World Bank, 2023). Public-private-academic partnerships may provide opportunities to accelerate the deployment of digital health solutions, in a way similar to the innovation accelerator models developed in Barcelona. In addition, the creation of a national digital health ethics charter, aligned with OECD and WHO guidelines, could offer a framework for addressing issues such as data use, artificial intelligence oversight, and citizen consent (OECD, 2023c; WHO, 2021b).

Expanding rural telehealth services through 5G and satellite connectivity represents another area with potential, with Singapore's experience showing how mobile outreach can extend specialist care to underserved populations (Man et al., 2025). Environmental sustainability considerations might also be integrated into health IT infrastructure, with energy-efficient data centers such as those adopted in Barcelona providing useful reference points (Zotova et al., 2025). Regulatory agility is another area of importance, as the ability to adapt rapidly in emergencies, such as the approval of telehealth services during the COVID-19 pandemic in Seoul, can be critical in responding to sudden crises.

In addition, integrating disaster preparedness, non-communicable disease prevention, and migrant and refugee health into digital governance can help ensure that digital tools address broader public health priorities (International Organization for Migration [IOM], 2022; WHO, 2022b). Artificial intelligence can support coordination across preventive, curative, and rehabilitative services, but its adoption should be guided by ethical frameworks and pilot-tested before scaling (European Commission, 2020).

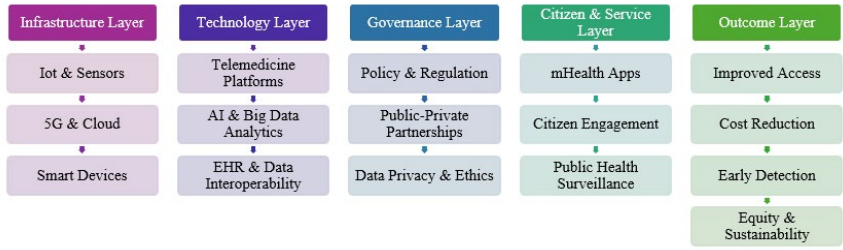
Figure 3. Recommended Framework for the Smart City Healthcare System



The framework in Figure 3 illustrates three interdependent pillars of capacity, equity, and governance that collectively shape the performance of digital health systems in smart cities. Capacity means building digital infrastructure and training local personnel. The focus of equity is inclusive access, digital literacy, and targeted support for vulnerable populations. Governance is concerned with data management, protection, and interoperability of ethics. Collectively, these pillars can enhance the transformative potential of cities towards more accessible, sustainable, and inclusive healthcare outcomes under the right circumstances

Figure 4 provides an example of a potential hierarchical structure for operationalizing smart city healthcare in Türkiye.

Figure 4. Recommended Framework for the Smart City Health Care System: Layered Model



The model focuses on the interaction between infrastructure, technology, governance, and citizen engagement to deliver outcomes like better access, cost-reduction, early-detection, and equity. Within this framework, goals may include enhancing national EHR interoperability, developing AI-enabled prevention systems in primary care, and expanding telehealth coverage in rural districts. Urban health agencies could also experiment with tools such as real-time digital twin simulations or net-zero primary care infrastructures. While aspirational in scope, this layered model is not a prediction but a conceptual guide: its successful implementation would depend on sufficient institutional capacity, sustained investment, and supportive legal and policy environments.

The smart cities can shift healthcare from reactive treatment to proactive wellbeing promotion by aligning governance innovation with technology. The smart cities that succeed will not only heal illness but actively shape healthier, more sustainable urban futures to achieve universal health coverage.

6.5. Future Research Directions

While this chapter has outlined policy recommendations and examples of good practice, further research is still needed to advance understanding of the social, ethical, and environmental dimensions of digital health governance. One priority for future inquiry is digital health literacy in Türkiye. Empirical studies should explore how different groups, including elderly citizens, low-income households, and migrant populations, access and use digital health platforms, and which interventions are most effective in reducing digital exclusion. Another important area concerns the ethical and legal implications of AI-supported healthcare. Ethnographic and case study-based research could provide valuable insight into how citizens and healthcare professionals perceive algorithmic decision-making, consent mechanisms, and liability in AI-driven services.

Environmental sustainability also warrants closer investigation. Comparative studies might assess how digital health infrastructures such as data centers, wearable devices, and telehealth systems align with climate goals and sustainability objectives, and what forms of governance best balance efficiency with environmental responsibility. In addition, more attention should be given to institutional coordination. Longitudinal research would be particularly useful for examining how inter-agency and multi-level governance arrangements evolve over time, especially when comparing the experiences of metropolitan centers and mid-sized Turkish cities. Cross-national learning models also represent a promising avenue for research. Future studies could analyze how knowledge transfer between global smart cities and Turkish municipalities can be made more equitable, shifting the focus from mere technology adoption to co-development and local adaptation.

These research directions would not only fill current gaps but also provide the evidence base for designing smart city digital health governance strategies that are context-sensitive, ethically sound, and environmentally sustainable.

References

Abaklı İnci, M., Korkut, E., Koç, M., & Tüzüner, T. (2022). Retrospective evaluation of the effectiveness of teledentistry approach during COVID-19 in pediatric dentistry: A parental perspective. *Digital Health*, *8*, 20552076221144194. https://doi.org/10.1177/20552076221144194

Ahmed, M. M., Okesanya, O. J., Olaleke, N. O., Adigun, O. A., Adebayo, U. O., Oso, T. A., Eshun, G., & Lucero-Prisno, D. E., III. (2025). Integrating digital health innovations to achieve universal health coverage: Promoting health outcomes and quality through global public health equity. *Healthcare, 13*(9), Article 1060. https://doi.org/10.3390/healthcare13091060

Akinci, F., Mollahaliloğlu, S., Gürsöz, H., & Öğücü, F. (2012). Assessment of the Turkish health care system reforms: A stakeholder analysis. *Health Policy, 107*(1), 21–30. https://doi.org/10.1016/j.healthpol.2012.05.002

Albiol-Perarnau, M., & Alarcón Belmonte, I. (2024). Blockchain en salud: Transformando la seguridad y la gestión de datos clínicos [Blockchain in health: Transforming security and clinical data management]. *Atención Primaria, 56*(5), Article 102848. https://doi.org/10.1016/j.aprim.2023.102848.

Bakibinga, P., Kamande, E., Kisia, L., Omuya, M., Matanda, D. J., & Kyobutungi, C. (2020). Challenges and prospects for implementation of community health volunteers' digital health solutions in Kenya: A qualitative study. *BMC Health Services Research, 20*(1), 888. https://doi.org/10.1186/s12913-020-05711-7

Bastos, D., Fernández-Caballero, A., Pereira, A., & Rocha, N. P. (2022). Smart city applications to promote citizen participation in city management and governance: A systematic review. *Informatics, 9*(4), 89. https://doi.org/10.3390/informatics9040089

Bayar, D. Y., Guven, H., Badem, H., & Soylu Sengor, E. (2020). National smart cities strategy and action plan: The Türkiye's smart cities approach. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 44*, 129–135. https://doi.org/10.5194/isprs-archives-XLIV-4-W3-2020-129-2020

Bellei, E. A., Moretto, C. F., Freitas, C. M. D. S., & De Marchi, A. C. B. (2025, September). A survey on digital solutions for health services management: Features and use cases from Brazilian national literature. *Healthcare 13*(18), 2348. https://doi.org/10.3390/healthcare13182348

Bello-Gomez, R. A., & Sanabria-Pulido, P. (2021). The costs and benefits of duality: Colombia's decentralization and the response to the COVID-19 pandemic. *Revista de Administração Pública, 55*, 165–179. https://doi.org/10.1590/0034-761220200567

Brambilla, A., Ergur, L., & Capolongo, S. (2023). Application of an evaluation tool for mega-hospital site sustainability. Assessment of public private partnership large sized healthcare infrastructures in European context. *Acta Bio-medica: Atenei Parmensis, 94*(S3), e2023156. https://doi.org/10.23750/abm.v94is3.14281

Choi, S., Li, X., Yoo, J., & Hwang, H. (2023). 5G based autonomous vehicle issue analysis: Text mining South Korean news data. In *Future of information and communication conference* (pp. 619–629). Springer Nature. https://doi.org/10.1007/978-3-031-28076-4_45

Cole, H. V. S., & Franzosa, E. (2022). Advancing urban health equity in the United States in an age of health care gentrification: A framework and research agenda. *International Journal for Equity in Health, 21*, Article 66. https://doi.org/10.1186/s12939-022-01669-6

Cuadros, D. F., Kiragga, A., Tu, L., Awad, S., Bwanika, J. M., & Musuka, G. (2025). Unpacking social and digital determinants of health in Africa: A narrative review on challenges and opportunities. *mHealth*, *11*, 41. https://doi.org/10.21037/mhealth-24-73

Custers, B., Sears, A. M., Dechesne, F., Georgieva, I., Tani, T., & van der Hof, S. (2019). *EU personal data protection in policy and practice.* T.M.C. Asser Press. https://doi.org/10.1007/978-94-6265-282-8

Celik, N. D., Kumcu, M. K., Aydemir, S. T., & Özkan, S. (2021). Patient communication and consultation experience with telemedicine in patients with movement disorders in COVID-19 pandemic: İts usability, benefits and problems. *Turkish Journal of Neurology, 27*, 9–14. https://doi.org/10.4274/tnd.2021.69851

Digital Health Interoperability Task Force. (2024). *Digital health interoperability task force report*. Canadian Medical Association; Canada Health Infoway; College of Family Physicians of Canada; Royal College of Physicians and Surgeons of Canada. https://policybase.cma.ca/media/PolicyPDF/PD25-06.pdf

Ekinci, B. (2022). Uzaktan sağlık hizmeti sunumu (Tele Tıp) projesi [Remote Health Service Delivery (Telemedicine) Project]. *Türkiye Health Literacy Journal, 3*(2), 122–124. https://doi.org/10.54247/SOYD.2022.53

Ertem, A., Güzel, A., & Zekioğlu, A. (2021). Evaluation of health literacy levels in adults: The case of Ankara province. *Journal of Pharmaceutical Research International, 33*(56A), 165–173. https://doi.org/10.9734/JPRI/2021/v33i56A33899

European Commission. (2019). *Decentralised citizens owned data ecosystem* (Project ID: 732546). CORDIS. https://cordis.europa.eu/project/id/732546

European Commission. (2020). *Handbook of sustainable urban development strategies*. https://territorial.ec.europa.eu/sustainable-development/strategies/handbook-sud/governance

European Commission. (2023a). *Human development and ageing*.https://research-and-innovation.ec.europa.eu/research-area/health/human-development-and-ageing_en

European Union. (2016). Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). *Official Journal of the European Union,* L 119, 1–88. https://eur-lex.europa.eu/eli/reg/2016/679/oj/eng

Evio, B. D., & Bonito, S. R. (2024). Formative evaluation of the implementation of eHealth in the Philippines: A qualitative study. *Acta Medica Philippina, 58*(12), 35–47. https://doi.org/10.47895/amp.v58i12.9289

Gandhi, A. P., & Soundappan, K. (2024). Perception towards electronic health records & uptake of digital health IDs among the urban residents in northern India: A mixed methods study. *The Indian Journal of Medical Research, 160*(1), 51–60. https://doi.org/10.25259/ijmr_664_23

Ghosh, A., Saini, A., & Barad, H. (2025). Transforming healthcare in India: The role of artificial ıntelligence and regulatory frameworks for sustainable growth. *World Medical & Health Policy, 17*, 475–490. https://doi.org/10.1002/wmh3.70015

Gökkaya, D., & Erdem, R. (2021). Türkiye'de kamu özel ortaklığı bağlamında şehir hastanelerinin değerlendirilmesi: Nitel bir araştırma [Evaluation of city hospitals in the context of public private partnership in Turkey: A qualitative research]. *Uluslararası İktisadi ve İdari İncelemeler Dergisi, (31),* 73–96. https://doi.org/10.18092/ULIKIDINCE.771797

Grabke, E. P., Heming, C. A. M., Hadari, A., Finelli, A., Ghai, S., Lajkosz, K., Taati, B., & Haider, M. A. (2025). Using AI to triage patients without clinically significant prostate cancer using biparametric MRI and PSA. *Abdominal Radiology, 50*, 5924–5933. https://doi.org/10.1007/s00261-025-05019-2

Gürsoy, K. (2015). An overview of the Turkish healthcare system after the Health Transformation Program: Main successes, performance assessment, further challenges, and policy options. *Sosyal Güvence*, *(7)*, 83–112. https://izlik.org/JA63BG28RN

Hernández Encuentra, E., González Caballero, J. L., Montagni, I., Fernández Gutiérrez, M., & Bas Sarmiento, P. (2025). Digital health literacy among the Spanish population: A descriptive and latent class analysis study. *European Journal of Public Health*, *35*(4), 617–623. https://doi.org/10.1093/eurpub/ckaf016

Hollimon, L. A., Taylor, K. V., Fiegenbaum, R., Carrasco, M., Garchitorena Gomez, L., Chung, D., & Seixas, A. A. (2025). Redefining and solving the digital divide and exclusion to improve healthcare: Going beyond access to include availability, adequacy, acceptability, and affordability. *Frontiers in Digital Health, 7*, Article 1508686. https://doi.org/10.3389/fdgth.2025.1508686

Huisman, L., van Duijn, S. M. C., Silva, N., van Doeveren, R., Michuki, J., Kuria, M., Otieno Okeyo, D., Okoth, I., Houben, N., Rinke de Wit, T. F., & Rogo, K. (2022). A digital mobile health platform increasing efficiency and transparency towards universal health coverage in low-and middle-income countries. *Digital Health, 8*, 20552076221092213. https://doi.org/10.1177/20552076221092213

International Institute for Management Development. (2024). *Smart city index rankings*. IMD Smart City Observatory. https://www.imd.org/smart-city-observatory/home/rankings/

International Organization for Migration. (2022). *Migration health 2021 impact overview*. IOM. https://www.iom.int/resources/migration-health-2021-impact-overview

Jacobs, D., & Kaufmann, W. (2021) The right kind of participation? The effect of a deliberative mini-public on the perceived legitimacy of public decision-making. *Public Management Review, 23*(1), 91–111. https://doi.org/10.1080/14719037.2019.1668468

Ji, H., Dong, J., Pan, W., & Yu, Y. (2024). Associations between digital literacy, health literacy, and digital health behaviors among rural residents: Evidence from Zhejiang, China. *International Journal for Equity in Health, 23*(1), 68. https://doi.org/10.1186/s12939-024-02150-2

Jones, P., Hillier, D., & Comfort, D. (2017). The sustainable development goals and the financial services industry. *Athens Journal of Business and Economics, 3*(1), 37–50. https://doi.org/10.30958/ajbe.3.1.3

Kenpahoom, S., Chinsan, A., Bunjongparu, P., & Wiwithkhunakorn, S. (2024). New public governance (NPG): Contemporary paradigm in public administration. *Journal of Political Science Mahamakut Buddhist University, 4*(1). https://so02.tci-thaijo.org/index.php/jpsmbu/article/view/266833

Kickbusch, I., & Gleicher, D. (2012). *Governance for health in the 21st century*. World Health Organization, Regional Office for Europe. https://iris.who.int/handle/10665/326429

Kitchin, R., Cardullo, P., & Di Feliciantonio, C. (2019). *The right to the smart city*. Emerald Publishing Limited.

Kopac, L., & Das, S. (2025). Pixel by pixel: Constructing smart cities with AI building blocks. In S. R. Mondal, L. Vartiak, & S. Das (Eds.), *Generative AI for a net-zero economy*. Springer. https://doi.org/10.1007/978-981-96-8015-3_11

Law No. 6698 (2016). Personal data protection law [Kişisel verilerin korunması kanunu]. Resmî Gazete, No. 29677, April 7, 2016. https://www.kvkk.gov.tr/Icerik/6649/Personal-Data-Protection-Law

Man, R.E.K., Ho, A.X.Y., Lee, E.P.X., Fenwick, E.K.D., Aravindhan, A., Ho, K.C., Tan, G.S.W., Ting, D.S.W., Wong, T.Y., Yeo, K.K., Goh, S.Y., Gupta, P., & Lamoureux, E. L. (2025). Awareness and attitudes of elderly Southeast Asian adults towards telehealth during the COVID-19 pandemic: A qualitative study. *Singapore Medical Journal, 66*(5), 256–264. https://doi.org/10.4103/singaporemedj.SMJ-2022-117

Manavgat, G., & Demirci, A. (2020). Decentralization matter of healthcare and effect on regional healthcare efficiency: Evidence from Turkey. *Sosyoekonomi, 28*(44), 261–281. https://doi.org/10.17233/sosyoekonomi.2020.02.12

Matei, A., & Gogu, M.-C. (2021). Adaptive public administration. In A. Farazmand (Ed.), *Global encyclopedia of public administration, public policy, and governance* (pp. 1–6). Springer. https://doi.org/10.1007/978-3-319-31816-5_4296-1

Mohammadzadeh, Z., Saeidnia, H. R., Lotfata, A., Hassanzadeh, M., & Ghiasi, N. (2023). Smart city healthcare delivery innovations: A systematic review of essential technologies and indicators for developing nations. *BMC Health Services Research, 23,* Article 1180. https://doi.org/10.1186/s12913-023-10200-8

Obermeyer, Z., Powers, B., Vogeli, C., & Mullainathan, S. (2019). Dissecting racial bias in an algorithm used to manage the health of populations. *Science, 366*(6464), 447–453.

Organisation for Economic Co-operation and Development. (2016). *Health data governance for the digital age*. https://www.oecd.org/en/publications/health-data-governance-for-the-digital-age_68b60796-en.html

Organisation for Economic Co-operation and Development. (2023a). *Digitalisation of health systems can significantly improve performance and outcomes*. https://www.oecd.org/en/about/news/press-releases/2023/11/digitalisation-of-health-systems-can-significantly-improve-performance-and-outcomes.html

Organisation for Economic Co-operation and Development. (2023b). *Health at a glance 2023: Digital health at a glance*. OECD Publishing. https://www.oecd.org/en/publications/health-at-a-glance-2023_7a7afb35-en/full-report/digital-health-at-a-glance_86518984.html

Organisation for Economic Co-operation and Development. (2023c). *Smart city data governance: Challenges and the way forward*. https://www.oecd.org/en/publications/smart-city-data-governance_e57ce301-en.html

Organisation for Economic Co-operation and Development. (2025). *Government at a glance 2025: Policy coherence and co-ordination for sustainable development*. OECD Publishing. https://www.oecd.org/en/publications/government-at-a-glance-2025_0efd0bcd-en/full-report/policy-coherence-and-co-ordination-for-sustainable-development_3657c016.html

Pehlivan, D., & Yiğit, A. (2022). Türkiye'de büyükşehir statüsüne sahip illerin sağlık hizmetleri performansının değerlendirilmesi [Evaluation of health services performance of provinces with metropolitan status in Türkiye]. *Giresun Üniversitesi İktisadi ve İdari Bilimler Dergisi, 8*(2), 194–211. https://doi.org/10.46849/guiibd.1191919

Peters, B. G. (2013). *Strategies for comparative research in political science*. Bloomsbury Academic Publishing.

Pierre, J. (2011). *The politics of urban governance*. Palgrave Macmillan.

Ramirez-Rubio, O., Daher, C., Fanjul, G., Gascon, M., Mueller, N., Pajín, L., Plasencia, A., Rojas-Rueda, D., Thondoo, M., & Nieuwenhuijsen, M. J. (2019). Urban health: An example of a "health in all policies" approach in the context of SDGs implementation. *Globalization and Health, 15*, Article 87. https://doi.org/10.1186/s12992-019-0529-z

Republic of Türkiye Ministry of Environment, Urbanization and Climate Change [Türkiye Cumhuriyeti Çevre, Şehircilik ve İklim Değişikliği Bakanlığı]. (2020). *National smart cities strategy and action plan (2020–2023).* https://akillisehirekosistem.csb.gov.tr/DataBank/Detail?mId=320037003700&dataBankDataTypeMId=3900360030003500

Republic of Türkiye Ministry of Health [Türkiye Cumhuriyeti Sağlık Bakanlığı]. (2025a). *Kişisel sağlık sistemi e-Nabız* [Personal health system e-Nabız]. https://www.saglik.gov.tr/TR,99585/kisisel-saglik-sistemi-e-nabiz.html

Republic of Türkiye Ministry of Health [Türkiye Cumhuriyeti Sağlık Bakanlığı]. (2025b). *Uzaktan sağlık hizmeti sunumu - Sağlık çalışanlarına yönelik* [Remote healthcare delivery - For healthcare professionals]. https://hsgm.saglik.gov.tr/tr/uzaktan-saglik-hizmeti-sunumu/saglik-calisanlarina-yonelik.html

Schaefer, G. O., & Ballantyne, A. (2022). Ethics of digital contact tracing wearables. *Journal of Medical Ethics, 48*(9), 611–615.

Sulku, S. N. (2012). The health sector reforms and the efficiency of public hospitals in Türkiye: Provincial markets. *The European Journal of Public Health, 22*(5), 634–638. https://doi.org/10.1093/eurpub/ckr163

Syakinah, A., Junaini, S. N., Masron, T., Kimura, Y., & Ahmad, A. A. (2025). Urbanization and aging in ASEAN: A comparative demographic analysis from 1970 to 2023. Geografia-Malaysian *Journal of Society and Space, 21*(2). https://ejournal.ukm.my/gmjss/article/view/82457

Trencher, G., & Karvonen, A. (2017). Stretching "smart": Advancing health and well-being through the smart city agenda. *Local Environment, 24*(7), 610–627. https://doi.org/10.1080/13549839.2017.1360264

United Nations University. (2023). *Digital health security and governance*. https://unu.edu/iigh/our-work/digital-health-security-and-governance

United Nations, Department of Economic and Social Affairs, Population Division. (2023). *World urbanization prospects*. https://population.un.org/wup/

United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development* (A/RES/70/1). https://digitallibrary.un.org/record/3923923

van Dijk, J. A. G. M. (2020). *The digital divide.* Polity Press.

World Bank. (2018). *Turkish health transformation program and beyond*. https://www.worldbank.org/en/results/2018/04/02/turkish-health-transformation-program-and-beyond

World Bank. (2023). *Interoperability in health: Implementation know-how brief. (*Digital-in-Health Flagship Program). https://documents1.worldbank.org/curated/en/099081723223512639/pdf/P175075056d30a0f50a64e0c7ae8f3ab3ea.pdf

World Economic Forum. (2021). *Being smart about smart cities: A governance roadmap*. https://www.weforum.org/stories/2021/07/being-smart-about-smart-cities-a-governance-roadmap-for-digital-technologies/

World Economic Forum. (2022). *Our Alliance is creating smart city governance*. https://www.weforum.org/impact/smart-cities-governance-alliance/

World Economic Forum. (2024). *Transforming healthcare: Navigating digital health with a value-driven approach*. https://www.weforum.org/publications/transforming-healthcare-navigating-digital-health-with-a-value-driven-approach/

World Health Organization. (2018). *WHO guidance for contingency planning.* https://apps.who.int/iris/bitstream/handle/10665/260554/WHO-WHE-CPI-2018.13-eng.pdf?ua=1

World Health Organization. (2021a). *Global strategy on digital health 2020–2025*. https://www.who.int/publications/i/item/9789240020924

World Health Organization. (2021b). *WHO guidance on artificial intelligence to improve healthcare, mitigate risks worldwide*. https://news.un.org/en/story/2021/06/1094902

World Health Organization. (2022a). *Digital health and COVID19*. https://www.who.int/europe/emergencies/situations/covid-19/digital-health-and-covid-19

World Health Organization . (2022b). *Global report on health equity for persons with disabilities*. WHO. https://www.who.int/publications/i/item/9789240063600

World Health Organization. (2022c). *Global strategy on digital health 2020–2025: Monitoring and evaluation framework.* Retrieved from 27 May 2025. https://www.who.int/docs/default-source/documents/gs4dhdaa2a9f352b0445bafbc79ca799dce4d.pdf

World Health Organization. (2024a). *Innovation for urban health: Policy brief*. https://iris.who.int/bitstream/handle/10665/376733/9789240090040-eng.pdf

World Health Organization. (2024b). *Governance strategy for digital health systems.* https://www.who.int/teams/digital-health-and-innovation/governance

World Health Organization. (2024c). *Ethical considerations and data protection principles*. https://smart.who.int/trust/ethical_principles.html

World Health Organization. (2025). *WHO launches Health Inequality Monitoring Network to catalyse progress towards health equity*. https://www.who.int/news/item/12-08-2025-who-launches-health-inequality-monitoring-network-to-catalyse-progress-towards-health-equity

World Health Organization, & UN-Habitat. (2016). *Global report on urban health: Equitable, healthier cities for sustainable development.* https://www.who.int/publications/i/item/9789241565271

Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). Sage Publications.

Zotova, O., Sazdovski, I., Martinez, M. A., Dasandi, N., Oliva, C., Pujadas i Rovira, J., Iniesta Blasco, C., de'Donato, F., Roychoudhury, M., Chen-Xu, J., Nilsson, M., & Tonne, C. (2025). Realizing a carbon-neutral healthcare system: A co-created theory of change in Catalonia, Spain. *Oxford Open Climate Change, 5*(1), kgaf018. https://doi.org/10.1093/oxfclm/kgaf018

Zuboff, S. (2019). *The age of surveillance capitalism: the fight for a human future at the new frontier of power*. Profile Books.

CHAPTER 3

A SWOT Analysis on Strategic Planning Capacity: A Comparison of London and Istanbul

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1. Introduction

Urbanization is a multidimensional phenomenon that has emerged alongside processes of industrialization and economic development, encompassing not only the spatial concentration of population but also transformations in social organization, modes of production, and governance structures. Following the Industrial Revolution, the numerical increase of cities and the spatial expansion of existing urban areas led to the development of division of labour, specialization, and increasingly complex social relations. In this context, urbanization should not be understood merely as a demographic process; rather, it represents a structural social transformation that reshapes urban lifestyles, social interactions, and patterns of interpersonal relations (Castells, 2009). Today, cities, characterized by dense populations, multifunctional land uses, and the coexistence of natural and built environments, occupy a central position in economic, social, and political processes.

The long-term development vision of cities is shaped through regional planning and strategic planning frameworks, while the reflection of this vision in physical space is realized through urban and land-use planning processes. However, the rapid acceleration of urbanization over the past century has generated a wide range of structural challenges, including housing shortages, transportation problems, infrastructure deficiencies, environmental degradation, and vulnerabilities related to climate change. Increasing population pressure, intensified migration flows, and the impacts of the climate crisis require cities to be reconsidered not only in terms of growth but also in relation to the principles of sustainability, resilience, and inclusiveness. In this regard, urban planning

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cannot be reduced to the regulation of physical space alone; instead, it should be understood as a strategic governance process that guides planned change while addressing social welfare, environmental protection, and economic development within an integrated framework (Healey, 1997; Hall, 2014; UN-Habitat, 2020).

At the same time, globalization has profoundly transformed the roles and functions of cities. With technological advancements, global economic integration, and the expansion of communication networks, cities have become centers not only of national spatial systems but also of multi-layered actors operating at the global scale. Metropolitan cities, in particular, are embedded in global networks of production, finance, and decision-making, positioning them within the hierarchy of global cities. This situation has made urban planning capacity, governance models, and strategic spatial vision key determinants of international competitiveness (Sassen, 2001). Nevertheless, integration into global networks may also intensify problems such as income inequality, spatial segregation, the loss of green spaces, and increasing social vulnerabilities. Consequently, the main challenge facing contemporary cities is to establish a balanced and sustainable planning approach that reconciles global competitive pressures with local needs.

Within this framework, the literature emphasizes that advanced global cities tend to be relatively more successful in achieving sustainability and social inclusion goals, owing to their strategic planning capacity, institutional coherence, and participatory governance models (Healey, 1997; Fainstein, 2010). In contrast, it is underlined that planning coherence weakens in rapidly growing cities characterized by centralized planning structures (Pierre, 2011; Bayat, 2013). However, a significant portion of the existing literature addresses the global city phenomenon through single-case studies and remains largely confined to analyses focusing on the position of specific metropolises within the world economy (for example, Sassen, 2001). Another strand of the literature discusses urban planning problems within the framework of normative ideals such as participation and governance, yet provides limited comparative insight into how these ideals function across different institutional and political contexts (for example, Healey, 1997). Nevertheless, urban planning capacity and governance models are closely related not only to levels of global competitiveness but also to the degree of centralization, institutional coordination, and the quality of decision-making processes. In this respect, a comparative examination of global and local cities operating under different governance regimes points to an important analytical gap in the urban planning literature (Robinson, 2011).

Building on this academic gap, the present study aims to examine urban planning from global and local perspectives through the cases of London and

Istanbul. The planning practices of London, shaped by a strong institutional structure, a long-term spatial vision, and a participatory planning approach, are comparatively analyzed alongside those of Istanbul, which have evolved under conditions of centralized governance, institutional fragmentation, and intense growth pressure. The distinctive contribution of this study lies in its examination of urban planning approaches in both cities not only in terms of physical space but also by incorporating legal and administrative structures, housing and transportation policies, and environmental sustainability dimensions, and in systematizing this comparison through the use of SWOT analysis.

In this context, the main objective of the study is to reveal the role of urban planning capacity in managing contemporary urban challenges through the cases of London and Istanbul, and to analyse how different governance models are reflected in planning outcomes. In line with this objective, the study focuses on the following research questions:

(i) In what structural and administrative aspects do the urban planning systems of London and Istanbul differ?

(ii) How does strategic planning capacity influence the effectiveness of housing, transportation, and environmental sustainability policies?

(iii) What governance and planning lessons can be drawn for Istanbul based on the experience of London?

Methodologically, the study adopts a literature review based on secondary sources and a comparative qualitative analysis approach, offering an in-depth synthesis grounded in existing research, theoretical frameworks, and societal contexts. SWOT analysis is employed to systematically evaluate the strengths and weaknesses, opportunities, and threats of each city.

Following the introduction, the article proceeds with a section addressing the theoretical and conceptual framework. This is followed by descriptive and up-to-date information on London, which demonstrates an approach to planned urbanization and sustainability, and on Istanbul, which is characterized by unplanned urbanization and structural problems. Subsequently, the methodology and findings of the research are presented, and the urban planning systems of both cities are compared in detail on the basis of SWOT analysis. In the conclusion and recommendations section, the findings of the study are evaluated.

2. Urban Planning and Strategic Planning Approaches: Theoretical and Conceptual Framework

Today, urban planning is regarded as a field of governance that cannot be

reduced solely to the physical organization of space. Rather, it encompasses physical, social, economic, and environmental dimensions in a holistic manner and operates as a multi-actor and multi-scalar domain of governance. In this context, planning extends beyond the regulation of urban space to include functions such as shaping social relations, enhancing quality of life, achieving sustainability objectives, and guiding economic structures.

The emergence and institutionalization of urban planning are closely associated with the intense population movements, rural to urban migration, and structural transformations in production relations triggered by the Industrial Revolution in the late nineteenth century. During this period, problems related to housing, public health, infrastructure, and spatial inequality that arose in cities as a result of industrialization made the development of modern planning thought imperative. As relations between rural and urban areas were redefined, new settlement patterns and planning practices began to be institutionalized (Hall, 2014). In contemporary contexts, however, globalization, neoliberal policies, and processes of metropolitanisation have transformed urban planning from a merely regulatory and technical field into a strategic, long-term, and institutionally capacity-based area of governance.

In the contemporary urbanization literature, the proliferation of urban spaces that become increasingly standardized, shaped by external economic and political dynamics, and stripped of distinctive identity as a result of globalization and neoliberal policies is discussed as one of the central problem areas of urban planning. In this respect, Augé's (1995) conceptualization of non-places explains the production of standardized urban spaces lacking a sense of belonging and spatial meaning, while Zukin (2010) demonstrates how global capital, market-oriented policies, and practices of cultural consumption transform cities into homogenized and branded spaces. Both approaches highlight the decisive role of the relationships between planning, markets, and governance in shaping spatial identity in contemporary cities. In response to these challenges, studies in urban planning and urban design aim to ensure functional and spatial coherence among the components that constitute the city and to create livable, functional, and competitive urban environments (Öztürk & Genç, 2014). Within this framework, planning is addressed not merely as a technical activity of regulation but as a process directly linked to institutional capacity, governance models, and strategic vision.

At the same time, the urban planning literature has a well-established theoretical tradition of seeking solutions that recognize the claims and interests of diverse social actors and aim to produce consensus among competing interests. This perspective became institutionalized through the tradition of advocacy

planning, which rejects a singular and objective notion of the public interest and conceptualizes planning as a pluralistic arena of negotiation. Pioneered by Paul Davidoff (1965), this approach argues that the interests of different social groups, particularly disadvantaged and marginalized populations, should be actively represented within planning processes.

Since the 1980s, this pluralist perspective has been further developed through communicative and collaborative planning approaches inspired by Habermas's theory of communicative action, which conceptualize planning as a process grounded in the production of shared reasoning. In the works of authors such as Healey (1997), Innes (1995), and Forester (1982), it is emphasized that mechanisms of participation, deliberation, and mutual learning in planning processes enhance democratic legitimacy and implementation capacity. This theoretical trajectory has redefined planning not merely as a technical regulatory activity but as a normative field of governance that seeks to reconcile the objectives of social justice and environmental sustainability (Fainstein & Campbell, 2011).

In this context, Campbell's (2013) concept of "conflicting urgencies" between sustainable development and social justice offers a critical contribution to understanding the core tension areas of contemporary urban planning. Campbell argues that the goals of economic development, environmental protection, and social justice often conflict with one another within the urban planning process. Accordingly, the fundamental function of planning is to generate common ground and balance among these competing objectives. By emphasizing that planning is not only a spatial but also an ethical and political activity, this approach highlights the importance of participatory and conciliatory governance models.

Within this theoretical background, communicative and collaborative planning approaches grounded in Jürgen Habermas's theory of communicative action occupy a significant place in the contemporary urban planning literature. Developed through the contributions of scholars such as Patsy Healey, Judith Innes, and John Forester, this approach conceptualizes planning processes as arenas of negotiation in which diverse social actors produce shared meanings and solutions through dialogue based on mutual understanding. In this framework, planning knowledge is not reduced solely to technical expertise but is defined as a pluralistic process of knowledge production that also encompasses local knowledge, experiential learning, and forms of practical reasoning. Communicative planning thus reconceptualises planning by moving beyond a technical rational activity toward a governance process grounded in participation, deliberation, and mutual learning.

Pluralism, which constitutes the theoretical foundation of this approach, is one of the key political theories underpinning planning theory. Based on a pluralist conception of democracy, this perspective acknowledges the inevitability and legitimacy of diverse interests, values, and claims within society. Consequently, it assumes that a singular, objective, and universal definition of the public interest is not feasible in the planning process. Instead, the public interest is understood to be shaped through processes of deliberation and compromise among different social groups. In this respect, communicative and pluralist planning approaches conceptualize urban planning not as a technical instrument that suppresses conflicting interests, but as a democratic process that recognizes, renders visible, and seeks to reconcile these interests. They further demonstrate that planning capacity depends not only on institutional structures but also on governance models and mechanisms of participation.

The theoretical and conceptual discussions addressed in this section demonstrate that urban planning has historically evolved from a technical field of regulation into a multi-actor, pluralist, and strategic governance process. The theoretical framework centered on advocacy, communicative, and collaborative planning approaches, as well as on the tensions between sustainable development and social justice, reveals that planning capacity is dependent not only on spatial tools but also on institutional structures, governance models, and participatory mechanisms. In this context, a comparative examination of London and Istanbul, which are characterized by different governance traditions, institutional structures, and planning cultures, provides an important analytical basis for making the effects of strategic planning capacity on sustainability, participation, and social inclusion visible. Indeed, in contemporary urban planning, sustainability has emerged as a core policy domain in which the objectives of environmental protection, economic development, and social justice are addressed in an integrated manner as a natural extension of these theoretical debates. For this reason, the following section examines the concept of sustainability in urban planning together with its theoretical dimensions and planning practices.

3. Sustainability in Urban Planning

The historical origins of the idea of sustainability in urban planning are closely linked to responses to the profound social and spatial problems caused by industrialization during the early modern period. Unhealthy living conditions, inadequate infrastructure, spatial disorder, and social inequalities that emerged in rapidly growing cities under the influence of the Industrial Revolution transformed planning from a purely technical regulatory activity into a field of

public responsibility. In this context, early planning approaches acknowledged the inability of market mechanisms to resolve the complex problems of cities and emphasized the necessity of public intervention.

One of the pioneering figures of this intellectual transformation, Frederick Law Olmsted Jr., emphasized in his address at the Second National Conference on City Planning held in Rochester in 1910 that urban planning was not merely an aesthetic or engineering-based activity but a holistic public practice encompassing social, economic, and political responsibilities (Olmsted, 1910). By arguing that urban problems should be addressed from the perspectives of social welfare, environmental quality, and the public interest, Olmsted's approach laid the theoretical foundations of what is today understood as sustainable planning.

The concept of sustainability moved beyond these early approaches and acquired a global institutional framework with the publication of Our Common Future, also known as the Brundtland Report, in 1987. Prepared by the World Commission on Environment and Development, the report defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987), and emphasized the integrated consideration of environmental, economic, and social dimensions (Gündoğdu & Aytekin, 2022). This definition encouraged a rethinking of urban planning in terms of long-term spatial vision, institutional capacity, and multi-actor governance.

Following the Brundtland Report, the concept of sustainable planning became one of the mainstream notions in the planning literature and, despite limitations in practice, came to be recognized as one of the fundamental normative frameworks shaping the future of cities. During this process, the discourse on sustainability evolved beyond a narrow focus on environmental protection and acquired a multidimensional content that also encompasses social justice, spatial equity, and participatory governance.

At this point, the relationship between sustainability and social justice emerges as one of the most significant areas of tension in contemporary urban planning. The spatially unequal distribution of economic, social, and environmental resources, along with the systematic neglect or marginalization of certain areas, deepens the problem of spatial injustice. Spatial injustice refers to the unequal access of different social groups to public services, healthy environmental conditions, economic opportunities, and decision-making processes, thereby undermining the social legitimacy of sustainability policies.

Environmental improvement projects and urban regeneration initiatives, in particular, may give rise to new forms of inequality such as green gentrification when their social dimensions are neglected. Investments in green spaces, large-scale infrastructure projects, and urban renewal processes can lead to the displacement of low-income groups and the deepening of social segregation. This situation raises the question of for whom and at what cost sustainability is pursued, making it necessary to critically examine the class-based and spatial implications of sustainable planning.

In this context, sustainable urban planning should be understood not merely as an approach focused on environmental objectives but as a normative governance model that also incorporates the principles of spatial justice, social inclusion, and democratic participation. For fair and sustainable urban development, the equal representation of all stakeholders in planning processes, the equitable distribution of resources, and the avoidance of environmental improvements that generate new social inequalities emerge as fundamental requirements.

This theoretical framework demonstrates that sustainability in urban planning is not merely an end goal but a process directly related to strategic planning capacity, institutional coherence, and governance models. Indeed, the cases of London and Istanbul provide a meaningful basis for comparison in terms of the extent to which sustainability principles are integrated into planning systems and how this integration is supported by institutional structures and decision-making processes. For this reason, sustainability will be addressed as one of the core dimensions in the SWOT-based comparative analysis conducted in the subsequent sections of the study, serving to evaluate the strategic planning capacity of both cities.

4. Case Study 1: London and the Planned Urbanization Sustainability Approach

4.1. The Historical Development of Urban Planning in London

The historical development of urban planning in London has largely been shaped by structural transformations triggered by major urban crises. The Great Plague of London in 1665 revealed the devastating effects of extreme density, unhealthy housing conditions, and inadequate infrastructure on urban life, demonstrating that cities are not only economic and political centers but also spaces of public health. The Great Fire of London in 1666, which followed this period, led to the elimination of unhealthy building stock and made it possible to develop the first planning principles concerning building regulations, street

widths, and construction materials. These experiences were decisive in terms of controlling population density and incorporating the spatial dimension of public health into planning processes.

With the Industrial Revolution, London became one of the fastest-growing metropolises in the world. According to official and historical demographic data from the United Kingdom, London's population increased from approximately 1.0 million in 1801 to around 6.5 million by 1901 (Centre for London, 2019). This rapid and largely uncontrolled population growth resulted in the organic and unplanned development of the city and brought about serious urban problems such as narrow streets, excessive density, and unhealthy living conditions (Mumford, 1961). These challenges reinforced the necessity of addressing planning not merely as a technical exercise but as a holistic and long-term instrument of governance.

The institutionalization of modern and strategic planning in London became more pronounced with the Greater London Plan of 1944, which was prepared in the aftermath of the Second World War. Developed by Patrick Abercrombie (1945), this plan aimed to relieve overconcentrated urban centers, to redistribute population and employment spatially, and to improve overall quality of life. Within the scope of the plan, residential areas were organized around suburbs and new satellite towns, industrial zones were relocated away from the city center, and the protection of green spaces and the reorganization of transportation infrastructure were identified as key priorities. This historical trajectory demonstrates that urban planning in London evolved into a structure characterized by learning from crises, producing long-term spatial visions, and relying on strong institutional capacity.

4.2. The Protection of Green Spaces and Transportation Policies in Urban Planning in London

4.2.1. The Protection of Green Spaces in Urban Planning in London

London's approach to urban planning has been constructed, within a framework of historical continuity, around the protection of green spaces and the guidance of urban development within environmental limits. This approach reflects a holistic planning perspective that focuses not only on recreational needs in the city's long-term spatial strategies but also on objectives related to public health, ecological balance, and climate adaptation. In this respect, London is widely regarded as one of the leading cities in Europe in terms of green space policies and sustainable urban practices.

The importance of green spaces for urban life has been strongly articulated in the London context since early periods. Charles Dickens's description of parks as the "lungs of London" in his work *Sketches by Boz* offers a powerful metaphor that draws attention to the role of green spaces in urban health in response to the density, pollution, and unhealthy living conditions generated by the Industrial Revolution (Dickens, 1836). This depiction underscores that green spaces should be regarded not merely as aesthetic elements but as vital urban infrastructure essential to the sustainability of urban life.

The systematic incorporation of green spaces into the planning process in London acquired an institutional framework through modern green belt policies. It is well documented that early efforts to limit development around the city date back to the sixteenth century, when construction was restricted by royal decrees in order to prevent the spread of epidemics, reduce fire risk, and ensure food security (Hall, 2014). Within the framework of modern planning, however, green belt policies took shape in the early twentieth century. The first official proposals emerged around London in 1935, and with the Green Belt Act of 1938 these areas were formally incorporated into planning documents and placed under protection (Amati, 2008).

The Town and Country Planning Act of 1947, which constitutes one of the foundational legal pillars of modern urban planning in the United Kingdom, further formalized green belt practices through local plans. Through this legislation, a controlled growth model grounded in the public interest was adopted, aiming to contain urban sprawl, protect natural and rural areas, and ensure planned development. The principal objective of green belt policy has been to keep land permanently open in order to prevent unplanned expansion while safeguarding the distinctive character and environmental values of historic cities.

The current London Plan of 2021 does not confine the concept of green space to parks and gardens alone but adopts a broader green infrastructure approach that encompasses green roofs, green walls, floodplains, urban forests, and areas of biodiversity. Within this framework, green spaces are conceptualized as strategic spatial elements that go beyond recreation to support water management, climate adaptation, and the continuity of ecological corridors (Sandford & Berry, 2024). However, recent studies indicate that the concepts of green belts and green spaces are often conflated, thereby highlighting the growing need for new local planning instruments that can address these distinctions more effectively (Rankl et al., 2023).

In line with the Open Space Strategy developed under the London Plan, parks, gardens, and urban woodlands across the city are systematically protected.

Today, the fact that approximately one third of London's total area consists of green spaces is widely regarded as a tangible outcome of this long-term planning approach.

4.2.2. Transportation Policies in London

London is one of the leading metropolises that address sustainability, accessibility, and environmental responsibility in transportation policies within an integrated strategic framework. More than nine million journeys are made every day in the city by means of buses, underground, rail, tram, and river transport, indicating that London possesses one of the most comprehensive and integrated public transportation networks globally. The planning and management of this system are institutionally carried out by the Greater London Authority, while transportation policies are implemented through binding documents such as the London Plan and the Mayor's Transport Strategy, which are prepared on the basis of the Greater London Authority Act of 1999 (Greater London Authority, 2021).

The core principle underlying transportation policies in London is the coordinated planning of land use decisions and transportation systems. This approach stands out as a strategic capacity element in guiding urban growth, reducing density in central areas, and ensuring sustainable accessibility between different parts of the city. In particular, reducing dependence on private car use and prioritizing pedestrian mobility, cycling networks, and public transportation systems aim both to mitigate environmental impacts and to promote a more equitable and inclusive use of public space (Banister, 2008).

Within this framework, the London Plan of 2021 envisages reducing the dominance of motorized vehicles on streets, which constitute approximately 80 percent of urban public space, strengthening pedestrian and cycling infrastructure, and integrating the principle of a city accessible for all into transportation policies. Investments such as increasing capacity in underground and rail networks, developing new lines, ensuring accessibility for people with disabilities at stations, and improving service quality in bus systems are addressed within a long-term planning perspective based on cost, timing, and impact analyses (Greater London Authority, 2021). Moreover, London's transportation strategies encompass not only intra-urban mobility but also the integration of regional transportation hubs such as airports with sustainable transport connections. Efforts to reduce the environmental impacts of aviation activities, enhance access to public transportation, and limit carbon emissions demonstrate that the principle of environmental responsibility has been institutionalized within London's transportation policies. When considered together with the

city's strong institutional structure, long-term vision, and legally binding planning instruments, this holistic approach emerges as a significant component of London's strategic planning capacity in the field of transportation.

4.3. Social Housing Policies and Urban Regeneration Practices in London

The strategies developed by London to address the housing crisis are based on a planning approach in which social housing production and urban regeneration policies are addressed in an integrated manner. In the face of rising housing demand, land prices, and spatial inequalities, city authorities position social housing policies not merely as a solution to housing shortages but also as one of the fundamental instruments of sustainable urban development and social integration. In this respect, London is considered one of the pioneering cities that have placed social housing production and urban renewal processes within an institutional framework through strategic planning documents.

One of the early and frequently cited examples of this approach in the literature is the Paddington Urban Regeneration Project, launched in 1998. Aimed at the redevelopment of a former industrial area, this project was implemented through a public private partnership model and planned via the Paddington Regeneration Partnership, which brought together local authorities, private sector actors, and property owners. While the project is regarded as a successful model of regeneration in terms of institutional coordination and financing, it has been criticized for its limited social inclusiveness due to the fact that the housing primarily targeted higher income groups. This situation clearly illustrates the tension between social justice and market dynamics in urban regeneration practices in London (Imrie & Lees, 2014).

Following the 2000s, public private partnership based urban regeneration projects gained momentum in London, with the London Plan of 2004 and its 2007 revision defining the strategic orientation of this process. These documents identified increasing the proportion of social housing, strengthening public participation, and reducing spatial segregation as key objectives in urban renewal processes. The areas of Southwark and Bermondsey along the River Thames represent significant examples illustrating the spatial impacts of this transformation. The conversion of former industrial areas into cultural, administrative, and financial functions enhanced urban attractiveness while simultaneously leading to the indirect displacement of low income groups through rising living costs. Tonkiss's concept of micro gentrification explains this process as a form of displacement that occurs without forced evictions but nevertheless transforms the social structure of neighbourhoods (Tonkiss, 2013).

In response to these challenges observed in practice, the Localism Act of 2011 aimed to enhance the effective participation of local authorities, neighbourhood level actors, and civil society organizations in planning processes. This regulation is considered an important institutional step reflecting London's transition from centralized planning toward a multi layered governance approach in urban regeneration policies (Kalender Çetinkaya, 2019).

In contemporary practices, the integration of urban regeneration projects with social housing provision has become more pronounced. Housing associations such as Notting Hill Genesis develop projects that take into account local needs and include housing types for different income groups. The regeneration process of the Aylesbury Estate in Southwark is noteworthy for its objective of producing a diverse range of housing, from single occupancy units to large family dwellings. Projects such as Barking Riverside and East Village reflect a holistic planning approach that aims not only at the transformation of physical space but also at strengthening social infrastructure and ensuring long term sustainability (Twinch, 2022). Within this framework, London's social housing and urban regeneration policies indicate a high level of strategic planning capacity, supported by strong institutional structures, binding planning documents, and multi actor governance mechanisms.

4.4. Governance and Participation in Urban Planning in London

London is regarded as one of the leading metropolises that has institutionalized governance and participation within urban planning. Particularly following the establishment of the Greater London Authority (GLA) after 2000, planning processes were restructured in line with a multi-level governance approach. A more coordinated and transparent planning model was adopted among central government, local authorities, the private sector, and civil society actors. This institutional transformation has played a decisive role in strengthening London's strategic planning capacity.

The London Plan documents prepared by the GLA emphasize that planning decisions should be shaped not solely on the basis of technical expertise but also through public deliberation and participation mechanisms. This approach gained a legal foundation with the Localism Act of 2011, which introduced the right to neighbourhood planning and encouraged the direct involvement of local communities in planning processes. As a result, planning authority has been gradually shared from the central level toward local and neighbourhood scales (Department for Communities and Local Government [DCLG], 2011).

Large scale urban regeneration projects in London demonstrate the practical implications of this governance approach. In particular, projects based on public private partnerships have sought to integrate social participation into planning processes. In the regeneration of the Aylesbury Estate led by Notting Hill Genesis, the inclusion of residents' views on housing typologies, social facilities, and public spaces is presented as an institutional example of the "planning with the community" approach. However, the micro gentrification effects generated by the regeneration process raise questions regarding the extent to which participation mechanisms are functional and whether they genuinely influence decision making processes (Lees et al., 2008; Tonkiss, 2013).

In this context, the renewal project of the Ledbury Estate in the Southwark area represents another noteworthy example developed within the framework of governance principles. The project was implemented through a multi stakeholder cooperation model involving Southwark Council, local residents, and the private sector partner Higgins Partnerships. The renewal process addressed not only housing production but also the improvement of public spaces, the expansion of green areas, and the strengthening of pedestrian and cycling connections. This approach demonstrates that governance is not limited to the built environment but also encompasses objectives related to social integration and environmental sustainability (Southwark Council, 2025). Furthermore, the implementation of long term and multi stage consultation mechanisms by Southwark Council indicates the institutionalization of transparency, accountability, and participation principles at the local level. In this respect, the Ledbury Estate project can be considered a concrete example of the multi layered governance model established between the public sector, the private sector, and society, reflecting the strong aspects of London's strategic planning capacity. Nevertheless, the London case also shows that participatory governance tools do not always produce social justice and spatial equality.

4.5. Current Urban Challenges in London: Housing Crisis, Traffic Congestion, and Urban Segregation

4.5.1. The Housing Crisis and Traffic Congestion in London

Alongside its high economic attractiveness and global city status, London has long been facing a deepening housing crisis accompanied by increasing pressure on transportation systems. The statement made by Mayor Sadiq Khan in 2023, which articulated the goal of eliminating street homelessness in the capital by 2030, reveals that the issue is not only social but also directly related to governance and planning capacity (Khan, 2023). This discourse indicates that homelessness and housing problems in London should no longer be addressed

through temporary market fluctuations but require structural interventions.

The primary causes of the housing crisis include high living costs, the inability of social housing supply to meet demand, rapid increases in private property prices, and the widespread expansion of gentrification processes. Particularly in central and regeneration areas, a significant portion of newly built luxury housing is acquired for investment purposes, which effectively constrains actual housing supply and leads to the displacement of low income groups from urban centres. This situation results in the spatial segregation of housing opportunities according to income levels and deepens urban inequalities. In recent years, the pressure created by rising rents has led to the emergence of alternative housing practices, including some groups choosing to live in canal boats known as narrowboats (Londra Aktüel, 2025). This trend can be considered a striking reflection of the housing crisis in everyday life.

Another major issue accompanying the housing crisis is traffic congestion and pressure on urban mobility. The London municipal government addresses this problem not only through capacity expansion of transport infrastructure but also through strategic policies aimed at transforming travel demand. Bus, cycling, and walking action plans developed within the framework of the Mayor's Transport Strategy aim to reduce private car use, promote active modes of transport, and position public transport as the backbone of urban life. In this context, the Bus Action Plan seeks to reduce dependency on private vehicles by making public transport more accessible and attractive, while the Cycling Action Plan aims to normalize cycling as an everyday mode of transport. The Walking Action Plan and the accompanying Leisure Walking Plan provide a holistic approach to public health and quality of life by creating continuous pedestrian routes connecting parks and green spaces. These policies developed by Transport for London link urban mobility to objectives of environmental sustainability and social inclusion.

Moreover, within the framework of the Accessibility, Diversity, and Inclusion Action Plan (Mayor of London, n.d.), the goal is to ensure that all users, including individuals with disabilities, can benefit from urban transport systems independently and safely. In this regard, London has developed a strategic vision that addresses transportation not merely as a technical infrastructure issue but within the context of social justice and public equality. The target of achieving 80 percent of all trips within the city by walking, cycling, and public transport by 2041 can be considered one of the strong aspects of London's long term planning capacity (Transport for London, n.d.-b). In conclusion, the London case demonstrates that complex urban problems such as the housing crisis and traffic congestion are addressed through a strong institutional structure, long

term strategic documents, and multi instrument policy frameworks. However, increasing gentrification, inequalities in access to housing, and the persistence of homelessness also make the limits of this capacity visible.

4.5.2. Urban Segregation in London

The spatial manifestation of economic, social, and cultural inequalities in metropolitan cities has long been discussed within the framework of urban segregation. Urban segregation refers not only to the physical separation of different social groups within the city but also to a structural process shaped by income distribution, labour markets, housing regimes, and public policies (Massey, 1990). According to Musterd and Ostendorf, the concepts of segregation, social polarization, and social exclusion occupy a central place in discussions on urbanization processes and urban policy in contemporary cities, while neoliberal restructuring and market oriented planning approaches further intensify these processes (Musterd & Ostendorf, 2013). In this context, urban segregation is understood as a multidimensional phenomenon in which social inequalities crystallize in space, producing enduring differences in access to public services, housing opportunities, and urban quality of life.

In the case of London, urban segregation is closely associated with rising income inequality, the market driven structure of the housing sector, and spatially uneven transport infrastructure. High housing prices and insufficient social housing supply lead to the exclusion of low and middle income groups from central and well serviced areas, while encouraging the formation of socio economically homogeneous neighbourhoods within the city. This process contributes to increasingly visible boundaries between affluent and deprived areas in London's spatial structure.

One of the most prominent dynamics of urban segregation in London is the process of gentrification. Particularly in East London, many former industrial areas and low income neighbourhoods have been opened to upper income demand through capital investment and urban regeneration projects. As noted by Neil Smith, gentrification is not merely a process of physical renewal but also a form of re spatialisation that carries class based, cultural, and political meanings. This process deepens income based spatial segregation by leading to the direct or indirect displacement of low income groups (Smith, 2005).

Income based spatial segregation in London strongly intersects with forms of ethnic and cultural segregation. The concentration of Bangladeshi, African origin, and Eastern European migrant communities in specific neighbourhoods has resulted in patterns of ethnic clustering in urban space. This situation reflects not only voluntary community formation but also a structural form

of segregation shaped by inequalities in the housing market, discriminatory practices, and the limited spatial choices available to low income groups (Peach, 2006; Phillips, 2010).

In London, eastern districts such as Tower Hamlets, Newham, and Hackney historically stand out as areas with a high concentration of Bangladeshi and other South Asian migrant communities. Similarly, the spatial concentration of African and Caribbean origin communities is notable in southern districts such as Brixton and Peckham. Migrants of Eastern European origin have become more visible particularly in areas such as Haringey, Barking and Dagenham, and Ealing (Vertovec, 2007). While these spatial concentrations provide advantages in terms of social networks and cultural continuity, they also generate persistent inequalities in education quality, employment opportunities, access to health services, and public investment. These processes create marked disparities in access to urban services, as schools, the quality of public spaces, and transport opportunities tend to be more limited in neighbourhoods with high concentrations of low income and ethnic minority populations. Moreover, the use of public space and the sense of urban belonging are negatively affected by these patterns of segregation. As argued by Wacquant (2008), such spatial concentrations over time produce "territorially stigmatized neighbourhoods" and extend social exclusion beyond the spatial dimension to a symbolic level.

From a planning perspective, limitations in governance and participation mechanisms also play a role in the deepening of urban segregation in London. Although planning documents emphasize principles of participation and inclusion, in practice low income and vulnerable groups are often unable to exert meaningful influence on decision making processes. Insufficient social housing production, strong market pressures, and the limited effectiveness of participatory planning tools reveal the weaker aspects of strategic planning capacity in addressing social inequalities. In conclusion, urban segregation in London constitutes an increasingly complex and deepening social problem shaped by the intersection of income inequality, structural problems in the housing market, ethnic spatial clustering, and limited participatory governance mechanisms.

5. Case Study 2: Istanbul, Unplanned Urbanization and Structural Problems

From the 1950s onward, industrialization policies and rural to urban migration in Türkiye profoundly transformed the demographic and spatial structure of Istanbul. The dissolution of agricultural production in rural areas and the growing attractiveness of industrial and service sectors in cities led

to rapid and uncontrolled population growth in Istanbul. In this process, the inadequacy of formal housing production resulted in the emergence of squatter housing and other forms of informal settlements. The phenomenon of gecekondu should be understood not only as a response to housing needs but also as a spatial manifestation of institutional weaknesses in state housing and planning policies.

The delay in the establishment of planned urban development in Istanbul, combined with deficiencies in the implementation of zoning plans and their weakening through political interventions, left the city's spatial development largely uncontrolled. The tolerance shown by central and local governments toward illegal construction, particularly during election periods, effectively institutionalized unplanned growth (Şengül, 2009). This situation generated legal uncertainty and led to the legitimization of illegal construction through zoning amnesties, thereby undermining the deterrent capacity of the planning system (Erder, 1996).

One of the most serious consequences of unplanned urbanization has been the increased vulnerability of Istanbul to disasters. The opening of riverbeds, floodplains, and geologically unsuitable areas to development has heightened the risks of flooding as well as earthquakes. Despite Istanbul's location along the North Anatolian Fault Line, a significant portion of the building stock lacks adequate engineering services, posing a serious threat to urban safety (Özerdem & Barakat, 2000; Koramaz, 2017).

In addition, intensive concretization and the reduction of green spaces have intensified the urban heat island effect in Istanbul. Rising temperatures, particularly in central districts, have negative impacts on public health and quality of life. Urban regeneration projects are often implemented through market oriented approaches that remain distant from participatory planning principles. This has resulted in the displacement of low income groups and the deepening of spatial inequalities (Balaban, 2013).

The dominance of neoliberal urbanization policies in Istanbul since the 1980s has led to the treatment of urban space as an area of investment and rent generation. The flexibilization of planning processes, the privatization of public land, and the acceleration of urban transformation through mega projects have produced outcomes that conflict with principles of social justice and spatial equity (Kuyucu & Ünsal, 2010). Consequently, unplanned urbanization in Istanbul has been shaped by the combined effects of migration pressure, weak institutional planning capacity, and neoliberal urban policies. This condition can be regarded as one of the fundamental weaknesses limiting Istanbul's strategic planning capacity.

5.1. The Development Process of Urban Planning in Istanbul

The development of urban planning in Istanbul has evolved in parallel with Türkiye's modernization process, shaped by a centralized planning approach, rapid population growth, and challenges in managing urban expansion. In the early years of the Republic, planning activities remained limited and fragmented. However, the 1930s marked a period in which modern urban planning principles were first systematically applied in Istanbul. In this context, the appointment of Henri Prost in 1936 to prepare the Istanbul Master Plan represented a significant turning point for the city's planned development. The Prost Plan was designed with objectives such as the preservation of historical heritage, the reorganization of transport axes, the expansion of public open and green spaces, and the transformation of unhealthy built environments (Istanbul Metropolitan Municipality Department of Urban Planning [İstanbul Büyükşehir Belediyesi Şehir Planlama Şube Müdürlüğü], n.d.). Nevertheless, the inability of the plan to evolve into a long term and comprehensive strategy was closely related to political, economic, and demographic pressures encountered during its implementation. This illustrates that planning processes in Istanbul have, from an early stage, progressed with weak implementation capacity and a fragile link between plans and decisions.

From the 1950s onward, accelerated industrialization and rural to urban migration deepened structural problems such as unplanned growth, the proliferation of squatter settlements, and infrastructure deficiencies. During this period, planning largely took the form of reactive interventions addressing existing problems, while short term zoning regulations prevailed over long term strategic objectives. Urban regeneration projects and new zoning plans introduced in the 1980s aimed at physical modernization, yet largely neglected social integration, participation, and environmental sustainability (Balaban, 2013). This constitutes one of the major weaknesses in Istanbul's strategic planning capacity.

The 1:100,000 scale Istanbul Environmental Master Plan, approved in 2009, represents one of the most significant steps toward comprehensive and upper scale planning for the city. With this plan, district level and lower scale planning activities that had previously been conducted in a fragmented manner were reconsidered within a hierarchical planning system. Spatial development decisions were intended to be aligned with environmental thresholds, transport systems, and population projections. However, revisions made during the implementation process, exceptional zoning decisions, and mega projects weakened the binding nature of the plan and limited its strategic guiding role. According to data from the Istanbul Metropolitan Municipality Department of Urban Planning,

the rapid approval of the plan and its controversial implementation process indicate that planning discipline was not carried out through sufficiently comprehensive and participatory procedures (Democratic Opening Platform in Architecture [Mimarlıkta Demokratik Açılım Platformu], 2009). It has also been reported that certain plan amendments and mega projects disrupted the boundaries established by the 1:100,000 scale Environmental Master Plan (The Union of Chambers of Turkish Engineers and Architects [Türk Mühendis ve Mimar Odaları Birliği], 2014). Furthermore, the inclusion of projects such as Canal Istanbul altered the plan's objectives of preventing northern expansion and protecting environmental thresholds, thereby undermining the strategic macro form of the 2009 plan (Vizyon 2050, 2020).

On the other hand, Urbanization and Urban Development Councils convened at regular intervals in Türkiye function as national scale strategic governance platforms for major cities, including Istanbul. For example, the 2009 Urbanization Council addressed a wide range of issues such as the spatial planning system, urban regeneration, disaster risk management, local governments, and participation. Similarly, the 2017 Urban Development Council developed policy recommendations under headings such as urban identity, planning and design, urban regeneration, and the role of local governments in the new vision of urbanization (Republic of Türkiye Ministry of Public Works and Settlement [Türkiye Cumhuriyeti Bayındırlık ve İskan Bakanlığı], 2009; Republic of Türkiye Ministry of Environment and Urbanization [Türkiye Cumhuriyeti Çevre ve Şehircilik Bakanlığı], 2017). Although these councils have articulated important principles for strategic planning, institutional and governance limitations persist in the consistent and sustainable implementation of their decisions at the local level. Today, Istanbul seeks to develop a new planning discourse around themes such as urban regeneration, climate change mitigation, smart city applications, and disaster resilience. However, this process continues to face challenges related to institutional fragmentation, conflicts between central and local authorities, and deficiencies in participatory governance.

5.2. Unplanned Urbanization and Zoning Problems in Istanbul

Istanbul is not only the most densely populated metropolis in Türkiye but also one of the cities where unplanned urbanization and zoning problems are most visible. The city's urban development has been shaped largely without a long term and comprehensive planning approach, particularly since the acceleration of rural to urban migration in the 1950s. The unplanned growth that emerged during this period, along with the proliferation of squatter settlements and

infrastructure deficiencies, has produced persistent problems in the city's spatial structure. The predominance of reactive and fragmented interventions in the planning process has been one of the main factors limiting Istanbul's strategic planning capacity. Neoliberal policies implemented after the 1980s further linked urban space to capital accumulation processes, while zoning amnesties and licensing practices effectively legitimized illegal construction and weakened the institutional integrity of the planning system (Yenice, 2014). During this period, urban transformation was approached less as a tool for social integration and environmental sustainability and more as a legal adjustment to existing problems.

With the 2000s, urban transformation processes were provided with a formal legal framework, and Law No. 6306 on the Transformation of Areas under Disaster Risk, enacted in 2012, emerged as a significant step aimed at reducing disaster risks. However, the limited integration of participation, spatial coherence, and long term strategic objectives in the implementation process indicates the persistence of structural problems related to planning capacity. From the perspective of strategic planning capacity, Istanbul continues to face substantial structural constraints, including weak plan continuity, the widespread use of exceptional zoning decisions, and the dominance of market oriented interventions.

5.3. Urban Transformation Policies in Istanbul: Opportunities and Threats

Urban transformation policies in Istanbul are primarily implemented within the framework of Law No. 6306 on the Transformation of Areas under Disaster Risk. This law regulates the redevelopment of buildings and areas exposed to disaster risk, particularly aiming to mitigate the impacts of hazards such as earthquakes through the designation of risky buildings and risky areas. Official statements regarding the scope and objectives of the law emphasize the renewal of existing building stock in risky areas in order to improve quality of life (Law No. 6306, 2012).

From a legislative perspective, in addition to Law No. 6306, regulations such as Law No. 5393 on Municipalities, Law No. 5216 on Metropolitan Municipalities, and Law No. 3194 on Zoning constitute the legal infrastructure governing transformation processes in Istanbul. Together, these instruments create a complex legal framework in which planning and implementation authorities are defined at multiple levels across the urban scale.

From a strategic standpoint, urban transformation practices have the potential to address Istanbul's structural weaknesses. One of the most significant opportunities lies in the modernization of risky buildings and areas located in a

high seismic risk region, transforming them into earthquake resistant structures. The existence of Law No. 6306 provides a legal basis for such interventions and facilitates the achievement of earthquake safety objectives. Furthermore, the transformation process can be used as a tool for infrastructure improvements, the enhancement of urban aesthetics, and the pursuit of environmental sustainability goals. It is frequently emphasized in the Turkish context that new construction can deliver gains such as improved energy efficiency and reduced environmental impacts. In addition, the multi actor governance structure involving central government, the Istanbul Metropolitan Municipality, district municipalities, public enterprises such as Emlak Konut GYO, and private sector partnerships enables transformation projects to be implemented in a multidimensional manner. This configuration represents an opportunity to expand strategic governance capacity in terms of financing and implementation scale.

At the same time, urban transformation practices in Istanbul also generate significant threats. First, empirical findings indicate that the designation of risky areas under Law No. 6306 does not sufficiently overlap with priority intervention zones in Istanbul, suggesting that transformation policies do not perform in full alignment with the objective of reducing earthquake risk. Analyses conducted by the Istanbul Planning Agency indicate that only a very small proportion of designated risky areas, for example 0.35 percent of Law No. 6306 areas, overlaps with priority intervention areas. This situation constitutes a threat in terms of the coherence of urban transformation with overall planning integrity and spatial strategic objectives (Turgut & Demirkol, 2023). Moreover, while the number of designated risky areas remains limited, large portions of the planning territory continue to require transformation, raising questions regarding the effectiveness and scope of transformation policies.

Another major threat from a strategic planning perspective concerns coordination deficiencies and authority fragmentation in planning and implementation processes (Gündoğdu, 2020). Transformation processes involving multiple institutions with different roles may constrain the system's capacity for integrated decision making and implementation. This represents a structural weakness that complicates the achievement of sustainable strategic objectives in urban transformation.

In sum, while urban transformation policies in Istanbul offer strategic opportunities through a strong legal framework and multi actor governance mechanisms, particularly in terms of earthquake risk reduction and sustainable urban development, they simultaneously entail strategic threats due to the limited designation of risky areas, weak planning coherence, and persistent coordination deficiencies.

5.3.1. Challenges and Threats in Urban Transformation in Istanbul

In Istanbul, the neglect of socio-economic structures in urban transformation processes stands out as one of the principal challenges and threats. The predominance of demolition and reconstruction oriented, rent-driven approaches in transformation policies leads to spatial interventions that disregard local communities' everyday practices, income levels, and social networks. This situation produces outcomes such as the displacement of low- and middle-income groups, the narrowing of access to housing, and the persistence of deficiencies in social infrastructure. In projects defined in a top-down manner by the central government, the failure to address transformation areas together with their residents and in a place-specific way reduces urban transformation from a tool of social improvement to a mechanism for commercial value creation. At both parcel-based and large-scale project levels, "success" is often measured solely by the completion of construction processes, while impacts such as the disruption of planning balances, increases in density, and transformations in social structure are largely overlooked. In this context, urban transformation in Istanbul has increasingly become a process that accelerates gentrification, deepens spatial and social inequalities, and undermines urban justice through the loss of shared commons (Dinçer, 2022).

Moreover, under the influence of neoliberal policies, urban transformation processes in Istanbul have generated significant structural problems as the state has moved beyond its regulatory role to become an active market actor in planning, land development, and housing production. The restructuring of institutions such as the Housing Development Administration of the Republic of Türkiye (TOKİ; Toplu Konut İdaresi Başkanlığı) and Emlak Konut Real Estate Investment Trust has opened public lands to market mechanisms, accelerating the commodification of urban space in line with capital accumulation. At the same time, planning processes have been largely centralized, weakening the influence of local governments and social actors. Within Lefebvre's framework of the production of space, this process points to the reconfiguration of urban space at the level of representations; within the context of Gramsci's concept of hegemony, it reflects the legitimization of market-based transformation through the production of social consent. This transformation, carried out through branded housing projects and gated communities, has led to the contraction of public space, the transfer of urban services to private management structures, and the deepening of spatial inequalities in parallel with the retreat of the social state. As a result, urban transformation practices in Istanbul produce a fragmented, exclusionary, and rent-oriented spatial structure rather than improving the city

in a holistic manner. This constitutes one of the major threats undermining strategic planning capacity (Serin et al., 2020).

5.4. Traffic, Transportation, and Infrastructure Deficiencies in Istanbul

Istanbul has become a city in which demand for transportation infrastructure has increased significantly due to population growth, urban sprawl, and large-scale projects. This situation has led to traffic congestion and longer travel times in public transportation. Istanbul faces a range of transportation problems, including traffic congestion, automobile dependency, and deficiencies in public transport infrastructure. While private vehicle use is widespread, the public transportation network remains inadequate in many areas. In addition, the limited extent of rail systems and aging infrastructure make it difficult to cope with increasing population and traffic volumes. These conditions contribute to environmental problems, particularly air pollution and carbon emissions, while deficiencies in accessibility disproportionately affect groups such as people with disabilities, the elderly, and children. Urban sprawl and high population density further strain the capacity of transport corridors, exacerbating these challenges.

As of 2024, Istanbul has approximately 5.5 million registered motor vehicles. This figure increases vehicle density per capita and intensifies the overall traffic burden (Kurye Haber, 2025). Istanbul has ranked as the city with the most congested traffic globally in 2024 and 2025, with drivers losing an average of 118 hours per year in traffic (Republic of Türkiye Ministry of Trade [Türkiye Cumhuriyeti Ticaret Bakanlığı], 2025). Consequently, one of the main problems in urban transportation is automobile dependency and traffic congestion. This results in reduced driving speeds and the consumption of a significant portion of daily life in traffic.

Although public transportation represents a preferred modal share for sustainable mobility in a megacity, daily usage rates remain lower than those of private vehicles, and urban mobility systems are still in the process of integration. For instance, as of 2025, a comprehensive mobility application covering all public transport modes has been introduced to facilitate planning and transfer processes. However, these systems have not yet attracted sufficient ridership to significantly reduce automobile dependency.

From an environmental perspective, the impact of the transportation sector on urban emissions is considerable. In 2022, CO_2 emissions from road transportation in Istanbul were calculated at approximately 15,039.68 Gg CO_2, with the majority stemming from energy consumption, while the transportation sector accounted for a substantial share (İbik, 2024).

In light of these data, Istanbul needs to develop strategic policies aimed at increasing access to public transportation, reducing private vehicle use, and optimizing traffic planning across all transport modes simultaneously in order to achieve its sustainable mobility goals.

At the same time, Istanbul signed the "Deadline 2020" commitment in 2019, thereby adopting the goal of becoming a carbon-neutral and resilient city by 2050. In 2022, the city's application to the Climate-Neutral Cities Mission under the European Commission's Horizon Europe Programme was accepted, and Istanbul was included among the 112 cities to be supported in achieving climate neutrality by 2030. In addition, within the framework of the European Union-supported Sustainable Urban Mobility Plan (SUMP), Istanbul became the first city in Türkiye to implement this approach. The Istanbul SUMP adopts a human- and environment-oriented, accessible, participatory, and innovative transportation planning perspective, addressing urban mobility in a holistic manner. The plan's 2040 vision aims to establish a safe, integrated, accessible, and affordable transportation system aligned with Istanbul's geographical and historical characteristics. The nine core objectives defined within this framework include promoting public transport and active mobility modes, reducing automobile dependency and traffic congestion, strengthening environmental sustainability, and developing an economically resilient transportation infrastructure. Furthermore, the plan envisions a transportation system that supports compact and polycentric urban development, minimizes environmental impacts, and improves urban logistics processes (Kundakcı, 2023).

5.5. Contemporary Urban Problems in Istanbul: Earthquake Risk, the Decline of Green Spaces, and Housing Policies

Istanbul is confronted with numerous urban problems alongside rapid population growth and urbanization. Foremost among these is earthquake risk. Particularly after the 1999 earthquake, many older buildings and infrastructure in the city have not been retrofitted in accordance with modern standards. Within the scope of the "Republic of Türkiye, Istanbul Province Disaster Prevention and Mitigation Master Plan Including Seismic Microzonation," prepared by the Japan International Cooperation Agency (JICA) and the Istanbul Metropolitan Municipality (IMM), four different earthquake scenarios were developed. According to the earthquake risk analysis for Istanbul, ground conditions and proximity to fault lines significantly influence the impacts of earthquakes on settlements. In particular, high acceleration values are expected in the scenario earthquake of magnitude 7.7 in the southern parts of the city bordering the Marmara Sea. A number of fully equipped healthcare facilities are

also located in these areas. However, due to high acceleration levels, potential damage to these facilities may render already insufficient health services incapable of meeting post-earthquake needs. Furthermore, in neighbourhoods with a building coverage ratio of 100 percent, evacuation and search and rescue operations are expected to be adversely affected after an earthquake. This situation is likely to further complicate post-disaster crisis management (Kundak & Türkoğlu, 2007). The fact that a large proportion of the existing building stock in the city is not earthquake resistant, particularly the presence of old and structurally weak buildings, constitutes a serious safety threat. In this context, housing policies in Istanbul should promote not only the construction of new buildings but also the retrofitting of existing structures to make them earthquake resistant. Strengthening urban transformation projects through earthquake-resistant construction and expanding the scope of such processes should be among the primary objectives of Istanbul's housing policies.

With its rapidly growing population and dense built environment, Istanbul has undergone significant environmental transformations. While forest and agricultural areas have been rapidly decreasing, residential areas have expanded. This situation has placed severe pressure on the city's natural resources and led to a decline in green spaces. The amount of green space per capita has been steadily decreasing, particularly due to rapid urbanization and population growth. The concept of green space encompasses not only vegetation cover but also social areas accessible to the public. According to the Planned Areas Zoning Regulation, green spaces refer to open areas such as playgrounds, picnic areas, and walking paths. However, in Istanbul, green spaces have been gradually diminishing due to increasing construction within the urban fabric, thereby intensifying the urban heat island effect. Climate change has resulted in rising temperatures and increased drought, while irregular precipitation patterns and intense rainfall events have caused urban flooding. Under these conditions, increasing open green spaces and strengthening forest ecosystems are essential for regulating the urban climate and creating more liveable environments. Expanding green spaces is necessary in order to reduce urban heat islands, decrease energy consumption for cooling purposes, and provide high-quality living environments (Akkemik et al., 2021). In the implementation of housing policies in Istanbul, steps should be taken to protect and expand green spaces. In new housing projects, the integration of green areas, green roofs, landscaped spaces, and the widespread adoption of sustainable green infrastructure are of critical importance. In this way, a healthier and more liveable environment can be created for Istanbul's rapidly growing population.

Istanbul's housing policies have reached a critical juncture where ensuring social justice is imperative in the face of rapidly increasing population and

housing demand. However, current housing production is generally focused on luxury developments and urban transformation projects, while failing to provide sufficient housing for low-income groups. This situation deepens income inequalities and leads to social injustice. Housing policies in Istanbul should therefore place greater emphasis on social housing projects and affordable housing production in order to meet the shelter needs of low-income and middle-income households. Moreover, rapidly expanding urban transformation projects may result in displacement and the victimization of property owners. For this reason, housing policies in Istanbul should prioritize on-site transformation projects within urban transformation processes, minimizing the risk of displacement and developing solutions that protect residents' living environments. Both social housing production and on-site transformation initiatives would contribute to the development of a more equitable and sustainable housing policy for Istanbul.

6. Research Methodology

6.1. SWOT Analysis

This study aims to analyse the urban planning and governance capacities of London and Istanbul from a comparative perspective and is structured on the basis of a qualitative research methodology. The analytical framework of the study is supported by the SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis, which is widely used in the strategic planning and policy evaluation literature. SWOT analysis is a systematic analytical tool that enables a holistic assessment of the internal dynamics of a system or policy (strengths and weaknesses) as well as its external environmental conditions (opportunities and threats) (Hill & Westbrook, 1997; Pickton & Wright, 1998).

Within the scope of the research, SWOT analysis is employed to comparatively evaluate the urban planning models of London and Istanbul. The analysis is structured around the themes of legal and administrative structure, housing policies and urban regeneration models, public transportation and transport planning, green space policies and environmental sustainability, and governance models, which are systematically addressed in the sixth chapter of the study. In the SWOT analysis, strengths and weaknesses are identified on the basis of the legal regulations, institutional arrangements, and administrative practices inherent in the planning systems of both cities. Opportunities and threats, on the other hand, are examined in relation to external structural factors such as neoliberal urbanization dynamics, the climate crisis, urban population pressure, governance reforms, and socio-spatial inequalities. This approach allows SWOT analysis to be used not only as a tool for measuring institutional

performance, but also as a strategic evaluation instrument that incorporates the broader policy context (Glaister & Falshaw, 1999).

The SWOT-based comparative analysis reveals a clear contrast between London's strategic planning approach, which is grounded in a long-term spatial vision and supported by strong mechanisms of institutional coordination, and Istanbul's planning structure, which is centralized, fragmented, and often open to short-term policy interventions. The literature emphasizes that, particularly in the case of London, strategic spatial planning is integrated with participatory governance and environmental sustainability objectives (Healey, 2007; Tewdwr-Jones, 2012). In contrast, in the context of Istanbul, planning processes are reported to struggle to achieve a holistic structure due to institutional fragmentation, rent-seeking pressures, and social vulnerabilities (Dinçer, 2022). In this respect, SWOT analysis is employed in the study not merely as a descriptive tool of the current situation, but also as an analytical method that enables the generation of policy learning and governance reform implications for Istanbul. Through SWOT analysis, the study aims to make visible the areas of weakness and threat within Istanbul's urban planning system, while also deriving applicable policy and governance lessons from the London experience.

6.2. Research Findings

This section presents the findings of the SWOT analysis conducted within the scope of the research in a comparative framework. SWOT analysis is used as an analytical tool that allows the evaluation of the urban planning and governance models of London and Istanbul in terms of both their internal institutional structures and external transformation dynamics. The analytical process is structured around the themes of legal and administrative structure, housing policies and urban regeneration models, public transportation and transport planning, green space policies and environmental sustainability, and governance models, which are examined in detail in the seventh chapter of the study. Accordingly, strengths and weaknesses are identified based on the legal regulations, institutional arrangements, and administrative practices inherent in the planning systems of both cities, while opportunities and threats are evaluated within the framework of external factors such as the climate crisis, neoliberal urbanization dynamics, population pressure, and socio-spatial inequalities.

The findings of the SWOT analysis make the structural differences visible between the urban planning capacities of London and Istanbul and provide a comprehensive overview of the main advantages and limitations faced by

both cities. In this context, Table 1 presents a comparative overview of the urban planning and governance models of London and Istanbul along the axes of strengths, weaknesses, opportunities, and threats. It systematically demonstrates the areas in which current planning practices exhibit institutional resilience and those in which the need for structural reform becomes more pronounced.

Table 1. Comparative SWOT Analysis of Urban Planning and Governance Models in London and Istanbul

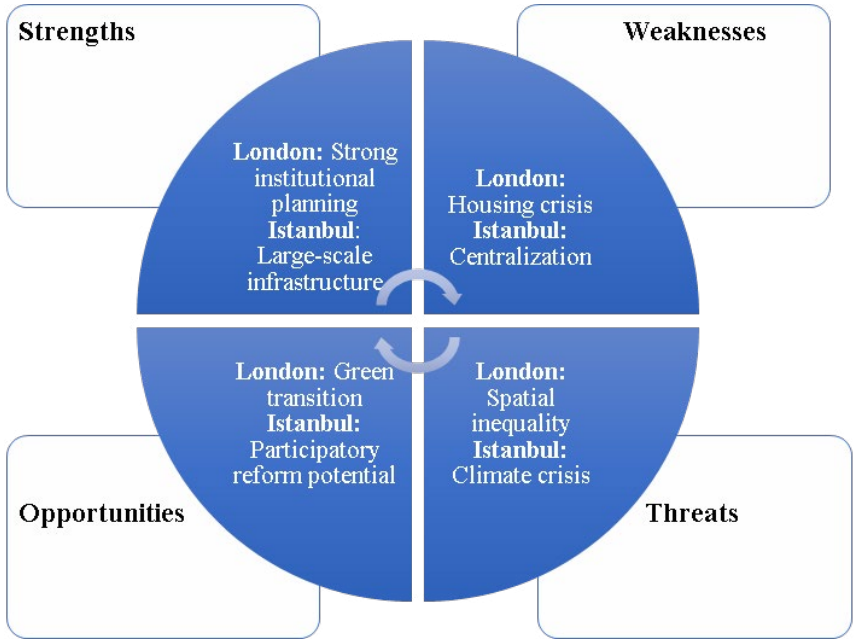
Strengths	Weaknesses
London: Strong and integrated strategic planning capacity through the institutionalized structure of the Greater London Authority (GLA) and the legally binding London Plan.	**London:** Deepening housing crisis resulting from excessive financialization of the housing market, high housing prices, and rent levels.
London: Integration of all transport modes under a single authority through Transport for London (TfL), enabling the development of sustainable transport-oriented policies.	**London:** Green Belt policies indirectly intensifying spatial inequalities by constraining housing supply.
London: A strong environmental protection regime through the Green Belt and Metropolitan Open Land (MOL).	**London:** Decision-making processes becoming difficult to understand at the societal level due to institutional complexity in governance structures.
Istanbul: High-capacity and multimodal transport infrastructure, including Marmaray, the Eurasia Tunnel, the Yavuz Sultan Selim Bridge, and maritime transportation.	**Istanbul:** An excessively centralized planning regime and limited decision-making capacity of local governments.
Istanbul: High potential for urban regeneration and infrastructure investments due to its large population and economic scale.	**Istanbul:** Institutional fragmentation in planning processes, frequent plan revisions, and legal uncertainty.
Istanbul: Development of data-driven and visionary planning initiatives through the Istanbul Planning Agency (IPA).	**Istanbul:** Rent-oriented urban regeneration practices leading to displacement and loss of social fabric.
Opportunities	**Threats**
Common: A global shift toward green infrastructure, resilient cities, and sustainable transport policies in response to the climate crisis.	**Common:** Increasing urban vulnerability due to climate change, disaster risks, and global economic fluctuations.

London: Potential for environmental leadership among global cities through carbon-neutral targets and green transition policies.	**London:** The risk of deepening social segregation due to the ongoing housing crisis and spatial inequalities.
London: Enhancement of spatial justice through the strengthening of social and affordable housing policies.	**London:** Growing pressure on housing and infrastructure systems as a result of population growth and migration.
Istanbul: Increased transport integration through the expansion of rail systems and the activation of maritime transport.	**Istanbul:** Rapid population growth and migration pressure exceeding infrastructural and environmental carrying capacity.
Istanbul: Growing public awareness supporting science-based and integrated planning reforms in response to earthquake and climate risks.	**Istanbul:** Irreversible loss of forests, agricultural lands, and water basins due to mega infrastructure projects.
Istanbul: Potential to strengthen participatory governance and multi-stakeholder decision-making mechanisms.	**Istanbul:** Further weakening of planning coherence due to tensions between central and local governments.

Note. Prepared by the authors.

Table 1 presents a comparative SWOT analysis that evaluates the urban planning and governance capacities of London and Istanbul within the framework of both internal structural characteristics and external transformation dynamics. The analysis demonstrates a clear contrast between London's strong institutional coherence and Istanbul's challenges related to centralization and fragmented governance. Accordingly, the SWOT analysis indicates that London offers a robust model characterized by an institutionalized, integrated, and strategic planning capacity, while at the same time facing structural challenges such as a persistent housing crisis and governance complexity. Istanbul, by contrast, exhibits a city profile with significant infrastructure scale and high transformation potential, yet with a limited strategic planning capacity due to centralization, fragmented governance, and weaknesses in environmental sustainability. The SWOT framework highlights that, for both cities, it is critical to preserve existing strengths while transforming weak areas through reform, improved governance, and integrated planning approaches. Figure 1 provides a concise summary of the SWOT comparison between the two cities.

Figure 1. SWOT Comparison of the Two Cities: London and Istanbul



Note. Prepared by the authors

This figure summarizes the fundamental differences between London and Istanbul in terms of their urban governance and planning approaches. London represents an institutional model based on transparent, participatory, and long term strategic planning, in which authority is shared between the metropolitan level, represented by the Mayor, and local districts, namely the boroughs. While this model offers key strengths such as strong institutional capacity and integrated transportation systems, it also entails challenges including high housing costs and social inequality. Istanbul, by contrast, operates within a hierarchical structure in which central government and ministerial authorities play a decisive role in decision making processes. This structure provides certain strengths, particularly the ability to make rapid decisions and to implement large scale projects effectively. However, it simultaneously faces complex challenges such as population pressure, earthquake risk, urban sprawl, and insufficient social infrastructure. In summary, London reflects the dynamics of a plan oriented and participatory system, whereas Istanbul embodies a model focused on project based and rapid transformation under centralized coordination. Both models contain distinct balances, opportunities, and challenges shaped by their respective urban contexts.

7. Comparison of Urban Planning Models in London and Istanbul

Istanbul and London have undergone different historical development trajectories and differ significantly in geographical, cultural, economic, and social terms. Within this context, the urban planning models of the two cities diverge markedly in line with their distinctive dynamics and conditions.

7.1. Differences in Legal and Administrative Structures in Urban Planning

a. London

London's urban planning system is structured within the framework of the Greater London Authority, established by the Greater London Authority Act of 1999 and operational since 2000. The Greater London Authority consists of a directly elected Mayor of London and the London Assembly, which performs an oversight function, and operates as a democratic, upper tier planning authority responsible for the city's strategic governance (Bowie, 2010). The Mayor holds strategic powers in areas such as spatial planning, housing, transportation, environment, and economic development, and these powers are primarily articulated through the London Plan (Greater London Authority, 2021).

The London Plan functions as a legally binding spatial development strategy covering the entirety of Greater London, guiding local planning decisions in accordance with principles of environmental protection and social inclusion (Healey, 1997). While the 33 London boroughs exercise local planning authority within their respective boundaries, these powers are subject to the strategic framework established by the Greater London Authority. As such, London's urban planning system is based on a multilevel governance model that combines local autonomy with centralized strategic coordination (LawTeacher, 2013).

b. Istanbul

Although urban renewal and urban transformation practices in Istanbul entered the academic literature in the 1970s, their emergence as a dominant instrument in planning practice occurred in the 1980s under the influence of neoliberal policies. During this period, the increasing involvement of the private sector in planning processes and the establishment of the Housing Development Administration (TOKİ) in 1984 paved the way for publicly led yet market oriented housing production. A critical turning point occurred in the 2000s through legal reforms, particularly Law No. 5366 and Law No. 6306 on the Transformation of Areas Under Disaster Risk, which accelerated

urban transformation processes and granted extraordinary powers to the central administration.

Under Law No. 6306, the designation of risky areas and buildings allows transformation to proceed without the consent of property owners, leading to the weakening of the principle of public interest in planning and the exclusion of local communities from decision making processes. This has resulted in urban transformation practices being conducted largely within a rent oriented framework, deepening social and spatial segregation and causing significant damage to cultural and social fabrics (Dinçer, 2022). At the same time, the involvement of multiple institutions and legal instruments in planning processes has generated authority conflicts and a lack of institutional coordination, thereby undermining planning coherence (Genç, 2008).

Although the Istanbul Metropolitan Municipality and district municipalities possess legally defined planning powers, the increasing interventions of the Ministry of Environment, Urbanization, and Climate Change through zoning legislation and special authorities significantly constrain the capacity of local governments to produce and implement plans. Frequent plan revisions facilitate speculative and rent driven decisions, erode legal certainty, and intensify uncertainty in investment and implementation processes (Şengül, 2009; Kuyucu & Ünsal, 2010; Dinçer, 2022). In this context, Istanbul's urban planning model presents a profile that struggles to develop a holistic and sustainable planning approach due to excessive centralization, fragmented administrative organization, and deviations from the principle of public interest.

7.2. Comparison of Housing Policies and Urban Transformation Models

a. London

Housing policies in London are shaped by objectives aimed at reducing the housing supply deficit, increasing the production of affordable housing, and safeguarding the right to housing for different income groups within the city. These policies focus not only on the quantitative expansion of housing stock but also on limiting adverse social effects such as gentrification and displacement. As the principal strategic document guiding housing policy, the London Plan emphasizes the production of social housing, accessibility, and principles of spatial equity (Greater London Authority, 2021).

Within this framework, the Affordable Homes Programme aims to support the delivery of affordable housing for low and middle income groups during the 2021 to 2026 period through approximately £4 billion in funding provided

by the central government and administered by the Mayor of London (Greater London Authority, 2025). Beyond increasing housing supply, the programme includes binding targets designed to preserve the proportion of social housing. In parallel, the Build to Rent model has gained prominence in recent years as a new form of ownership and production based on housing constructed specifically for rental purposes. The completion of more than 70,000 Build to Rent units in London, accounting for approximately 27 percent of new housing supply, indicates the growing significance of this model within the housing market (Brill & Durrant, 2021).

The legal foundation of housing policy in London has been strengthened particularly through the Planning and Compulsory Purchase Act 2004, which granted local authorities expanded powers in planning processes and facilitated the acceleration of social housing and regeneration projects. As a result, housing policies in London present a relatively integrated framework that seeks to limit the social costs of urban transformation through strong institutional capacity, legal enforceability, and intervention instruments attentive to social balance. Nevertheless, despite this robust institutional framework and the emphasis on social housing, extremely high housing prices and rental levels in central areas of London severely constrain access to affordable housing for low and middle income groups. Rising land values and market pressures, particularly in central and inner boroughs, render the supply of affordable housing insufficient to meet demand. This dynamic forces large segments of the population out of central London toward peripheral areas, satellite towns, and locations beyond the metropolitan region, leading to longer commuting distances, higher transportation costs, and deepening spatial inequalities. The literature emphasizes that this process is closely linked to the increasing financialization of the housing market in London and that spatial segregation has not been prevented despite social housing policies (Hamnett, 2009; Watt & Minton, 2016). In this respect, while the London case offers a strong model in terms of strategic planning and social housing provision, it also exhibits a significant structural weakness in its inability to resolve the issue of housing affordability under intense market pressures.

b. Istanbul

Housing policies in Istanbul have developed against a historical background shaped by intense migration pressures, rapid and unplanned urbanization, and the widespread emergence of informal housing. These policies are largely directed by the central government, with the Housing Development Administration of Türkiye (TOKİ) occupying a dominant role in housing production and urban

transformation processes. The extensive reliance on free market actors for housing supply, combined with limited urban land and increasing population pressure, has led to persistently rising housing and rental prices in Istanbul. This situation has progressively restricted access to the right to adequate housing for low and middle income households.

Urban transformation practices are predominantly initiated through the designation of risky areas by the central administration, with projects characterized by limited social participation and a strong orientation toward private sector involvement and rent based development. Transformation processes conducted under Law No. 6306 have been widely criticized due to displacement, loss of social fabric, weak consensus mechanisms, and legal uncertainties. These dynamics indicate that housing policies in Istanbul display a fragile structure in terms of social justice, inclusiveness, and sustainability.

7.3. Public Transport and Transportation Planning

a. London

Transportation planning in London is implemented through a centralized and integrated governance model under the authority of Transport for London (TfL), closely aligned with urban sustainability and climate objectives. TfL coordinates the underground, buses, suburban rail services, trams, cycling infrastructure, and road management within a single institutional framework, thereby ensuring institutional coherence and operational efficiency across the transport system (TfL, n.d.-a). London's transport policies are grounded in a strategic framework that seeks to reduce private car use, promote public transport and active mobility modes, and achieve long term zero carbon targets.

The London Underground, which began operation in 1863 and is among the oldest metro systems in the world, is continuously upgraded through capacity expansions, line extensions, and technological modernization, while large scale projects such as Crossrail, also known as the Elizabeth Line, have further strengthened metropolitan accessibility. In addition, the expansion of the electric bus fleet, the development of cycle superhighways, and the redesign of pedestrian priority public spaces constitute key components of London's sustainable transport strategy.

Demand management instruments represent another distinctive feature of London's transport policy. Measures such as the Congestion Charge, ultra-low emission zones (ULEZ), and parking restrictions function as effective regulatory tools aimed at reducing automobile dependency and encouraging the use of public transport (Leape, 2006). This integrated approach demonstrates that

London has developed a user oriented transport model characterized by high environmental sensitivity and strong strategic planning capacity. Nevertheless, the institutional coherence and environmental achievements attained in London's transport planning have also been subject to critical evaluation in the literature. In particular, demand management instruments such as the Congestion Charge, ULEZ, and high public transport fares are argued to impose a disproportionate financial burden on low income groups and to exacerbate spatial inequalities (Lucas, 2012). Rising transport costs may push lower income residents living in central areas toward peripheral locations, increasing commuting distances between home and workplace and heightening the risk of social exclusion (Banister, 2008). In this context, while London's transport model represents a strong example of environmental sustainability, it also contains structural tensions in terms of social justice and accessibility, indicating that sustainable transport policies should be assessed not only through their environmental outcomes but also in relation to their socio spatial impacts.

b. Istanbul

The transportation planning structure in Istanbul is shaped within a multi actor and fragmented governance framework. Transport services are distributed among several institutions, including the Istanbul Metropolitan Municipality, the Ministry of Transport and Infrastructure, and the Turkish State Railways. This institutional fragmentation generates coordination problems in strategic transport planning and complicates the establishment of an integrated governance model (Istanbul Metropolitan Municipality, 2022). Istanbul's public transport system comprises a wide range of modes, including metro and light rail systems, Marmaray, bus rapid transit, buses, maritime transport, minibuses, and shared taxis, and this diversity constitutes a significant potential for the city.

One of the strongest aspects of Istanbul's transport system lies in large scale infrastructure investments such as the Marmaray line, the Eurasia Tunnel, and the Yavuz Sultan Selim Bridge, as well as maritime transport operating along the Bosphorus. Marmaray provides a high capacity rail backbone at both urban and regional scales, enabling fast and uninterrupted connections between the Asian and European sides of the city. The Eurasia Tunnel offers an alternative road based crossing of the Bosphorus with the aim of alleviating congestion, particularly for private vehicle traffic. The Yavuz Sultan Selim Bridge, in turn, is a strategic transport investment intended to redirect heavy vehicles and transit traffic toward the northern corridor, thereby reducing pressure on the urban core. Despite these advantages, maritime transport remains underutilized relative to Istanbul's natural and geographical potential, and although rail system

investments have increased in recent years, full integration among transport modes and effective demand management have not yet been achieved.

Among the main disadvantages of Istanbul's transport planning are severe traffic congestion, dependence on Bosphorus crossings, a challenging topography, and high levels of private car use. In addition, the limited extent of cycling infrastructure across the city and the insufficient development of pedestrian oriented transport policies in both central and peripheral areas weaken the pursuit of sustainable mobility objectives. Within this framework, while Istanbul's transport system offers significant advantages in terms of capacity and modal diversity, it exhibits a fragile strategic planning capacity due to institutional fragmentation, lack of integration, and the limited internalization of sustainable transport policies. From a SWOT perspective, the principal threats in the transport sector for Istanbul include increasing population pressure, automobile dependency, and governance deficiencies, whereas key opportunities lie in the expansion of rail system investments, the activation of maritime transport, and the development of integrated transport management models.

7.4. Green Space Policies and Environmental Sustainability

a. London

London stands out among global cities for its strong institutional framework and long term planning approach in the fields of green space policy and environmental sustainability. Large scale public parks such as Hyde Park, Regent's Park, Hampstead Heath, and Richmond Park constitute the core components of the city's green infrastructure, and it is reported that approximately 33 percent of London's total area is composed of green spaces (Greater London Authority, 2021). The designations of Metropolitan Open Land (MOL) and the Green Belt provide these areas with strong legal protection against development and are strictly regulated through local authorities.

The London Plan conceptualizes green spaces not merely as recreational areas but as strategic infrastructure elements essential for climate change mitigation, public health, and ecological resilience. Within this framework, energy efficient building standards are mandated, while the use of solar energy in municipal buildings and the establishment of local energy cooperatives are actively promoted. In addition, the integration of parks with cycling and pedestrian networks strengthens green mobility connections and contributes to sustainable urban movement (Greater London Authority, 2021).

Nevertheless, London's green space policies also involve certain structural limitations. In particular, rapidly increasing housing prices and intense

development pressure in central areas generate spatial inequalities in access to green spaces. Access for low income groups may be more restricted in the outer zones of the city, thereby raising concerns related to environmental justice (Wolch et al., 2014). Furthermore, while the Green Belt policy effectively constrains urban sprawl, it has been criticized for indirectly deepening the housing crisis by limiting housing supply (Cheshire & Sheppard, 2002). In this respect, although London possesses a strong model that integrates green spaces into its planning system as a core component of environmental, social, and spatial sustainability, it faces significant governance challenges in ensuring equitable and balanced access to green areas under conditions of increasing population pressure and an ongoing housing crisis.

b. Istanbul

In Istanbul, extensive green areas such as Emirgan Grove, Belgrad Forest, Gülhane Park, and Maçka Park play an important role in maintaining ecological balance and meeting recreational needs. However, the distribution of green spaces across the city remains fragmented, and a systematic green infrastructure network has not yet been fully integrated. According to analyses conducted in 2022, the per capita amount of open and green space in Istanbul is approximately 7.20 square meters, a figure that remains well below the standards recommended by the World Health Organization (Green Area Management System Istanbul [Yeşil Alan Yönetim Sistemi], 2025). Consequently, green spaces in Istanbul are insufficient in relation to population growth and spatial expansion.

Another development that contributes to Istanbul's environmental sustainability capacity involves steps taken by local authorities to plan, measure, and make green spaces accessible to the public through strategic initiatives and inventory projects such as the Green Space Management System. Within this framework, strategy documents for the years 2024, 2030, and 2050 have been prepared with the aim of making green space policies more systematic, participatory, and sustainable (Green Istanbul [Yeşil İstanbul], 2021).

Rapid urban growth, unplanned development, and mega infrastructure projects in Istanbul exert substantial pressure on green and natural areas, thereby undermining environmental sustainability objectives. Green space planning in the city is pursued through a fragmented approach that lacks ecological integrity and connectivity, and it lags behind contemporary planning perspectives that prioritize climate sensitivity and biodiversity. While green space policies in Türkiye continue to be largely reduced to minimum per capita area calculations, the amount of active green space per capita in Istanbul remains extremely low. According to data from the Istanbul Planning Agency, this figure was 2.67 square

meters in 2016, and in the World Cities Culture Forum's 2019 study, Istanbul ranked last among 37 cities with 2.2 square meters per capita, whereas London and Oslo recorded 33 and 68 square meters respectively (Istanbul Planning Agency [IPA; İstanbul Planlama Ajansı], 2020). In particular, the contraction of agricultural and forest areas weakens ecosystem services in the urban periphery and highlights the urgent need for holistic and strategic green space policies.

7.5. A Comparative Assessment of Governance Models in London and Istanbul

a. London

London possesses an institutional structure characterized by strategic planning and participatory governance principles. Through the Greater London Authority (GLA), strategic decisions are produced in key policy areas such as spatial development, transportation, the environment, and housing by the directly elected Mayor of London and the London Assembly. This structure contextualizes and coordinates borough level plans through long term spatial strategies such as the London Plan, while also supporting the participation of civil society and stakeholders in decision making processes. In this way, London's governance model is oriented toward ensuring coherence between planning and implementation and toward institutionalizing transparency and accountability mechanisms (Sandford & Berry, 2024).

Despite these strengths, London's governance system is also associated with certain policy related limitations. An assessment of London's governance arrangements has argued that the system is excessively complex, making it difficult for citizens to interact with service providers, and that this complexity may lead to democratic outcomes such as insufficient participation and low levels of public satisfaction (Bogdanor, 2007). In addition, debates persist regarding the difficulties faced by planning decisions in balancing environmental regulations with economic expectations, particularly in the context of housing supply and the provision of local services. It has been noted that certain components of the plan have not sufficiently accelerated new housing production in practice, resulting in delays in the achievement of planning objectives (Edgar, 2024).

In this respect, while London's governance model stands out for its strong institutional resilience, comprehensive strategic planning practices developed in recent decades, and its capacity to support stakeholder participation, it also encounters challenges related to governance complexity, delays in the implementation of planning objectives, and the limited influence of certain social groups. These characteristics highlight not only the elements that strengthen

London's strategic planning capacity but also critical areas of evaluation with regard to social justice and democratic inclusiveness.

b. Istanbul

Despite being Türkiye's largest metropolis in economic and demographic terms, Istanbul does not possess a high degree of local autonomy or fiscal capacity, and the central government continues to play a decisive role in planning and project related decisions. Within Istanbul's current planning system, the involvement of multiple public institutions generates complexity and jurisdictional conflicts during the preparation, approval, and implementation of plans. This situation results in a lack of consistency in spatial planning processes and an expansion of central government interventions.

The influence of central authorities allows strategic decisions to be taken independently of the Istanbul Metropolitan Municipality (IMM) and district municipalities, and it has led to practices such as the designation of special project areas and risk areas that can restrict the planning authority of the IMM. This institutional configuration may produce a weak picture in terms of democratic governance principles and local participation. Although urban vision documents such as the Vision 2050 Action Plan prepared by the Istanbul Planning Agency (IPA) aim to strengthen local participation and to enhance the role of local actors in planning processes, there remain significant debates regarding their implementation capacity and continuity in practice (IMM & IPA, 2024).

From the perspective of participatory governance, while public meetings and participation mechanisms do exist in Istanbul, they often remain consultative in nature, and the direct influence of broader social groups on decision making processes tends to be limited. At the same time, certain elements within Istanbul's governance system can be identified as potential advantages. In particular, strategic planning documents developed by the IPA and the IMM include commitments to increasing the participation of local actors and emphasize the importance of inter institutional cooperation in planning processes. Such initiatives theoretically open the way for more inclusive and collaborative governance models. However, due to legal and institutional barriers in central local coordination, the practical implementation of these objectives remains limited.

In conclusion, Istanbul's governance model is characterized by a strong influence of the central administration, limited functioning of participation and transparency mechanisms, and weaknesses in the consistency and accountability of planning decisions. When compared with governance models

such as London's, which are organized around principles of local autonomy, transparency, and accountability, this situation constitutes a significant weakness that constrains Istanbul's strategic urban governance capacity.

8. Conclusion and Recommendations

The comparative SWOT analysis conducted in this study clearly reveals the structural differences, core capacities, and vulnerable areas of the urban planning and governance models of London and Istanbul. The findings indicate that London offers a long-term and predictable model of urban development through its institutionalized governance structure, legally binding strategic planning instruments, and integrated transport and environmental policies. However, the excessive financialization of the housing market, high housing costs, and the indirect supply constraints associated with Green Belt policies demonstrate that the London model contains significant structural limitations in terms of social justice and accessibility.

From the perspective of Istanbul, the SWOT findings show that the city possesses a high transformation potential due to large-scale infrastructure investments, multimodal transportation opportunities, and its demographic and economic dynamism. Nevertheless, this potential has not been translated into a sustainable and integrated planning capacity as a result of an overly centralized planning regime, institutional fragmentation, frequent plan revisions, and rent-oriented urban transformation practices. In particular, weaknesses in environmental sustainability, green space continuity, and participatory governance increase Istanbul's vulnerability in the face of the climate crisis and disaster risks.

Within this framework, the main lesson that can be drawn from the London model for Türkiye in general and for Istanbul in particular is the establishment of a balanced governance structure between strong central coordination and local autonomy. In Istanbul, planning processes should be restructured away from short-term and project-based approaches and reoriented around legally binding, long-term, and strategic spatial plans. The creation of a clear and explicit legal framework that reduces conflicts of authority between central and local governments would strengthen institutional coordination and predictability in planning processes.

At the same time, in line with the opportunities highlighted in the SWOT analysis, the climate crisis and earthquake risk should be regarded not only as threats for Istanbul but also as important transformation opportunities for science-based, integrated, and participatory planning reforms. Strengthening green infrastructure, integrating rail and maritime transport systems, and

redefining social and affordable housing policies around the principle of public interest emerge as critical tools for reducing urban inequalities.

In conclusion, this study demonstrates that the urban planning models of London and Istanbul should not be evaluated through simplistic dichotomies of "good" or "bad," but rather through their context-specific strengths and weaknesses. The SWOT analysis indicates that both cities must preserve their existing advantages while transforming their structural weaknesses through governance reforms, participatory planning instruments, and policies that place environmental sustainability at the center. For Istanbul, such a transformation requires the restructuring not only of physical space but also of decision-making processes and the broader culture of governance.

References

Abercrombie, P. (1945). *Greater London plan 1944*. His Majesty's Stationery Office.

Akkemik, Ü., Tolunay, D., Erdönmez, C., Atmış, E., & Kurdoğlu, O. (2021). İstanbul'un yeşil alan sorunları çerçevesinde yeşil duvarların irdelenmesi ve öneriler [Evaluation of green walls and suggestions in terms of green space problems of Istanbul]. *Bartın Orman Fakültesi Dergisi, 23*(1), 337–345. https://doi.org/10.24011/barofd.858230

Amati, M. (2008). Green belts: A twentieth-century planning experiment. In M. Amati (Ed.), *Urban green belts in the twenty-first century* (pp. 1–17). Ashgate.

Augé, M. (1995). *Non-places: Introduction to an anthropology of supermodernity* (J. Howe, Trans.). Verso.

Balaban, O. (2013). Neoliberal yeniden yapılanmanın Türkiye kentleşmesine bir diğer armağanı: Kentsel dönüşümde güncelin gerisinde kalmak [Another legacy of neoliberal restructuring on Turkish urbanization: Falling behind current trends in urban transformation]. In P. Tan & A. Çavdar (Eds.), *Müstesna şehrin istisna hali* [The exceptional state of the exceptional city] (pp. 51–80). Sel Yayınları.

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy*, *15*(2), 73–80. https://doi.org/10.1016/j.tranpol.2007.10.005

Bayat, A. (2013). *Life as politics: How ordinary people change the Middle East* (2nd ed.). Stanford University Press.

Bogdanor, V. (2007, January 30). *The government of London*. Gresham College. https://www.gresham.ac.uk/watch-now/government-london

Bowie, D. (2010). *Politics, planning and homes in a world city*. Routledge. https://doi.org/10.4324/9780203855577

Brill, F., & Durrant, D. (2021). The emergence of a Build to Rent model: The role of narratives and discourses. *Environment and Planning A: Economy and Space*, *53*(5), 1140–1157. https://doi.org/10.1177/0308518X20969417

Campbell, S. D. (2013). Sustainable development and social justice: Conflicting urgencies and the search for common ground in urban and regional planning. *Michigan Journal of Sustainability, 1*(1), 75–91. https://doi.org/10.3998/mjs.12333712.0001.007

Castells, M. (2009). *The rise of the network society.* John Wiley & Sons. https://doi.org/10.1002/9781444319514

Centre for London. (2019). *London: UK capital and country*. https://centreforlondon.org/reader/london-uk-capital-country/annex-1/

Cheshire, P., & Sheppard, S. (2002). The welfare economics of land use planning. *Journal of Urban Economics, 52*(2), 242–269. https://doi.org/10.1016/S0094-1190(02)00003-7

Davidoff, P. (1965). Advocacy and pluralism in planning. *Journal of the American Institute of Planners, 31*(4), 331–338. https://doi.org/10.1080/01944366508978187

Democratic Opening Platform in Architecture [Mimarlıkta Demokratik Açılım Platformu]. (2009, September 7). *İstanbul'un Çevre Düzeni Planı'nı İstanbul'un şehir plancıları tartışıyor* [Istanbul's urban planners are discussing the Istanbul Environmental Plan]. Retrieved May 9, 2025, from https://mimdap.org/haberler/ystanbulun-cevre-duzeni-planyny-ystanbulun-thehir-plancylary-tartythyyor-12-eylul-2009/

Department for Communities and Local Government. (2011). *A plain English guide to the Localism Act*. DCLG Publications. https://assets.publishing.service.gov.uk/media/5a79a0b740f0b642860d98a2/1896534.pdf

Dickens, C. (1836). *Sketches by Boz: Scenes and characters* (Chap. XII, *Greenwich Fair*). Victorian London. https://www.victorianlondon.org/books/boz-112.htm

Dinçer, İ. (2022). Kentsel dönüşümde kaybedilen müşterekler ve "sonra"ya sorular [The lost common spaces in urban transformation and the question of "what happens next?"]. *Mimarlık*, 427, 8–9.

Edgar, L. (2024, March 19). London mayor directed to review policies in the London Plan. *The Planner*. https://www.theplanner.co.uk/2024/03/19/london-mayor-directed-review-policies-london-plan#rsupsf-filtered=yes

Erder, S. (1996). *İstanbul'a bir kent kondu: Ümraniye* [A town landed on İstanbul: Ümraniye]. İletişim Publishing.

Fainstein, S. S. (2010). *The just city*. Cornell University Press.

Fainstein, S. S., & Campbell, S. (Eds.). (2011). *Readings in urban theory* (3rd ed.). Wiley-Blackwell.

Forester, J. (1982). Planning in the face of power. *Journal of the American Planning Association*, *48*(1), 67–80. https://doi.org/10.1080/01944368208976167

Genç, F. N. (2008). *Türkiye'de kentsel dönüşüm: Mevzuat ve uygulamaların genel görünümü* [Urban transformation in Türkiye: An overview of legislation and practices]. *Yönetim ve Ekonomi Dergisi, 15*(1), 115–130.

Glaister, K. W., & Falshaw, J. R. (1999). Strategic planning: Still going strong? *Long Range Planning*, *32*(1), 107–116. https://doi.org/10.1016/S0024-6301(98)00131-9

Greater London Authority. (2021). *The London Plan: The spatial development strategy for Greater London.*

Greater London Authority. (2025). *Homes for Londoners: Affordable homes programme 2021–2026.* Retrieved May 9, 2025, from https://www.london.gov.uk/programmes-strategies/housing-and-land/housing-and-land-funding-programmes/homes-londoners-affordable-homes-programme-2021-2026

Green Area Management System Istanbul [Yeşil Alan Yönetim Sistemi İstanbul; GAMS]. (2025). *Planning approach*. Retrieved September 10, 2025, from https://yaysis.istanbul/en/planning-approach/spatial-analysis

Green Istanbul [Yeşil İstanbul]. (2021). *Yeşil Alan Yönetim Sistemi Strateji Belgesi* [Green Area Management System strategy document]. Istanbul Metropolitan Municipality Department of Parks, Gardens and Green Areas. https://yesil.istanbul/project-detail_yesil-alan-yonetimi-strateji-belgesi

Gündoğdu, H. G. (2020). *Türkiye'de kamu yönetiminde koordinasyon* [Coordination of public administration in Türkiye]. Nobel Bilimsel Eserler.

Gündogdu, H. G., & Aytekin, A. (2022). The effects of sustainable governance to sustainable development. *Operational Research in Engineering Sciences: Theory and Applications, 5*(2), 117–151.

Hall, P. (2014). *Cities of tomorrow: An intellectual history of urban planning and design since 1880* (4th ed.). John Wiley & Sons.

Hamnett, C. (2009). Spatially displaced demand and the changing geography of house prices in London, 1995–2006. *Housing Studies*, *24*(3), 301–320. https://doi.org/10.1080/02673030902814580

Healey, P. (1997). *Collaborative planning: Shaping places in fragmented societies.* UBC Press.

Healey, P. (2007). *Urban complexity and spatial strategies: Towards a relational planning for our times.* Routledge.

Hill, T., & Westbrook, R. (1997). SWOT analysis: It's time for a product recall. *Long Range Planning*, *30*(1), 46–52. https://doi.org/10.1016/S0024-6301(96)00095-7

Innes, J. E. (1995). Planning theory's emerging paradigm: Communicative action and interactive practice. *Journal of Planning Education and Research, 14*(3), 183–189. https://doi.org/10.1177/0739456X9501400307

Imrie, R., & Lees, L. (Eds.). (2014). *Sustainable London?: The future of a global city.* Policy Press.

İbik, T. (2024). Sürdürülebilir kent içi ulaşım ve CO_2 emisyonu: İstanbul ili örneği [Sustainable urban transport and CO_2 emissions: The example of Istanbul]. *Yönetim ve Ekonomi Dergisi, 31*(3), 597–622. https://doi.org/10.18657/yonveek.1482257

Istanbul Metropolitan Municipality [İstanbul Büyükşehir Belediyesi]. (2022). *İstanbul ulaşım ve hareketlilik raporu* [Istanbul transportation and mobility report]. https://cdn-uym.ibb.gov.tr/cdn/uym/NewReports/Istanbul_Ulasim_ve_Hareketlilik_Raporu_Haziran_2022.pdf

Istanbul Metropolitan Municipality [İstanbul Büyükşehir Belediyesi] & Istanbul Planning Agency [İstanbul Planlama Ajansı]. (2024). *İstanbul Vizyon 2050 eylem planı* [Istanbul Vision 2050 action plan]. https://sehirplanlama.ibb.istanbul/wp-content/uploads/2025/05/VIZYON-EYLEM-PLANI-web_yeni.pdf

Istanbul Metropolitan Municipality Department of Urban Planning [İstanbul Büyükşehir Belediyesi Şehir Planlama Şube Müdürlüğü]. (n.d.). *İBB Atatürk Kitaplığı* [Istanbul Metropolitan Municipality Atatürk Library]. Retrieved May 6, 2025, from https://sehirplanlama.ibb.istanbul/beyoglu-arsivi-haritalar/

Istanbul Planning Agency [İstanbul Planlama Ajansı]. (2020). *İstanbul kentsel analiz raporu* [Istanbul urban analysis report]. Vision 2050 Office. https://vizyon2050.istanbul/upload/content/202093_185264.pdf

Kalender Çetinkaya, S. (2019). Sürdürülebilir kentler ve toplumlar İngiltere Prince's Foundation for Building Community örneği [Sustainable cities and communities case study of Prince's Foundation for Building Community]. *İdealkent, 10*(27), 573–593. https://doi.org/10.31198/idealkent.508982

Khan, S. (2023). *Help end rough sleeping today.* Retrieved May 4, 2025, from https://www.london.gov.uk/join-our-mission-end-rough-sleeping

Koramaz, E. (2017). *Yaşanan seller doğal afet değildir! Çarpık kentleşme ve yetersiz altyapı sellere neden olmaktadır* [The floods that occurred were not natural disasters! Unplanned urbanization and inadequate infrastructure are causing the floods]. Retrieved May 11, 2025, from https://www.tmmob.org.tr/icerik/yasanan-seller-dogal-afet-degildir-carpik-kentlesme-ve-yetersiz-altyapi-sellere-neden

Kundakcı, E. (2023). *İstanbul'da sürdürülebilir ulaşıma doğru: Kent gündemine bakış* [*Towards sustainable transportation in Istanbul: A look at the city's agenda*]. İstanbul Planlama Ajansı. https://ipa.istanbul/images/Calismalar/istanbulda-surdurulebilir-ulasima-dogru-22954.pdf

Kundak, S., & Türkoğlu, H. (2007). İstanbul'da deprem riski analizi [Earthquake risk analysis in Istanbul]. *İTÜ Dergisi Mimarlık, Planlama, Tasarım, 6*(2), 37–46.

Kurye Haber. (2025). İstanbul trafiği zirveye yerleşti: Araç sayısı 5,5 milyon, motosiklet sayısı 800 bin'i aştı [Traffic in Istanbul reaches peak: Number of vehicles exceeds 5.5 million, number of motorcycles over 800,000]. https://kuryehaber.com/2025/01/istanbul-trafigi-zirveye-yerlesti-arac-sayisi-55-milyon-motosiklet-sayisi-800-bini-asti/

Kuyucu, T., & Ünsal, Ö. (2010). 'Urban transformation'as state-led property transfer: An analysis of two cases of urban renewal in Istanbul. *Urban Studies*, *47*(7), 1479–1499. https://doi.org/10.1177/0042098009353629

Law No. 6306 (2012). Afet riski altındaki alanların dönüştürülmesi hakkında kanun [Law on the transformation of areas under disaster risk]. *Resmî Gazete* [Official Gazette of the Republic of Türkiye], No. 28309, May 31, 2012. https://resmigazete.gov.tr/eskiler/2012/05/20120531-1.htm

LawTeacher. (2013, November). *Greater London Authority Act 1999.* https://www.lawteacher.net/acts/greater-london-authority-act-1999.php?vref=1

Leape, J. (2006). The London congestion charge. *Journal of Economic Perspectives*, *20*(4), 157–176. https://doi.org/10.1257/jep.20.4.157

Lees, L., Slater, T., & Wyly, E. (2008). *Gentrification.* Routledge.

Londra Aktüel. (2025, April 19). *Londra'da konut krizi derinleşiyor: Kiralardan kaçanlar botlara taşınıyor* [*Housing crisis deepens in London: Those fleeing rent are moving to boats*]. https://londraaktuel.com/londrada-konut-krizi-derinlesiyor-kiralardan-kacanlar-botlara-tasiniyor

Lucas, K. (2012). Transport and social exclusion: Where are we now? *Transport Policy*, *20*, 105–113. https://doi.org/10.1016/j.tranpol.2012.01.013

Massey, D. S. (1990). American apartheid: Segregation and the making of the underclass. *American Journal of Sociology*, *96*(2), 329–357. https://doi.org/10.1086/229532

Mayor of London. (n.d.). *Old Oak and Park Royal Development Corporation equity, diversity and inclusion strategy and action plan 2022–2027.* https://www.london.gov.uk/sites/default/files/equity_diversity_and_inclusion_strategy_and_action_plan_2022-2027.pdf

Mumford, L. (1961). *The city in history: Its origins, its transformations, and its prospects*. Harcourt, Brace & World.

Musterd, S., & Ostendorf, W. (Eds.). (2013). *Urban segregation and the welfare state: Inequality and exclusion in western cities*. Routledge.

Olmsted, F. L. (1910). City planning: An introductory address. *American Civic Association, 2*(4), 1–30.

Özerdem, A., & Barakat, S. (2000). After the Marmara earthquake: Lessons for avoiding short cuts to disasters. *Third World Quarterly*, *21*(3), 425–439. https://doi.org/10.1080/713701047

Öztürk, S., & Genç, P. (2014). The relationship between urban design and urban quality of life: "A case study of Kastamonu city-Turkey". *Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi, 15*(2), 114–125. https://doi.org/10.17474/acuofd.36085

Peach, C. (2006). Islam, ethnicity and South Asian religions in the London 2001 census. *Transactions of the Institute of British Geographers, 31*(3), 353–370. https://doi.org/10.1111/j.1475-5661.2006.00214.x

Phillips, D. (2010). Minority ethnic segregation, integration and citizenship: A European perspective. *Journal of Ethnic and Migration Studies, 36*(2), 209–225. https://doi.org/10.1080/13691830903387337

Pickton, D. W., & Wright, S. (1998). What's SWOT in strategic analysis? *Strategic Change*, *7*(2), 101–109. https://doi.org/10.1002/(SICI)1099-1697(199803/04)7:2<101::AID-JSC332>3.0.CO;2-6

Pierre, J. (2011). *The politics of urban governance.* Bloomsbury Publishing.

Rankl, F., Barton, C., & Carthew, H. (2023). *Green belt*: *Research briefing.* The House of Commons Library. Retrieved May 4, 2025, from https://researchbriefings.files.parliament.uk/documents/SN00934/SN00934.pdf

Republic of Türkiye Ministry of Environment and Urbanization [Türkiye Cumhuriyeti Çevre ve Şehircilik Bakanlığı]. (2017). *Şehircilik Şûrası: Şehirlerimizde kimlik, planlama ve tasarım konuları. Şûra belgeleri* [Urban planning council: Issues of identity, planning and design in our cities. Council documents]. https://sehirciliksurasi.csb.gov.tr/s-ranin-gerekcesi-ve-amaci-i-272

Republic of Türkiye Ministry of Public Works and Settlement [Türkiye Cumhuriyeti Bayındırlık ve İskân Bakanlığı]. (2009). *Kentleşme Şûrası 2009: Komisyon raporları ve genel kurul çalışmaları* [Urbanization Council 2009: Commission reports and general assembly minutes]. https://webdosya.csb.gov.tr/db/kentges/editordosya/genel_kurul_kitabi.pdf

Republic of Türkiye Ministry of Trade [Türkiye Cumhuriyeti Ticaret Bakanlığı]. (2025). *Trafik yoğunluğu: İstanbul dünyada zirvede, ABD'ye yıllık faturası 85 milyar dolar* [Traffic congestion: Istanbul ranks first in the world for traffic problems, costing US$85 billion annually]. https://dtybs.ticaret.gov.tr/blog/post/31636/

Robinson, J. (2011). Cities in a world of cities: The comparative gesture. *International Journal of Urban and Regional Research*, *35*(1), 1–23. https://doi.org/10.1111/j.1468-2427.2010.00982.x

Sandford, M., & Berry, R. (2024). *The Greater London Authority: Powers and functions*. Retrieved May 4, 2025, from https://www.london.gov.uk/who-we-are/what-london-assembly-does/london-assembly-research-unit-publications/greater-london-authority-powers-and-functions

Sassen, S. (2001). *The global city: New York, London, Tokyo.* Princeton University Press.

Serin, B., Smith, H., & McWilliams, C. (2020). The role of the state in the commodification of urban space: The case of branded housing projects, Istanbul. *European Urban and Regional Studies*, *27*(4), 342–358. https://doi.org/10.1177/0969776420920921

Smith, N. (2005). *The new urban frontier: Gentrification and the revanchist city*. Routledge.

Southwark Council. (2025). *Major milestone reached at Ledbury Estate renewal as council works to replace unsafe towers and transform the estate.* Retrieved May 4, 2025, from https://www.southwark.gov.uk/news/2025/major-milestone-reached-ledbury-estate-renewal-council-works-replace-unsafe-towers-and

Şengül, H. T. (2009). *Kentsel çelişki ve siyaset* [Urban conflict and politics]. İmge Yayıncılık.

Tewdwr-Jones, M. (2012). *Spatial planning and governance: Understanding UK planning*. Palgrave Macmillan.

The London Plan. (2021). *Chapter 10 transport: The London plan 2021.* Retrieved May 4, 2025, from https://www.london.gov.uk/programmes-strategies/planning/london-plan/the-london-plan-2021-online/chapter-10-transport?

The Union of Chambers of Turkish Engineers and Architects [Türk Mühendis ve Mimar Odaları Birliği; UCTEA]. (2014). *3. havalimanına ilişkin basın toplantısı 16 Eylül 2014 tarihinde yapıldı* [A press conference regarding the 3rd airport was held on September 16, 2014]. Istanbul Branch of the Chamber of Civil Engineers. Retrieved May 9, 2025, from https://istanbul.imo.org.tr/TR%2C55649/3-havalimanina-iliskin-basin-toplantisi-16-eylul-2014-tarihinde-yapildi.html

Tonkiss, F. (2013). *Cities by design: The social life of urban form*. Polity Press.

Transport for London. (n.d.-a). *About TfL.* Retrieved May 25, 2025, from https://tfl.gov.uk/corporate/about-tfl/

Transport for London. (n.d.-b). *The Mayor's transport strategy.* Retrieved May 11, 2025, from https://tfl.gov.uk/corporate/about-tfl/the-mayors-transport-strategy

Turgut, S. F., & Demirkol, Ö. T. (2023). Kentsel dönüşüm yasa değişikliği: Dönüşüm kimin için? [Changes to the urban transformation law: Who is the transformation for?]. *İstanbul Planlama Ajansı Kent Gündemine Bakış*.

Twinch, E. (2022). *Notting Hill Genesis submits plans for 600 homes on Aylesbury estate*. Retrieved May 4, 2025, from https://www.housingtoday.co.uk/news/notting-hill-genesis-submits-plans-for-600-homes-on-aylesbury-estate/5118705.article

UN-Habitat. (2020). *World cities report 2020: The value of sustainable urbanization*. United Nations Human Settlements Programme. Retrieved September 22, 2025, from https://unhabitat.org/sites/default/files/2020/10/wcr_2020_report.pdf

Vertovec, S. (2007). Super-diversity and its implications. *Ethnic and Racial Studies, 30*(6), 1024–1054. https://doi.org/10.1080/01419870701599465

Vizyon 2050. (2020, August 25). *History of Istanbul metropolitan area planning.* Retrieved May 9, 2025, from https://vizyon2050.istanbul/newdetail-2-8-history_of_istanbul_metropolitan_area_planning

Wacquant, L. (2008). *Urban outcasts: A comparative sociology of advanced marginality*. Polity Press.

Watt, P., & Minton, A. (2016). London's housing crisis and its activisms: Introduction. *City*, *20*(2), 204–221. https://doi.org/10.1080/13604813.2016.1151707

World Commission on Environment and Development. (1987). *Our common future.* Oxford University Press.

Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. *Landscape and Urban Planning, 125*, 234–244. https://doi.org/10.1016/j.landurbplan.2014.01.017

Yenice, M. S. (2014). Türkiye'nin kentsel dönüşüm deneyiminin tarihsel analizi [A historical analysis of Türkiye's urban transformation experience]. *Balıkesir Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *16*(1), 76–88.

Zukin, S. (2010). Naked city: The death and life of authentic urban places. Oxford University Press. https://doi.org/10.1093/oso/9780195382853.001.0001

CHAPTER 4

Management of Disaster and Climate-Induced Migration: Local Government Capacity and Policies in the Case of Antalya

Halil Durur[1], Arzu Dilaveroğlu[2]

1. Introduction

Although many sociologists and anthropologists trace the phenomenon of migration back to human history, migration and mobility have existed since the very beginning of life on Earth. From the emergence of living beings, movement has been a fundamental strategy for meeting basic needs, particularly access to food. Because this mobility has been continuous, living beings have persistently experienced displacement and migration over time.

The fundamental driving force behind migration is the necessity of survival or the aspiration for a better quality of life. Individuals tend to migrate due to factors such as war, education, language acquisition, employment, health conditions, food crises, climate change, or natural disasters. Disasters, in particular, are natural phenomena that have occurred throughout history and continue to pose significant challenges.

Türkiye's geological and climatic characteristics create conditions conducive to the frequent occurrence of natural disasters such as earthquakes, forest fires, floods, and similar events. These disasters not only result in sudden destruction but also generate long lasting and structural impacts on the socioeconomic and demographic composition of affected regions. For example, the earthquake that occurred in Van in 2011 forced hundreds of thousands of people into displacement. Similarly, following the earthquakes of 6 February 2023, many institutions in Antalya were mobilized to provide assistance to disaster affected regions. Some individuals affected by the earthquakes resided temporarily in Antalya, while others chose to settle there permanently, and some eventually

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returned either to their original places of residence or to other regions. This process clearly demonstrates the demographic and socioeconomic transformations that disasters impose on urban areas.

In addition, the forest fires that occurred in various regions of Türkiye in 2021 and 2022, particularly in Manavgat, led to the evacuation of many residents and their temporary relocation to safer areas. Storms, tornadoes, floods, and overflows experienced in Antalya have also resulted in significant loss of life and property, underscoring once again the importance of disaster preparedness and effective response mechanisms. These natural disasters have profoundly affected the living conditions and social structures of local communities, leading to lasting changes in the regional demographic landscape.

The main research question of this study is to examine how climate change affects disaster-induced migration dynamics in Antalya and to analyze the roles played by local governments and other relevant actors in managing these processes. The study focuses specifically on forced migration resulting from the destructive impacts of disasters such as forest fires, earthquakes, storms, tornadoes, floods, and inundations on residential and agricultural areas. Antalya constitutes a particularly relevant case, given its geographical location within the Mediterranean basin, its exposure to multiple climate-related hazards, and its growing role as a destination for post-disaster internal migration in Türkiye.

To examine displacement dynamics within a broader analytical framework, the study draws on selected statistical indicators from the *Global Report on Internal Displacement* published by the Internal Displacement Monitoring Centre (IDMC). These data allow disaster-related displacement to be assessed across different temporal and spatial dimensions, situating Antalya's experience within wider national and global trends. However, the primary emphasis of the study lies not in quantitative measurement alone, but in understanding governance responses, institutional capacity, and policy adaptation at the local level.

The core objective of the study is to analyze how climate change influences migration dynamics triggered by natural disasters in Antalya and to evaluate how these dynamics are addressed by local governments and other stakeholders. Particular attention is given to the post-disaster experiences of displaced populations, including adaptation processes in new settlement areas, the potential for return migration, and the governance challenges that emerge in these contexts. Within this framework, the study examines the roles of key actors such as the Türkiye's Disaster and Emergency Management Presidency (Afet ve Acil Durum Yönetimi Başkanlığı [AFAD]), local governments, and non-governmental organizations in developing policy responses to disaster-related

displacement. The empirical focus centers on an in-depth analysis of disasters, migration, and climate change responses as reflected in the activity reports of the Antalya Metropolitan Municipality (Antalya Büyükşehir Belediyesi [AMM], 2020; 2021; 2022; 2023). Strategic policy documents, including the disaster risk reduction plan prepared by the Antalya Provincial Directorate of Disaster and Emergency Management, the disaster risk reduction and climate adaptation action plan, and the earthquake master plan of the AMM, are examined through content analysis. This approach enables a systematic assessment of how disaster risk, climate adaptation, and migration considerations are integrated into local governance practices.

By situating disaster-induced migration within the intersecting domains of climate change, urban resilience, and local governance, this study aims to contribute to both academic debates and policy discussions. The findings are expected to provide valuable insights for policymakers at local and national levels in the development of more effective disaster management and risk reduction strategies. At the same time, the study seeks to support the formulation of policies that promote resilient communities, reduce disaster risks, and address the long-term socio-spatial consequences of climate- and disaster-related migration.

2. Disasters and Migration

The concept of disaster generally refers to the destructive consequences caused by natural events; however, in contemporary disaster management literature, it is addressed within a much broader conceptual framework. While the Turkish Language Association defines a disaster as destruction caused by various natural events, AFAD conceptualizes it as the consequences of natural, technological, or human induced events that affect society as a whole or specific segments of it, lead to physical, economic, and social losses, disrupt daily life and human activities, and exceed the coping capacity of the affected community using its own resources. In this perspective, a disaster is defined not merely as an isolated event but rather through the impacts and outcomes it generates (Turkish Language Association [Türk Dil Kurumu; TDK], n.d.; AFAD, n.d.). Disasters are generally classified into two main categories based on their origins: anthropogenic disasters and natural disasters. Anthropogenic disasters encompass events that arise directly or indirectly from human activities and result in social, economic, and environmental destruction. Human induced fires, drought and sinkhole formation resulting from unplanned and excessive groundwater use, wars, biological, chemical, and nuclear accidents, as well as terrorist acts, are commonly cited examples of this category.

Natural disasters, on the other hand, occur as a result of geological, meteorological, and climatic processes and play a decisive role in the emergence of migration phenomena. Sudden onset events such as earthquakes, floods, landslides, avalanches, and similar hazards, along with slow onset processes such as drought and climate change, particularly in vulnerable regions, trigger forced population movements. In this context, although migration initially emerges as a consequence of natural disasters, it may also acquire the characteristics of a secondary anthropogenic disaster due to the demographic, economic, and socio psychological effects it produces.

Within the disaster literature, natural disasters are further categorized as sudden onset and slow onset disasters. Sudden onset disasters include events such as earthquakes, floods, landslides, tornadoes, hurricanes, and fires, which have high destructive potential over a short period of time, whereas slow onset disasters encompass long term processes such as drought, erosion, and climate change, whose impacts intensify gradually over time. When evaluated in the context of Antalya, these types of disasters not only shape internal migration dynamics but also directly affect the capacity of local governments in managing migration and disasters.

Disasters not only generate destructive impacts on the physical environment but also produce profound socio economic consequences that transform social structures and adversely affect ecological balance. Data from the IDMC demonstrate the global scale reached by forced displacement caused by disasters as well as by conflict and violence. Accordingly, in 2020 the total number of people displaced as a result of natural disasters and political factors reached 40.5 million, representing the highest level recorded in the past decade.

During the same period, disaster related displacement was significantly higher than displacement caused by conflict and violence. Indeed, while approximately 9.8 million people were displaced due to conflict and violence in 2020, the number of those displaced by disasters amounted to 30.7 million. A substantial proportion of these displacements resulted from climate and weather related disasters, with floods, storms, and similar meteorological events emerging as key drivers of forced migration. In this period, China, the Philippines, and Bangladesh stood out as the countries experiencing the highest levels of disaster induced displacement (Tek, 2021).

As of 2022, disasters became one of the primary determinants of new internal displacement worldwide, accounting for more than half of total displacements and leading to approximately 32.6 million new cases of forced internal movement. Data published by the IDMC in 2023 clearly reveal the decisive influence of disasters on internal migration dynamics. In this context,

Table 1 presents regional and global internal displacement data based on the IDMC statistics for 2022.

Table 1. Regional and Global Internal Displacement according to IDMC 2022 Statistics

Region	Based on conflict and violence	Based on migration
Sub-Saharan Africa	9 million	7,4 million
Middle East and North Africa (MENA)	482,000	305,000
East Asia and the Pacific	1,2 million	10,1 million
South Asia	35,000	12,5 million
American continent	533,000	2,1 million
Europe and Central Asia	17,1 million	107, 000
Total	**28,3 million**	**32,6 million**

Note. From IDMC (2023).

Findings based on IDMC data indicate that in 2022 new internal displacements in Sub Saharan Africa increased by 17 percent compared to the previous year, reaching 16.5 million people. The primary driver of this increase was disaster induced displacement, which nearly tripled to 7.4 million and represented the highest level ever recorded for the region. In the Middle East and North Africa region, displacement caused by conflict and violence continued to decline for the third consecutive year. Nevertheless, disaster triggered displacement increased by 25 percent compared to the previous year, reaching approximately 305,000 cases.

In East Asia and the Pacific, disasters constituted the main cause of displacement in 2022. However, the total number of displacements recorded in the region, at 10.1 million, remained below the 13.7 million recorded in 2021 and below the ten-year average of 11.6 million. This relative decline is largely attributed to the continued influence of the La Niña climate phenomenon for a third consecutive year, which limited precipitation and cyclone activity across much of East and Southeast Asia.

In South Asia, disasters have traditionally remained the principal driver of displacement, and 2022 was no exception to this pattern. Approximately 12.5 million disaster related displacements were recorded in the region, a figure corresponding to nearly twice the ten-year average. In the Americas, the number

of displacements increased from around two million in 2021 to 2.6 million in 2022, with approximately 80 percent of these movements attributed to disasters. Brazil and the United States emerged as the leading countries, together accounting for nearly one third of displacement across the continent.

In Europe and Central Asia, 2022 marked a significant turning point in displacement trends, primarily due to the armed conflict in Ukraine. This crisis alone resulted in 16.9 million displacements, making Ukraine the fastest growing case of conflict induced displacement at the global level (IDMC, 2023).

An examination of IDMC internal displacement data for the period between 2008 and 2022 reveals that in 2022 approximately 28 million people experienced new internal displacement due to conflict and violence, while 32.2 million were displaced as a result of natural disasters. By contrast, the total stock of internally displaced persons in the same year consisted of 60.9 million displaced by conflict and violence and 8.9 million displaced by disasters (IDMC, 2023).

These data demonstrate that disasters are a decisive factor in new internal displacement, whereas conflict and violence remain more dominant in the overall stock of internally displaced populations. Nevertheless, disaster induced displacement has shown an increasing trend within internal migration movements over time. Forced migration driven by natural disasters as well as by conflict and violence generates multidimensional economic, social, and political impacts, giving rise to significant governance challenges. When risk conditions are eliminated, it becomes essential to develop comprehensive policies that support the safe and voluntary return of displaced populations. In this context, Table 2 presents region based statistics on internal displacement caused by conflict and violence and by disasters according to IDMC 2023 data.

Table 2. Internal Displacement by Region according to IDMC 2023 Statistics

Region	Based on conflict and violence	Based on migration
Sub-Saharan Africa	13,466,000	6,032,000
Middle East and North Africa (MENA)	4,058,000	1,331,000
East Asia and the Pacific	1,462,000	9,036,000
South Asia	69,000	3,596,000
American continent	637,000	2,123,000
Europe and Central Asia	779,000	4, 276,000
Total	20,5 million	26,4 million

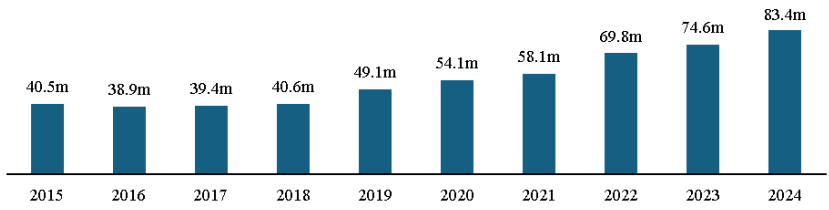
Note. From IDMC (2024, pp. 2-3).

According to the data presented in Table 2, displacement caused by conflict, violence, and natural disasters remained at a high level worldwide in 2023. The IDMC 2024 report indicates that, at the global level, 20.5 million people were displaced due to conflict and violence, while 26.4 million were displaced as a result of natural disasters. Africa, particularly Sub Saharan Africa and the Middle East and North Africa regions, stands out as one of the areas where both types of displacement were most prevalent. In Asia, natural disasters constituted a significant driver of displacement, especially in the East Asia and Pacific region. The report further notes that in 2023 approximately 4,053,000 people in Türkiye were internally displaced due to natural disasters (IDMC, 2024, pp. 2-3).

Internally displaced persons, also referred to as internal migrants, are defined as individuals or groups who are forced to leave their habitual places of residence due to armed conflict, widespread violence, human rights violations, or disasters, but who remain within internationally recognized state borders (IDMC, 2025, p. 5). In this context, Figure 1 presents data on the year-end total number of internally displaced persons by year for the period 2015-2024.

Internally displaced persons are thus understood as individuals or communities who have been compelled to abandon their permanent residences as a result of armed conflict, generalized violence, human rights violations, or natural disasters, while remaining within the internationally recognized borders of their country (IDMC, 2025, p. 5). Accordingly, Figure 1 provides data on the year end totals of internally displaced persons for the period between 2015 and 2024.

Figure 1. Year End Total Number of Internally Displaced Persons by Year (2015-2024)



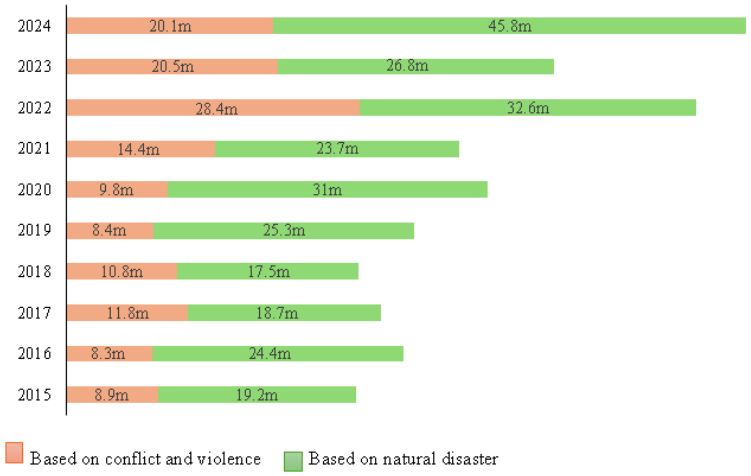
Note. From IDMC (2025); IDMC (n.d.).

The data presented in Figure 1 indicate the total number of individuals who remained internally displaced at the end of the relevant year and therefore represent a stock indicator. In this context, the reported figures include not only

newly displaced persons during the given year but also those carried over from previous years whose situations have not yet been resolved through durable solutions.

As illustrated in the graph, the number of individuals forced into internal migration for various reasons more than doubled during the 2015–2024 period. This trend demonstrates the deepening nature of forced internal displacement and highlights the growing need for more effective policies and measures at both local and global levels to address the underlying drivers of this process. Within this framework, Figure 2 presents annual internal displacement movements by source type for the period between 2015 and 2024.

Figure 2. Annual Internal Displacement Movements by Source Type (2015-2024)



Note. From IDMC (2025, n.d.).

The data presented in Figure 2 illustrate the total number of annual displacement movements resulting from conflict and violence as well as natural disasters over time. According to the methodological approach adopted by the IDMC, this indicator refers to forced displacement events recorded within a given year and may include multiple displacement episodes experienced by the same individual. For this reason, these data are considered a flow indicator. In line with this conceptual distinction, a direct correspondence between the year-end totals of internally displaced persons presented in Figure 1 and the annual displacement totals shown in Figure 2 should not be expected. As emphasized in IDMC reports, in contexts where protracted and repeated displacement is

widespread, individuals may be displaced multiple times within a single year, while some displacement situations may reach temporary or durable solutions within the same period. Consequently, high annual displacement figures may coexist with different levels of internally displaced populations at the end of the year.

An examination of the trends in Figure 2 reveals a marked increase in disaster-related displacement, particularly in 2020, 2022, and 2024. Indeed, in 2024 alone, approximately 45.8 million people worldwide were displaced solely as a result of natural disasters.

Public policies implemented during the COVID-19 pandemic to mitigate health risks had a significant impact on individual mobility practices and migration decisions (González-Leonardo et al., 2022; Şengün & Emeç, 2022, pp. 2098-2099). In this context, the decline observed in migration tendencies throughout 2021 can be interpreted as a concrete reflection of the effects of such policy interventions on societal behavioural patterns. In particular, the tightening of border controls, travel restrictions, and comprehensive public health measures led many individuals to postpone migration decisions or to reassess them altogether.

The increase in forced internal displacement and the resulting migration movements clearly demonstrate the transformative impact of climate change–induced extreme weather events on migration dynamics. At the same time, a notable rise in conflict- and violence-related displacement was observed in 2022. The simultaneous escalation of disaster- and conflict-induced migration during this period highlights the crisis-amplifying and mutually reinforcing roles of these two factors. These findings suggest that disasters and conflicts should not be treated as independent processes but rather as interconnected dynamics that trigger multiple and overlapping crises (Bettini et al., 2017). In this regard, sustainable migration policies must adopt a holistic approach that addresses not only disaster risks but also underlying socio-political vulnerabilities.

3. Disaster-Induced Migrations in Türkiye

According to records from the International Disaster Database (EM-DAT), a total of 32 large-scale flood disasters occurred in Türkiye between 1903 and 2006. As a result of these events, 1,272 people lost their lives and approximately 99,000 individuals were left homeless (Republic of Türkiye Ministry of Forestry and Water Affairs [Orman ve Su İşleri Bakanlığı], 2013). Complementing this historical overview, Table 3 presents data on disaster-induced internal displacement in Türkiye based on IDMC statistics for the period between 2018 and 2024.

Table 3. Disaster-induced Internal Displacement in Türkiye according to IDMC Statistics (2018-2024)

Reasons for Relocation	2018	2019	2020	2021	2022	2023	2024	Grand Total
Avalanche	78	302	546	180	1.340			2.446
Earthquake	7	14	39.760		1.089	4.047.329	64	4.088.263
Storm				14	1	856		871
Landslide						42	496	538
Wildfire	50		500	80.699	1.460	4.171	6.501	93.381
Flood	500	224	177	3.238	3.048	580	1.294	9.061
Dry mass movement							102	102
Mixed disasters							112	112
Grand Total	**635**	**540**	**40.983**	**84.131**	**6.938**	**4.053.002**	**8.569**	**4.194.774**

Note. From IDMC (2025).

Data from the IDMC, established in Geneva, Switzerland in 1998, indicate that earthquakes have been one of the primary natural triggers of disaster induced internal displacement in Türkiye during the period between 2018 and 2024. According to IDMC statistics, natural disasters led to large scale forced displacement in Türkiye throughout this period, with the major earthquakes that occurred in 2023 emerging as the most significant driver of disaster related internal migration. Nevertheless, other types of natural hazards, including floods, avalanches, landslides, and forest fires, have also played an important role in displacement processes. These findings demonstrate that Türkiye is highly vulnerable to natural disasters due to its geological structure and climatic characteristics, and they clearly underline the importance of disaster risk management, preparedness, and resilience oriented policies. Moreover, given expectations that the frequency and intensity of natural disasters will increase as a result of climate change, these statistics constitute a critical data set for future planning and policy development.

One of the most significant disaster induced mass displacement events in Türkiye in the 2000s was the 2011 Van earthquake. As a result of this disaster, more than 250,000 people were displaced either temporarily or permanently (Tiryaki Yenilmez, 2023, p. 44). An examination of Table 3, which presents

IDMC data, reveals that following earthquakes, forest fires constitute the second most significant type of disaster leading to displacement. In particular, after large scale fires in 2021, 2022, and 2023, populations living in several settlements, especially in Manavgat, were evacuated and temporarily relocated to safer areas. Floods represent another major type of disaster causing displacement in Türkiye. Beyond triggering forced migration, disasters also result in substantial loss of life and property, generating profound socio economic and demographic impacts on affected communities.

The relatively lower displacement figures observed in Table 3 for periods prior to 2018 should not be interpreted as an indication that disasters were less frequent or had more limited impacts during those years. On the contrary, significant advances in mass communication technologies and data collection capacity in recent years have enabled disasters and displacement events to be recorded in a more systematic and comprehensive manner. Consequently, it should be taken into account that many incidents occurring before 2018 may not have been fully reflected in official statistics.

The earthquakes centered in Kahramanmaraş on 6 February 2023 triggered one of the largest displacement movements in the history of Türkiye. These earthquakes directly affected more than 15 million people, and it has been reported that approximately 3.3 million individuals showed a tendency to migrate outside the affected region (Sağıroğlu et al., 2023, p. 7). In the annual IDMC data, the sharp increase in figures recorded under the earthquake category for 2023 clearly reflects the statistical impact of this mass displacement process. These data serve as a fundamental reference for the development of disaster management policies, the planning of reconstruction processes, and the effective coordination of national and international assistance mechanisms.

3.1. An Example of Disaster Induced Migration: The Kahramanmaraş and Gaziantep Centered Earthquakes

The earthquakes that occurred on 6 February 2023, centered in Kahramanmaraş and Gaziantep, directly affected a total of eleven provinces in Türkiye, namely Kahramanmaraş, Hatay, Gaziantep, Malatya, Diyarbakır, Kilis, Şanlıurfa, Adıyaman, Osmaniye, Adana, and Elazığ. The impacts of the disaster extended beyond Türkiye's borders, reaching cities in Syria such as Idlib, Aleppo, Hama, Latakia, Raqqa, and Tartus. As a result, millions of people were profoundly affected, and thousands lost their lives (Sağıroğlu et al., 2023, p. 8; World Bank Group, 2023, p. 10). In this respect, the earthquakes constitute a multidimensional disaster with severe humanitarian, demographic, and socio economic consequences at the regional scale.

According to the Post Earthquake Migration and Human Mobility Situation Assessment Report, the number of registered citizens of the Republic of Türkiye residing in the provinces directly affected by the disaster was identified as 14,013,196. This figure corresponds to 16.43 percent of Türkiye's total population, clearly demonstrating the extensive demographic scope of the earthquake's impact (Sağıroğlu et al., 2023). In the same regions, the registered foreign population was recorded as 1,771,194, representing 36.48 percent of the total registered foreign population in Türkiye. An examination of the demographic distribution of the foreign population indicates that 33,159 individuals were residing with residence permits, accounting for 2.45 percent of all foreigners holding residence permits nationwide. By contrast, the vast majority of the foreign population in the earthquake affected region consisted of Syrians under temporary protection status. A total of 1,738,035 Syrians living in the region represented 49.64 percent of the total Syrian population under temporary protection in Türkiye.

Following the disaster, it was estimated that approximately 3.3 million survivors exhibited a tendency to leave the earthquake affected region and migrate elsewhere (Sağıroğlu et al., 2023, p. 7). This finding indicates that post disaster migration dynamics are not limited solely to physical spatial mobility, but rather constitute a structural phenomenon influencing social reconstruction processes, population distribution, and regional development trajectories. In this context, visa facilitation measures provided by various countries, including Switzerland, Canada, Germany, and Belgium, to disaster affected individuals residing in Türkiye and Syria emerged as a significant factor accelerating international migration movements in the aftermath of the earthquake (Euronews, 2023; Gönültaş, 2023; Topcu, 2023).

Post disaster international migration movements have the potential to generate several structural challenges for Türkiye. In particular, adverse effects such as the loss of skilled labour, economic contraction in out migration regions, and the weakening of social cohesion may emerge. In addition, the tendency of some individuals under temporary protection status residing in the earthquake affected areas to return to Syria after the disaster has brought debates on forced return and safe return back to the agenda.

Incidents of looting and security breaches observed in the aftermath of the disaster further indicate that the crisis experienced in the region was not limited to physical destruction alone, but also involved a deepening of social and administrative vulnerabilities (Samsun Haber, 2023).

Following disasters, individuals tend to relocate temporarily or permanently in line with heightened risk perceptions and survival motivations (Varnacı

Uzun, 2024, p. 4). Indeed, the internal migration movements observed after the 6 February earthquakes exhibited a two stage spatial pattern. In the initial stage, migration was directed toward neighbouring provinces due to geographical proximity and urgent shelter needs. In the subsequent months, however, migration increasingly concentrated in metropolitan areas, influenced by factors such as employment opportunities, quality of life, and economic sustainability. This process confirms the distinction frequently emphasized in the post disaster internal migration literature between temporary displacement and permanent resettlement.

An examination of the distribution of disaster affected individuals who migrated from the earthquake region to other provinces and resided there temporarily or permanently reveals that Ankara was the province receiving the highest number of migrants, with 205,454 individuals, followed by Antalya with 154,086 individuals (Sağıroğlu et al., 2023). These figures demonstrate that Antalya emerged as a significant center of attraction in the post disaster period and assumed a strategic role in terms of migration dynamics. Table 4 presents the ten provinces from which Antalya received the highest net migration in 2023.

Table 4. The Top Ten Provinces from which Antalya Received the Highest Net Migration in 2023

Receiving Province	Sending Province	In-migration	Out-migration	Net Migration
Antalya	Hatay	12.660	1.946	10.714
Antalya	İstanbul	14.705	10.518	4.187
Antalya	Kahramanmaraş	4.406	1.022	3.384
Antalya	Malatya	3.339	533	2.806
Antalya	Adıyaman	2.172	561	1.611
Antalya	Diyarbakır	3.125	1.519	1.606
Antalya	Van	3.005	1.406	1.599
Antalya	Adana	3.482	1.951	1.531
Antalya	Gaziantep	3.139	1.680	1.459
Antalya	Ankara	7.261	6.370	891
Antalya	Other	61.062	61.252	-190
Antalya	**Total**	**118.356**	**88.758**	**29.598**

Note. From Turkish Statistical Institute Population Statistics Portal (n.d.).

The large-scale displacement movements that emerged in the aftermath of the 6 February 2023 earthquakes became particularly evident through internal migration dynamics directed from the disaster-affected regions toward provinces that suffered comparatively less damage. In this context, the data presented in Table 4 indicate that Antalya received the highest level of net migration from Hatay in the post-earthquake period. At the same time, it is observed that a certain proportion of the population migrating to Antalya during the same year showed a tendency to return to their place of origin, namely Hatay.

The literature explaining return migration decisions among individuals displaced after disasters emphasizes the strengthening of spatial attachment, urban memory, and a sense of place as key determinants of return tendencies (Nacak & Kuday, 2025, p. 10). This perspective suggests that post-disaster migration processes are not characterized by one-directional and permanent mobility, but rather display a multi-phased and dynamic structure.

The findings presented in Table 4 clearly demonstrate that, following the 6 February 2023 earthquakes, Antalya received substantial net migration particularly from provinces that experienced severe damage. The net migration of 10,714 individuals from Hatay to Antalya indicates that Hatay became the primary source of migration for Antalya. Hatay is followed by Kahramanmaraş with 3,384 individuals, Malatya with 2,806 individuals, and Adıyaman with 1,611 individuals. This distribution can be interpreted as a quantitative reflection of the theoretical framework suggesting that post-disaster internal migration initially flows toward nearby and safer locations and subsequently concentrates in cities offering relatively higher economic and social opportunities.

The fact that Antalya received significant net migration not only from disaster-affected provinces but also from cities outside the disaster zone indicates that the city is perceived not merely as a temporary post-disaster refuge, but also as an attractive center with long-term settlement and livelihood reconstruction potential. The net migration of 4,187 individuals from Istanbul suggests that Antalya has emerged as an alternative attraction center to major metropolitan areas, while the relatively limited net migration from Ankara, amounting to 891 individuals, implies that migration decisions are largely shaped by factors such as private sector employment opportunities, cost of living, and overall urban quality of life.

The negative net migration value of minus 190 in the category of "Other" provinces indicates that migration flows toward Antalya are not random. Rather, they reflect a selective migration pattern shaped by disaster-related, economic, and social push and pull factors. These findings suggest that post-earthquake internal migration should be understood not as a temporary population

movement, but as a structural transformation process with the potential to permanently alter regional population distributions. Within this framework, Table 5 presents the statistical overview of net internal migration directed toward Antalya over the last five years.

The data presented in Table 5 encompass interprovincial internal migration movements that refer to the relocation of an individual's permanent residence from one province to another. Within this framework, a comparative examination of net internal migration flows directed toward Antalya between 2020, when the COVID-19 pandemic began, and 2024 makes it possible to assess in a holistic manner how the earthquakes of 6 February 2023 transformed migration dynamics across the pre-disaster, disaster, and post-disaster periods. The findings indicate that disaster-induced migration did not merely generate a temporary demographic fluctuation; rather, it led to a structural reconfiguration of Antalya's position within Türkiye's internal migration system. In this respect, the marked weakening of migration flows toward Antalya during the pandemic period clearly reflects the direct impact of public health measures and mobility restrictions on migration behaviour.

In the pre-disaster year of 2022, Antalya recorded a relatively limited increase in net internal migration, amounting to 13,018 individuals, largely driven by economic factors and seasonal mobility. During this period, the principal provinces of origin were Şanlıurfa, Van, Diyarbakır, and Istanbul, indicating that Antalya continued to maintain its attractiveness through its tourism-based labour market and lifestyle-oriented appeal. The limited contribution of provinces severely affected by the earthquakes during this period, particularly the net migration of only 918 individuals from Hatay, suggests that disaster-induced forced displacement had not yet become a decisive push factor shaping migration toward Antalya.

The year 2023 represents a clear turning point in migration dynamics. In this year, Antalya's net internal migration rose to 29,598 individuals, reflecting an increase of approximately two and a half times compared to the pre-disaster period. This rise was largely shaped by migration flows originating from provinces severely affected by the earthquakes. Hatay ranked first with a net migration of 10,714 individuals, followed by Kahramanmaraş, Malatya, and Adıyaman. This concentration of migration from disaster-affected areas indicates that Antalya's migration profile was substantially redefined during this period along the axis of disaster-induced forced migration. This transformation demonstrates that Antalya emerged not only as a destination sought for short-term safety, but also as an important secondary destination for displaced populations seeking medium-term economic and social stability.

Table 5. Statistical Overview of Net Internal Migration to Antalya Over the Last Five Years

2020		2021		2022		2023		2024	
Source Province	**Net Migration**	**Source Province**	**Net Migration**	**Source Province**	**Net Migration**	**Source Province**	**Net Migration**	**Source Province**	**Net Migration**
İstanbul	4.946	Afyon karahisar	1.766	Şanlıurfa	2.008	Hatay	10.714	İstanbul	2.684
Ankara	2.072	Artvin	1.700	Van	1.555	İstanbul	4.187	Van	2.223
Isparta	1.630	Balıkesir	1.274	Diyarbakır	1.348	K. Maraş	3.384	Şanlıurfa	1.630
Şanlıurfa	1.255	Ardahan	834	İstanbul	1.148	Malatya	2.806	Ankara	1.456
Diyarbakır	1.213	Aydın	757	Hatay	918	Adıyaman	1.611	Diyarbakır	1.218
Van	758	Batman	729	Adana	829	Diyarbakır	1.606	Burdur	1.207
Konya	659	Bolu	637	Gaziantep	604	Van	1.599	Konya	1.107
Adana	518	Iğdır	369	Ankara	559	Adana	1.531	Gaziantep	891
İzmir	487	K. Maraş	292	Mardin	481	Gaziantep	1.459	Şırnak	773
Burdur	475	Bursa	260	Konya	368	Ankara	891	Adana	750
Other	6.697	Other	-818	Other	3.200	Other	-190	Other	10.680
Total	**20.710**	**Total**	**7.800**	**Total**	**13.018**	**Total**	**29.598**	**Total**	**24.619**

Note. Turkish Statistical Institute Population Statistics Portal (n.d.).

In the post-disaster year of 2024, a partial normalization trend in migration volume was observed, with net internal migration declining to 24,619 individuals. Nevertheless, this level remained significantly above that of the pre-disaster period, indicating that the effects of disaster-induced migration extended beyond the initial phase of displacement. During this period, the renewed prominence of economically motivated migration from provinces such as Istanbul, Van, and Şanlıurfa, alongside continued inflows from disaster-affected areas, points to the emergence of a complex migration regime in which forced displacement and voluntary internal migration became increasingly intertwined. This pattern suggests that a segment of disaster migrants shifted from temporary displacement toward permanent or semi-permanent settlement in Antalya.

When the five-year period is considered as a whole, disaster-induced migration appears not as a temporary deviation, but as a key catalyst of long-term demographic and spatial transformation. Antalya's internal migration system has evolved from a structure predominantly shaped by labour market dynamics into a more complex and multi-layered system encompassing humanitarian displacement, secondary migration, and permanent resettlement. These findings underscore the need to conceptualize disaster migration as a multi-stage and path-dependent process that generates lasting impacts on urban growth, housing demand, and regional inequalities.

In this context, Antalya provides a striking example of how cities geographically proximate to disaster areas can become critical nodes in post-disaster population redistribution and how they can absorb demographic pressures that extend well beyond the emergency response phase. Accordingly, policies addressing disaster-induced migration should move beyond short-term humanitarian assistance and be formulated through comprehensive strategies that incorporate long-term urban planning, housing policies, and labour market integration in receiving regions. The case of Antalya strengthens the empirical evidence that large-scale natural disasters can permanently transform internal migration systems and once again highlights the importance of integrating disaster risk and migration management into regional development policies.

4. Disasters and Migration in the Activity Reports of AMM

Antalya's increasing attractiveness in recent years in the face of disaster-induced migration movements has generated not only demographic and spatial consequences but has also brought to the forefront the question of how local governments manage disaster risks and migration processes. In this context, understanding the impact of natural disasters on migration dynamics in Antalya

necessitates an examination of the approaches to disaster management and climate adaptation articulated in the city's existing policy documents.

Article 7 of Law No. 5216 on Metropolitan Municipalities regulates the authorities and responsibilities of metropolitan municipalities and, in particular, stipulates under subparagraph (u) that planning and preparedness processes related to natural disasters should be carried out at the metropolitan scale. Within this framework, municipalities are obliged to conduct disaster-related planning and preparedness activities in alignment with plans prepared at the provincial level and to provide vehicles, equipment, and material support to other regions in times of disaster. In addition, the provision of fire and emergency services, the inspection of facilities producing or storing explosive and flammable materials, the monitoring of disaster risk precautions in public and private buildings, and the execution of related licensing procedures are among the core responsibilities of municipalities.

Within this legal framework, disaster-induced migration and displacement have become an increasingly significant dimension of municipal disaster management policies. Forced migration movements emerging in the aftermath of disasters constitute critical factors that local governments must take into account in their planning, preparedness, and response processes. Municipalities are required to adopt measures to meet basic needs such as temporary shelter, health services, food, and access to clean water in the post-disaster period and to manage these processes through a comprehensive approach. At the same time, local governments are expected to play an active role in resettlement, social cohesion, and integration processes.

The AMM, provides various social services for individuals migrating to the city due to disasters and economic factors. In this context, educational seminars are organized to support the adaptation process of newly arrived populations and to enhance social awareness. These seminars aim to facilitate migrants' adjustment to urban life practices and to promote a shared culture of coexistence with the resident urban population (AMM, 2020, p. 37). Such practices contribute to strengthening social integration in migration and displacement processes that emerge in the aftermath of disasters.

The disaster management activities of the AMM are not limited to social services but also encompass institutional capacity and coordination dimensions. Within the framework of fire services, the municipality ensures coordination among metropolitan units, civil society organizations, and volunteer groups. To enhance disaster awareness, seminars, training programs, drills, and informational publications are conducted. Moreover, the vehicle, equipment, and logistical infrastructure of the Disaster Coordination Center is being strengthened, and

the center is continuously updated to adapt to changing risk conditions. In addition, the preparation of the Earthquake and Disaster Master Plan aims to enhance the city's resilience to disasters and to accelerate post-disaster recovery processes (AMM, 2020, pp. 33-34).

To address urgent post-disaster needs, the AMM conducted tabletop exercises within the scope of the Disaster Response Plan (TAMP) through the Disaster Management Decision Support System (AYDES), under the coordination of the Antalya Provincial Directorate of Disaster and Emergency Management (AMM, 2020, p. 219). These activities aimed to enhance the effectiveness of disaster management processes.

The AMM also makes extensive use of technology and information infrastructure in disaster management and migration processes. During the Manavgat forest fire, the Disaster Aid Tracking System enabled the assessment of requests from affected households and the identification of needs, operating in an integrated manner with the warehouse stock management system. The Disaster Vehicle Dispatch Management System facilitated the effective coordination of vehicles in the field. Within the Disaster Coordination Center, operational processes were spatially monitored and managed through the use of geographic information systems, unmanned aerial vehicles, and satellite imagery (AMM, 2021, p. 27).

The intervention activities carried out by the AMM during and after the Manavgat fire reflect a comprehensive approach to post-disaster displacement and migration processes. Citizens who lost their homes in the fire were provided with container housing support (AMM, 2021, p. 98), while evacuation, treatment, and care services were delivered for stray and vulnerable animals (AMM, 2021, p. 132). In addition, maintenance, repair, and renovation needs of households affected by the fire, as well as those of persons with disabilities, were addressed (AMM, 2021, p. 140). These practices demonstrate that the AMM approaches post-disaster migration and displacement processes through a multidimensional and holistic framework.

In this context, the data presented in the AMM's 2022 Activity Report (2022a) and the Sustainable Energy and Climate Action Plan (SECAP) (AMM, 2022b) provide an opportunity to assess the strategies developed by the city against climate-related risks and the potential impacts of these strategies on migrant populations. The findings presented in Table 6 reveal the spatial relationship between the migrant population living in Antalya and levels of climatic hazard, indicating that disaster risks generate multidimensional consequences not only in environmental terms but also with respect to social vulnerabilities and migrant groups.

Accordingly, the data included within the SECAP framework demonstrate that disaster management in Antalya should not be confined solely to physical risk reduction but rather should evolve toward a holistic governance approach encompassing migration, displacement, and social cohesion processes. In this respect, policy documents concretize the role assumed by local governments in managing the impacts of natural disasters on migration dynamics and highlight the importance of forward-looking adaptation policies.

Table 6. Climatic Hazard Levels of Migrants according to the SECAP

Climatic Hazard	Level
Cold Wave	Medium
Extreme Flooding and Precipitation	High
Sea Level Rise	High
Extreme Weather Events	High
Forest Fires	High

Note. AMM (2022b).

The data presented by AMM (2022b) within the scope of the SECAP indicate that the migrant population residing in the city exhibits a high level of vulnerability to the impacts of climate change. The increasing frequency and intensity of extreme weather events, rising sea levels, and the growing prevalence of forest fires directly affect migrants' living conditions and generate significant risks in terms of human security. In this context, climate change emerges as a key determinant of socio-spatial security not only for the local population but also for communities that have settled in the city through migration.

The findings reported in Table 6 demonstrate that the most pronounced climatic risks faced by migrants in Antalya are extreme precipitation events and the resulting floods. Migrants residing in informal settlements and areas with inadequate infrastructure are particularly exposed to such hazards. Flooding not only undermines housing conditions but also exacerbates public health risks and threatens the continuity and stability of living environments. In addition, rising sea levels directly affect migrants living in coastal areas by increasing the likelihood of inundation of residential zones and intensifying the risk of forced displacement.

In this regard, enhancing the resilience of the migrant population in Antalya to the adverse effects of climate change should be considered a core priority of local disaster and migration governance policies. Strengthening infrastructure investments in areas with high concentrations of migrants, expanding early

warning and risk monitoring systems, increasing awareness-raising activities related to climate-induced hazards, and implementing socio-economic empowerment programs constitute key components of this process. Moreover, inclusive climate adaptation policies developed through cooperation between local authorities and civil society organizations hold significant potential to generate comprehensive and sustainable solutions that are responsive to the specific needs of migrant populations.

4.1. Responses of AMM to Disasters and Climate Change

The AMM has adopted a multidimensional approach within the framework of intervention, risk reduction, and adaptation policies in response to natural disasters triggered by climate change. One of the most concrete manifestations of this approach was the comprehensive disaster response activities carried out during the large-scale forest fire that started in the Manavgat district on 28 July and spread to the districts of Gündoğmuş, Akseki, and İbradı. In parallel with emergency response efforts, the social dimension of the disaster was also addressed through the deployment of teams composed of social workers and sociologists tasked with conducting social assessments and damage identification in affected neighbourhoods. Based on the expressed needs of disaster victims, referrals were made to relevant municipal units. In addition, psychosocial support services were provided to children affected by the fire through psychologists and child development specialists. These practices underscore the critical role of local governments' social support mechanisms in managing forced migration and displacement processes resulting from disasters (AMM, 2021, p. 256).

Beyond its response capacity, AMM has also developed preventive and planning-oriented policies aimed at reducing climate change-related risks and preventing disaster-induced displacement. In this context, the Fire Risk Map, initiated in 2015 and completed in 2019, was prepared using Geographic Information Systems, with update efforts continuing as of 2021 (AMM, 2021, p. 259). This map contributes to the identification of high-risk areas for forest fires and supports the development of preventive measures.

Within the framework of the Türkiye Disaster Response Plan, AMM has implemented various initiatives and contributed to the preparation of the Antalya Provincial Disaster Risk Reduction Plan. This plan includes actions aimed at reducing the physical, economic, and social impacts of disasters on settlements and communities (AMM, 2021, p. 259). In addition, AMM was selected as one of the pilot municipalities within the Technical Assistance Project for Strengthening AFAD's Capacity for Disaster Risk Reduction and Adaptation Related to Climate Change in Türkiye. The project aims to enhance the

institutional capacity of local governments to address climate change-induced disaster risks and to strengthen urban resilience. Within this framework, EU Climate Diplomacy Week activities were also hosted in Antalya (AMM, 2022a, p. 128).

Regarding seismic risk, the Antalya Earthquake Master Plan is included among the core responsibilities of the Metropolitan Municipality within the scope of the Provincial Disaster Risk Reduction Plan coordinated by the Provincial Directorate of Disaster and Emergency Management. The plan aims to transform Antalya into a more earthquake-resilient city and is expected to be completed by 2025. As the initial step of the planning process, the first Antalya Earthquake Master Plan Workshop was held on 11 August 2022, during which the roadmap and planned activities were defined (AMM, 2022a, p. 172).

Throughout 2023, the AMM adopted a multi-layered disaster governance approach focused on disaster risk reduction, climate change adaptation, and institutional capacity building. In this regard, AMM became an active stakeholder in the Technical Assistance Project for Strengthening AFAD's Capacity for Disaster Risk Reduction and Adaptation Related to Climate Change in Türkiye, in which AMM and Trabzon Metropolitan Municipalities were selected as pilot cities. Through this project, the identification of climate change-related disaster risks, the enhancement of local adaptation capacities, and the development of planning tools aligned with international policy frameworks were targeted. Moreover, following the earthquakes of 6 February 2023, housing, household goods, and basic needs assistance were provided to disaster-affected individuals who relocated to Antalya, and systematic aid and referral processes were carried out through Disaster Coordination Units (AMM, 2023). Veterinary services and adoption activities for animals affected by the earthquake further demonstrated that disaster management was approached through a holistic, ecosystem-based perspective rather than a solely human-centered one.

At the same time, AMM emphasized innovative and participatory practices aimed at increasing public awareness and developing science-based risk reduction policies. Training programs, drills, and fire safety inspections conducted under the coordination of the Fire Department and the Disaster Affairs Department exceeded targeted levels following the declaration of 2023 as the "Year of Disaster Drills." Within the scope of the Earthquake Master Plan process, the digitization of the building stock inventory in coordination with district municipalities, the establishment of the Building Inventory Earthquake Information System, and the implementation of land use change analyses based on Geographic Information Systems and machine learning indicate a transition toward data-driven disaster risk management in Antalya.

Furthermore, the deployment of an earthquake simulation truck, conferences organized with the participation of academics, and awareness-raising activities for preschool children stand out as creative initiatives aimed at disseminating disaster awareness across society (AMM, 2023). These activities demonstrate that AMM has adopted a local governance approach that integrates prevention, preparedness, and social resilience, rather than limiting disaster management to the response phase alone.

AMM's activities in 2023 are characterized by data-driven, capacity-building, and awareness-raising practices addressing climate change-related risks at the local level. In line with the Antalya Provincial Disaster Risk Reduction Plan, a comprehensive building stock inventory was created, and the city's risk profile was updated through the analysis of extensive datasets covering geological and geotechnical conditions, hydrogeology, seismicity, landslide susceptibility, and liquefaction risks. In addition, innovative initiatives aimed at raising public awareness of climate change-related risks were implemented in 2023. Land use change maps for the 2014-2023 period were produced using satellite imagery and machine learning techniques, enabling the scientific monitoring of the spatial impacts of climate change. Moreover, hands-on training activities organized for children in daycare centers offered a creative approach to fostering climate and disaster awareness at an early age (AMM, 2023). These practices illustrate that climate change in Antalya is addressed not merely as an environmental issue, but as a multidimensional challenge encompassing urban resilience, disaster risk, and social cohesion. Finally, current statistics on disaster-induced displacement in Antalya are presented in Table 7.

Table 7. Statistics on Disaster Induced Displacement in Antalya

Causes of Displacement	Year	Number of Migrants
Wildfire	2018	50
Flood	2020	7
Wildfire	2021	80.699
Wildfire	2023	56
Flood	2024	1203
Grand Total		**82.015**

Note. IDMC (2025).

According to IDMC data, wildfires and floods have emerged in recent years as the primary types of disasters triggering displacement within the city.

The large-scale wildfire that occurred in 2021 stands out as the period during which disaster-induced displacement in Antalya reached its highest intensity. This situation indicates that, under the influence of climate change, extreme weather events and related disasters are becoming more frequent and more destructive across the Mediterranean basin. Large-scale population displacement generates significant pressures on housing provision, access to basic services, social cohesion, and the local economy.

The Antalya City Disaster Risk Reduction and Climate Adaptation Action Plan (ADRCAP [Antalya Şehri Afet Riskini Azaltma ve İklime Uyum Eylem Planı], 2024), prepared under the coordination of AFAD, provides a detailed assessment of the city-specific impacts of climate change. According to the plan, temperature increases are projected to range between 1.77 and 2.03°C for the 2041-2060 period and between 2.16 and 2.42°C for the 2061-2080 period. These increases are expected to be more pronounced in the higher elevations of districts such as Akseki, İbradı, Gündoğmuş, Manavgat, and Serik (ADRCAP, 2024, p. 109). Increases in the number of summer and tropical days are anticipated to vary between coastal and inland areas, while a marked upward trend in sea surface temperatures is observed across the Mediterranean. Changes in precipitation regimes are expected to heighten flood and drought risks, particularly in and around Elmalı, Korkuteli, and Akseki (ADRCAP, 2024, pp. 108-110).

AFAD data indicate that Antalya ranks among the provinces experiencing the highest number of disaster events in Türkiye, with more than 2,000 disasters recorded over the past 30 years. These figures suggest an average of approximately 70 disaster events per year in the city (ADRCAP, 2024, p. 41). Data from the Turkish State Meteorological Service further reveal that Antalya was the province most affected by atmospheric-origin disasters during the 2010-2021 period (ADRCAP, 2024, p. 38).

Finally, a study conducted by Kırkpınar (2024) in the city of Antalya found that a significant proportion of temporary assembly areas designated by AFAD lack sufficient functionality in the event of a potential disaster. This finding underscores the need to strengthen spatial planning and infrastructure investments at the local level in order to ensure the effective management of post-disaster sheltering and displacement processes. In this context, the responses of the AMM to disasters and climate change extend beyond the scope of emergency response alone, pointing instead to a comprehensive local governance approach that integrates risk reduction, climate adaptation, social support mechanisms, and the management of migration and displacement processes.

5. Conclusions and Policy Implications

5.1. Conclusion

This study demonstrates that climate change–induced natural disasters exert multidimensional effects on migration dynamics in Antalya and that these effects are not confined to moments of acute crisis but instead generate lasting transformations in the city's demographic, spatial, and socio-economic structures. The Antalya case clearly illustrates that disasters trigger migration through both direct mechanisms, such as wildfires, floods, and earthquakes, and indirect pathways, including heightened risk perceptions, the deterioration of livelihoods, and declining quality of life. In this respect, disasters have become a structural factor shaping population mobility not only through their actual occurrence but also through their perceived likelihood.

A joint assessment of the activity reports of the AMM for the 2020-2023 period and the ADRCAP and SECAP policy documents indicates a gradual shift in Antalya's disaster governance framework from a predominantly response-oriented approach toward one centered on risk reduction, climate adaptation, and social resilience. The development of wildfire risk maps, building stock inventories, the Earthquake Master Plan, climate adaptation measures, early warning systems, geographic information systems, and machine learning–based spatial analyses reflects a significant enhancement of institutional capacity aimed at anticipating and managing disaster impacts. Nevertheless, as evidenced by IDMC data, the 2021 wildfires in particular, along with recurrent flood events in recent years, have resulted in high levels of disaster-induced displacement in Antalya, reinforcing the city's role as a post-disaster destination.

The substantial net in-migration experienced by Antalya following the 6 February 2023 earthquakes further indicates that post-disaster internal migration constitutes not a temporary demographic reaction but a structural transformation process with direct implications for urban and regional policy in the medium and long term. Cities such as Antalya, which possess relatively advanced economic capacity, service infrastructure, and employment opportunities, tend to attract displaced populations in the aftermath of disasters. This dynamic generates new pressures on housing markets, infrastructure provision, social cohesion, and environmental sustainability, thereby producing additional layers of vulnerability.

At the same time, the impacts of climate change on Antalya's tourism and agricultural sectors indirectly shape migration dynamics. Extreme heat events, floods, and wildfires negatively affect tourism seasons and employment continuity, while losses in agricultural production constrain rural livelihoods and increase migration toward urban areas. This process intensifies pressure on

urban infrastructure and creates conditions conducive to the deepening of social inequalities. Consequently, the Antalya case demonstrates that climate change generates a multi-sectoral and multi-scalar risk environment in which disasters accelerate migration processes.

In conclusion, this study underscores that post-disaster migration should be addressed not merely as a spatial redistribution of population but as a comprehensive governance issue requiring the coordinated management of housing, employment, social cohesion, health services, infrastructure, and environmental sustainability policies. Antalya provides a salient example of how disaster- and climate-induced migration dynamics can be managed through local government capacity, planning instruments, and adaptive governance approaches.

5.2. Policy Recommendations

In order to manage disaster- and climate change–induced migration effectively in Antalya, local governments should address disaster, climate, and migration policies within an integrated framework. In this regard, disaster risk reduction and climate change adaptation plans prepared by the AMM and district municipalities should be implemented not merely as strategic documents, but as functional policy instruments supported by concrete implementation and monitoring mechanisms. Ensuring institutional coordination among these plans constitutes a fundamental prerequisite for reducing vulnerabilities arising from disasters and migration.

The governance of disaster- and climate-induced migration processes should be based on a participatory and multi-actor approach. Incorporating the needs and experiences of groups directly affected by disasters and migration into decision-making processes is likely to enhance policy effectiveness. Within this context, it is essential to strengthen continuous cooperation mechanisms among local governments, central authorities, civil society organizations, and academic institutions.

Antalya's emergence as a net in-migration destination in the post-disaster period has generated increasing pressure on housing and infrastructure systems. Accordingly, the expansion of social housing provision, the stabilization of rental markets, and the strengthening of infrastructure capacity in areas experiencing concentrated in-migration should be treated as priority policy domains. Designing post-disaster temporary shelter solutions in a manner that takes long-term settlement needs into account can play a preventive role in mitigating the deepening of urban vulnerabilities.

From an economic perspective, policies should be developed to support the integration of populations displaced by disasters and climate-related events into the labour market. The sensitivity of Antalya's tourism and agricultural sectors to climate change increases employment vulnerability in these fields. Therefore, the promotion of climate-resilient agricultural practices and the adoption of measures aimed at reducing climate risks in the tourism sector can contribute to balancing migration pressures.

Finally, in order to manage more effectively the interlinkages between disasters, climate change, and migration, data-driven decision-making processes should be strengthened. Geographic information systems, early warning mechanisms, and systematic data monitoring can enhance the predictability of disaster and migration dynamics. At the same time, educational and awareness-raising activities aimed at increasing disaster and climate literacy across society should be regarded as complementary measures for strengthening individual and collective resilience.

References

Antalya City Disaster Risk Reduction and Climate Adaptation Action Plan [Antalya Şehri Afet Riskini Azaltma ve İklime Uyum Eylem Planı]. (2024). *Türkiye'de iklim değişikliğinden kaynaklanan afet risklerinin uyumlaştırılması ve azaltılmasında AFAD'ın kapasitesinin artırılması için teknik yardım projesi* [Technical assistance project for enhancing AFAD's capacity in harmonizing and mitigating disaster risks arising from climate change in Türkiye].

Antalya Metropolitan Municipality. (2020). *Antalya Büyükşehir Belediyesi 2020 faaliyet raporu* [*Antalya Metropolitan Municipality 2020 activity report*]. https://www.antalya.bel.tr/Content/UserFiles/Files/2020-YILI-FAALIYET-RAPORU-WEB.pdf

Antalya Metropolitan Municipality. (2021). *Antalya Büyükşehir Belediyesi 2021 faaliyet raporu* [*Antalya Metropolitan Municipality 2021 activity report*]. https://www.antalya.bel.tr/Content/UserFiles/Files/2021-YILI-FAALIYET-RAPORU-WEB.pdf

Antalya Metropolitan Municipality. (2022a). *Antalya Büyükşehir Belediyesi 2022 faaliyet raporu* [*Antalya Metropolitan Municipality 2022 activity report*]. https://www.antalya.bel.tr/Content/UserFiles/Files/ABB-2022-FAALiYET-RAPORU.pdf

Antalya Metropolitan Municipality. (2022b). *SECAP: Sürdürülebilir Enerji ve İklim Eylem Planı 2022* [*SECAP: Sustainable Energy and Climate Action Plan 2022*]. https://www.antalya.bel.tr/Content/UserFiles/Files/YarinlardaBizVariz/Dokumanlar/2022/SECAP-SURDURULEBILIR-ENERJI-VE-IKLIM-EYLEM-PLANI-2022.pdf

Antalya Metropolitan Municipality. (2023). *Antalya Büyükşehir Belediyesi 2023 faaliyet raporu* [*Antalya Metropolitan Municipality 2023 activity report*]. https://www.antalya.bel.tr/Content/UserFiles/Files/ABB-2023-YILI-FAALIYET-RAPORU-(BILGI-ISLEM).pdf

Bettini, G., Nash, S. L., & Gioli, G. (2017). One step forward, two steps back? The fading contours of (in) justice in competing discourses on climate migration. *The Geographical Journal*, *183*(4), 348–358. https://doi.org/10.1111/geoj.12192

Disaster and Emergency Management Presidency [Afet ve Acil Durum Yönetimi Başkanlığı]. (n.d.). *Afet tanımı* [Definition of disaster]. Retrieved September 10, 2025, from https://www.afad.gov.tr/aciklamali-afet-yonetimi-terimleri-sozlugu

Euronews. (2023, March 19). *Kanada, Türkiye ve Suriye'de depremlerden etkilenenlere vize kolaylığı sağlayacak* [Canada will provide visa facilitation to those affected by the earthquakes in Türkiye and Syria]. https://tr.euronews.com/2023/03/19/kanada-turkiye-ve-suriyede-depremlerden-etkilenenlere-vize-kolayligi-saglayacak

González-Leonardo, M., López-Gay, A., Newsham, N., Recaño, J., & Rowe, F. (2022). Understanding patterns of internal migration during the COVID-19 pandemic in Spain. *Population, Space and Place*, *28*(6), e2578. https://doi.org/10.1002/psp.2578

Gönültaş, B. (2023). *Almanya depremzedelere vize kolaylığı sağlamak için görev gücü oluşturdu* [Germany has formed a task force to facilitate visa procedures for earthquake victims]. Retrieved September 16, 2025, from https://www.aa.com.tr/tr/asrin-felaketi/almanya-depremzedelere-vize-kolayligi-saglamak-icin-gorev-gucu-olusturdu/2816404

Internal Displacement Monitoring Centre. (2023). *GRID 2023: Internal displacement and food security.* https://www.internal-displacement.org/publications/2023-global-report-on-internal-displacement-grid/

Internal Displacement Monitoring Centre. (2024). *GRID 2024: Global report on internal displacement.* https://www.internal-displacement.org/publications/2024-global-report-on-internal-displacement-grid/

Internal Displacement Monitoring Centre. (2025). *GRID 2025: Global report on internal displacement.* https://www.internal-displacement.org/global-report/grid2025/

International Displacement Monitoring Centre. (n.d.). *IDMC data portal*. https://www.internal-displacement.org/database/displacement-data/

Kırkpınar, A. (2024). *Sel ve deprem bağlamında geçici afet barınma alanlarının mevcut durum değerlendirmesi: Antalya kenti* [Current situation assessment of temporary disaster shelter areas in the context of floods and earthquakes: Antalya city] [Unpublished master's thesis]. Akdeniz Üniversitesi.

Nacak, İ., & Kuday, E. (2025). Şubat 2023 depremleri sonrası Hatay'dan göç eden depremzedelerin geri dönüş motivasyonları [Reasons why earthquake victims who migrated to Hatay after the February 2023 earthquakes are returning to Hatay]. *İnsan ve Toplum*, *15*(3), 10–39. https://doi.org/10.12658/M0768

Republic of Türkiye Ministry of Forestry and Water Affairs [Orman ve Su İşleri Bakanlığı]. (2013). *Yukarı havza sel kontrol ve eylem planı 2013–2017* [Upstream watershed flood control and action plan 2013–2017]. https://webdosya.csb.gov.tr/db/cem/icerikler/sel-brosur-tr-mail-20211108102804.pdf

Sağıroğlu, A. Z., Ünsal, R., & Özenci, F. (2023). *Deprem sonrası göç ve insan hareketlilikleri: Durum değerlendirme raporu* [Post-earthquake migration and human mobility: Situation assessment report] (AYBÜ-GPM Report Series No. 15, updated 2nd ed.). Ankara Yıldırım Beyazıt Üniversitesi Göç Politikaları Uygulama ve Araştırma Merkezi.

Samsun Haber. (2023, February 6). *Depremi fırsat bildiler! Marketleri ve dükkânları yağmaladılar* [Earthquake opportunism: Instances of looting in retail establishments]. https://www.samsunhaber.com/depremi-firsat-bildiler-marketleri-ve-dukkanlari-yagmaladilar

Şengün, H., & Emeç, B. (2022). Covid-19 küresel salgınının (pandemi) Türkiye'nin göç yönetimine etkisi [Impact of covid-19 pandemic on Türkiye's migration management]. *İdealkent*, *13*(37), 2083–2107. https://doi.org/10.31198/idealkent.1127526

Tek, Ö. B. (2021, August 17). *2020'de 30 milyon insan afetler nedeniyle yer değiştirdi* [*In 2020, 30 million people were displaced due to natural disasters*]. https://www.iklimhaber.org/2020de-30-milyon-insan-afetler-nedeniyle-yer-degistirdi/

Tiryaki Yenilmez, D. (2023). Deprem ve göç ilişkisi üzerine bir değerlendirme [An evaluation on the relationship between earthquake and migration]. *Akademik Düşünce Dergisi*, (7), 39–52. https://doi.org/10.53507/akademikdusunce.1282303

Topcu, E. (2023, February 22). *Depremzedeler vizeyle Almanya'ya nasıl gidebilir?* [How can earthquake victims travel to Germany with a visa?]. Retrieved September 10, 2025, from https://www.dw.com/tr/depremzedeler-vizeyle-almanyaya-nas%C4%B1l-gidebilir/a-64781559

Turkish Language Association [Türk Dil Kurumu]. (n.d.). *Afet* [Disaster]. In *Güncel Türkçe Sözlük*. Retrieved September 10, 2025, from https://sozluk.gov.tr

Turkish Statistical Institute Population Statistics Portal. (n.d.). *İller arası göç* [Inter-provincial migration]. Retrieved September 25, 2025, from https://nip.tuik.gov.tr/?value=IllerArasiGoc

World Bank Group. (2023). *Syria earthquake 2023: Rapid damage and needs assessment (RDNA).* World Bank.

Varnacı Uzun, F. (2024). Antakya'ya yönelik yer duygusu: Şubat 2023 depremleri sonrası gitmek mi zor kalmak mı? [Sense of place towards Antakya: Is it difficult to leave or to stay after the February 2023 earthquakes?]. *Ege Coğrafya Dergisi*, *33*(1), 1–30. https://doi.org/10.51800/ecd.1455130

CHAPTER 5

Sustainable Cities: Ageing and Accessibility in Türkiye

Ferhan Saniye Palaz[1]

1. Introduction

As of 2024, Türkiye's fertility rate remains below the population replacement level of 2.10 (Turkish Statistical Institute [TURKSTAT], 2025b), while the proportion of people aged 65 and older has reached 10.6% of the total population (TURKSTAT, 2025a). Türkiye has thus entered the demographic phase of population ageing, making it necessary for policymakers and researchers to examine urban accessibility. In Türkiye, the pace of population ageing has been more rapid than in many developed countries, leaving less time to prepare for and adapt institutional structures to the emerging needs of older adults (Eryurt, 2023).

The first significant international response to population ageing was the 1982 Vienna World Assembly on Ageing, followed by the 2002 Madrid International Plan of Action on Ageing, which outlined a comprehensive roadmap to guide national policy development (United Nations, 1982; 2002). In alignment with these global efforts, Türkiye developed its first National Plan on Ageing in 2007, in collaboration with universities and civil society organizations (State Planning Organization [Devlet Planlama Teşkilatı], 2007). A review of Türkiye's development planning shows that the 10th Development Plan (2014–2018) included the establishment of a "Special Commission on Ageing," which produced a report directly addressing issues related to quality of life (Republic of Türkiye Ministry of Development [Türkiye Cumhuriyeti Kalkınma Bakanlığı], 2014). In 2015, the "Türkiye Active and Successful Ageing Study" was conducted in collaboration with Ankara University and the Ministry of Health, incorporating indicators from the Active Ageing Index (United Nations Economic Commission for Europe [UNECE], 2015) to assess accessibility among the older population in Türkiye (Özmete, 2016). Even though efforts have been made to understand the needs of the older population in Türkiye, urban accessibility has not been sufficiently examined.

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Ensuring older adults' access to essential services within their local environments is crucial for creating sustainable cities and communities. However, Türkiye offers limited evidence of progress in this area, which is particularly concerning given the country's rapidly growing older population. Existing policies and practices do not adequately address inequalities in age-friendly urban development and accessibility. This study, therefore, seeks to examine the current state of urban accessibility for older adults in Türkiye.

The first step in addressing this issue involves understanding the geographical distribution and demographic characteristics of the ageing population in Türkiye, based on the most recent statistics. The initial point of reference is the rural–urban distribution of the older population. According to the latest data, 30.1% of older adults in Türkiye live in areas classified as rural, 14.6% in medium-density cities, and 55.3% in high-density urban areas (TURKSTAT, 2023). In contrast, only 16.1% of the general population aged 16–64 lives in rural areas. This demographic imbalance is largely a result of rural-to-urban migration among younger cohorts, which began in the 1950s. Data on the current young population living in urban areas suggest that future cohorts of the ageing population will be residing dominantly in urban areas. Thus, it can be assumed that Türkiye's older population in urban areas will increase. The statistics also show a tendency for the current population aged 65 and older to live in urban areas. Recent research shows that older adults in Türkiye have increasingly been migrating both from rural to urban areas and from large metropolitan centres to mid-sized cities (Koç&Saraç, 2018). These trends collectively suggest that the proportion of older adults living in medium- and high-density urban areas is likely to continue increasing, underscoring the relevance of this study's first research question: *(1) To what extent does the built environment in Türkiye support independent living among the ageing population?*

To answer this question, it is essential to consider both the living arrangements and the household composition of older adults in Türkiye. Two main indicators help illuminate these aspects. Regarding preferred living arrangements in the context of healthcare needs, among adults aged 50 and over, 54.6% prefer to stay in their own homes and receive in-home-care or day care services. Meanwhile, 24.2% would choose to live with an adult child, and only 5.9% would prefer to enter a nursing home (TURKSTAT, 2024). In many countries, there are alternative types of living arrangements for the older population, which can be categorised under institutional care, such as retirement housing, nursing homes, and care homes. Among them, nursing and care homes are where care is provided. Retirement Housing has three distinguished features: restricted occupancy by a minimum age threshold of 50, a communal lounge where activities such as coffee mornings are organised, and varying levels of support (Gray, 2015).

In Türkiye, institutional care options remain limited. Statistics indicate that ageing-in-place is the most widely accepted living arrangement, preferred over any form of institutional care. When it comes to living preferences, older people in Türkiye tend to remain in their own homes for as long as possible. If that is not feasible, they prefer to live with their children. Institutional settings are not a commonly preferred option. This trend suggests a likely increase in the number of community-dwelling older adults in the future. Our second research question is: *(2) What are the region-specific needs for ensuring sustainable and age-friendly cities in Türkiye, particularly in terms of public space, pedestrian infrastructure, and public transportation accessibility?*

A third key consideration is household composition, particularly the prevalence of older adults living alone. Currently, there are 1,750,900 older adults who are living alone, and 74% of them are women (TURKSTAT, 2025a). These figures highlight the need to better understand the lives of older people living alone as a social risk group —particularly older women— that must be addressed in urban policy and planning. Considering this group's needs and vulnerabilities, understanding how access to and utilisation of care are shaped should be a priority for social policy. Living alone as a community-dwelling older adult raises broader questions about the meaning of community as a social unit—beyond simply living outside of institutional settings, it involves coexisting and interacting with fellow community members. This also brings forth the question of what instrumental supports are necessary to enable access to care outside institutional frameworks.

Population ageing poses diverse challenges across national contexts, shaped by variations in healthcare systems, housing markets, and cultural expectations around care. The demographic profile of Türkiye—marked by a growing urban, community-dwelling, and living-alone older population—highlights the urgency of planning age-friendly cities and communities as a pillar of sustainable urban development. Our third research question is: *(3) How does urban accessibility affect the psychological well-being of older adults?*

A key challenge lies in preparing for these demographic shifts in ways that ensure age-friendly strategies benefit both current and future generations of older adults (Van Hoof et al., 2018). To address this challenge, this study maps urban accessibility among Türkiye's 50+ population—not only those aged 65 and older—and aims to provide evidence-based insights to inform sustainable urban governance. As noted above, the country's rapidly ageing population underscores the urgent need for action by researchers and policy makers. To our knowledge, this is the first study in Türkiye to systematically examine urban accessibility among the older population using nationally representative data,

and the first to analyse the link between accessibility and well-being among adults aged 50 and over. Regional variation provides a comparative perspective that enhances understanding of disparities and contextual needs. The global ageing of urban populations necessitates the adoption of more age-friendly approaches within the broader frameworks of sustainable city development, urban planning, and governance.

To address the three research questions outlined above, the second section of this study presents the theoretical background, followed by a detailed explanation of the methodology. The results section first provides descriptive findings, followed by the outcomes of the multiple linear regression analysis. Finally, the findings are discussed, and policy recommendations are presented.

2. Theoretical Background

While the idea of sustainable cities and communities is widely accepted as a policy goal, its practical meaning remains debated. A sustainable city is one that ensures equitable access to resources, protects the environment, and fosters long-term well-being through integrated, locally grounded planning (Bulkeley & Betsill, 2005). Older age necessitates a responsive and adaptable environment that can accommodate the evolving physical and social needs of older adults. Accordingly, both urban and rural settings must be considered in evaluating how environments affect older people's lives (Steels, 2015).

As individuals age, their need for more specialized and resource-intensive services increases. In recent years, various strategies and policies have emerged to address the specific needs of older people (Steels, 2015). To respond to the challenges of an ageing population, global frameworks have emerged. A major policy tool developed to support such efforts is the Active Ageing Index (AAI), which provides a cross-national comparative framework based on four key dimensions: (1) employment, (2) social participation, (3) independent, healthy, and secure living, and (4) enabling environments for active ageing (European Commission & UNECE, 2019). These dimensions also align closely with local age-friendly policies, such as the promotion of walkable neighbourhoods, equitable access to healthcare and services, and community-based care models. The AAI serves as a reference for policymakers, highlighting priorities and urgencies in current ageing policies (UNECE/EC, 2015). By emphasizing social participation, independent living, and an enabling environment for older adults, the AAI is a tool ensuring that local policies foster equitable access to resources, support inclusive communities, and enhance the overall well-being of ageing populations through local infrastructure and services (European Commission & UNECE, 2019). We observe that the AAI's perspective aligns

with "sustainable age-in-place" practices, particularly in terms of the built environment's effectiveness in facilitating active social engagement (Landorf et al., 2008).

While the AAI offers a policy tool for evaluating ageing outcomes across countries, the WHO (World Health Organization)'s Global Age-Friendly Cities Guide provides a practical urban planning framework that operationalizes these principles at the municipal level. It encourages municipalities to adopt principles that support older adults' ability to live independently (Plouffe & Kalache, 2010). Older people are especially sensitive to their neighbourhoods, as they tend to spend more time at home, rely more on local resources, and are often more emotionally attached to their communities (Poulsen et al., 2011, p. 221). Environmental barriers—including poor lighting, narrow sidewalks, and unsafe crossings—can exert what Lawton and Nahemow (1973) called "environmental press" on older adults, generating stress and limiting activity (as cited in Buffel, 2017, p. 2). Access to services such as recreational areas and fresh food markets can encourage healthy habits like exercise and nutrition. In addition to the built environment, health is also shaped by social aspects of place, such as trust and social capital (Lochner et al., 1999). Public transit offers a low-cost and environmentally sustainable mode of transportation that supports independent mobility, making it particularly valuable for addressing the mobility needs of an ageing population. Given its potential to enhance mobility among older adults, it is essential to ensure that public transport systems are accessible to individuals of all abilities and provide reliable access to desired destinations (Ravensbergen et al., 2022).

When it comes to studying with the older population, a devoted concept is the age-friendly city, defined as "a place where older people are actively involved, valued, and supported with infrastructure and services that effectively accommodate their needs" (Van Hoof et al., 2018). Following this concept, age-friendly communities are inclusive communities that promote autonomy by ensuring access to meaningful activities, relationships, and mobility. As Scharlach and Lehning (2013, pp. 110–113) argue, age-friendly environments must reduce disabling conditions and challenge ageist norms that otherwise lead to exclusion and decline. To maintain the well-being of community-dwelling older people, a holistic approach is needed (Lawler, 2001).

The concept of "ageing-in-place" reflects older adults' desire to remain in familiar physical and social environments as they age (Wiles et al., 2012). Starting from earlier studies, it refers to the ability of older people to continue to live in their own homes even after functional decline and increased dependence (Emlet & Moceri, 2012). This preference shows the importance of not only

the built environment but also social infrastructure in enabling autonomy in late life. Supporting ageing-in-place means supporting an independent living which requires both physical and social environments that are age-friendly and inclusive. In this study, ageing-in-place will be discussed, focusing on both the social and physical infrastructure.

In Türkiye, ageing-in-place is more than a preference; it is shaped by limited institutional care options and strong care norms which rely heavily on filial expectations. While this may reduce formal care costs (Gitlin, 2003), it also places pressure on families and communities to provide informal care, a responsibility that is increasingly strained under demographic changes (Akkan & Şanlı, 2023). The ageing population thus presents both a policy challenge and a social imperative to create environments that support autonomy, dignity, and mobility for older adults.

Built environments—such as pedestrian infrastructure, transportation systems, and public amenities—can either support or hinder ageing-in-place (WHO, 2007). These environments often determine whether older individuals can continue living independently or become reliant on others. For vulnerable social groups such as older adults, equitable access to resources is essential to advancing social justice and reducing urban inequalities. To our knowledge, there is no study in Türkiye that has analysed accessibility and the well-being of older adults at the national level using regionally comparative quantitative data.

This study aims to examine the extent to which built environments in Türkiye support independent living among older adults, identify region-specific accessibility needs for promoting sustainable and age-friendly urban development, and assess the impact of urban accessibility on the psychological well-being of individuals aged 50 and over. Drawing on the nationally representative 2023 Türkiye Ageing Profile Survey (N = 26,767), the study combines regional-level descriptive statistics and multiple linear regression analysis to explore both spatial inequalities in accessibility and their relationship to well-being.

3. Methods

To address our three research questions, we used nationally representative data that provide information on the urban accessibility of populations aged 50 and over. Utilizing such data enables the development of a comprehensive understanding of the extent to which different regions are age-friendly and helps identify the key areas of concern.

3.1. Data and Research Questions

The Türkiye Ageing Profile Survey was conducted by the TURKSTAT in collaboration with the Ministry of Family and Social Services. The field application was conducted from October 23 to December 18, 2023. The micro data set presents information on demographics, working life and economic conditions, health, independent living, care and social assistance, environment, participation in social life, life satisfaction, disasters and emergencies, rights and ageism, dwelling, and general information on the environment.

All settlements within the borders of the Republic of Türkiye were covered using the Address Based Population Register System (ABPRS). The data include 29,785 individuals aged 50 and above, drawn through a multi-stage cluster sampling method. The sample is nationally representative and covers all 12 NUTS-1 (The Nomenclature of Territorial Units for Statistics- 1) regions. Institutional populations (e.g., nursing homes, prisons, military facilities) were excluded. Only households with at least one-person aged 50+ were eligible.

In this study, we excluded proxy responses (see Chapter 3, 2, for further information) due to high data missing in certain variables. The final analytical sample consists of 26,767 self-respondents aged 50 to 90 (M = 62.8, SD = 9.2). There are 14,161 women (52.9%) and 12,606 men (47.1%) in our sample. The present study is guided by the following three research questions: (1) To what extent does the built environment in Türkiye support independent living among the ageing population? (2) What are the region-specific needs for ensuring sustainable and age-friendly cities in Türkiye, particularly in terms of public space, pedestrian infrastructure, and public transportation accessibility? (3) How does urban accessibility affect the psychological well-being of older adults?

3.2. Data Collection Instrument

Three questionnaires were used in the survey: (1) a household form to list all members, (2) a household questionnaire answered by a key respondent, and (3) an individual questionnaire asked to all-household members aged 50 and over. Data were primarily collected through computer-assisted personal interviews (CAPI). When in-person interviews were not possible, computer-assisted telephone interviews (CATI) were used. For individuals unable to respond due to age-related health issues, a household or non-household member provided information as a proxy. In such cases, subjective questions related to personal perceptions or experiences were omitted. Our study uses only data from the individual questionnaire and is designed at the individual level.

3.3. Variables

3.3.1. Descriptive Variables

To evaluate the built environment as supporting independent living, descriptive analyses were conducted across three types of accessibility: (1) public spaces, (2) pedestrian, and (3) public transportation. Variables with consistently low expected cell frequencies (e.g., reasons for being unable to go outside) were excluded from the chi-square analysis to ensure statistical validity and clarity.

Regional comparisons were based on the NUTS-1 classification (12 regions), which allows for spatially disaggregated insights into differences in urban accessibility for adults aged 50 and above (see Table 1).

Table 1. Population 50 Years Old and Over in Each Region (N = 26767)

	n	%
TR1	3367	12.6
TR2	1932	7.2
TR3	3472	13.0
TR4	2573	9.6
TR5	2657	9.9
TR6	2810	10.5
TR7	1861	7.0
TR8	2253	8.4
TR9	1390	5.2
TRA	1187	4.4
TRB	1416	5.3
TRC	1849	6.9

Regions and cities in each region are as follows: TR1 İstanbul (İstanbul), TR2 West Marmara (Tekirdağ, Edirne, Kırklareli, Balıkesir, Çanakkale), TR3 Aegean (İzmir, Aydın, Denizli, Muğla, Manisa, Afyonkarahisar, Kütahya, Uşak),

TR4 East Marmara (Bursa, Eskişehir, Bilecik, Kocaeli, Sakarya, Düzce, Bolu, Yalova), TR5 West Anatolia (Ankara, Konya, Karaman), TR6 Mediterranean (Antalya, Isparta, Burdur, Adana, Mersin, Hatay, Kahramanmaraş, Osmaniye), TR7 Central Anatolia (Kırıkkale, Aksaray, Niğde, Nevşehir, Kırşehir, Kayseri, Sivas, Yozgat), TR8 West Black Sea (Zonguldak, Karabük, Bartın, Kastamonu, Çankırı, Sinop, Samsun, Tokat, Çorum, Amasya), TR9 East Black Sea (Trabzon, Ordu, Giresun, Rize, Artvin, Gümüşhane), TRA North East Anatolia (Erzurum, Erzincan, Bayburt, Ağrı, Kars, Iğdır, Ardahan), TRB Central East Anatolia (Malatya, Elazığ, Bingöl, Tunceli, Van, Muş, Bitlis, Hakkari), TRC South East Anatolia (Gaziantep, Adıyaman, Kilis, Şanlıurfa, Diyarbakır, Mardin, Batman, Şırnak, Siirt).

Public space accessibility (coded as 1 = Yes, 2 = No) included the following binary items: going outside unassisted, transportation problems, environmental problems, security risks, inadequate stairs/ramps/sidewalks, poor lighting, lack of green areas, insufficient seating (e.g., benches, pergolas), and inadequate restrooms.

Pedestrian accessibility (coded as 1 = Yes, 2 = No) included problems with: crossing the street, walking on sidewalks, short traffic light durations, using pedestrian-priority zones, and seeing traffic signs/signals. Public transport accessibility (recoded as 1 = Yes, 0 = No) included: reaching bus stops, difficulty in waiting at the stop, boarding or exiting vehicles, and standing during trips.

3.3.2. Dependent and Independent Variables for Multivariate Analysis

Self-rated health was recoded following the Survey of Health, Ageing, and Retirement in Europe (SHARE) classification. Responses were dichotomized as 0 = "good or very good health" and 1 = "less than good health" (Mehrbrodt et al., 2019). Gender was recoded as 1 = male and 0 = female. Age was treated as a continuous variable, based on respondents' reported age at the time of the survey.

The following binary variables were coded as 1 = Yes and 0 = No: Living alone, ability to go outside without help, difficulty accessing healthcare services, feeling safe walking alone at night in one's neighbourhood, and difficulty moving around as a pedestrian (see Table 2).

Table 2. The Characteristics of the Sample (N = 26767)

	n	%
Age (n = 26767)		
50-64	16557	61.9
65-74	6929	25.9
75-90	3281	12.3
Self-rated health (n = 26767)		
Good or very good	17543	65.5
Less than good	9224	34.5
Living alone (n = 26767)		
Yes	3348	12.5
No	23419	87.5
Going outside unassisted (n = 26767)		
Yes	24422	91.2
No	2345	8.8
Difficulty accessing healthcare (n = 26689)		
Yes	6700	25.1
No	19989	74.9
Pedestrian difficulties (n = 5224)		
Yes	3172	60.7
No	2052	39.3
Safety walking at night (n = 25608)		
Yes	19746	77.1
No	5862	22.9

The Geriatric Depression Scale (GDS) was used as a continuous outcome variable to proxy psychological well-being. Items 5, 7, 9, 15, 19, 21, 28, 29, and 30 were recoded as 0 = Yes, 1 = No, while all other items were coded as 1 = Yes, 0 = No. A total score was calculated, ranging from 0 to 30, with higher scores indicating more depressive symptoms. The value for Cronbach's Alpha for the GDS was $\alpha = .897$ ($M = 9.15$, $SD = 6.5$). Normality was examined using the Kolmogorov–Smirnov test, which was significant ($D = .123$, $p < .001$), which formally indicates a deviation from a normal distribution. However, as Tabachnick and Fidell (2013) note (cited in Pallant, 2020), normality tests

are highly sensitive to large sample sizes, where even trivial departures from normality can yield significant results. Therefore, in addition to the significance test, we inspected descriptive statistics (skewness and kurtosis) and visual plots (histogram and Q–Q plots). These indicated that the distribution of the GDS was approximately normal, with skewness and kurtosis values within the recommended ±1.0 range. Accordingly, the assumption of normality was considered adequately met for the planned analyses.

Evidence from SHARE data indicates that access to local services is linked to fewer depressive symptoms and greater psychological resilience (Stoeckel & Litwin, 2015). Furthermore, age-friendly neighbourhood design (Cheng et al., 2019) and the availability of walkable, safe environments (Scharlach & Lehning, 2013) have been identified as key determinants of urban accessibility for older people.

3.4. Analysis

The analysis was conducted in two stages.

Stage 1. Descriptive Analysis and Chi-Square Tests: To explore regional variation in built environment accessibility and autonomous living among adults aged 50 and over, chi-square tests of independence were conducted. Categorical variables and binary indicators were compared across 12 NUTS-1 regions. Adjusted standardized residuals were calculated to identify regions with significantly higher or lower frequencies. A threshold of ±2.0 was used to denote statistically significant deviations (Field, 2009, p.740). Effect sizes were evaluated using Cramér's V, interpreted according to Rea and Parker's (1992) classification: 0.10 = weak, 0.20 = moderate, 0.40 = relatively strong.

Stage 2. Linear Regression Analysis: A multiple linear regression analysis was conducted to assess the relationship between the built environment and well-being, measured by the total score on the Geriatric Depression Scale (GDS). Independent variables included age, gender, perceived health status, living alone, ability to go outside unassisted, pedestrian difficulties, difficulty accessing healthcare, and perceived safety when walking alone at night. All predictors were entered simultaneously. The model's overall effect size was evaluated using R^2 and Adjusted R^2 values. The Statistical Package for Social Sciences (SPSS 23) software was used for data analysis. After finalising the sample, the reliability of the scale was first examined using Cronbach's alpha coefficient. The distribution of numerical variables was assessed through Q–Q plots, P–P plots, skewness and kurtosis values, and the Kolmogorov–Smirnov test results. Given the characteristics of the dependent variable and the nature of the research question, multiple linear regression was selected, following the verification of its

underlying assumptions. In the model, the variance inflation factor (VIF) was checked to ensure that it remained below 10, thereby confirming the absence of multicollinearity. Model fit was evaluated using the Durbin–Watson statistic (acceptable range: 1.5–2.5). A significance level of $p < 0.05$ was adopted to indicate statistical significance

4. Results

4.1. Descriptive Analysis Results

Our detailed descriptive analysis revealed several key findings that highlight the main areas of concern for each region. The primary accessibility barriers were identified as the lack of green spaces, insufficient seating and resting areas, inadequate toilet facilities, concerns regarding safety and security, and environmental challenges. These issues were particularly pronounced in three regions: İstanbul (TR1), East Marmara (TR4), and the Mediterranean (TR6).

With respect to pedestrian accessibility and barriers, our findings pointed out short traffic light durations and the limited visibility of traffic signs as major concerns. These problems were especially evident in Northeast Anatolia (TRA), Central East Anatolia (TRB), Southeast Anatolia (TRC), the Aegean (TR3), East Marmara (TR4), and the East Black Sea (TR9).

4.1.1. Accessibility of Public Spaces

4.1.1.1. Going Outside Unassisted

Chi-square tests revealed statistically significant regional differences in the ability of adults aged 50 and over to go outside without assistance. Although the association was weak in strength, the results indicate a variation across Türkiye's 12 NUTS-1 regions (see Table 3).

In East Marmara (TR4), the ability to go out without assistance is higher than expected (AR = +5.5). Similarly, İstanbul (TR1), West Marmara (TR2), and the Aegean (TR3) also show higher-than-expected levels of independent outdoor activity (AR = +4.6; AR = +3.3; AR = +3.0, respectively). By contrast, in Southeast Anatolia (TRC), the inability to go out without assistance is higher than expected (AR = –10.6). Likewise, Northeast Anatolia (TRA) and Central East Anatolia (TRB) exhibit higher-than-expected levels of inability to go out without assistance (AR = –5.5; AR = –4.9, respectively).

Other regions, such as West Anatolia (TR5), Mediterranean (TR6), and West Black Sea (TR8), displayed weak and statistically non-significant deviations, suggesting moderate or average levels of accessibility. In East Black Sea (TR9), residuals were negligible, indicating no substantial regional divergence.

4.1.1.2. Accessibility Barriers

Among respondents who did use public spaces (n= 21,295), notable regional variation was observed in their reported difficulties (see Table 3). Regional differences were evident in the reporting of lack of green spaces among adults aged 50 and older, with a moderate effect size. İstanbul (TR1), East Marmara (TR4), and Mediterranean (TR6) reported significantly more problems related to green space availability than expected, with adjusted residuals ranging from +2.3 to +22.9. By contrast, West Marmara (TR2), Aegean (TR3), West Black Sea (TR8), and East Black Sea (TR9) exhibited significantly fewer reports of green area shortages than expected, with adjusted residuals ranging from –4.4 to –10.8.

Regional differences were also evident in the reporting of inadequate toilet facilities among adults aged 50 and older, with a moderate effect size. İstanbul (TR1), East Marmara (TR4), and Mediterranean (TR6) reported significantly more problems related to inadequate toilet access than expected, with adjusted residuals ranging from +7.7 to +16.5. By contrast, West Marmara (TR2), Aegean (TR3), West Anatolia (TR5), Central Anatolia (TR7), West Black Sea (TR8), East Black Sea (TR9), and Southeast Anatolia (TRC) exhibited significantly fewer reports of toilet-related difficulties than expected, with adjusted residuals ranging from –12.2 to –3.4.

Regional differences were also evident in the reporting of insufficient seating and rest areas among adults aged 50 and older, with a weak to moderate effect size. İstanbul (TR1), East Marmara (TR4), and Mediterranean (TR6) reported significantly more problems related to insufficient seating than expected, with adjusted residuals ranging from +4.7 to +13.9. By contrast, West Marmara (TR2), West Anatolia (TR5), West Black Sea (TR8), and East Black Sea (TR9) exhibited significantly fewer reports of seating-related difficulties than expected, with adjusted residuals ranging from –10.6 to –4.4.

Regional differences were also evident in reports of safety and security problems among adults aged 50 and older, with a weak to moderate effect size. İstanbul (TR1), East Marmara (TR4), and Mediterranean (TR6) reported significantly more problems related to safety and security than expected, with adjusted residuals ranging from +3.8 to +18.7. By contrast, West Marmara (TR2), Aegean (TR3), West Anatolia (TR5), West Black Sea (TR8), East Black Sea (TR9), and Southeast Anatolia (TRC) exhibited significantly fewer reports of safety- and security-related difficulties than expected, with adjusted residuals ranging from –7.6 to –2.3.

Regional differences were also evident in the reporting of environmental problems among adults aged 50 and older, with a weak to moderate effect

size. İstanbul (TR1), East Marmara (TR4), and Mediterranean (TR6) reported significantly more problems related to environmental conditions than expected, with adjusted residuals ranging from +3.9 to +17.0. By contrast, West Marmara (TR2), Aegean (TR3), West Anatolia (TR5), West Black Sea (TR8), East Black Sea (TR9), and Northeast Anatolia (TRA) exhibited significantly fewer reports of environmental difficulties than expected, with adjusted residuals ranging from –9.3 to –2.0.

Regional differences were evident in stair-related accessibility problems among adults aged 50 and older, with a weak effect size. İstanbul (TR1), Mediterranean (TR6), West Black Sea (TR8), and Central East Anatolia (TRB) reported significantly more stair accessibility problems than expected, with adjusted residuals ranging from +2.5 to +4.6. By contrast, West Marmara (TR2) exhibited a markedly positive deviation, with significantly fewer individuals reporting stair-related difficulties (AR = –11.2). East Black Sea (TR9) also performed better than expected (–5.7), indicating potentially more accessible residential environments.

Regional differences were also evident in reported poor lighting conditions among adults aged 50 and older, with a weak effect size. İstanbul (TR1), Mediterranean (TR6), Central East Anatolia (TRB), and Southeast Anatolia (TRC) reported more lighting-related problems than expected, with adjusted residuals ranging from +4.3 to +6.7. By contrast, West Marmara (TR2), Aegean (TR3), and East Black Sea (TR9) exhibited fewer reports of poor lighting than expected, with adjusted residuals ranging from –3.1 to –7.7.

Regional differences were also evident in the reporting of public transport accessibility problems among adults aged 50 and older, with a week effect size. İstanbul (TR1), Mediterranean (TR6), Northeast Anatolia (TRA), Central East Anatolia (TRB), and Southeast Anatolia (TRC) reported more problems related to transport accessibility than expected, with adjusted residuals ranging from +3.6 to +10.0. By contrast, West Marmara (TR2), Aegean (TR3), East Marmara (TR4), West Anatolia (TR5), and East Black Sea (TR9) exhibited fewer reports of transport-related difficulties than expected, with adjusted residuals ranging from –8.7 to –3.9.

Table 3. Summary of Chi-Square Results for Public Space Use, Access Barriers, and Environmental Conditions by Region

Variable	n	Chi-square (df)	p-value	Cramér's V	Effect size
Going outside unassisted	26767	224.91 (11)	< .001	0.092	Weak
Inaccessible stairs	21295	202.91 (11)	< .001	0.098	Weak
Poor lighting	21295	230.66 (11)	< .001	0.104	Weak
Lack of green space	21295	717.93 (11)	< .001	0.184	Moderate
Insufficient seating/rest areas	21295	483.71 (11)	< .001	0.151	Moderate
Inadequate toilets	21295	673.06 (11)	< .001	0.178	Moderate
Transportation problems	21295	391.88 (11)	< .001	0.136	Weak
Safety concerns	21295	534.81 (11)	< .001	0.158	Moderate
Environmental problems	21295	496.21 (11)	< .001	0.153	Moderate

Note. All chi-square tests were statistically significant at p < .001. Cramér's V values represent effect sizes based on Rea and Parker (1992): 0.10 = weak, 0.20 = moderate, 0.40 = relatively strong. n indicates the number of valid cases used in each chi-square test.

4.1.2. Pedestrian Accessibility and Barriers

Chi-square tests revealed regional differences in all five indicators of pedestrian-related difficulties among adults aged 50 and older (see Table 4). Short traffic light durations showed these regional disparities, with a moderate effect size. Northeast Anatolia (TRA, +6.3), East Black Sea (TR9, +2.8), Aegean (TR3, +2.9), and East Marmara (TR4, +2.0) reported greater difficulties, whereas West Black Sea (TR8, –6.0), West Marmara (TR2, –4.6), and Mediterranean (TR6, –2.5) reported significantly fewer.

Difficulty seeing traffic signs or lights showed clear regional disparities, with a moderate effect size. Southeast Anatolia (TRC, +4.9), East Black Sea (TR9, +4.3), Northeast Anatolia (TRA, +4.1), and Central East Anatolia (TRB, +3.9) reported significantly more visual difficulties, whereas İstanbul (TR1, –4.5), West Black Sea (TR8, –4.2), and Mediterranean (TR6, –3.3) reported significantly fewer. These findings highlight considerable regional variations in pedestrian safety and accessibility for older adults across Türkiye.

The other three indicators had a weak effect. For difficulty crossing streets, Northeast Anatolia (TRA, +2.3) reported more difficulties, whereas İstanbul

(TR1, –3.3) and West Marmara (TR2, –2.3) reported fewer than expected. Difficulties walking on sidewalks also differed, with Central East Anatolia (TRB, +3.3) and Northeast Anatolia (TRA, +2.0) experiencing greater issues, while West Black Sea (TR8, –3.2) reported fewer difficulties. For using pedestrian-priority roads, Northeast Anatolia (TRA, +4.3), İstanbul (TR1, +3.7), and Southeast Anatolia (TRC, +2.6) reported more issues, while West Black Sea (TR8, –5.7) and West Marmara (TR2, –4.6) reported fewer problems.

Table 4. Summary of Chi-Square Results for Pedestrian Accessibility Barriers by Region

Variable	n	Chi-square (df=11)	p-value	Cramér's V	Effect size
Crossing the street	21295	30.72	.001	.077	Weak
Walking on sidewalks	21295	31.90	.001	.078	Weak
Short traffic light duration	21295	120.98	< .001	.152	Moderate
Using pedestrian-priority roads	21295	92.59	< .001	.133	Weak
Seeing traffic signs/ lights	21295	116.82	< .001	.150	Moderate

Note. All chi-square tests were statistically significant at $p < .001$. Cramér's V values represent effect sizes based on Rea and Parker (1992): 0.10 = weak, 0.20 = moderate, 0.40 = relatively strong. n indicates the number of valid cases used in each chi-square test.

4.1.3. Public Transport Accessibility Barriers

Regional differences were evident across all indicators related to public transport accessibility, with weak to moderate effect sizes (see Table 5). Difficulty accessing public transport stops differed by region. Central East Anatolia (TRB, +10.9), Southeast Anatolia (TRC, +6.7), and Northeast Anatolia (TRA, +4.9) reported more difficulties, whereas West Marmara (TR2, –6.7), Aegean (TR3, –5.3), East Marmara (TR4, –4.5), and İstanbul (TR1, –4.1) reported fewer problems.

Difficulties waiting at transport stops also varied. Central East Anatolia (TRB, +9.4), Southeast Anatolia (TRC, +7.5), Northeast Anatolia (TRA, +5.5), and İstanbul (TR1, +4.5) reported higher than expected waiting-related difficulties. In contrast, West Marmara (TR2, –7.4), Aegean (TR3, –5.5), East Marmara (TR4, –4.6), and East Black Sea (TR9, –4.2) showed lower difficulties.

Boarding and alighting difficulties differed by region ($\chi^2(11) = 149.95$, $p < .001$, Cramér's V = .110). Northeast Anatolia (TRA, +6.4), Southeast Anatolia (TRC, +4.9), and Central East Anatolia (TRB, +2.9) reported more difficulties. Conversely, Aegean (TR3, –6.0), West Marmara (TR2, –5.2), and East Black Sea (TR9, –3.2) had fewer difficulties.

Difficulty standing in public transport vehicles was also associated with the region. Southeast Anatolia (TRC, +6.9), Central East Anatolia (TRB, +3.5), and Northeast Anatolia (TRA, +3.4) reported greater standing difficulties. West Marmara (TR2, –8.0), Aegean (TR3, –8.0), East Black Sea (TR9, –5.7), and West Black Sea (TR8, –5.6) indicated fewer problems.

Table 5. Summary of Chi-Square Results for Public Transport Accessibility Barriers by Region

Variable	n	Chi-square (df=11)	p-value	Cramér's V	Effect size
Reaching the stop	12409	283.73	< .001	0.15	Weak
Difficulty in waiting at the stop	12409	314.52	< .001	0.16	Weak
Boarding/alighting problems	12409	149.95	< .001	0.11	Weak
Difficulty standing in the vehicle	12409	285.41	< .001	0.15	Weak

Note. All chi-square tests were statistically significant at $p < .001$. Cramér's V values represent effect sizes based on Rea and Parker (1992): 0.10 = weak, 0.20 = moderate, 0.40 = relatively strong. n indicates the number of valid cases used in each chi-square test.

4.2. Linear Regression Results

Perceived health status, healthcare accessibility, and the ability to go outside unassisted were the strongest determinants of depression. A multiple linear regression analysis was conducted to examine the association between urban accessibility and well-being among individuals aged 50 and older, using the Geriatric Depression Scale (GDS) score as the dependent variable. The model was statistically significant, $F(8, 4900) = 178.26$, $p < .001$, and accounted for approximately 22.5% of the variance in GDS scores ($R^2 = .225$, Adjusted $R^2 = .224$). The Durbin-Watson statistic was 1.640, indicating that the assumption of independent residuals was met. All variance inflation factor (VIF) values ranged between 1.070 and 1.202, confirming that multicollinearity was not a concern.

The strongest contributors to lower depression scores were better perceived health (β = -0.224, p < .001), the ability to go outside without help (β = -0.159, p < .001), and feeling safe walking alone at night (β = -0.127, p < .001). Difficulty accessing healthcare was the strongest contributor to higher depression scores (β = 0.165, p < .001), followed by living alone (β = 0.054, p < .001), and experiencing difficulty as a pedestrian (β = 0.074, p < .001). The last significant but weaker predictor was being male (β = -0.087, p < .001), men had lower levels of depression. Age was not a statistically significant predictor (B = 0.014, p = .158). These findings indicate that independent mobility and environmental safety are important determinants of well-being among older adults in Türkiye, beyond demographic and health-related factors (see Table 6).

Table 6. Multiple Linear Regression Predicting Geriatric Depression Score

Predictor	B	SE	β	t	p	95% CI
Constant	2.731	0.156		17.56	< .001	[2.426, 3.036]
Age	0.014	0.01	0.018	1.42	0.158	[-0.006, 0.033]
Gender (ref = female)	-0.393	0.053	-0.087	-7.41	< .001	[-0.497, -0.289]
Perceived health (ref = good health)	1.032	0.062	0.224	16.6	< .001	[0.910, 1.153]
Living alone (ref = no)	0.243	0.06	0.054	4.08	< .001	[0.125, 0.361]
Going outside unassisted (ref = no)	-0.701	0.058	-0.159	-12.02	< .001	[-0.814, -0.589]
Pedestrian difficulty (ref = no)	0.331	0.059	0.074	5.64	< .001	[0.216, 0.446]
Healthcare access difficulty (ref = no)	0.786	0.064	0.165	12.26	< .001	[0.661, 0.910]
Feels safe walking at night (ref = no)	-0.56	0.06	-0.127	-9.39	< .001	[-0.678, -0.443]

Note. N = 4909. R^2 = .225, Adjusted R^2 = .224, F(8, 4900) = 178.26, p < .001. Durbin-Watson = 1.640. VIF values ranged from 1.070 to 1.202, indicating no multicollinearity.

5. Discussion

This study combined regional-level descriptive statistics and multiple linear regression analysis to examine both accessibility inequalities and their relationship to well-being.

5.1. What Does Descriptive Analysis Tell Us About Accessibility?

The results highlight inequality in terms of ageing and independent mobility. Older adults in western and more urbanized regions appear to benefit from age-friendly infrastructures more —though significant limitations remain, as discussed below—while those in the eastern parts of the country face substantial mobility barriers. It should be emphasized that Türkiye is a geographically large country, with each region shaped by distinct topographies, which gives these challenges a local character.

Starting with going outside unassisted as a main indicator of autonomous living, we see that the western regions of Türkiye support such a life better than the other regions. İstanbul, a metropolis with around 16 million residents (TURKSTAT, 2025c), experienced a major migration flow in the early 1950s as a centre of job opportunities, on top of its historical and cultural attractions. These qualities make the region an ongoing project of demographic change and urban accessibility. West Marmara is closely connected to İstanbul, while East Marmara demonstrates the best accessibility results among all 12 regions. The Aegean, another coastal region, also shows outcomes supportive of autonomous living. The overall results regarding going outside unassisted can further be interpreted through the lens of city–coast integration. The literature also shows that various design strategies are applied to improve city–coast integration by transforming coastal areas into functional, comfortable, and easily accessible public spaces usable for multiple purposes, thereby aiming to provide more liveable environments for city residents (Aköz Çevrimli, 2025).

Even though "going outside unassisted" showed a more age-friendly picture in favour of İstanbul and East Marmara, a detailed look shows the problematic areas. İstanbul, East Marmara, and Mediterranean regions demonstrated a persistent inaccessibility in terms of green spaces, sufficient seating, public toilets, safety, and overall environment, which also raises concerns about the extent to which even the more age-friendly regions provide an encouraging environment for older people. Since older adults in Türkiye are increasingly migrating to mid-sized coastal cities (Koç & Saraç, 2018), there is a need for a deeper understanding of how to create more supportive environmental conditions in these regions.

We observe a clear pattern of inaccessibility in the eastern parts of Türkiye. South-eastern Anatolia, Central Eastern Anatolia, and North-eastern Anatolia represent the regions where this inequality is most prevalent. The literature on geography and accessibility has already shown that the South-eastern Anatolia Region remains underdeveloped, with accessibility studies clearly emphasizing the necessity of improving transportation (Şen, 2019). Our study supports this by analysing pedestrian and public transport accessibility among older adults, offering a more detailed understanding of the region. In particular, South-eastern, Central Eastern, and North-eastern Anatolia face severe accessibility problems in areas that could be relatively easily improved, such as traffic light durations and the visibility of traffic signs and signals. Lastly, South-eastern Anatolia experiences disadvantages across all indicators of public transport accessibility. This is important because the literature shows that features of neighbourhood design—such as traffic calming measures, pedestrian pathways, and sidewalks—can significantly influence perceived safety and increase the likelihood of walking and other forms of active travel among older adults (Cheng et al., 2019).

Our results are also consistent with Türkiye's Active Ageing Index scores for 2024. At the NUTS-1 level, the highest score for the independent, healthy, and safe living component was observed in the Aegean Region, followed by the West Anatolia and East Marmara regions. In contrast, the lowest scores were recorded in the South-eastern Anatolia Region, followed by the North-eastern Anatolia Region and İstanbul (TURKSTAT, 2025d). These findings closely align with our descriptive results on overall accessibility.

5.2. One Step Beyond: The Relationship Between Urban Accessibility and Well-Being

The regression analysis underscores the critical role of environmental and mobility-related factors in shaping the psychological well-being of older adults in Türkiye. Our findings resonate with current literature, which showed that particularly perceived access to local services is associated with fewer depressive symptoms and greater psychological resilience (Stoeckel & Litwin, 2015). While perceived health remains the most powerful predictor of lower depressive symptoms, the ability to go outside unassisted and the feeling of safety while walking alone at night also emerge as significant protective factors. These findings highlight that beyond individual health and demographic characteristics, the accessibility and safety of the built environment contribute meaningfully to emotional well-being in later life, along with the current literature (Buffel, 2017).

Difficulties in accessing healthcare services and pedestrian environments were among the strongest predictors of elevated depression scores, reinforcing the notion that infrastructural and service-based inequalities can amplify vulnerability. Interestingly, age itself did not predict depression, suggesting that it is not chronological ageing per se, but rather the socio-environmental conditions surrounding ageing that shape mental health outcomes. The literature shows that healthy habits do not solely depend on personal choices, social factors also play a significant role (Palaz, 2023). Accessing services such as recreational areas and fresh food markets can encourage healthy habits, such as exercise and nutrition. In addition to the built environment, health is also shaped by social aspects of place, such as trust and social capital (Lochner et al., 1999).

Our results align with previous findings across Europe, where neighbourhood accessibility has been linked to mental well-being among older adults. This study also resonates with evidence on the role of environmental deprivation. Feelings of insecurity tend to increase with age and are intensified in poorly maintained urban spaces (De Donder et al., 2005). Living in deprived neighbourhoods leads to cumulative disadvantage over time, constraining movement and inclusion. Conversely, walkable and safe environments foster stronger social capital and engagement (Scharlach & Lehning, 2013), which is especially important for older adults who live alone. Our findings show that one-person households face a higher risk of depression. Given the increase in the 65+ population living alone in Türkiye (TURKSTAT, 2025a), this topic warrants focused examination. In line with existing research, our findings empirically support the inclusion of social, spatial, and mobility dimensions in well-being interventions.

5.3. Limitations and Future Research

Our data source, the Türkiye Ageing Profile Survey, has strong qualities such as being nationally representative and capturing regional variation. To the best of our knowledge, the Türkiye Ageing Profile Survey has not previously been analysed in terms of urban governance and age-friendly cities. One limitation of the data source is the quality of data collected through the CATI (Computer-Assisted Telephone Interviewing) method. Another limitation is the lack of inclusiveness in survey language. Since Türkiye's older population is highly heterogeneous, it is recommended that future surveys be conducted in multiple languages, such as Kurdish and Arabic. The Türkiye Ageing Profile Survey has been conducted only once; therefore, our study uses cross-sectional data, which means the results cannot demonstrate causality or long-term effects. Using longitudinal data would allow us to observe changes over time and provide insight into generational differences. In future studies, comparable

results with other countries can be produced using longitudinal data sources, such as the SHARE, the Health and Retirement Study (HRS), and the English Longitudinal Survey of Ageing (ELSA) (Palaz, 2021a, 2021b). Research using SHARE demonstrates that while most older Europeans enjoy good accessibility, a minority do not, with urban residents reporting better access than those in rural areas (Stoeckel & Litwin, 2015). Future research in Türkiye should investigate urban–rural disparities in accessibility among older adults, thereby generating evidence to guide age-friendly city planning and the development of equitable urban policies that address regional inequalities.

6. Policy Recommendations

The findings of this study reveal clear regional differences in the accessibility of public spaces, pedestrian infrastructure, and transportation systems for Türkiye's ageing population. These structural barriers undermine older adults' autonomy, mobility, and psychological well-being. In addition, perceptual and individual-level barriers further exacerbate these vulnerabilities, as evidenced by the regression analysis.

When considered alongside the United Nations Sustainable Development Goals (SDGs), particularly Goal 11, these regional disparities in Türkiye form the basis for targeted policy recommendations aimed at achieving more sustainable cities and communities. By 2030, it is essential to ensure universal access to adequate, safe, and affordable housing and basic services; expand accessible and reliable public transport systems, with special attention to the needs of older persons and other vulnerable groups; promote participatory and integrated approaches to urban planning; and invest in inclusive, green, and age-friendly public spaces. These targets offer a normative and operational framework through which local and national governments can design policies that reflect both demographic realities and the principles of social justice. To this end, we offer the following policy recommendations based on our findings:

1. Regionally tailored evidence-based interventions: In İstanbul (TR1), immediate infrastructure improvements in stair accessibility, public lighting, green spaces, seating areas, toilets, transportation, and security are required. For East Marmara (TR4), improvements should focus on enhancing public spaces, particularly seating and toilet infrastructure, environmental quality, and security, while preserving existing advantages in transportation accessibility. Mediterranean (TR6) and Southeast Anatolia (TRC) require targeted investments in public transportation to improve mobility. For regions reporting relatively fewer issues—such as West Marmara, Aegean, and Black Sea regions—policies should concentrate on maintaining current favourable conditions

through ongoing infrastructure monitoring and improvements. Additionally, special attention must be paid to mobility challenges identified in TRA and TRB, ensuring targeted accessibility enhancements. Ultimately, these targeted actions can significantly reduce inequalities and improve the overall well-being of older adults across Türkiye.

2. Enhancing Pedestrian Environments: Priority should be given to Northeast Anatolia (TRA), with investments in improved pedestrian infrastructure—particularly pedestrian priority roads, sidewalk quality, clear and visible traffic signage, and extended traffic light durations—to enhance safety and mobility. For Southeast Anatolia (TRC) and Central East Anatolia (TRB), policies should specifically focus on improving pedestrian-priority roads and enhancing visibility conditions through better signage and lighting. Metropolitan areas, especially İstanbul (TR1), require targeted interventions addressing pedestrian infrastructure quality and the usability of pedestrian-priority pathways. Conversely, regions like West Marmara (TR2) and West Black Sea (TR8), which reported fewer difficulties, should aim to maintain and reinforce their favourable pedestrian conditions through continuous monitoring, infrastructure upgrades, and adherence to age-friendly urban planning standards. These targeted policy actions are essential to ensuring equitable and inclusive pedestrian environments for older adults across all regions of Türkiye.

3. Ensuring Equitable Public Transport: Immediate infrastructure investments should prioritize Central East Anatolia (TRB), Southeast Anatolia (TRC), and Northeast Anatolia (TRA), where significant improvements in transport stop accessibility, conditions at waiting areas, ease of boarding and alighting, and onboard seating provisions are urgently needed. For metropolitan regions such as İstanbul (TR1), specific measures should aim at enhancing comfort and safety at transport stops and reducing waiting-related difficulties through improved shelters, seating, and clear signage. Conversely, in regions demonstrating favourable conditions—West Marmara (TR2), Aegean (TR3), East Marmara (TR4), and East Black Sea (TR9)—maintenance and further enhancement of existing infrastructure should continue, ensuring that current advantages are sustained through regular monitoring and incremental upgrades. Such geographically targeted policies will play a crucial role in fostering inclusive, age-friendly public transport environments throughout Türkiye.

4. Addressing Well-being and Social Risk Factors: Interventions should prioritize improving access to healthcare services, especially in underserved or remote areas, given their strong association with depressive symptoms. Ensuring that older adults can move around their neighbourhoods unassisted and feel secure while doing so requires investments in barrier-free infrastructure, well-

lit streets, and pedestrian safety measures. Moreover, attention must be paid to the emotional toll of living alone, which, although a weaker predictor, remains statistically significant. Urban planning, transport, and health sectors must collaborate to develop integrated, age-friendly environments that proactively support autonomy and well-being. Such multisectoral strategies will be essential for advancing both active ageing and social equity across Türkiye's diverse regional contexts.

5. Building Inclusive Urban Governance: The built environment can facilitate social interaction and engagement in later life by enabling opportunities to meet others. Community building, in this context, involves promoting a sense of belonging and strengthening intergenerational connections, thereby enhancing social cohesion among older people and across age groups (Van Hoof et al., 2018). Understanding sustainable development and the governance of urban areas requires moving beyond a framework that treats the urban solely as a discrete scale of political authority (Bulkeley & Betsill, 2005). Instead, a multilevel governance perspective allows us to explore how sustainability is shaped through interactions across different institutional levels. Within this framework, the civic engagement of older adults emerges as a critical mechanism through which local sustainability agendas are both constructed and challenged. Older individuals, particularly when engaged in neighbourhood initiatives or participatory planning, contribute to a more inclusive and responsive model of urban governance. Their involvement not only enhances the legitimacy of local decision-making processes but also brings attention to age-specific needs—such as accessibility, safety, and equitable service provision—thereby aligning with broader goals of socially sustainable cities. Recent findings by Bui et al. (2020) have shown that encouraging advocacy and civic engagement among older people through age-friendly community programs is essential to incorporate their voices into local policy, which remains a key agenda point for policy-makers in Türkiye.

References

Akkan, B., & Canbazer Şanlı, C. (2023). Aging and social protection in a familialist welfare regime: Elderly poverty and social pensions in Turkey. In S. I. Rajan (Ed.), *Handbook of aging, health and public policy: Perspectives from Asia* (pp. 1–17). Springer. https://doi.org/10.1007/978-981-16-1914-4_209-1

Aköz Çevrimli, B. (2025). Accessibility in urban coastal areas: Antalya-Konyaaltı case. *PLANARCH- Design and Planning Research, 9*(1), 67–78. https://doi.org/10.54864/planarch.1583093

Buffel, T. (2017). Ageing migrants and the creation of home: Mobility and the maintenance of transnational ties. *Population, Space and Place, 23*(5), Article e1994. https://doi.org/10.1002/psp.1994

Bui, C. N., Coyle, C. E., & Freeman, A. (2020). Promoting self-advocacy among older adults: Lessons from Boston's Senior Civic *Academy. Journal of Applied Gerontology, 40*(4), 452–458. https://doi.org/10.1177/0733464820902628

Bulkeley, H., & Betsill, M. (2005). Rethinking sustainable cities: Multilevel governance and the 'urban' politics of climate change. *Environmental Politics*, *14*(1), 42–63. https://doi.org/10.1080/0964401042000310178

Cheng, L., Chen, X., Yang, S., Cao, Z., De Vos, J., & Witlox, F. (2019). Active travel for active ageing in China: The role of built environment. *Journal of Transport Geography*, *76*, 142–152. https://doi.org/10.1016/j.jtrangeo.2019.03.010

De Donder, L., Verté, D., & Messelis, E. (2005). Fear of crime and elderly people: Key factors that determine fear of crime among elderly people in West Flanders. *Ageing International*, *30*(4), 363–376.

Emlet, C. A., & Moceri, J. T. (2012). The importance of social connectedness in building age-friendly communities. *Journal of Aging Research*, *2012*(1), 173247. https://doi.org/10.1155/2012/173247

Eryurt, M. A. (2023). Yaşlanma ve demografi [Aging and demographics]. In K. Canatan & M. Küçük (Eds.), *Yaşlanma sosyolojisi.* (pp. 91-120). DBY Publishing.

European Commission & United Nations Economic Commission for Europe. (2019). *2018 Active Ageing Index: Analytical report.* Publications Office of the European Union. https://ec.europa.eu/social/main.jsp?catId=738&langId=en&pubId=8270&type=2&furtherPubs=yes

Field, A. (2009). *Discovering statistics using SPSS* (3rd ed.). SAGE Publications.

Gitlin, L. N. (2003). Conducting research on home environments: Lessons learned and new directions. *The Gerontologist*, *43*(5), 628 –637.

Gray, A. (2015). Social capital and neighbourhood in older people's housing. In F. Nyqvist & A. K. Forsman (Eds.), *Social capital as a health resource in later life: The relevance of context* (pp. 65–88). Springer.

Koç, İ., & Saraç, M. (2018). Türkiye'de yaşlı göçünün büyüklüğünün ve yönünün değişimi [The change in the size and direction of older adults migration in Turkey]. *Senex: Yaşlılık Çalışmaları Dergisi,* 2(2), 19 –37. https://doi.org/10.24876/senex.2018.11

Landorf, C., Brewer, G., & Sheppard, L. A. (2008). The urban environment and sustainable ageing: Critical issues and assessment indicators. *Local Environment,* 13(6), 497-514. https://doi.org/10.1080/13549830802259896

Lawler, K. (2001). *Aging in place: Coordinating housing and health care provision for America's growing elderly population.* Joint Center for Housing Studies, Harvard University.

Lawton, M. P., & Nahemow, L. E. (1973). Ecology and the aging process. In C. Eisdorfer & M. P. Lawton (Eds.), *The psychology of adult development and aging* (pp. 619–674). American Psychological Association.

Lochner, K., Kawachi, I., & Kennedy, B. P. (1999). Social capital: A guide to its measurement. *Health & Place*, *5*(4), 259–270. https://doi.org/10.1016/s1353-8292(99)00016-7

Mehrbrodt, T., Gruber, S., & Wagner, M. (2019). *Scales and multi-item indicators.* SHARE Survey of Health, Ageing and Retirement in Europe.

Özmete, E. (2016). *Türkiye aktif ve sağlıklı yaşlanma araştırması* [Research on active and healthy aging in Türkiye]. T.C. Sağlık Bakanlığı Sağlığın Geliştirilmesi Genel Müdürlüğü.

Palaz, F. S. (2021a). Sağlık ve emeklilik araştırması [Health and Retirement Survey (HRS)]. In M. Şentürk (Ed.), *Dünyada yaşlanma araştırmaları* (pp. 17 –38). Nobel.

Palaz, F. S. (2021b). Avrupa sağlık, yaşlanma ve emeklilik araştırması [European health, aging and retirement survey (SHARE)]. In M. Şentürk (Ed.), *Dünyada yaşlanma araştırmaları* (pp. 123 –140). Nobel.

Palaz, F. S. (2023). İyi sağlık algısına etki eden faktörlerin yaşam seyri yaklaşımı ile incelenmesi [A longitudinal analysis of factors influencing perceived health status using a life course approach]. *Turkish Journal of Public Health, 21*(1), 71-86. https://doi.org/10.20518/tjph.1106798

Pallant, J. (2020). *SPSS kullanma kılavuzu* [SPSS user manual]. (S. Balcı, Trans.). Anı Publishing.

Plouffe, L., & Kalache, A. (2010). Towards global age-friendly cities: Determining urban features that promote active aging. *Journal of Urban Health*, *87*(5), 733 –739. https://doi.org/10.1007/s11524-010-9466-0

Poulsen, T., Christensen, U., Lund, R., & Avlund, K. (2011). Measuring aspects of social capital in a gerontological perspective. *European Journal of Ageing, 8*(4), 221–232. https://doi.org/10.1007/s10433-011-0205-5

Ravensbergen, L., Van Liefferinge, M., Isabella, J., Merrina, Z., & El-Geneidy, A. (2022). Accessibility by public transport for older adults: A systematic review. *Journal of Transport Geography*, *103*, 103408. https://doi.org/10.1016/j.jtrangeo.2022.103408

Rea, L. M., & Parker, R. A. (1992). *Designing and conducting survey research: A comprehensive guide.* Jossey-Bass Publishers.

Republic of Türkiye Ministry of Development [Türkiye Cumhuriyeti Kalkınma Bakanlığı]. (2014). *Onuncu kalkınma planı: Yaşlanma özel ihtisas komisyonu raporu* [Tenth development plan: Report of the special commission on aging]. T.C. Kalkınma Bakanlığı.

Republic of Türkiye State Planning Organization [Türkiye Cumhuriyeti Devlet Planlama Teşkilatı]. (2007). *Türkiye'de yaşlıların durumu ve yaşlanma ulusal eylem planı (2007-2012)* [The situation of the elderly in Türkiye and the national action plan (2007-2012)]. T.C. Başbakanlık Devlet Planlama Teşkilatı. https://www.aile.gov.tr/media/33628/turkiyede-yaslilarin-durumu-ve-yaslanma-ulusal-eylem-plani.pdf

Scharlach, A. E., & Lehning, A. J. (2013). Ageing-friendly communities and social inclusion in the United States of America. *Ageing & Society*, *33*(1), 110 –136.

Steels, S. (2015). Key characteristics of age-friendly cities and communities: A review. *Cities*, *47*, 45–52. https://doi.org/10.1016/j.cities.2015.02.004

Stoeckel, K. J., & Litwin, H. (2015). Accessibility to neighbourhood services and well-being among older Europeans. In A. Börsch-Supan et al. (Eds.), *Ageing in Europe – Supporting policies for an inclusive society* (pp. 39-48).

Şen, Ö. (2019). Güneydoğu Anadolu Bölgesi ilçelerinin coğrafi ve potansiyel erişilebilirlik analizi [The analysis of geographic and potential accessibility of Southeastern Anatolia Region Districts]. *Türk Coğrafya Dergisi, (73),* 61–66. https://doi.org/10.17211/tcd.544288

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Pearson.

Turkish Statistical Institute. (2023, May 11). *Kent-kır nüfus istatistikleri, 2022* [Urban-rural population statistics, 2022]. https://veriportali.tuik.gov.tr/tr/press/49755

Turkish Statistical Institute. (2024, March 22). *Türkiye yaşlı profili araştırması, 2023* [Turkey elderly profile research, 2023]. https://data.tuik.gov.tr/Bulten/Index?p=Turkiye-Yasli-Profili-Arastirmasi-2023-53809

Turkish Statistical Institute. (2025a, March 13). *İstatistiklerle yaşlılar 2024* [Statistics on the elderly 2024]. https://data.tuik.gov.tr/Bulten/Index?p=Istatistiklerle-Yaslilar-2024-54079

Turkish Statistical Institute. (2025b, May 13). *Doğum istatistikleri 2024* [Birth statistics 2024]. https://data.tuik.gov.tr/Bulten/Index?p=Dogum-Istatistikleri-2024-54196

Turkish Statistical Institute. (2025c, February 6). *Adrese dayalı nüfus kayıt sistemi sonuçları, 2024* [Address-based population registration system results, 2024]. https://data.tuik.gov.tr/Bulten/Index?p=Adrese-Dayali-Nufus-Kayit-Sistemi-Sonuclari-2024-53783

Turkish Statistical Institute. (2025d, April 25). *Aktif yaşlanma endeksi, 2024* [Active aging index, 2024]. https://data.tuik.gov.tr/Bulten/Index?p=Aktif-Yaslanma-Endeksi-2024-57937

United Nations. (1982). *Report of the World Assembly on Ageing: Vienna, 26 July–6 August 1982 (A/CONF.113/43).* United Nations. https://www.un.org/en/conferences/ageing/vienna1982

United Nations. (2002). *Follow-up to the International Year of older persons: Second World Assembly on ageing (A/RES/57/167).* United Nations. https://undocs.org/A/RES/57/167

United Nations Economic Commission for Europe & European Commission. (2015). *Active Ageing Index 2014: Analytical report.* United Nations Economic Commission for Europe.

United Nations Economic Commission for Europe. (2015). *Active ageing index 2014: Analytical report* (Prepared by A. Zaidi & D. Stanton). European Commission's Directorate General for Employment, Social Affairs and Inclusion.

Van Hoof, J., Kazak, J. K., Perek-Białas, J. M., & Peek, S. T. (2018). The challenges of urban ageing: Making cities age-friendly in Europe. *International Journal of Environmental Research and Public Health*, *15*(11), 2473. https://doi.org/10.3390/ijerph15112473

Wiles, J. L., Leibing, A., Guberman, N., Reeve, J., & Allen, R. E. S. (2012). The meaning of "Aging in place" to older people. *The Gerontologist*, *52*(3), 357–366. https://doi.org/10.1093/geront/gnr098

World Health Organization. (2007). *Global age-friendly cities: A guide.* WHO Press. https://www.who.int/publications/i/item/9789241547307

CHAPTER 6

A BWM-Based Multi-Criteria Prioritization of IFRS S1 Sustainability Disclosure Elements: Evidence from Expert-Driven Evaluation for Sustainable Finance Decision-Making

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1. Introduction

Sustainable finance is defined as a form of financing that supports activities and sectors contributing to sustainability objectives such as environmental and ecosystem protection, preservation of biodiversity, combating climate change, reducing poverty and hunger, and addressing social inequalities (Demir & Uğurlu, 2024, p. 189). In this context, the aim is not to redefine the concept of "finance" but to emphasize how existing financial resources can be used effectively in line with sustainability goals. For this reason, the term "finance for sustainability" is also widely used in the literature (Arslan, 2022, p. 98).

Sustainable financial management has gained prominence as an approach that seeks to ensure that economic growth occurs in a manner compatible with environmental and social responsibilities and that places long-term value creation at its core. In recent years, the effects of Environmental, Social, and Governance (ESG) factors on the financial system have become increasingly visible. Risks associated with climate change, the inefficient use of natural resources, and rising societal expectations have reshaped corporate financial management practices.

Today, sustainable finance goes beyond traditional approaches focused solely on profitability, adopting long-term value creation as a fundamental objective. In this transformation, transparency and accountability have emerged as critical elements that enhance investor confidence, support market stability, and respond

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to societal expectations. Transparency strengthens stability in capital markets by ensuring a reliable flow of information for investors, regulators, and society. The clear reporting of firms' environmental impacts, carbon footprints, social responsibility practices, and corporate governance mechanisms enhances the accuracy of investment decisions and reinforces stakeholder trust. Accountability, on the other hand, extends beyond the mere disclosure of information; it refers to assuming responsibility for the outcomes of decisions and strategies. It requires institutions to support their sustainability commitments with concrete and measurable targets and to report their progress regularly and publicly (Istanbul Chamber of Industry, 2024, p. 6; Turkish Industry and Business Association, n.d.). The increasing environmental and social risks worldwide have made it imperative for companies to report not only their financial performance but also their sustainability impacts in a transparent manner. To this end, the International Sustainability Standards Board (ISSB), established by the International Financial Reporting Standards (IFRS) Foundation, developed the IFRS S1 standard to promote global alignment in sustainability reporting. The standard is built upon four core components, namely Governance, Strategy, Risk Management, and Metrics and Targets, which aim to provide a transparent presentation of firms' current sustainability performance and their capabilities for long-term value creation.

Globally, sustainability reporting has become increasingly critical as financial markets demand reliable, comparable, and decision-useful information (IFRS S1, 2023). In this context, IFRS S1, published by the ISSB in 2023, provides a common framework for organizations to disclose sustainability-related financial information. IFRS S1 aims to ensure that such information is transparent and comparable, recognizing that sustainability-related risks and opportunities can materially affect an organization's cash flows, access to finance, and cost of capital over the short, medium, and long term. The standard requires institutions to adopt an approach that includes the identification, assessment, and monitoring of sustainability risks and opportunities. Effective management of these processes supports the efficient use of scarce resources and enables more informed strategic decision-making.

In addition, IFRS S1 requires sustainability disclosures to be consistent and comparable with financial reports. It ensures that institutions regularly report progress toward their sustainability goals and that these disclosures are meaningful and decision-useful for investors. Ultimately, the correct prioritization of criteria under IFRS S1 enables institutions to translate sustainability commitments into concrete, measurable targets and to report progress toward these targets effectively (IFRS S1, 2023).

IFRS S1 provides a comprehensive reporting framework that extends beyond climate change to address environmental, social, and governance dimensions in an integrated manner. By offering reliable, consistent, and financially relevant sustainability information essential for investors' decision-making processes, it has become an increasingly central reference point for regulators and a global benchmark in sustainability reporting. Its widespread adoption not only reduces compliance costs for firms but also strengthens international investor confidence and supports the flow of capital toward sustainable business models.

Despite its comprehensive structure, IFRS S1 leaves critical questions unanswered regarding how reporting criteria should be prioritized for different stakeholder groups, which indicators can deliver the highest impact at the lowest cost, and how these priorities can guide decision-making processes. These gaps highlight the widening divide between the theoretical orientation of the standards and the practical implementation needs, underscoring the need for empirically grounded, methodologically sound prioritization studies.

This study employs the Best–Worst Method (BWM) to address this gap, aiming to systematically evaluate reporting sub-criteria under the core components of IFRS S1—governance, strategy, risk management, and metrics and targets. The originality of the study lies in its analytical modeling of uncertainty across expert judgments, which allows for the objective determination of the relative importance of criteria and the identification of policy priorities based on a "highest impact, lowest cost" framework. Accordingly, the research contributes to the hierarchical positioning of critical reporting areas under IFRS S1 through scientific methods, offers a theoretical expansion to the literature on sustainable finance governance, and provides a practical tool enabling decision-makers to design sustainability strategies that are more effective, accountable, and aligned with investor expectations.

Following the introduction, the study is structured as follows: The subsequent section presents the literature review, including the theoretical framework and relevant empirical studies. This is followed by the methodology section, which elaborates on the Best–Worst Method (BWM) employed in the research. The findings are then presented, followed by a discussion that evaluates the results in light of theoretical and practical literature. The final section provides conclusions along with the theoretical and managerial implications of the study. The paper concludes with the limitations and recommendations for future research.

2. Literature Review

In this study, the sub-criteria identified in line with the reporting requirements of IFRS S1 are evaluated using the Best–Worst Method (BWM),

allowing systematic modeling of differences in expert judgments and generating prioritization outcomes that reflect a balance between highest impact and lowest cost for policy alternatives. Through the consistent, comparative, and verifiable assessment structure offered by BWM, the study contributes to enhancing transparency, accountability, and effectiveness in sustainability reporting for both policymakers and practitioners.

Academic research on sustainability reporting has expanded significantly following the publication of IFRS S1 and IFRS S2. One of the most prominent themes in the literature concerns firms' preparedness for transitioning to these new standards. Governance structures, corporate oversight mechanisms, and firms' internal capacities have been examined as key determinants in this context. For example, a study conducted in Indonesia found that board size positively influences readiness for complying with IFRS S1 and S2, whereas the contribution of independent board members was less significant than expected (Dewi & Kamiliya, 2025). This finding suggests that the role of governance structures in the compliance process should be considered multidimensionally rather than through a single perspective.

Another important strand of the literature examines the implications of IFRS S1 and S2 for the broader reporting ecosystem. Scholars emphasize that these standards should be analyzed across multiple areas such as financial accounting, managerial accounting, auditing, and information systems (Pratama et al., 2024). However, the current body of research remains at an early stage, with limited empirical evidence and a continued need for field-based studies. Systematic reviews in sectors such as mining indicate that IFRS S1 and S2 have begun to improve reporting quality and have contributed to advances in risk management and governance; yet substantial shortcomings persist in technically complex areas such as Scope 3 emissions measurement (Pratama et al., 2024). These limitations, driven by challenges in technical capacity and data availability, represent a global problem.

A further line of research focuses on the market effects of ESG disclosures. Empirical studies in emerging markets reveal that comprehensive sustainability reporting enhances investor confidence and positively influences market valuations. These effects appear particularly pronounced in firms with high levels of foreign ownership and in family-owned firms (Ioannou & Serafeim, 2015). Such findings indicate that sustainability reporting is increasingly viewed not merely as a matter of social responsibility but as a strategic component of financial decision-making. Nevertheless, studies directly examining the influence of IFRS S1 on these dynamics remain limited, presenting an important gap in the literature.

In the Turkish context, existing research is largely conceptual and theoretical. Scholars discuss how IFRS S1 and S2 can be interpreted through the lenses of planetary boundaries, materiality, and practical implementation, and they propose roadmaps for ESG, BRSR, and GHG/CBAM compliance for Turkish firms (Elmacı, 2024; 2025). However, there is a lack of empirical studies assessing the impact of these standards on financial performance, cost of capital, or investor confidence in Türkiye. This gap highlights the need for future research that applies these standards in the Turkish setting.

Overall, the literature is structured around three key axes. The first concerns transition readiness and the role of governance in IFRS S1 compliance. The second reflects reporting quality and transparency, with particular attention to the reliability of climate-related and emissions disclosures. The third relates to market reactions and investor perceptions, where the effects of ESG disclosures and the new standards on capital markets warrant further investigation. Major gaps in the literature include limited empirical data, insufficient research on emerging markets, technical challenges in calculating Scope 3 emissions, and unresolved issues regarding alignment across reporting frameworks. Addressing these gaps will strengthen academic contributions and support firms in developing more robust sustainability strategies.

IFRS S1 and S2, introduced in 2023 to standardize sustainability reporting globally, mark the beginning of a new reporting era in which companies are required to treat sustainability information with the same rigor as financial reporting. Accordingly, Table 1 presents information on the recent studies conducted within this scope.

Table 1. Key Studies in the Literature on IFRS S1 and IFRS S2

Author(s)	Purpose / Focus	Findings / Implications
Heinzle, 2023	The study examines the readiness of Liechtenstein and Swiss banks for IFRS S1 compliance and their sustainability transparency practices, evaluating how banks can enhance the quality and comparability of financial information by improving risk and opportunity reporting.	The findings indicate that although banks have made progress in sustainability transparency, their data and reporting infrastructure require further development for full IFRS S1 integration. The study shows that the application of IFRS S1 improves risk management and information quality.
Köse & Çetin, 2023	The study explores the role of IFRS S1 and S2 in reporting sustainability- and climate-related disclosures following the issuance of the standards. It aims to explain the development process of these standards and contribute to their alignment with sustainability regulations in Türkiye.	IFRS S1 and S2 enable firms to transparently disclose sustainability- and climate-related risks and opportunities, thereby improving reporting quality; their coherent implementation with Türkiye's sustainability regulations and the European Green Deal is crucial.
Pratama et al., 2024	The study examines potential contributions of accounting research and conceptual/practical challenges in implementing IFRS S1 and S2 after the standards' publication.	Although IFRS S1 and S2 enhance the quality and integrity of integrated financial and sustainability reporting, challenges persist regarding data consistency, measurement uncertainty, and compliance auditing. The study highlights the need for capacity building and empirical research.
Akdoğan, 2024	The study compares national and international frameworks for sustainability reporting, evaluating the emergence, scope, and implementation processes of IFRS S1-S2 and Türkiye's TFRS S1-S2, while examining transparency and standardization in reporting.	The study finds that differences across sustainability reporting frameworks hinder global standardization. Implementation of IFRS S1-S2 and TFRS S1-S2 strengthens transparency, consistency, and accountability, thereby enhancing international alignment.
Komala & Murtanto, 2024	The study compares PT Indofood's GRI-based sustainability reporting with IFRS S1 and S2, analyzing compliance requirements and examining regulations related to the transition toward integrated reporting that links sustainability impacts to financial performance and strategy.	Findings indicate that PT Indofood's GRI-based reporting does not meet IFRS S1 and S2 integration requirements; full compliance necessitates a transition to an integrated reporting model that links sustainability impacts to financial metrics.

Kusuma & Gani, 2024	The study evaluates PT Bank Mandiri's 2023 sustainability report in accordance with IFRS S1 and S2, identifying strengths in governance disclosures and weaknesses in strategy, risk management, and metrics-related information.	The findings show that while governance disclosures are strong, significant gaps remain in strategy, risk management, and climate-related strategies. Firms need to improve transparency and the level of detail required for compliance.
Dewi & Kamiliya, 2025	The study investigates the effect of board characteristics—particularly board size—on IFRS S1/S2 transition readiness in non-financial companies in Indonesia.	The results show that board size positively influences transition readiness, whereas the moderating effect of independent directors is weaker than expected.
Pratama et al., 2025	The article analyzes the effects of IFRS S1 and S2 on sustainability reporting in the mining sector during 2022–2024, examining firms' compliance processes, improvements in reporting quality and governance, and identifying technical, financial, and operational barriers.	The study finds that IFRS S1 and S2 enhance governance and risk management in the mining sector, but deficiencies still persist in Scope 3 emissions reporting. Effective implementation requires technological capacity, strong governance, and sector-specific guidance.
Kamal, 2025	The article analyzes the transformative effects of IFRS S1 and S2 on corporate reporting, examining regulatory and data-related challenges during implementation and assessing their effects on strategy, governance, and investor relations.	IFRS S1 and S2 enhance transparency and stakeholder trust by integrating sustainability into strategic decision-making, although compliance and data management challenges remain. The standards provide a comprehensive framework for risk management and sustainable value creation.
Castillo Delgadillo & Díaz-Peña, 2025	The study addresses the inadequacy of traditional valuation methods under the new sustainability disclosures introduced by IFRS S1 and S2, and increased uncertainty. It proposes a Real Options Valuation (ROV)-based capital budgeting framework that integrates sustainability disclosures into valuation.	Findings indicate that the ROV approach is more flexible and effective than Net Present Value (NPV) under uncertainty. Integrating IFRS S1 and S2 disclosures strengthens financial transparency and enhances strategic decision-making.
Wahyuni, 2025	The study examines the role of IFRS S1 and S2 in enhancing transparency and accountability in ESG reporting, evaluating their potential to improve reporting quality and support more accurate disclosure of ESG impacts.	IFRS S1 and S2 have strong potential to improve transparency, accountability, and reporting quality in ESG disclosures; however, challenges remain in data standardization, cross-country interpretation differences, and firms' readiness for compliance.

A comprehensive review of the literature reveals numerous studies examining the effects of IFRS S1 and S2 on sustainability reporting and financial information disclosure (Heinzle, 2023; Köse & Çetin, 2023; Pratama et al., 2024; Akdoğan, 2024; Komala & Murtanto, 2024; Kusuma & Gani, 2024; Dewi & Kamiliya, 2025; Pratama et al., 2025; Kamal, 2025; Castillo Delgadillo & Díaz-Peña, 2025; Wahyuni, 2025). These studies generally analyze compliance levels across the banking, mining, and food industries; identify gaps in sustainability reporting; and evaluate impacts on reporting quality. The findings consistently indicate that the standards enhance transparency, accountability, and overall reporting quality by integrating financial and sustainability information. However, significant limitations remain, including data management challenges, shortcomings in strategy and risk management disclosures, insufficient metrics and target reporting, organizational capacity constraints, and variability in international interpretations (Heinzle, 2023; Kusuma & Gani, 2024; Wahyuni, 2025).

Current studies largely rely on sectoral samples and qualitative methodologies (Pratama et al., 2024; Komala & Murtanto, 2024), with limited focus on incorporating uncertainty, differences in expert judgment, and policy prioritization into sustainability disclosure frameworks. Accordingly, the existing literature does not adequately address the quantitative modeling of uncertainty or expert divergence, nor does it systematically assess the balance between policy, cost, and impact when prioritizing sub-criteria within the IFRS S1 framework.

Given these limitations, there is a clear need for research that prioritizes sub-criteria related to sustainable financial management under IFRS S1 using scientifically robust methods that incorporate uncertainty and expert judgment variation. Multi-criteria decision-making (MCDM) approaches—particularly pairwise comparison–based weighting methods—offer a suitable solution. Among these, the Best–Worst Method (BWM), which emphasizes consistency, is particularly well-suited for generating reliable insights.

This study aims to fill the identified gap by modeling the Governance, Strategy, Risk Management, and Metrics & Targets criteria—defined under IFRS S1's "sustainability-related financial information disclosure" requirements—using BWM while accounting for uncertainty and variability in expert evaluations. By scientifically prioritizing critical reporting criteria for sustainable financial management, the study provides theoretical contributions to the literature and offers practical guidance for decision-makers seeking to implement sustainability strategies with an optimal balance of high impact and low cost. In doing so, it contributes to both the sectoral and institutional application of IFRS S1 and addresses existing methodological and conceptual shortcomings in the literature.

3. Method

In line with the research objectives and the conceptual framework established in the preceding sections, this study employs an integrated quantitative decision-making approach to systematically evaluate the sub-criteria derived from IFRS S1 sustainability reporting requirements. The methodological design aims to capture expert judgments in a structured, consistent, and analytically robust manner, ensuring that the prioritization of policy alternatives reflects both theoretical foundations and practical considerations. Within this scope, the Best–Worst Method (BWM) is utilized to determine the relative importance of the criteria by leveraging pairwise comparisons and consistency-based optimization. The following subsections present the operational steps of the BWM, the construction of the decision framework, and the empirical findings obtained through the analysis.

3.1. BWM

The Best-Worst Method (BWM) is a technique used to determine criteria weights based on pairwise comparison. The most significant criterion and the least important criterion are determined in BWM, and each criterion is compared separately to these two criteria in pairwise comparisons. These comparisons use a scale of 1-9, as suggested by Saaty (1977). The application steps of BWM are given below (Rezaei, 2015).

I- Criteria and experts are determined.

II-Each expert determines the most important criterion and the least important criterion. If there is more than one most or least important criterion, only one of them is used for pairwise comparisons. At this point, the process will be separate for each expert.

III-Experts compare the criteria with the most important one. When the most significant criterion is compared to the other criterion, a value of 1 signifies that the two criteria are equally important. On the other hand, a value of 9 indicates that the most important criterion is absolutely more important than the criterion it is compared to. Equation (1) shows the pairwise comparison scores between the most important one and the remaining criteria.

IV-Experts compare criteria with the least important one. When the least important criterion is compared to the other criterion, a value of 1 signifies that the two criteria are equally important. On the other hand, a value of 9 indicates that the least important criterion is absolutely less important than the criterion it is compared to. Equation (2) shows the pairwise comparison

scores between the most important one and the remaining criteria.

V-A mathematical model is created to determine the weighting coefficients of the criteria. The values that provide the best solution for this model are then found via Equation (3), where j=1,…,n.

VI-The consistency of the comparisons is checked. Comparisons containing inconsistencies are returned to the expert(s).

VII-The integrated criteria weight values are found by averaging the weight coefficients obtained as from each expert's evaluations.

$$A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn}) \tag{1}$$

$$A_L = (a_{1L}, a_{2L}, \ldots, a_{nL})^T \tag{2}$$

$$\begin{gathered} Min\ \xi \\ Subject\ to \\ \left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \xi, \forall j \\ \left|\frac{w_j}{w_L} - a_{jL}\right| \leq \xi, \forall j \\ \sum_{j=1}^{n} w_j = 1 \\ w_j \geq 0, \forall j \end{gathered} \tag{3}$$

3.2. Findings

In line with the objectives of this study, a comprehensive set of twelve criteria derived from the core disclosure requirements of IFRS S1 was identified and presented in Table 2. These criteria encompass governance structures, strategic integration, risk assessment mechanisms, and key performance measurement components that collectively shape the sustainability-related financial disclosures expected under IFRS S1. To ensure analytical rigor and contextual validity in the prioritization process, four subject-matter experts with extensive professional experience and in-depth knowledge of sustainable finance, corporate reporting, and IFRS standards were consulted. Their evaluations form the basis of the Best–Worst Method (BWM) application, enabling a systematic comparison of the relative importance of each criterion.

The criteria selected, ranging from board-level oversight and internal control systems (C1-C3) to strategic sustainability alignment (C4-C6), risk identification and assessment processes (C7-C9), and metrics and target-setting

practices (C10-C12)- reflect the multidimensional structure of IFRS S1. By integrating expert judgments with the structured logic of BWM, the study aims to produce a robust and transparent prioritization framework that supports decision makers in determining which reporting components yield the highest impact with the lowest implementation cost. This structured evaluation not only enhances the methodological robustness of the research but also provides actionable insights for policymakers, regulators, and firms seeking to comply effectively with IFRS S1.

Table 2. The List of Criteria

Code	Criterion	Source
C1	Roles and Responsibilities of the Board of Directors and the Sustainability Committee	IFRS S1 (2023)
C2	ESG Oversight and Internal Control Mechanisms	IFRS S1 (2023)
C3	Governance Transparency, including Disclosure Practices and the Presence of Independent Board Members	IFRS S1 (2023)
C4	Disclosure of the Impact of Sustainability Issues on the Business Model, Revenue Structure, and Cost Structure	IFRS S1 (2023)
C5	Short-, Medium-, and Long-Term ESG Strategies and Alignment Plans	IFRS S1 (2023)
C6	Identification of Sector-Specific Strategic Risks	IFRS S1 (2023)
C7	ESG Materiality Analysis and Risk Identification Processes	IFRS S1 (2023)
C8	Assessment of Physical and Transition-Related Sustainability Risks	IFRS S1 (2023)
C9	Scenario Analyses, including Climate-Related Scenario Assessments	IFRS S1 (2023)
C10	Reporting of Financially Material Greenhouse Gas (GHG) Emissions, including Scope 1, Scope 2, and Scope 3 Compliance	IFRS S1 (2023)
C11	Targets and Performance Indicators, including Net-Zero Commitments, Target Years, and Interim Milestones	IFRS S1 (2023)
C12	Data Quality, Measurement Intervals, and Verification (Assurance) Procedures	IFRS S1 (2023)

In alignment with the methodological requirements of the Best–Worst Method (BWM), the twelve criteria derived from the disclosure components of IFRS S1 were subjected to expert evaluation to determine their relative importance within the sustainability reporting framework. Four experts with more than a decade of professional experience in sustainable finance, ESG risk assessment, and corporate reporting were invited to conduct systematic pairwise comparisons. In accordance with the BWM procedure, each expert identified the criterion they considered the most important (best) and the criterion they considered the least important (worst). They then provided numerical assessments indicating the comparative preference of the best criterion over all others, as well as the comparative preference of all criteria over the worst.

This dual comparative structure increases the internal consistency of the judgment matrix and strengthens the reliability of the resulting priority weights. It reduces cognitive burden and minimizes pairwise comparison errors, which is one of the primary methodological advantages of BWM when compared to traditional multi-criteria decision-making techniques. The experts' assessments constitute the core input for constructing a coherence-tested optimization model that produces objective and reproducible criterion weights. Table 3 presents the detailed best-to-others and worst-to-others evaluations submitted by the experts, and these data form the empirical basis for the subsequent computation of BWM weights.

Table 3. Experts' Evaluations on the Importance of the Criteria

The Pairwise Comparisons Between the Most Important Criterion and the remaining ones													
Experts	Work experience & title	Best to Others	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Expert 1	12 years/ Dr. Economist	C12	4	4	2	4	4	3	4	9	5	6	4	1
Expert 2	12 years/ Assoc. Prof. Dr.	C3	2	3	1	4	4	7	5	9	6	9	5	6
Expert 3	15 years/ Director	C4	4	4	5	1	6	5	5	6	8	8	8	9
Expert 4	12 years/ Manager	C3	6	9	1	5	3	4	5	4	5	4	4	4

The Pairwise Comparisons Between the Least Important Criterion and the remaining ones

Experts	Work experience & title	Worst to Others	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Expert 1	12 years/ Dr. Economist	C8	5	6	8	6	6	7	6	1	4	5	5	9
Expert 2	12 years/ Assoc. Prof. Dr.	C10	8	7	8	7	6	5	5	4	3	1	4	2
Expert 3	15 years/ Director	C12	7	7	6	9	6	7	6	6	2	2	2	1
Expert 4	12 years/ Manager	C2	3	1	9	4	6	5	4	5	4	5	5	5

The individual weighting results derived from each expert's evaluations are presented in Table 4 in order to demonstrate the variability in expert judgments and the relative emphasis placed on each criterion. The table provides a comprehensive overview of the criterion-specific weight distributions, which exhibit notable differences across experts, thereby reflecting the multidimensional nature of the assessment process. For instance, Expert 1 and Expert 4 assign substantially higher weights to C3, while Expert 2 prioritizes C1 and C3, and Expert 3 attributes the greatest significance to C4. These variations highlight the heterogeneity in expert perspectives and underscore the importance of incorporating multiple viewpoints to enhance the robustness of the decision-making framework.

In addition to the individual weight vectors, Table 4 also presents the integrated weight coefficients obtained through the aggregation procedure. These integrated weights synthesize the diverse expert assessments into a single coherent weighting scheme, ensuring methodological consistency and minimizing individual subjectivity. The resulting integrated weights reveal that C3 and C4 emerge as the most influential criteria within the evaluation structure, followed by C5 and C1. Conversely, C10 and C9 receive the lowest weights, indicating relatively limited influence on the final decision outcome. This hierarchical ordering not only clarifies the relative importance of each criterion but also provides empirical grounding for subsequent stages of analysis, including performance evaluation and ranking.

Overall, the comparative examination of expert-specific and integrated weights contributes to a more nuanced understanding of the decision context, while the integrated weighting structure strengthens the analytical reliability of the model by capturing both expert diversity and collective consensus.

Table 4. The Weight Coefficients of the Criteria

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
The weights (based on Expert 1's evaluations)	0,0533	0,0355	0,2131	0,0639	0,1066	0,0799	0,0639	0,0799	0,0639	0,0799	0,0799	0,0799
The weights (based on Expert 2's evaluations)	0,1640	0,1094	0,2237	0,0820	0,0820	0,0469	0,0656	0,0365	0,0547	0,0149	0,0656	0,0547
The weights (based on Expert 3's evaluations)	0,0982	0,0982	0,0786	0,2688	0,0655	0,0786	0,0786	0,0655	0,0491	0,0491	0,0491	0,0207
The weights (based on Expert 4's evaluations)	0,0533	0,0355	0,2131	0,0639	0,1066	0,0799	0,0639	0,0799	0,0639	0,0799	0,0799	0,0799
The integrated weights	0,0922	0,0697	0,1821	0,1197	0,0902	0,0713	0,0680	0,0654	0,0579	0,0560	0,0686	0,0588
Rank	3	6	1	2	4	5	8	9	11	12	7	10

As shown in Table 4, the integrated weighting results provide a consolidated representation of the relative importance of each criterion across all expert evaluations. The comparative assessment of experts' individual weight distributions and the aggregated weights indicates a coherent prioritization pattern within the decision model. Among all criteria, C3 (Governance Transparency, including Disclosure Practices and the Presence of Independent Board Members) emerges as the most influential dimension, receiving the highest integrated weight (0.1821). This underscores the central role of governance transparency in shaping the overall evaluation structure, particularly in contexts where accountability, openness, and independent oversight mechanisms are essential for effective decision-making.

Following C3, C4 (Disclosure of the Impact of Sustainability Issues on the Business Model, Revenue Structure, and Cost Structure) ranks as the second most important criterion (0.1197). This finding highlights the increasing relevance of clearly articulated sustainability strategies and their financial implications, reflecting contemporary expectations that institutions not only adopt sustainable practices but also transparently communicate their economic impacts.

The subsequent criteria, including C5 (0.0902) and C1 (0.0922), also carry substantial influence, emphasizing the multidimensional nature of sustainability and governance considerations within the decision framework. In contrast, criteria such as C10 (0.0560) and C9 (0.0579) receive comparatively lower weights, indicating that although they remain part of the evaluative structure, their relative contribution to the overall decision-making process is more limited.

Overall, the ranking results derived from integrated weights reveal a clear hierarchy of priorities, with governance transparency and the articulation of sustainability impacts positioned at the forefront. This hierarchical structure provides a robust empirical basis for subsequent analyses and demonstrates that the decision framework is strongly shaped by considerations of institutional openness and the strategic integration of sustainability into organizational models.

4. Discussion

As shown in Table 4, the integrated weighting results reveal that C3 (governance transparency, including openness and the presence of independent board members) holds the highest relative importance within the decision model (0.1821). This finding aligns strongly with the broader literature, which emphasizes that transparent governance structures play a decisive role in firms' readiness and capacity to adopt the IFRS S1 sustainability disclosure requirements.

For instance, Dewi and Kamiliya (2025) highlight that board size and governance characteristics significantly influence the transition preparedness of Indonesian companies. However, they also note that independent board members do not always generate the expected moderating effect. The prominence of C3 in the current study, therefore, confirms the literature's consensus that effective oversight, accountability mechanisms, and decision-making transparency are foundational for credible sustainability reporting. The current results also reflect a more optimistic assessment of independent board effectiveness compared with some empirical studies. This divergence may stem from differences in sectoral characteristics or expert expectations regarding the future institutionalization of independent oversight mechanisms.

The second most influential criterion, C4 (clarity of the sustainability strategy and its financial implications), also corresponds well with prior research stressing the rising necessity for institutions to articulate how sustainability considerations reshape their business models, revenue structures, and cost dynamics. Studies such as Akdoğan (2024) and Komala and Murtanto (2024) underline the importance of integrating sustainability metrics with financial performance indicators, particularly when transitioning from framework-based reporting such as GRI to integrated sustainability disclosure under IFRS S1 and IFRS S2. The prioritization of C4 in this study supports these claims by demonstrating that experts view financially explicit sustainability strategy disclosures as crucial for credible and decision-useful reporting. This reinforces the argument by Pratama and colleagues (2024), who note that the integration of sustainability and financial information is both conceptually necessary and practically challenging because of measurement uncertainty and data consistency issues.

The relative importance of C5 (risk management clarity) and C1 (effectiveness of the governance structure), which occupy the next tier of prioritization, further confirms the multidimensional nature of effective sustainability reporting. These findings are broadly consistent with the literature. Studies focusing on the banking, mining, and food sectors, such as Heinzle (2023), Kusuma and Gani (2024), and Pratama et al. (2025), repeatedly stress that effective risk management disclosure and robust governance systems strengthen reporting reliability and stakeholder confidence. However, some sector-specific studies, particularly those examining extractive industries, show persistent weaknesses in risk management transparency. This is especially evident in disclosures related to areas such as Scope 3 emissions. Therefore, the relatively high prioritization of C5 in the present study may reflect expert expectations or normative judgments rather than the current empirical performance of firms. This is an important distinction that suggests room for methodological reflection. The discrepancy

could also be attributed to the expert pool's familiarity with governance and risk-based regulatory processes or to contextual differences among industries.

In contrast, criteria such as C10 (quality of specific metric disclosures) and C9 (clarity and robustness of long-term sustainability targets) receive comparatively lower weights. This indicates that although these elements remain conceptually relevant, experts perceive them as less central within the near-term IFRS S1 compliance landscape. This result diverges from the arguments of Wahyuni (2025), who identifies metric transparency and target-setting as core components of effective ESG disclosure under IFRS S1 and IFRS S2. Similarly, Pratama et al. (2024) find that industries with high environmental impact tend to struggle more with metric- and target-based reporting, especially around Scope 3 calculations. The relatively lower importance attributed to these criteria in the present study may therefore stem from practical concerns related to data availability, measurement accuracy, or organizational capacity, which remain significant obstacles to robust disclosure. In this sense, the experts' lower weighting appears to reflect a realistic assessment of the challenges firms face rather than a dismissal of the conceptual significance of these metrics. This misalignment with some literature may thus be interpreted as showing that governance and strategic clarity currently represent more actionable and attainable priorities than technically complex quantitative disclosures.

Overall, the findings show a coherent pattern that aligns with major themes in the IFRS S1 literature. The prioritization of governance transparency and strategic clarity confirms the assertions of Köse and Çetin (2023) and Kamal (2025), who argue that the transition to IFRS S1 requires organizations not only to adopt new reporting formats but also to cultivate internal capacities and governance structures that facilitate credible sustainability disclosures. In contrast, the lower weighting of metrics- and target-related criteria suggests that empirical challenges, such as limited datasets, methodological inconsistencies, and sector-based reporting constraints, continue to shape expert perceptions of feasibility. These concerns are consistent with the discussions presented by Pratama et al. (2024) and Wahyuni (2025).

In summary, the results of this study contribute to the existing literature by demonstrating that governance transparency and strategically articulated sustainability implications form the backbone of effective IFRS S1-aligned reporting. While the findings reinforce the centrality of governance, which is already well supported in prior research, they also reveal a relative deprioritization of complex metric-driven disclosures. This highlights the practical limitations faced by organizations undergoing the IFRS S1 transition. The integrated BWM-based weighting framework therefore provides a nuanced and empirically

grounded prioritization model that not only confirms key themes in the literature but also proposes a structured hierarchy of IFRS S1 policy and reporting criteria. This hierarchy reflects real-world feasibility, expert insights, and the emerging needs of sustainable finance management.

5. Conclusion and Implications

This study aimed to identify and prioritize policy and reporting criteria essential for sustainable finance management within the framework of IFRS S1–aligned disclosure practices. Using the Best–Worst Method (BWM), expert-based evaluations were aggregated to generate an integrated weighting structure for twelve key sustainability governance and reporting criteria. The analysis produced statistically robust results, demonstrated by the high degree of consistency across expert judgments and the convergence of weight coefficients, thus ensuring the methodological reliability of the prioritization process. In this regard, the integrated weights derived from the four experts revealed that governance-related criteria consistently received higher importance scores, confirming both the theoretical expectations and empirical trends observed in the sustainability reporting literature.

Based on these integrated results, management transparency (C3) emerged as the most influential criterion. This outcome underscores the central role of transparent governance mechanisms in ensuring credible and decision-useful sustainability disclosures. The prominence of C3 indicates that stakeholders assign significant value to governance structures that support accountability, clarity of oversight, active engagement of independent directors, and mechanisms that prevent conflicts of interest. The statistical ranking obtained through BWM strengthens this interpretation by demonstrating a clear and substantial weight difference between C3 and lower-ranked criteria. From an evaluative standpoint, this finding suggests that governance transparency functions not merely as an administrative requirement but as an institutional safeguard that enhances the legitimacy, reliability, and comparability of sustainability reporting practices.

The emphasis on management transparency also has important implications for the prevention of greenwashing and the enhancement of auditability. Transparent governance structures make it possible to report financial, environmental, and social indicators with greater accuracy and alignment with global sustainability frameworks such as the Global Reporting Initiative (GRI) and the European Union Taxonomy. Thus, the findings suggest that transparency contributes to institutional integrity by enabling external verification, strengthening regulatory compliance, and promoting responsible decision-making in financial institutions. This outcome directly supports the

study's overarching objective of determining how sustainability disclosures can effectively guide long-term financial and social outcomes.

The second most important criterion, the disclosure of sustainability's impact on business models and cost–revenue structures (C4), further reinforces the integrative nature of sustainable finance. The statistical significance of C4's weight demonstrates that experts perceive sustainability not merely as an add-on policy but as a core strategic element shaping financial institutions' operational and economic architectures. This suggests that institutions that recognize sustainability as a component of value creation are more likely to adapt successfully to long-term market expectations, regulatory shifts, and stakeholder priorities. Moreover, the prioritization of C4 confirms that sustainable finance requires a comprehensive understanding of how environmental and social initiatives influence profitability, risk mitigation, cost efficiency, and competitive advantage. In this context, the study contributes to the literature by empirically demonstrating that sustainability-oriented business model transformations hold a pivotal role in shaping the future trajectory of sustainable finance management.

Taken together, the results of this research present several important implications. First, they demonstrate statistically grounded evidence that governance transparency and strategic alignment are the core determinants of high-quality sustainability disclosures. Second, the findings highlight the importance of integrating financial and non-financial information when formulating policies for sustainable finance, thereby responding directly to the study's initial purpose of identifying priority criteria within IFRS S1–based reporting structures. Third, by applying the BWM methodology to expert evaluations, the study contributes a structured, empirically validated, and replicable model for determining disclosure priorities, offering both methodological and practical value to scholars, practitioners, and policymakers. This model can be applied across different sectors and regions to improve reporting consistency, guide regulatory design, and support capacity-building efforts in sustainability governance.

In conclusion, the study provides a theoretically informed and empirically grounded prioritization of sustainability reporting criteria that can guide financial institutions, regulators, and standard-setting bodies in enhancing the quality and reliability of IFRS S1–aligned disclosures. By identifying transparency and strategic integration as primary determinants of sustainable finance effectiveness, the research offers a set of actionable insights that contribute meaningfully to both the academic literature and the practical implementation of sustainable financial governance frameworks.

5.1. Limitations and Future Research

This study, despite providing a structured and empirically grounded prioritization of IFRS S1–based sustainability reporting criteria, is not without limitations. First, the analysis does not empirically evaluate the macro-level effects of mandatory IFRS S1 and IFRS S2 adoption on firms' financial performance, cost of capital, or investor confidence in Türkiye. As the national implementation process is still in its early stages, the absence of longitudinal or panel-based datasets restricts the ability to quantify how these standards influence market behavior, capital flows, and institutional trust. Second, the study does not fully capture the challenges encountered by companies and SMEs in adapting to sustainability reporting requirements, particularly those related to technical capacity constraints, financial burdens of compliance, and limited access to reliable data infrastructures. These challenges warrant a deeper sector-specific inquiry. Third, significant measurement limitations persist in Türkiye regarding complex sustainability indicators, such as Scope 3 emissions, value-chain-based impact assessments, and integrated climate–transition metrics. The scarcity of validated models and nationally calibrated methodologies limits the extent to which these indicators can be incorporated into robust analytical frameworks.

These limitations provide fertile ground for future research, and it is expected that subsequent studies will not only address these gaps but also inspire new academic debates in the field of sustainable finance reporting. Future research should prioritize empirical investigations into the financial and market consequences of IFRS S1/S2 adoption using advanced econometric techniques, including panel data models, causality tests, and structural break analyses. Such studies would yield critical evidence for regulators, investors, and policymakers, offering insights that go beyond current descriptive approaches. Additionally, future work could position itself at the forefront of the literature by examining the sustainability reporting readiness and capacity gaps of SMEs through mixed-method approaches that combine survey analysis, capability mapping, and institutional diagnostics.

Another promising research avenue involves the development of locally adapted methodologies for the measurement and verification of complex sustainability metrics, including Scope 3 emissions, biodiversity impacts, and supply-chain externalities. Studies that establish innovative and scalable data models in this domain would represent pioneering contributions not only to the Turkish context but also to emerging markets more broadly. Moreover, analyzing the conceptual and regulatory harmonization challenges between IFRS S1/S2 and other major frameworks such as ESRS, CSRD, and GRI

would yield actionable insights into multi-standard compliance costs, regulatory interoperability, and firms' strategic choices regarding disclosure regimes. Such analyses could influence national-level policy design and create new comparative perspectives that challenge widely accepted assumptions about global reporting convergence.

Finally, future theoretical research could explore avant-garde themes such as the integration of planetary boundaries, distributive fairness, and double-materiality perspectives into financial disclosure systems. These concepts remain underexplored within mainstream financial reporting scholarship, yet they hold the potential to reshape sustainability accounting as a discipline. Studies that operationalize these concepts and propose novel measurement architectures would contribute original knowledge to the field and open new intellectual horizons for both researchers and practitioners.

References

Akdoğan, M. U. (2024). Sürdürülebilirlik bilgilerinin raporlanmasında kullanılan raporlama çerçevelerine toplu bakış ve tek raporlama çerçevesine duyulan ihtiyaç-güncel gelişmeler [Overview of reporting frameworks used in reporting sustainability information and the need for a single reporting framework, latest developments]. *Muhasebe ve Denetime Bakış, 24*(72), 217–238. https://doi.org/10.55322/mdbakis.1448567

Arslan, H. (2022). Sürdürülebilir finansal yaklaşımlar [Sustainable financial approaches]. In Y. Aslan (Ed.), *Muhasebe, finans ve denetim alanlarında kritik yaklaşımlar* (pp. 95–105). Efe Akademi Yayınları.

Castillo Delgadillo, V. M., & Díaz-Peña, L. D. C. (2025). Real options for IFRS-S1 and S2 2024 mandatory disclosures: An alternative approach to capital budgeting valuation. *Journal of Risk and Financial Management*, *18*(10), 540. https://doi.org/10.3390/jrfm18100540

Demir, F., & Uğurlu, K. M. (2024). Sürdürülebilir finans ve döngüsel ekonomi [Sustainable finance and circular economy]. In C. Şahin (Ed.), Güncel finansal gelişmeler ve uygulamalar (pp. 177–196). Özgür Yayınları. https://doi.org/10.58830/ozgur.pub494.c2094

Dewi, M., & Kamiliya, A. (2025). IFRS Sustainability standards implementation readiness: Does board of directors matters? *Journal of Auditing, Finance, and Forensic Accounting*, *13*(1), 91–109. https://journal.trunojoyo.ac.id/jaffa/article/view/29839

Elmacı, O. (2024). Gezegensel sınırlar eşiğinde sağlık işletmelerinde performans ölçüm ve raporlamasına yönelik vizyon arayışları (balanced scorecard/entegre raporlama) [Healthcare enterprises on the verge of planetary boundaries: Vision quests for performance measurement and reporting (balanced scorecard/integrated reporting)]. *Journal of Life Economics, 11*(2), 85–97. https://doi.org/10.15637/jlecon.2324

Elmacı, O. (2025). *Türk işletmeleri için sürdürülebilirlik raporlamasında ESG, BRSR ve GHG/CBAM uyumu: Küresel tedarik zincirlerine yönelik pratik çerçeveler ve stratejiler – Sistematik bir yol haritası* [Sustainability reporting for Turkish businesses: ESG, BRSR, and GHG/CBAM Compliance: Practical frameworks and strategies for global supply chains – A systematic roadmap]. https://portal.dpu.edu.tr/orhan.elmaci/makale_oku/1140/turk-isletmeleri-icin-surdurulebilirlik-raporlamasinda-esg-brsr-ve-ghgcbam-uyumu-sistematik-bir-yol-haritasi

Heinzle, M. (2023). *Preparation for the IFRS S1 requirements: Illustration of the current implementation status at banks in Liechtenstein and Switzerland* [Doctoral dissertation, FH Vorarlberg University of Applied Sciences].

International Financial Reporting Standards Foundation. (2023). *IFRS S1: General requirements for disclosure of sustainability-related financial information.* https://www.ifrs.org/issued-standards/ifrs-sustainability-standards-navigator/ifrs-s1-general-requirements/

Ioannou, I., & Serafeim, G. (2015). The impact of corporate social responsibility on investment recommendations: Analysts' perceptions and shifting institutional logics. *Strategic Management Journal*, *36*(7), 1053-1081. https://doi.org/10.1002/smj.2268

Istanbul Chamber of Industry [İstanbul Sanayi Odası]. (2024). *Sürdürülebilir finans raporu* [Sustainable finance report]. Besfin.

Kamal, S. S. (2025). From compliance to competitive edge: A finance leader's guide to IFRS S1 and S2. *Journal of Advance Research in Business, Management and Accounting (4),* 17–27. https://doi.org/10.61841/gwkxrs41

Komala, L. K., & Murtanto, M. (2024). Analysis of sustainability report standards and adjustment of IFRS S1 & IFRS S2 standards implementation. *International Journal of Accounting, Management, Economics and Social Sciences (IJAMESC), 2*(5), 1643–1657.

Köse, T., & Çetin, Ö. O. (2023). Uluslararası sürdürülebilirlik açıklama standartları IFRS S1 ve IFRS S2'nin yayınlanmasının ardından sürece ve standartlara ilişkin bir değerlendirme [An assessment of the process and standards following the publication of international sustainability disclosure standards IFRS S1 and IFRS S2]. *Uluslararası Yönetim Akademisi Dergisi, 6*(4), 1145–1158. https://doi.org/10.33712/mana.1374381

Kusuma, K. N., & Gani, L. (2024). Implementation of Published IFRS S1 and S2 Standards Globaly. *Dinasti International Journal of Economics, Finance & Accounting*, *5*(3), 943-954. https://doi.org/10.38035/dijefa.v5i3.2734

Pratama, A., Dewi, N., Sofia, P., Muhammad, K., & Megawati, L. R. (2024). Sustainability reporting ecosystem and IFRS S1 and S2: How accounting research can assist its implementation. *Journal of Ecohumanism*, *3*(4), 3101–3129. https://doi.org/10.62754/joe.v3i4.3830

Pratama, G. S., Serafina, K., Sareng, I. D., & Ramadhan, Y. (2025). Implementation challenges and impacts of IFRS S1 and IFRS S2 on sustainability reporting quality: A systematic review of the mining industry (2022-2024). *International Journal of Accounting, Management, Economics and Social Sciences (IJAMESC), 3*(1), 36–50.

Rezaei, J. (2015). Best-worst multi-criteria decision-making method. *Omega*, *53*, 49–57. https://doi.org/10.1016/j.omega.2014.11.009

Saaty, T. L. (1977). A scaling method for priorities in hierarchical structures. *Journal of Mathematical Psychology*, 15(3), 234–281. https://doi.org/10.1016/0022-2496(77)90033-5

Turkish Industry and Business Association [Türk Sanayicileri ve İş İnsanları Derneği]. (n.d.). *Sürdürülebilir finansman ve destek modelleri notu* [Note on sustainable financing and support models]. Retrieved September 23, 2025, from https://tusiad.org/tr/tum/item/10509-surdurulebilir-finansman-ve-destek-modelleri-notu

Wahyuni, P. D. (2025). The role of IFRS S1 and S2 in enhancing transparency and accountability of ESG reports: A systematic review. *Asian Journal of Economics, Business and Accounting, 25(*1), 1–12. https://doi.org/10.9734/ajeba/2025/v25i11628

CHAPTER 7

A Simulation-Based Comparison of Traffic Signal Systems for Managing Urban Congestion at a Signalized Intersection

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1. Introduction

Urban traffic congestion is one of the most pressing challenges faced by modern cities, significantly affecting daily life, economic productivity, and environmental quality. As urban populations continue to grow and vehicle ownership increases, the strain on transportation infrastructure becomes more severe, leading to longer travel times, increased fuel consumption, and elevated stress levels among commuters.

Effective traffic management, particularly at intersections, plays a critical role in mitigating these issues. Intersections play a critical role in urban traffic networks as the points where different traffic streams converge, diverge, or cross. They are key elements in determining the overall efficiency, safety, and capacity of a road system. Properly functioning intersections help maintain smooth traffic flow, minimize delays, and reduce the likelihood of accidents. However, if inadequately managed, intersections can become major bottlenecks and significantly contribute to traffic congestion.

There are several types of intersections, each suited to different traffic conditions. Uncontrolled intersections lack traffic signs or signals and are typically found in low-traffic areas. Stop-controlled intersections use stop signs to assign right of way. Signalized intersections are managed by traffic lights and are commonly used in busy urban areas to regulate flow. Roundabouts are circular intersections that promote continuous movement and reduce collision points. Additionally, T-intersections (TI), where one road ends and meets another perpendicularly, are common in both urban and rural areas and can be controlled with signs, signals, or left uncontrolled depending on the context.

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The appropriate choice and design of an intersection depend on traffic volume, road function, and safety considerations.

Signalized intersections, when properly designed and optimized, can help regulate traffic flow, reduce delays, and improve overall urban mobility. On the other hand, if signalized intersections are poorly designed or improperly timed, they can disrupt traffic flow, increase delays, and contribute to urban congestion rather than alleviate it.

Many studies mention that poorly designed intersections with unoptimized signalization decrease traffic safety, increase the number of waiting vehicles, and cause long waiting times, which indirectly affect fuel consumption, air pollution, and human health (Kamrani et al., 2014; Aramesh & Ghorbanian, 2020; Fabianova et al., 2020; Phung et al., 2020; Bore & Ambunda, 2025).

Numerous expensive projects have been undertaken to enhance traffic flow, yet they ultimately failed to deliver the anticipated outcomes (Kamrani et al., 2014, p. 167). However, before starting an expansive project with the help of a simulation software, a model can be developed, and the outcomes of different scenarios can be calculated. Simulation serves as an effective and flexible tool for evaluating the impact of different design choices and control strategies at intersections. Whether an intersection is being planned from scratch or undergoing structural modifications, simulation allows traffic engineers to assess how changes such as signal installation, signal timing adjustments, or geometric alterations will affect traffic flow. One of its key advantages is the ability to experiment with multiple scenarios in a risk-free, cost-efficient virtual environment. By creating a valid simulation model, planners can predict congestion levels, identify bottlenecks, and optimize intersection performance before implementing any physical changes, thus improving both safety and efficiency in urban traffic systems.

Various simulation software tools exist, some designed for general-purpose applications and others developed for specific domains. Arena, AnyLogic, and Gama are examples of general-purpose simulation software. PTV VISSIM is an example of specific traffic simulation software that most of the studies encountered in the literature used. For detailed information about traffic-specific simulation software, readers may refer to the study by Pell et al. (2017) comparing 17 different traffic-specific simulation software.

This study presents a simulation-based comparison of different traffic signal systems, aiming to evaluate their effectiveness in managing congestion at a signalized TI in the city of Tokat, Türkiye. With this aim, the study seeks to answer the question: "Do alternative signalization scenarios at an intersection reduce traffic congestion?" In the literature, in addition to simulation studies on

highway traffic, traffic in certain parts of a city, and unsignalized intersections, there are also simulation studies specifically focusing on traffic problems at signalized intersections (Abohashima et al., 2019; Aramesh & Ghorbanian, 2020; Fabianova et al., 2020; Phung et al., 2020; Roy et al., 2020; Cav et al., 2021; Bindzar et al., 2024; Kollar et al., 2024). This study contributes to the literature as it is likely the first attempt to address a traffic problem at a signalized intersection in Tokat by modeling it through simulation and determining signal durations with a scenario based on traffic density, and it is also among the limited number of such studies conducted in Türkiye. In Tokat, traffic lights operate with predetermined timing, and there are no systems that adjust according to traffic density. This study can guide decision-makers by revealing the impact of adaptive traffic lights. The current situation of the TI is modeled in Arena simulation software. Then, two different scenarios are simulated: S1 is based on different light timing for peak hours, and S2 is based on timing depending on the number of vehicles in the queue.

The rest of the study is as follows. In Section 2, traffic congestion is discussed, and literature related to simulation studies on traffic is reviewed. Following that, information about the TI that is the subject of the study is presented, and both the current situation model and alternative scenarios are simulated. In the findings section, the results of the current situation and the two alternative scenarios are compared, and then the study is concluded.

2. Traffic Congestion

Traffic congestion occurs when travel time or delays are longer than what is typical during periods of light traffic. Unacceptable congestion, on the other hand, is defined as delays that exceed a predetermined standard. This standard can change depending on the type of road, mode of transport, location, and even the time of day. Several key factors contribute to congestion in a road network (Lomax et al., 1997, pp. 2-3):

- Duration: How long the congestion lasts.
- Extent: The total number of people or vehicles impacted.
- Intensity: The severity of the travel disruption.
- Reliability: The effect of unexpected traffic disruptions on the overall transportation system.

Traffic congestion is generally categorized into two main types: recurring and non-recurring. Recurring congestion is predictable and happens regularly, often during peak travel times each day. In contrast, non-recurring congestion is

unpredictable and arises from unexpected events that reduce the road's capacity, such as bad weather, accidents, road work, or other unforeseen circumstances (Kummetha et al., 2024, p. 460).

While measuring congestion scope may depend on geography (from an individual intersection to a whole country), transportation mode (roadways, buses, rail in roadway etc.), roadway type (freeways and toll roads, arterials etc.), time of the day (morning peak, noon peak etc.), day of the week (holiday or weekend), planning context (existing conditions, future demand, etc.) and level of detail (Lomax et al., 1997, p.14). Congestion can be quantified using various metrics. Travel time, speed, level of service (density), delay, and other factors can be used as measures of congestion (Kummetha et al., 2024, p. 460).

2.1. Literature

Literature about traffic congestion and simulation was reviewed. Related literature can be classified according to its primary focus and software used. In terms of primary focus or the problem addressed; there are studies about intersection optimization and traffic signal management (Abohashima et al., 2019; Aramesh & Ghorbanian, 2020; Fabianova et al., 2020; Phung et al., 2020; Roy et al., 2020; Cav et al., 2021; Liu & Song, 2022; Bindzar et al., 2024; Kollar et al., 2024; Bore & Ambunda, 2025; Tan et al., 2025), unsignalized intersections and mixed traffic (Kamrani et al., 2014; Yuniawan et al., 2018; Dutta & Ahmed, 2019; Arathi et al., 2023; Pallela & Kota, 2025), freeway or arterial congestion and mitigation (Concas et al., 2021; Kummetha et al., 2024) and general traffic modelling and simulation (Saval et al., 2023). In terms of simulation software used categorization can be made as studies using Arena simulation software (Kamrani et al., 2014; Yuniawan et al., 2018; Abohashima et al., 2019; Aramesh & Ghorbanian, 2020; Roy et al., 2020), studies using PTV VISSIM simulation software (Dutta & Ahmed, 2019; Fabianova et al., 2020; Bindzar et al., 2024; Kollar et al., 2024; Bore & Ambunda, 2025; Pallela & Kota, 2025), AnyLogic simulation software (Liu & Song, 2022), and GAMA open-source modelling and simulation (Saval et al., 2023). All these studies are summarized and listed in Table 1.

Table 1. Literature about Traffic Congestion and Simulation

Author(s) and Year	Problem	Method	Result
Kamrani et al., 2014	traffic flow at two adjacent unsignalized TIs during rush hours	Simulation with Arena	67% reduction in average waiting time for the specified route and a 53% decrease in average waiting time across the entire system
Yuniawan et al., 2018	high traffic density at the 4-way intersection	Simulation with Arena	significantly reducing vehicle queues and improving traffic flow at the intersection
Abohashima et al., 2019	urban traffic congestion, particularly during peak hours, by optimizing traffic light scheduling at two consecutive intersections	Simulation with Arena	optimal green/red percentages and cycle time combination to reduce network congestion
Dutta & Ahmed, 2019	modeling mixed traffic at unsignalized TIs, determine optimal calibration parameters	PTV VISSIM Traffic Simulation Software	errors within acceptable limits (15%) between simulated and field data
Aramesh & Ghorbanian, 2020	urban traffic congestion, focusing on minimizing wait times and air pollution at a complex TI with three traffic lights, considering uncertainty in vehicle numbers and emission rates	Simulation with Arena and OptQuest optimizer	optimal traffic light periods were determined via a utility function approach
Fabianova et al., 2020	modeling a congested signalized intersection, first in its current state, and then with two proposed modifications aimed at increasing throughput	PTV VISSIM Traffic Simulation Software	significantly decreased waiting vehicles, the first model achieving a 75% reduction in average line length, and the second facilitating smoother right turns and notable queue reductions
Phung et al., 2020	exploring temporary control strategies for intersections, optimizing traffic signal timing, implementing two-stage left-turn boxes, and assigning traffic direction	Simulation with Arena	importance of temporary control strategies for alleviating recurrent congestion and related air pollution
Roy et al., 2020	managing traffic flow at intersections by addressing the limitations of traditional traffic lights with fixed timing.	The relationship between idle time, cycle time, effective green time, and traffic arrival rates analyzed by MATLAB, and the results validated with Arena.	a method for estimating traffic congestion, and shows that a density-based approach can lead to more optimal traffic flow.

Cav et al., 2021	traffic congestion and delays at intersections by proposing two simple, adaptive traffic signal management protocols that leverage vehicle-to-infrastructure communication to gather real-time traffic data, enabling dynamic adjustments to traffic light durations or sequences, or both.	Simulation with Arena	reduced overall vehicle waiting time by an average of 80%, with specific reductions of 81% for left-turn queues and 68% for straight-pass and right-turn queues.
Concas et al., 2021	proactively detecting and mitigating traffic congestion on freeways and arterials. combining traditional sources like radar and probe data with newer ones such as Bluetooth and connected vehicle (CV) data, to identify conditions indicative of impending congestion	An algorithm for predicting congestion intensity using microsimulation	significant reductions in both recurring and non-recurring congestion and improved safety
Liu & Song, 2022	tackles the issue of urban traffic congestion, which leads to significant delays and driver frustration, in a congested area in Tianjin	Simulation with AnyLogic	by optimizing traffic light display times within the road network, the simulation reduced average vehicle travel time from 145.46 seconds to 132.31 seconds
Arathi et al., 2023	assess skewed, uncontrolled intersections	PTV VISSIM Traffic Simulation Software	The new model more accurately predicts capacity and level of service, analyzes the impact of various factors, and proposes skew-angle-based volume warrants to aid design engineers
Saval et al., 2023	simplify the creation of detailed traffic simulations, easy definition of driver operational behaviors, including lane changes, and less normative mixed traffic	GAMA open-source modeling and simulation platform	Accurate model for reproducing real-world traffic conditions.
Bindzar et al., 2024	evaluate the performance of different intersection designs and their impact on peak-hour traffic flow in a major urban area	mesoscopic simulation with PTV VISSIM software	modifying signal plans while retaining traditional signalized intersections was the most effective solution. pros and cons of various intersection designs, assisting decision-makers in choosing optimal solutions for urban traffic management.

Kollar et al., 2024	model a complex traffic junction with two interconnected signalized intersections.	PTV VISSIM traffic simulation software	comparing total traffic throughput across different model variants to present the permeability variations effectively
Kummetha et al., 2024	proactively detecting and mitigating freeway traffic congestion by fusing conventional data (radar, loop detectors) with newer sources like Bluetooth and connected vehicles (CV)	An algorithm for predicting congestion intensity ad microsimulation	effective in reducing both recurring and non-recurring congestion, despite a limitation in simultaneously disentangling congestion types
Bore & Ambunda, 2025	assess and improve traffic operations on a street in Ongwediva during peak hours, gathering data on traffic volume, vehicle composition, and turning proportions	PTV VISSIM micro-simulation	introducing traffic signals significantly reduced vehicle delays (30-87%), queue lengths (2-80%), and emissions (20-40%)
Pallela & Kota, 2025	complex traffic dynamics at unsignalized intersections in India, characterized by heterogeneous traffic and a lack of lane discipline	PTV VISSIM micro-simulation	heavy vehicles significantly reduce capacity and highlighting the impact of vehicle composition and conflicting volumes. need for vehicle-specific modeling, improved lane discipline, and potential signalization at complex intersections to enhance safety and efficiency.
Tan et al., 2025	Optimizing city-scale traffic signals	Spatially Iterative Coordination for Parallel Opt. (SICPO)	21.6% faster average travel time and 62.8 times shorter wall-clock time

Traffic simulation studies on intersections can be classified as those examining one or multiple intersections, and as signalized or unsignalized intersections. Abohashima et al. (2019), Aramesh & Ghorbanian (2020), Fabianova et al. (2020), Phung et al. (2020), Roy et al. (2020), Cav et al. (2021), Bindzar et al. (2024), and Kollar et al. (2024) are examples of studies in the literature focusing on signalized intersections.

The studies by Abohashima et al. (2019) and Kollar et al. (2024) differ from this research as they focus on two consecutive intersections, while the works of Fabianova et al. (2020), Phung et al. (2020), Roy et al. (2020), Cav et al. (2021), and Bindzar et al. (2024) focus on four-way intersections. The study by

Aramesh & Ghorbanian (2020) is highly similar to this research, as it specifically examines a single signalized TI.

A review of the literature on traffic simulation reveals that the number of studies focusing on signalized T-intersections is limited. Similarly, the number of traffic simulation studies conducted in Türkiye is also low. This study contributes to the literature as it is likely the first attempt to address a traffic problem at a signalized intersection in Tokat by modeling it through simulation and determining signal durations with a scenario based on traffic density, and it is also among the limited number of such studies conducted in Türkiye.

3. A Signalized T-Intersection (TI) in Tokat, Türkiye

The case study in this research focuses on traffic congestion at a signalized TI (See Figure 1) located at the intersection with the Organized Industrial Zone Road, along the main road connecting Tokat city center and the university campus, situated 8 km west of the center.

Figure 1. The Overview of the TI from Google Maps



Traffic congestion occurs at this intersection, particularly during the morning hours (between 8:00 and 9:00 AM) in the east-to-west direction, from the city center to the university campus. In the evening hours (between 5:00 and 6:00 PM), congestion occurs in the opposite direction, from the campus to the city center (west to east). Apart from unexpected incidents such as accidents, traffic congestion is generally not observed at this junction during the rest of the day. In this study, to avoid repetition of the same model, the morning congestion period (8:00–9:00 AM) has been considered.

Based on counting and observations conducted at the intersection, three kinds of data were collected: the number of vehicles coming from three different directions and the time between arrivals, the directions they take after passing through the intersection, and the green light clearance time of vehicles. In the morning hours, arrival rates of vehicles are defined as follows: from the city center (east), 5 vehicles every 10 seconds based on a Random (Exponential) distribution; from the campus side (west), 3 vehicles every 10 seconds based on a Random (Exponential) distribution; and from the Organized Industrial Zone (south), 2 vehicles every 15 seconds based on a Random (Exponential) distribution. Of the vehicles coming from the city center (east direction), 60% continue toward the campus (west), 35% turn toward the Organized Industrial Zone (south), and 5% make a U-turn to return to the city center (east). Of the vehicles arriving from the campus side (west direction), 80% head toward the city center (east), 15% turn toward the Organized Industrial Zone (south), and 5% make a U-turn to return to the campus (west). For vehicles coming from the Organized Industrial Zone (south direction), 80% continue toward the city center (east), while 20% continue toward the campus (west).

Some simplifying assumptions have been made regarding the current situation. Vehicle speeds in traffic have not been taken into account. Factors such as initial acceleration, variable speeds while approaching the signal, and deceleration are difficult to accurately represent in the model. Therefore, calculations were based on the number of vehicles passing through the intersection during the green light period. Accordingly, vehicle passing times at the signal were defined using a triangular distribution as TRIA (1,2,3) seconds. Additionally, since all roads around the intersection have two lanes, it is assumed that two vehicles can pass through the signal simultaneously. Another assumption is that, although there are normally different types of vehicles in traffic (e.g., motorcycles, cars, buses, trucks) with varying acceleration and cruising speeds, all vehicles in the model were considered as a single type (car). It was also assumed that no incidents, such as accidents or breakdowns, would occur. Although these assumptions deviate from real-world conditions, they are essential at this stage for constructing a simplified yet valid model. Incorporating such elements into the model would necessitate more detailed data collection, including the arrival frequencies of different vehicle types, as well as the incidence rates of accidents and vehicle breakdowns. The omission of these factors leads to a higher number of vehicles passing through the intersection in both the current situation and alternative scenario models compared to actual conditions. Nevertheless, maintaining identical assumptions across both the current and alternative scenarios is crucial to ensure comparability. Furthermore, given the infrequent nature of rare events such as accidents and breakdowns, along with the relatively low volume

of heavy vehicle traffic on the main road, their exclusion can be considered reasonable. Future research will aim to address these limitations through more comprehensive data collection and the development of more complex models.

3.1. Simulation Model of Current Situation (CS)

The model created in the Arena simulation software (Version 14) for the current situation (CS) is shown in Figure 2, and its animation is presented in Figure 3. Arena simulation software was employed in this study due to its robust capability to model complex stochastic systems and its wide use in traffic and transportation research. Its flexibility in scenario analysis and comprehensive performance measurement tools provide a reliable basis for evaluating the effectiveness of alternative traffic signal strategies.

Figure 2. Arena Simulation Model for the Current Situation

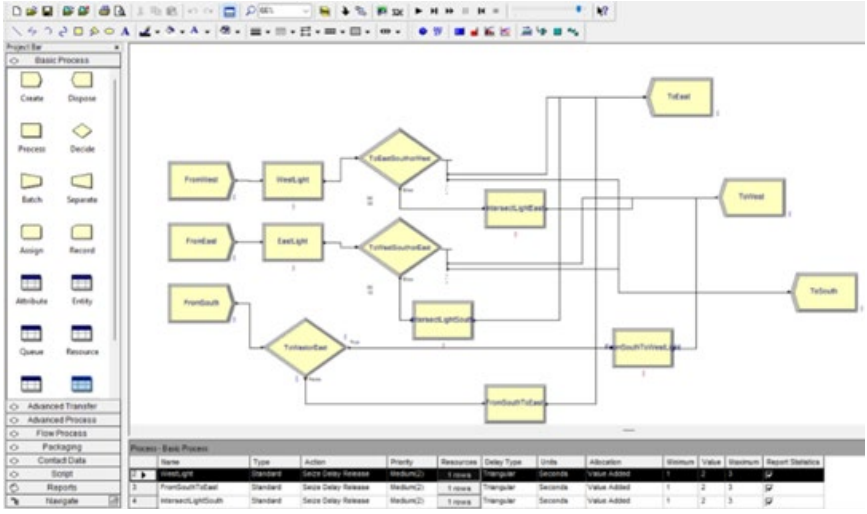
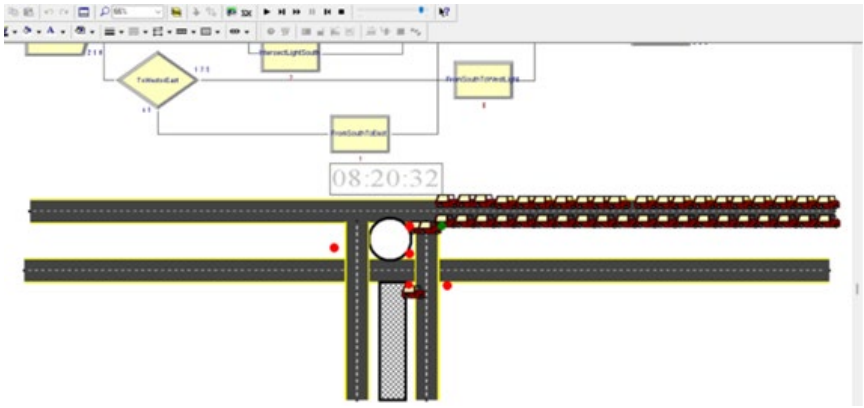
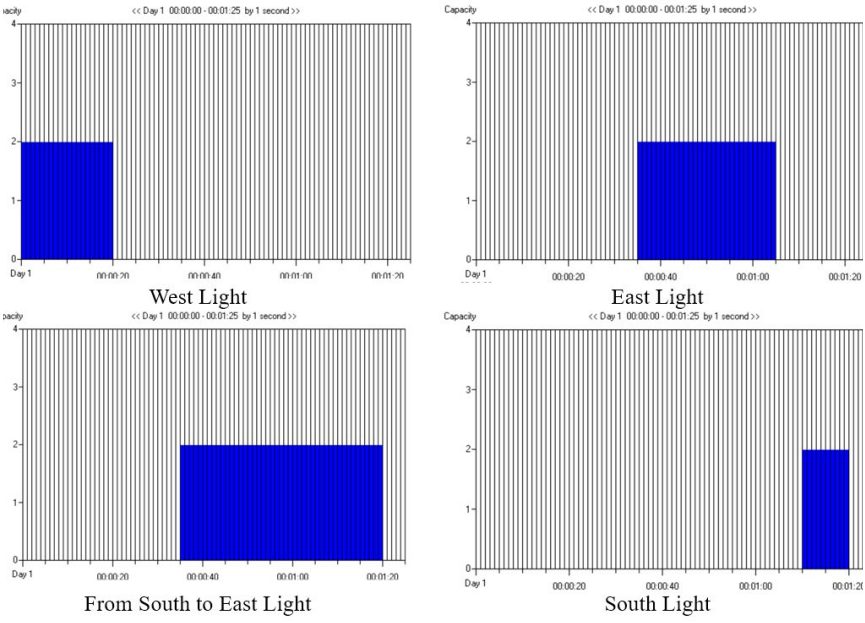


Figure 3. Animation of the Arena Simulation Model



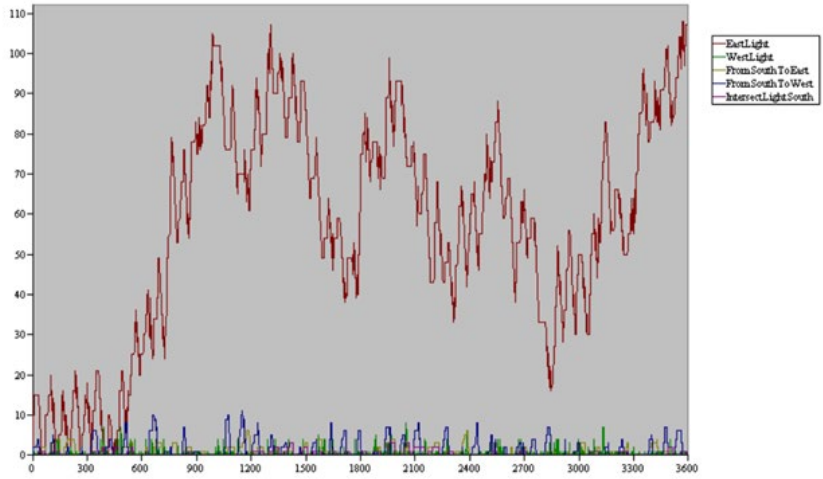
Predetermined and constant green light times for the CS are defined as schedules in Arena, as seen in Figure 4. There is an 80-second cycle. From 0 to 20th second, the west light is green; from 20 to 35th second, all lights for the vehicles are red, and only the pedestrian light is green. From 35 to 65th second, the east light is green, and from 35 to 80th second, the light from south to east is green. And lastly, from 70 to 80th second, the south light is green. The cycle of the TI is 80 seconds.

Figure 4. Schedule of Green Lights in CS



The model was run step by step, and it was observed that vehicle behavior and waiting times at the traffic lights accurately reflected real-world conditions. The model was verified. In the developed CS model, the system initially contains no vehicles, which does not reflect real-world traffic conditions. To address this issue, queue lengths at the intersection were continuously monitored through time-dependent plots. While the queues on the other bounds of the intersection exhibited relatively stable patterns over time, the eastbound approach showed a noticeable increase after approximately 600 seconds (10 minutes), as illustrated in Figure 5. Therefore, a 10-minute warm-up period was introduced. Given that the study concentrates on traffic conditions between 8:00 and 9:00 a.m., the total simulation run length was set to 70 minutes, incorporating the warm-up period.

Figure 5. Number of Vehicles in the Queue at the Traffic Lights



When the CS model was run for a 70-minute period simulating the morning peak between 8:00 and 9:00 AM, considering a warm-up period, a total of 3,200 vehicles were recorded as having passed through the intersection. However, this result is equivalent to conducting a single experiment with stochastic inputs. When the experiment is repeated, it is likely that different outcomes will be obtained. Therefore, it is more appropriate to determine the number of replications at the point where the relevant statistic reaches a steady state and to run the model with that replication number. In this study, the CS model was executed in Arena's Process Analyzer tool with 1, 10, 20, 30, 40, and 50 replications, respectively. As shown in Figure 6, after 50 replications, the

number of vehicles passing through the intersection (number out) stabilized at around 3,218 vehicles. Accordingly, the number of replications was set to 50 for both the CS model and the alternative scenarios.

Figure 6. Number out for Different Number of Replications

	Scenario Properties			Control	Responses
	S	Name	Program File	Reps	Num Reps	Entity 1.NumberOut
1		Current	49 : Model3.p	1	1	3200.000
2		Current10rep	49 : Model3.p	10	10	3236.900
3		Current20rep	49 : Model3.p	20	20	3218.300
4		Current30rep	49 : Model3.p	30	30	3228.400
5		Current40rep	49 : Model3.p	40	40	3217.075
6		Current50rep	49 : Model3.p	50	50	3218.540

When the CS model was executed with 50 replications, the number of vehicles passing through the intersection in each replication was reported in Table 2. For these 50 replications, the average number of vehicles passing through the intersection (number out) was calculated as 3,218.5 (min: 3,020; max: 3,376).

Table 2. Number out Values for 50 Replications

Rep #	# Out	Rep #	# Out	Rep #	# Out	Rep #	# Out	Rep #	# Out
1	3200	11	3198	21	3257	31	3132	41	3320
2	3187	12	3186	22	3191	32	3241	42	3304
3	3164	13	3239	23	3237	33	3174	43	3220
4	3247	14	3320	24	3040	34	3161	44	3188
5	3217	15	3376	25	3115	35	3156	45	3238
6	3225	16	3289	26	3261	36	3168	46	3232
7	3280	17	3219	27	3214	37	3142	47	3281
8	3307	18	3302	28	3187	38	3239	48	3313
9	3058	19	3207	29	3184	39	3251	49	3283
10	3062	20	3285	30	3167	40	3180	50	3283

Note. * Rep # : Number of Replications, # Out: Number Out

When the values of the number of vehicles passing through the intersection (number our) for 50 replications were compared with the observed value of 3,215 using a One-Sample t-test in SPSS 18.0 (Table 3), no significant difference was found within the 95% confidence interval ($p = 0.723 > 0.05$). The absence of a significant difference between the results obtained from 50 replications of the model and the real-life observation provides evidence supporting the validity of the model.

Table 3. One-Sample t-Test for Number Out

	Test Value = 3215					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
NumOut	,357	49	,723	3,54000	-16,3974	23,4774

In S1, just the schedule for the green light is different from CS, all else is the same. When the model for S1 is run for a 70-minute period, including a 10-minute warm-up period simulating the morning peak between 8:00 and 9:00 AM, the average number of vehicles passing through the intersection for 50 replications is calculated as 3,376.5, as seen in Table 5. The minimum value for the number out of 50 replications is 3,125, and the maximum value is 3,652. The minimum value may be considered as the worst case, and the maximum value may be considered as the best case among 50 replications. For the eastbound traffic signal, where vehicle density was highest, the average waiting time for 50 replications was calculated as 13.3 seconds, the maximum average was 23.3 seconds, and the maximum value was 106.3 seconds. The maximum value may be considered as the worst case. For the eastbound traffic signal, where vehicle density was highest, the average number of waiting vehicles for 50 replications was 6.7, the maximum average was 12.3, and the maximum value was 75. The maximum value may be considered as the worst case. This scenario may also be applied to evening peak hours, by increasing the green light time for westbound and decreasing it for eastbound.

As seen in Table 4, when the model for CS is run for a 70-minute period, including a 10-minute warm-up period simulating the morning peak between 8:00 and 9:00 AM, the average number of vehicles passing through the intersection for 50 replications is calculated as 3,218.5. The minimum value for the number out of 50 replications is 3040, and the maximum value is 3,376. The minimum value may be considered as the worst case, and the maximum value may be considered as the best case among 50 replications. For the eastbound traffic signal, where vehicle density was highest, the average waiting time for 50 replications was calculated as 218.5 seconds, the maximum average was 471.6 seconds, and the maximum value was 662.9 seconds. The maximum value may be considered as the worst case. For the eastbound traffic signal, where vehicle density was highest, the average number of waiting vehicles for 50 replications was 111.5, the maximum average was 243.6, and the maximum value was 383. The maximum value may be considered as the worst case.

Table 4. Results of 50 Replications for CS

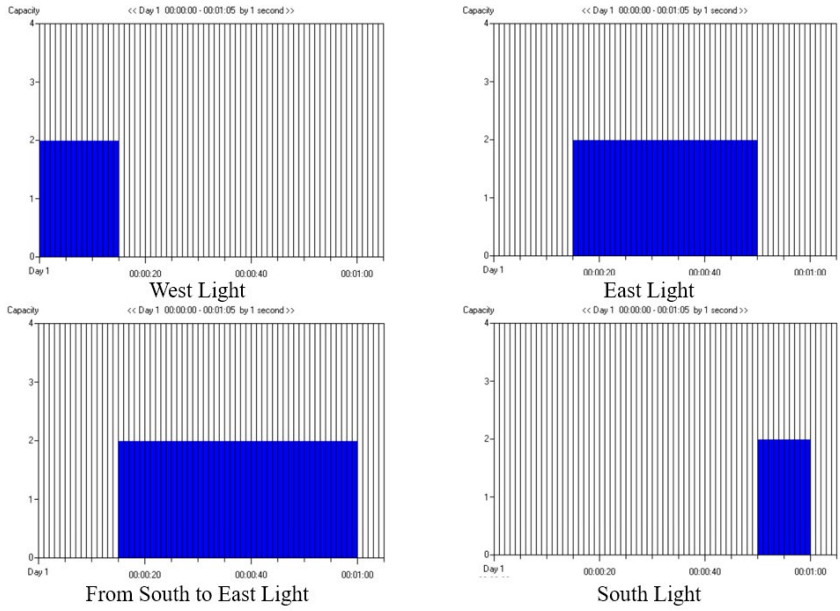
	Average	**Minimum Value**	**Maximum Value**
Number Out	3218.5	3040	3376
Waiting Time	**Average**	**Maximum Average**	**Maximum Value**
West Light	1.2	1.5	16.8
From South To East	31.3	36.7	76.8
From South To West	8.5	10.1	38.7
Intersect Light South	31.8	38.1	69.9
East Light	218.5	471.6	662.9
Number Waiting	**Average**	**Maximum Average**	**Maximum Value**
West Light	0.4	0.5	16
From South To East	0.8	1.2	10
From South To West	0.9	1.2	15
Intersect Light South	0.5	0.6	7
East Light	111.5	243.6	383

3.2. Scenario 1 (S1): Different Timing for Peak Hours

In large and densely populated cities, an average waiting time of 4 minutes and a maximum of 8 minutes at a traffic signal may not be considered very long. However, in a comparatively smaller city like Tokat, such waiting times at a single signalized intersection are perceived as high. Moreover, considering that there are other signalized intersections with their own levels of congestion both before and after the junction in question, it becomes clear that this traffic density represents a problem worth studying.

In the CS, the green light cycle was fixed at 80 seconds, predetermined and constant throughout the day. It would be better for reducing cycle time by increasing the green light time for eastbound and decreasing it for others to reduce waiting time and the number of vehicles waiting at eastbound light. In S1, since traffic density is higher on the east side during the morning hours, the green light duration for the eastbound signal was increased by 5 seconds to 35 seconds, while the duration for the westbound signal was reduced by 5 seconds to 15 seconds. Additionally, the 15-second all-red phase, during which all vehicles were stopped, and only pedestrians had a green light, was removed, reducing the total cycle time to 60 seconds. The related timing adjustments can be seen in Figure 7. The removal of the 15-second pedestrian-only phase may be debatable; however, it was observed that pedestrian movement at the intersection is minimal. In the CS, even though there are no pedestrians, a 15-second pedestrian-only phase is active every cycle, and it causes vehicle queues to get longer. In this scenario, pedestrians still have sufficient time to cross the intersection safely during the red light phases for vehicles on each side of the road. But in this scenario, pedestrians are required to cross the road not in a single attempt, but by waiting in the median. It's still a safe and reasonable solution for an intersection with very little pedestrian traffic. Alternatively, systems that include pedestrian push buttons -activating a green light only when a pedestrian is present- could be implemented.

Figure 7. Schedule of Green Lights in S1



In S1, just the schedule for the green light is different from CS; all else is the same. When the model for S1 is run for a 70-minute period, including a 10-minute warm-up period simulating the morning peak between 8:00 and 9:00 AM, the average number of vehicles passing through the intersection for 50 replications is calculated as 3,376.5, as seen in Table 5. The minimum value for the number out of 50 replications is 3,125, and the maximum value is 3,652. The minimum value may be considered as the worst case, and the maximum value may be considered as the best case among 50 replications. For the eastbound traffic signal, where vehicle density was highest, the average waiting time for 50 replications was calculated as 13.3 seconds, the maximum average was 23.3 seconds, and the maximum value was 106.3 seconds. The maximum value may be considered as the worst case. For the eastbound traffic signal, where vehicle density was highest, the average number of waiting vehicles for 50 replications was 6.7, the maximum average was 12.3, and the maximum value was 75. The maximum value may be considered as the worst case. This scenario may also be applied to evening peak hours by increasing the green light time for westbound and decreasing it for eastbound.

Table 5. Results of 50 Replications for Scenario 1

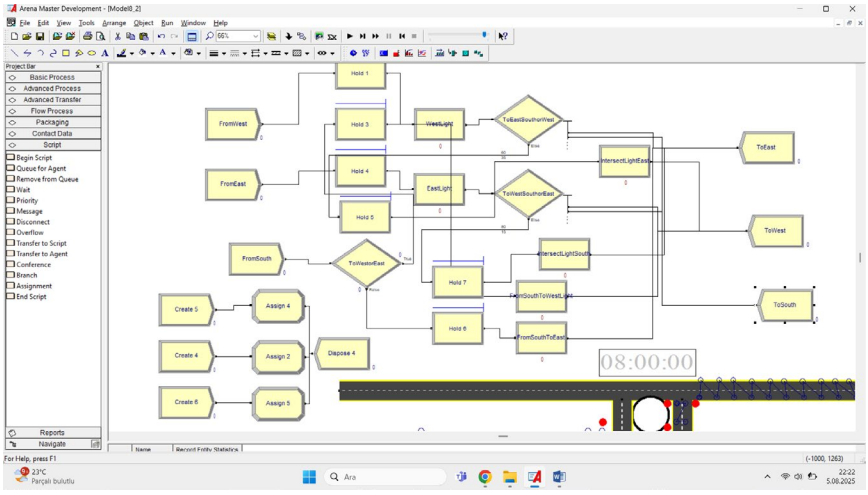
	Average	Minimum Value	Maximum Value
Number Out	3376.5	3125	3652
Waiting Time	**Average**	**Maximum Average**	**Maximum Value**
West Light	1.2	1.5	15.6
From South To East	20.9	26.3	50.8
From South To West	2.3	2.8	18.6
Intersect Light South	20.8	26.5	51.3
East Light	13.3	23.3	106.3
Number Waiting	**Average**	**Maximum Average**	**Maximum Value**
West Light	0.4	0.5	17
From South To East	0.6	0.8	7
From South To West	0.3	0.3	12
Intersect Light South	0.3	0.5	5
East Light	6.7	12.3	75

3.3. Scenario 2 (S2): Timing Based on Number of Vehicles in the Queue

S1 may reduce waiting time and the number of vehicles waiting at the congested side of the intersection during the morning peak. However, it cannot provide a good solution for different times of the day or for a non-recurring congestion, such as an accident or a breakdown. In S2, green light times are not predetermined and constant. The green light duration is determined dynamically based on the number of vehicles waiting in the queue. Since both the green light durations and the time intervals are not fixed, it is not possible to define

these durations using schedules, as was done in the previous two models. There is also no fixed cycle time, such as 60 or 80 seconds; the cycle time can vary. The existing model has been extended and improved by adding new modules (see Figure 8). Using Assign modules, the number of vehicles waiting in the queue, the green light duration, and the green light start and end times for the east, west, and south directions were defined as separate variables. Since the number of vehicles in the queue constantly changes, but the related variables are intended to be updated periodically rather than continuously, a separate loop was created for the Assign modules. Hold modules were used to release entities when the green light is active for the corresponding direction.

Figure 8. Arena Simulation Model for S2



When the model for S2 is run for a 70-minute period, including a 10-minute warm-up period simulating the morning peak between 8:00 and 9:00 AM, the average number of vehicles passing through the intersection for 50 replications is calculated as 3,387.4, as seen in Table 6. The minimum value for the number out of 50 replications is 3,173, and the maximum value is 3,625. The minimum value may be considered as the worst case, and the maximum value may be considered as the best case among 50 replications. For the eastbound traffic signal, where vehicle density was highest, the average waiting time for 50 replications was calculated as 13.1 seconds, the maximum average was 20.3 seconds, and the maximum value was 81.1 seconds. The maximum value may be considered as the worst case. For the eastbound traffic signal, where vehicle density was highest, the average number of waiting vehicles for 50 replications was 6.1, the maximum average was 11.1, and the maximum value was 72. The

maximum value may be considered as the worst case. This scenario does not need to be applied to evening peak hours, because it already actively seeks the queues and determines green light time dynamically.

Table 6. Results of 50 Replications for Scenario 2

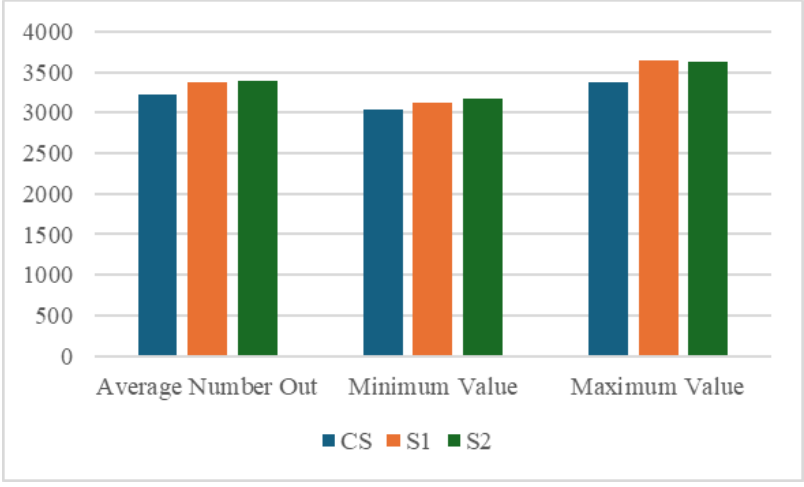
	Average	Minimum Value	Maximum Value
Number Out	3387.4	3173	3625
Waiting Time	**Average**	**Maximum Average**	**Maximum Value**
West Light	3.9	4.7	27.9
From South To East	1.9	2.9	16.1
From South To West	1.4	2.1	17.6
Intersect Light South	1.2	2.5	12.3
East Light	13.1	20.3	81.1
Number Waiting	**Average**	**Maximum Average**	**Maximum Value**
West Light	1.2	1.6	30
From South To East	0.1	0.1	15
From South To West	0.1	0.2	18
Intersect Light South	0.1	0.1	11
East Light	6.1	11.1	72

4. Findings

The results of CS, S1, and S2 are compared in Table 7. "Number Out" represents the total number of vehicles that passed through the intersection during the simulated one-hour period. Average values for the number out statistic is the average value of 50 replications. According to the average number out of S1 (3,376.5 ± 35.6 vehicles, 95% confidence interval) and S2 (3,387.4 ± 33.8 vehicles, 95% confidence interval), yield higher values than the CS (3,218.5 ±

20.1 vehicles, 95% confidence interval). The average number out (number of vehicles passing through the intersection) increased by 4,9% in S1 and 5.2% in S2 when compared with the CS. Minimum value for the number of our statistic may be considered as the worst case among 50 replications. According to the minimum number out value, S1 (3,125 vehicles) and S2 (3,173 vehicles) yield higher values than the CS (3,040 vehicles). The minimum value for number out is 3.1% higher in S1 and 4.4% higher in S2 when compared with the CS. The maximum value for the number out statistic may be considered as the best case among 50 replications. According to the maximum number, out of value S1 (3,652 vehicles) and S2 (3,625 vehicles) yield higher values than the CS (3,376 vehicles). The maximum value for the number out is 8.2% higher in S1 and 7.4% higher in S2 when compared with the CS. These comparisons may be seen in Figure 9.

Figure 9. Comparison of the Number of Outbound Vehicles (Vehicles Passing Through the Intersection)



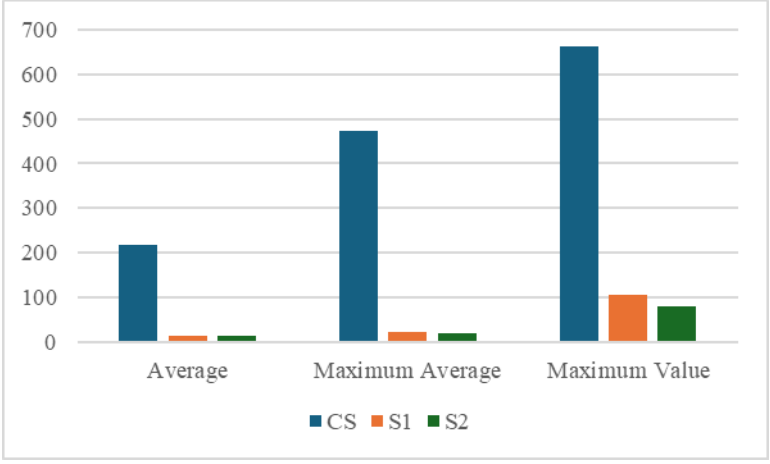
Since this study focuses on morning traffic density, the statistics for the heavily congested eastbound direction are particularly important. Instead of evaluating all indicators, examining the East Light statistics in terms of waiting time and number of vehicles waiting can provide insight into the outcomes of the scenarios.

Table 7. Comparison of CS, S1 and S2 Model Results for 50 Replications

	Current Situation (CS)			Scenario 1 (S1)			Scenario 2 (S2)		
	Average	Minimum Value	Maximum Value	Average	Minimum Value	Maximum Value	Average	Minimum Value	Maximum Value
Number Out	3218.5	3040	3376	3376.5	3125	3652	3387.4	3173	3625
Waiting Time	Average	Maximum Average	Maximum Value	Average	Maximum Average	Maximum Value	Average	Maximum Average	Maximum Value
West Light	1.2	1.5	16.8	1.2	1.5	15.6	3.9	4.7	27.9
From South to East	31.3	36.7	76.8	20.9	26.3	50.8	1.9	2.9	16.1
From South to West	8.5	10.1	38.7	2.3	2.8	18.6	1.4	2.1	17.6
Intersect Light South	31.8	38.1	69.9	20.8	26.5	51.3	1.2	2.5	12.3
East Light	218.5	471.6	662.9	13.3	23.3	106.3	13.1	20.3	81.1
Number Waiting	Average	Maximum Average	Maximum Value	Average	Maximum Average	Maximum Value	Average	Maximum Average	Maximum Value
West Light	0.4	0.5	16	0.4	0.5	17	1.2	1.6	30
From South to East	0.8	1.2	10	0.6	0.8	7	0.1	0.1	15
From South to West	0.9	1.2	15	0.3	0.3	12	0.1	0.2	18
Intersect Light South	0.5	0.6	7	0.3	0.5	5	0.1	0.1	11
East Light	111.5	243.6	383	6.7	12.3	75	6.1	11.1	72

"Waiting Time" refers to the waiting time in the queue before passing the traffic light. Average is the average of 50 replications; maximum average is the average of the maximum values of 50 replications, and maximum value is the maximum value of 50 replications for waiting times. According to average waiting time at East Light S1 (13.3 ± 0.7 seconds 95% confidence interval) and S2 (13.1 ± 0.6 seconds 95% confidence interval) yield lower values than the CS (218.5 ± 26.5 seconds 95% confidence interval). Average waiting time decreased by 93.9% in S1 and 94% in S2 when compared with the CS. Kamrani et al. (2014) provided a 67% reduction in average waiting time, and Cav et al. (2021) reduced overall vehicle waiting time by an average of 80%. Scenarios in this study reduced the average waiting time by about 94% and it is a considerable improvement when compared with the results in the literature. According to average of maximum waiting times at East Light S1 (23.3 seconds) and S2 (20.3 seconds) yield lower values than the CS (471.6 seconds). The average of the maximum waiting time decreased by 95.1% in S1 and 95.7% in S2 when compared with the CS. According to the maximum waiting time value at East Light S1 (106.3 seconds) and S2 (81.1 seconds) yield lower values than the CS (662.9 seconds). Maximum waiting time decreased by 83.9% in S1 and 87.7% in S2 when compared with CS. These comparisons may be seen in Figure 10.

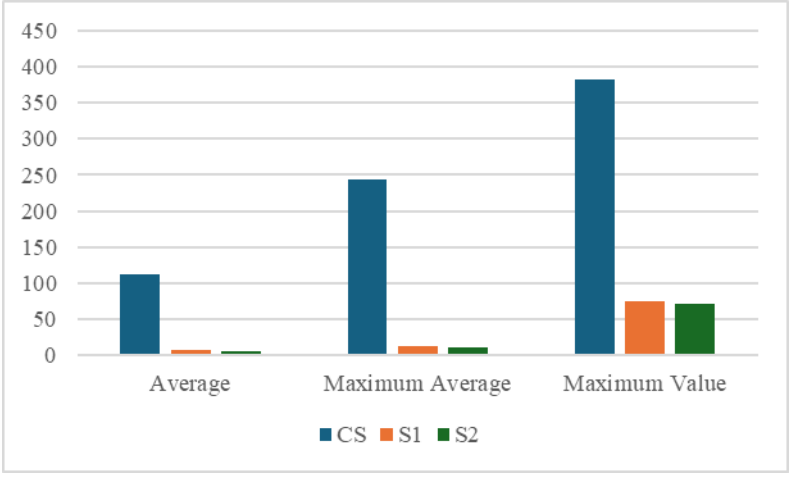
Figure 10. Comparison of Waiting Times at East Light



"Number Waiting" refers to the number of vehicles in the queue at the traffic light. Average is the average of 50 replications, maximum average is the average of the maximum values of 50 replications, and maximum value is the maximum value of 50 replications for the number waiting. According to the average number of waiting vehicles at East Light S1 (6.7 ± 0.4 vehicles 95%

confidence interval) and S2 (6.1 ± 0.4 vehicles 95% confidence interval) yield lower values than the CS (111.5 ± 14.4 vehicles 95% confidence interval). The average number of waiting vehicles decreased by 93.9% in S1 and 94.5% in S2 when compared with the CS. Fabianova et al. (2020) gained a 75% reduction in average line length, and Bore & Ambunda (2025) reduced queue lengths from 2 up to 80%. Scenarios in this study reduced the number of waiting vehicles by about 94% and it is a considerable improvement when compared with the results in the literature. According to average of maximum number of waiting vehicles at East Light S1 (12.3 vehicles) and S2 (11.1 vehicles) yield lower values than the CS (243.6 vehicles). The average of the maximum number of waiting vehicles decreased by 94.9% in S1 and 95.4% in S2 when compared with the CS. According to the maximum number of waiting vehicles value at East Light S1 (75 vehicles), and S2 (72 vehicles) yield lower values than the CS (383 vehicles). The maximum number of waiting vehicles value decreased by 80.4% in S1 and 81.2% in S2 when compared with CS. These comparisons may be seen in Figure 11.

Figure 11. Comparison of Number of Waiting Vehicles at East Light



5. Conclusion

Urban traffic congestion is a major challenge for modern cities, impacting daily life, the economy, and the environment. Effective traffic management, particularly at intersections, plays a critical role in dealing with congestion. Properly functioning intersections help maintain smooth traffic flow and minimize delays. On the other hand, if not well-managed, intersections can

become major bottlenecks and significantly contribute to traffic congestion.

This study presents a simulation-based comparison of different traffic signal systems, aiming to evaluate their effectiveness in managing congestion at a signalized TI in the city of Tokat, Türkiye. After modeling the current situation of TI, two different scenarios were modeled and run. In S1, a different timing for peak hours and in S2, a timing based on the number of vehicles in the queue was applied. Both scenarios increased the number of vehicles passing through the intersection by about 5% (S1 increased 4.9% and S2 increased 5.2%). According to the average number of vehicles passing through the intersection S1 (3376.5 ± 35.6 vehicles, 95% confidence interval) and S2 (3387.4 ± 33.8 vehicles, 95% confidence interval) yield higher values than the CS (3218.5 ± 20.1 vehicles, 95% confidence interval). Both scenarios decreased the average waiting time by about 94% (S1 decreased 93.9%, and S2 decreased 94%). According to average waiting time at East Light S1 (13.3 ± 0.7 seconds 95% confidence interval) and S2 (13.1 ± 0.6 seconds 95% confidence interval) yield lower values than the CS (218.5 ± 26.5 seconds 95% confidence interval). Both scenarios decreased the average number of vehicles in the queue by about 94% (S1 decreased 93.9% and S2 decreased 94.5%) for the congested eastbound of TI. According to the average number of waiting vehicles at East Light S1 (6.7 ± 0.4 vehicles 95% confidence interval) and S2 (6.1 ± 0.4 vehicles 95% confidence interval) yield lower values than the CS (111.5 ± 14.4 vehicles 95% confidence interval).

All studies in the literature focusing on traffic congestion and simulation at intersections have achieved results that help reduce congestion. In this respect, the findings of this study are consistent with those reported by Kamrani et al. (2014), Yuniawan et al. (2018), Abohashima et al. (2019), Aramesh & Ghorbanian (2020), Fabianova et al. (2020), and Cav et al. (2021). Kamrani et al. (2014) provided a 67% reduction in average waiting time, Fabianova et al. (2020) gained a 75% reduction in average line length, Cav et al. (2021) reduced overall vehicle waiting time by an average of 80% and Bore & Ambunda (2025) reduced queue lengths by 2-80%. About a 94% reduction in average waiting time and the average number of waiting vehicles are considerable results of this study when compared with the results in the literature. This study contributes to the literature as it is likely the first attempt to address a traffic problem at a signalized intersection in Tokat by modeling it through simulation and determining signal durations based on traffic density, and it is also among the limited number of such studies conducted in Türkiye.

S1 can be implemented at a much lower cost and appears to be effective in addressing recurring congestion during peak hours. Implement S2 would

require cameras monitoring the intersection and image processing technology to detect traffic density. This would lead to higher cost, but it would allow signal timings to be adjusted in real time during nonrecurring congestion situations. In Tokat, traffic lights operate with predetermined timings, and there are no systems that adjust according to traffic density. This study can guide decision-makers by revealing the potential impact of adaptive traffic lights.

The study also has some limitations. It only considers the morning peak hours. Running the simulation over a full 24-hour period could better highlight the strengths of dynamic/intelligent systems like those in S2. Such systems can adjust signal timings dynamically based on traffic density, providing more effective solutions not only for regular peak-hour congestion (recurrent congestion) but also for unexpected traffic buildups during the day caused by incidents such as accidents (nonrecurring congestion).

Testing only two scenarios constitutes another limitation of the study. In addition to examining different scenarios, the parameters in the existing two scenarios, such as cycle times and signal timings, could have been tested with different values to determine their optimal levels. This issue may be further investigated in future research.

Additionally, due to some simplifying assumptions in the model used in this study, details such as traffic speed, different vehicle types, and pedestrians were not included. In future studies, these details can be incorporated to further enhance the model and make it more representative of real-world traffic systems.

Another limitation is that the study focused only on a single intersection. Solutions that alleviate traffic at this intersection may cause the next intersection to become more congested. Therefore, future studies examining an entire main artery or region with more comprehensive models could yield more realistic and applicable results.

References

Abohashima, H. S., Gheith, M., & Eltawil, A. (2019, October). Solving the urban traffic lights scheduling problem using discrete event simulation and design of experiments. In *Proceedings of the International Conference on Computers and Industrial Engineering (CIE)*.

Aramesh, S., & Ghorbanian, A. (2020). Multi-objective optimization for a complex intersection using design of experiments and simulation. *Journal Européen des Systèmes Automatisés*, *53*(6), 791–802.

Arathi, A. R., Harikrishna, M., & Mohan, M. (2023). Simulation-based performance evaluation of skewed uncontrolled intersections. *International Journal of Intelligent Transportation Systems Research*, *21*(2), 349–360.

Bindzar, P., Marasova, D., Brodny, J., Tutak, M., Ulewicz, R., & Sliva, A. (2024). Modeling the impact of intersection design configurations on traffic flow during peak hour in smart cities: A case study on urban roads in Slovakia. *IEEE Access, 12*, 83072–83090.

Bore, O. K., & Ambunda, R. (2025). Microscopic evaluation of traffic operations on urban arterial roads: The case of Ongwediva, Namibia. *Transportation Research Procedia, 89*, 594–620.

Cav, C., Colak, A., & Unver, N. F. (2021, August). Adaptive traffic signal control to reduce delay time at a single intersection point. In *2021 International Conference on Innovations in Intelligent Systems and Applications (INISTA)* (pp. 1–6). IEEE.

Concas, S., Kamrani, M., & Kummetha, V. C. (2021). *Proactive congestion management*. National Institute for Congestion Reduction Research Report.

Dutta, M., & Ahmed, M. A. (2019). Calibration of VISSIM models at three-legged unsignalized intersections under mixed traffic conditions. *Advances in Transportation Studies, 48*, 31–46.

Fabianova, J., Michalik, P., Janekova, J., & Fabian, M. (2020). Design and evaluation of a new intersection model to minimize congestions using VISSIM software. *Open Engineering*, *10*(1), 48–56.

Kamrani, M., Abadi, S. M. H. E., & Golroudbary, S. R. (2014). Traffic simulation of two adjacent unsignalized T-junctions during rush hours using Arena software. *Simulation Modelling Practice and Theory*, *49*, 167–179.

Kollár, A., Skapinyecz, R., & Erdei, L. (2024). A simulation-based comparative analysis of interconnected signalized intersections and roundabouts from the aspect of permeability. *European Transport 96*, Paper No. 7. https://doi.org/10.48295/ET.2024.96.7

Kummetha, V. C., Kamrani, M., Concas, S., Kourtellis, A., & Dokur, O. (2024). Proactive congestion management via data-driven methods and connected vehicle-based microsimulation. *Journal of Intelligent Transportation Systems*, *28*(4), 459–475.

Liu, Y., & Song, Y. (2022). Research on simulation and optimization of road traffic flow based on Anylogic. In *E3S Web of Conferences* (Vol. 360, p. 01070). EDP Sciences.

Lomax, T. J., Turner, S., Shunk, G., Levinson, H. S., Pratt, R. H., Bay, P. N., & Douglas, G. B. (1997). *Quantifying congestion: Volume 1: Final report* (NCHRP Report 398; Project 7–13 FY'92). Transportation Research Board, National Research Council. https://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_398.pdf

Pallela, S. S., & Kota, R. B. (2025). Simulation-based capacity and delay analysis of unsignalized intersections in mixed traffic conditions. *Journal of The Institution of Engineers (India): Series A, 106*(3), 773–787.

Pell, A., Meingast, A., & Schauer, O. (2017). Trends in real-time traffic simulation. *Transportation Research Procedia*, *25*, 1477–1484.

Phung, P. T. K., Thi, N. T., & Cuc, V. T. K. (2020). A study on urban traffic congestion using simulation approach. In *2020 5th International Conference on Green Technology and Sustainable Development (GTSD)* (pp. 555–561). IEEE.

Roy, R., Ghosh, S. K., Zoha, N., & Islam, M. A. U. (2020). Analysis and optimization of traffic congestion at single intersection using MATLAB and Arena simulation. *ITEGAM-JETIA*, *6*(23), 34–40.

Saval, A., Minh, D. P., Chapuis, K., Tranouez, P., Caron, C., Daudé, É., & Taillandier, P. (2023). Dealing with mixed and non-normative traffic. An agent-based simulation with the GAMA platform. *PLOS ONE*, *18*(3), e0281658.

Tan, W. J., Andelfinger, P., Cai, W., Eckhoff, D., & Knoll, A. (2025). Spatial iterative coordination for parallel simulation-based optimization of large-scale traffic signal control. *Simulation*, *101*(5), 539–556.

Yuniawan, D., Fajar, P. A., Hariyanto, S., & Setiawan, R. (2018). Traffic queue modeling using Arena simulation software (a case study of Mergan 4-Way intersection in Malang City). In *MATEC Web of Conferences* (Vol. 204, Article 02009). EDP Sciences.

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