TRANSFORMATION OF PUBLIC SPACE IN DIGITAL AGE

PhD Dissertation

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Eskişehir 2024

TRANSFORMATION OF PUBLIC SPACE IN DIGITAL AGE

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PhD Dissertation

Department of Architecture

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Eskişehir

Eskişehir Technical University

Institute of Graduate Programs

August 2024

FINAL APPROVAL FOR THESIS

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ABSTRACT

TRANSFORMATION OF PUBLIC SPACE IN DIGITAL AGE

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Eskişehir Technical University, Institute of Graduate Programs, August 2024

Supervisor: Prof. Dr. Nuray ÖZASLAN

This thesis explores how digital technologies are transforming public spaces and their impact on urban identity and morphology. The research focuses on the integration of digital tools such as smart information systems, digital communication networks, and digital solutions, analyzing their roles in enhancing accessibility, inclusivity, sustainability, safety, and resilience. The study includes case examples from cities like Singapore, Barcelona, Tokyo, Amsterdam, and Istanbul to illustrate these dynamics. The findings demonstrate that digitalization profoundly alters urban functionality and user experience. Case studies reveal that digital tools facilitate new forms of engagement, redefine urban services, and influence both the physical and conceptual aspects of urban identity. For instance, Istanbul's Kadıköy Square exemplifies how digital infrastructure can shift social dynamics and spatial configurations, while cities like Tokyo and Amsterdam highlight changes in urban form and infrastructure due to digital integration. Key insights show that innovations such as digital displays, interactive installations, and smart technologies contribute to sustainability and urban development goals, affecting transportation and infrastructure planning. However, challenges such as inconsistent digital adoption and the rapid evolution of technology are noted. Future research should address these challenges by examining diverse urban contexts and long-term impacts. Recommendations include customizing digital solutions to local needs, improving security and sustainability, and preserving cultural heritage in the face of digital advancements. This research emphasizes the need for a nuanced, interdisciplinary approach to integrating digital technologies into urban design.

Keywords: Public space, Digitalization, Smart city, Urban space, Digital age.

ÖZET

KAMUSAL ALANIN DIJITAL ÇAĞ'DA DÖNÜŞÜMÜ

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Eskişehir Teknik Üniversitesi, Lisansüstü Eğitim Enstitüsü, Ağustos 2024

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Bu tez, dijital teknolojilerin kamusal alanları nasıl dönüştürdüğünü ve bunların kentsel kimlik ve morfoloji üzerindeki etkilerini araştırmaktadır. Araştırma, akıllı bilgi sistemleri, dijital iletişim ağları ve dijital çözümler gibi dijital araçların entegrasyonuna odaklanarak, bu araçların erişilebilirlik, kapsayıcılık, sürdürülebilirlik, güvenlik ve dayanıklılığı artırmadaki rollerini analiz etmektedir. Çalışma, bu dinamikleri örneklemek için Singapur, Barcelona, Tokyo, Amsterdam ve İstanbul gibi şehirlerden vaka örnekleri içermektedir. Bulgular, dijitalleşmenin kentsel işlevselliği ve kullanıcı deneyimini derinden değiştirdiğini göstermektedir. Vaka çalışmaları, dijital araçların yeni etkileşim biçimlerini kolaylaştırdığını, kentsel hizmetleri yeniden tanımladığını ve kentsel kimliğin hem fiziksel hem de kavramsal yönlerini etkilediğini ortaya koymaktadır. Örneğin, İstanbul'un Kadıköy Meydanı, dijital altyapının sosyal dinamikleri ve mekansal düzenlemeleri nasıl değiştirebileceğini örneklerken, Tokyo ve Amsterdam gibi şehirler dijital entegrasyon nedeniyle kentsel form ve altyapıdaki değişiklikleri vurgulamaktadır. Anahtar bulgular, dijital ekranlar, etkileşimli yerleştirmeler ve akıllı teknolojiler gibi yeniliklerin sürdürülebilirlik ve kentsel gelişim hedeflerine katkıda bulunduğunu, ulaşım ve altyapı planlamasını etkilediğini göstermektedir. Ancak, tutarsız dijital benimseme ve teknolojinin hızlı evrimi gibi zorluklar da belirtilmektedir. Gelecek araştırmalar, bu zorlukları çeşitli kentsel bağlamları ve uzun vadeli etkileri inceleyerek ele almalıdır. Öneriler arasında yerel ihtiyaçlara göre dijital çözümler özelleştirmek, güvenlik ve sürdürülebilirliği iyileştirmek ve dijital ilerlemelere karşı kültürel mirası korumak yer almaktadır. Bu araştırma, dijital teknolojilerin kentsel tasarıma entegrasyonunda incelikli, disiplinler arası bir yaklaşımın gerekliliğini vurgulamaktadır.

Anahtar Sözcükler: Kamu alanı, dijitalleşme, Akıllı şehir, Kentsel alan, Dijital çağ

ACKNOWLEDGEMENTS

First and foremost, I extend my profound gratitude to my esteemed supervisor, Prof. Dr. Nuray Özaslan, whose unwavering support has been pivotal throughout these years. Professor Nuray has been a nurturing mentor to me, especially during the academic challenges I faced abroad. Without her steadfast guidance and encouragement, completing my studies and this thesis would not have been possible. I am deeply thankful to her for her invaluable mentorship and steadfast support.

I extend my thanks to my dear jury members who have illuminated the path with their invaluable guidance.

I am grateful to my parents and brother who have been my pillars of support throughout my years of education, encouraging me to pursue the path of knowledge and never doubt my abilities for a moment, with all my heart.

To my spouse Dr. Arya Sabouryfar, who has been a constant source of encouragement and support throughout my doctoral journey, always being hopeful even when I felt disheartened, I am thankful.

Additionally, I extend my utmost gratitude to Eskisehir Technical University and the country of Türkiye for providing me with this opportunity to achieve my doctoral degree. I wish for peace, friendship, and tranquility for this country and for the entire world.

Fatemeh BADEL

08/08/2024

STATEMENT OF COMPLIANCE WITH ETHICAL PRINCIPLES AND RULES

I hereby truthfully declare that this thesis is an original work prepared by me; that I have behaved in accordance with the scientific ethical principles and rules throughout the stages of preparation, data collection, analysis and presentation of my work; that I have cited the sources of all the data and information that could be obtained within the scope of this study, and included these sources in the references section; and that this study has been scanned for plagiarism with "scientific plagiarism detection program" used by Eskişehir Technical University, and that "it does not have any plagiarism" whatsoever. I also declare that, if a case contrary to my declaration is detected in my work at any time, I hereby express my consent to all the ethical and legal consequences that are involved.

Fatemeh BADEL

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GLOSSARY OF SYMBOLS AND ABBREVIATIONS

EU	:	European Union
SDM	:	Safe Distancing Measures
IMD	:	Institute for Management Development
SNDGO	:	The Smart Nation and Digital Government Office
PMO	:	Prime Minister's Office
GovTech	:	Government Technology Agency
SNDGG	:	The Smart Nation and Digital Government Group
LaaP	:	Lamppost-as-a-Platform
UMAI	:	Urban Morphological Artificial Intelligence
AI	:	Artificial Intelligence
AR	:	Augmented Reality
IBB	:	İstanbul Büyükşehir Belediyesi
IMM	:	Istanbul Metropolitan Municipality
APs	:	Access Points
IoT	:	Internet of Things
BD	:	Big Data
ICT	:	Information and Communication Technologies

1. INTRODUCTION

Urban public spaces have undergone various transformations over time due to the usage patterns of citizens and prevailing governance. From agora spaces to virtual public spaces today, this subject has always been of interest to architects and urban planners. The process of growth and changes in public spaces, closely linked to society and dominant culture, has always been the subject of study by researchers. These urban spaces are not merely places for leisure; they have garnered the most attention from municipalities and policymakers. In addition to citizens, architects, urban planners, investors, policymakers, merchants, city officials, and artists are among the groups that value public spaces and, in some cases, benefit from them. Although it may seem that today public spaces are designed by urban planners for citizens to use, it is a mutual process whereby cities are built by citizens (Figure 1.1).

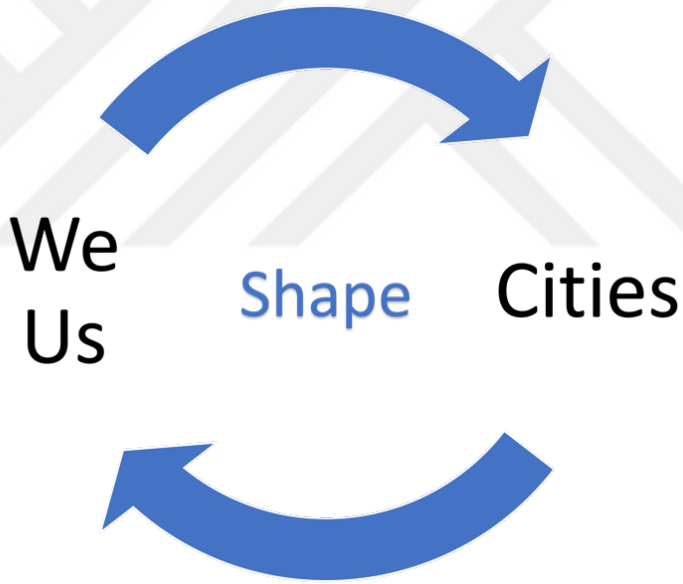


Figure 1.1. *Gehl, J. (2013). Cities for people. Island press.*

There are many characteristics influencing the formation of cities and public spaces. For example, behavioral patterns, beliefs, culture, geographical locations, economic positions, and more. All these factors play a significant role in the formation of public spaces and the evolution of urban growth processes. In the last decade of the twentieth century, after the emergence of technology, citizens' needs have changed. Traditional urban spaces are no longer responsive to all citizens' needs. Citizens' expectations of urban public spaces have also changed compared to the past. Citizens

show more enthusiasm for more responsive urban public spaces and are more inclined to stay in these spaces to fulfill their new needs. The new situation that has arisen after the presence of technologies and the digitalization of cities has significantly impacted our lives. Jane Jacobs (1961) argues that well-designed public spaces are crucial for vibrant urban life and social interaction. She emphasizes the importance of mixed-use areas, street-level activity, and a diversity of uses to promote social cohesion and a sense of community. Since technological development and changes in the form of communications and social interactions have changed, the relationship between citizens and city authorities has also undergone fundamental changes, allowing citizens to directly participate in their urban development process. For example, within the Smart City research community, scholars have highlighted the role of participatory design techniques in addressing ways to combine big data 1with the tacit knowledge from citizens in urban planning processes (Moore & Elliot, 2016). Participatory design straddles the line between research-led and design-led approaches, addressing real-world challenges and seeking innovative solutions while engaging users as active partners rather than mere subjects (Von Wirth et al., 2019).

In the past decade, technological development has significantly impacted all aspects of urban life, creating challenges for urban planning. This is evident in the implementation of vast sensor networks that manage diverse facets of city life, from irrigation to parking. Such projects highlight the transformative potential of integrating technology into conventional urban planning (Mwenda, 2023). The old layers of urban infrastructure are changing with the new layers of digital services, requiring a comprehensive urban transformation process to transform new urban public spaces. The digitalization of urban public spaces can be examined from various perspectives. Addressing the question of what changes are needed in future public spaces requires changes in current urban spaces to facilitate the easier design of future public spaces. Digitalization of public spaces presents both challenges and opportunities that can be evaluated to assess cities. As the quality of life in a city is determined by the quality of its public spaces (Praliya & Garg, 2019), digital technologies can enhance key quality of life indicators by 10 to 30 percent, resulting in safer streets, shorter commutes, and reduced carbon emissions (Woetzel et al., 2018).

[1] It refers to a large volume of data, used to analyze the collected data and extract relevant information about the city (Qi and Tao, 2018).

This study investigates the transformations that public spaces experience worldwide following the integration of digital layers. By examining five successful examples of smart cities, the study aims to better understand these transformations. Five cities were selected to evaluate projects that have utilized digital tools in urban environments. Four cities (Singapore, Barcelona, Tokyo, Amsterdam) were chosen based on the Smart City Index (IMD), and Istanbul was selected as a city in the process of becoming smart. Analyzing the characteristics and impacts of digitalization projects in these cities provides insights into the evolution of public spaces and highlights commonalities in creating effective digitalized public spaces.

1.1. The Definition of the Problem

Theoretical Implications: The digital revolution2, which accelerated from the mid-20th century, has brought profound changes to urban life through advancements in digital technologies such as artificial intelligence, machine learning, and blockchain (Keseru & Randhahn, 2023; Cohn, 2024). This era has reshaped public spaces and interactions by integrating digital tools into everyday life. William Mitchell's City of Bits articulates how information technology has fundamentally altered architectural and spatial experiences, suggesting that urban environments now blend physical and digital realms (Mitchell, 1996). This theoretical shift demands a reevaluation of urban design, where traditional spatial concepts are disrupted by the digital overlay of public spaces. Mitchell (1996) posits that the Internet has transformed public space into a new form of interaction and communication, emphasizing the need to understand these shifts in the context of urban design and planning.

In line with this, scholars such as Menezes and Costa (2017) highlight that digital media and the Internet influence place-making and social interactions, leading to the creation of new virtual dimensions within public spaces. This transformation is accompanied by a need to develop new theoretical frameworks that account for the evolving interplay between physical and digital environments (Mehta, 2014). The integration of digital tools

[2] The Digital Revolution, also known as the Third Industrial Revolution, represents a major shift from mechanical and analogue technologies to digital electronics, beginning in the latter half of the 20th century. This era is marked by the widespread adoption of digital computers, record-keeping systems, and communication technologies, ushering in the Information Age. This period of rapid technological advancement set the stage for the Fourth Industrial Revolution (Schoenherr, 2004).

into urban planning processes underscores the necessity of addressing how these innovations reshape conventional concepts of place and social interaction.

Practical Examples: Practically, the transformation of public spaces through digital technologies is manifest in several ways. Digital displays, Wi-Fi (Wi-Fi as digital connectivity tools) access in public spaces, interactive art installations, and urban games have become common, reflecting a shift from artistic or marketing objectives to more substantive goals such as sustainability and urban development (Menezes & Costa, 2017). These applications illustrate how digital tools can enhance the functionality and experience of public spaces.

Urban mobility is another significant area impacted by digitalization. Innovations like ride-sharing apps and autonomous vehicles are altering transportation patterns and infrastructure requirements. Urban planners must adapt by incorporating new technologies and designing infrastructure that accommodates these changes (Durand et al., 2021; Macharis & Geurs, 2019). This evolution in transportation technology necessitates a reevaluation of how urban spaces are designed to support modern mobility solutions. The evolution of urban morphology 3is also influenced by advancements in AI and machine learning. Tools like Urban Morphological Artificial Intelligence (UMAI) are revolutionizing the analysis and design of urban elements, enabling more efficient and data-driven planning processes (Stojanovski, 2021). This integration of AI with urban design underscores the need for multidisciplinary collaboration to effectively harness computational technologies in shaping urban environments. Moreover, the use of Internet of Things (IoT) 4and urban sensors plays a crucial role in enhancing urban environments. These technologies contribute to smarter city plans by providing real-time data that improves efficiency, safety, and sustainability (Matei & Cocoșatu, 2024). The application of these tools illustrates how digital innovations can optimize urban management and enhance the quality of public spaces.

[3] Urban morphology explores the intricate human-environment relationships through perceptual, social, visual, functional, and temporal dimensions (Carmona et al., 2003). Perceptual studies focus on sensory navigation and space comprehension, social studies examine urban form's impact on interactions and safety, and the functional dimension seeks optimal land use for efficiency and resource conservation. Integrating these dimensions into design enhances quality of life. Urban morphology also reviews theories on the formation and transformation of urban environments, drawing from geography, planning, design, and sociology (Chen, 2021).

[4] It refers to an intelligent network of objects equipped with sensors, software, and Internet connection which allows for continuous data collection and transition, remote monitoring, and control of devices (Kim et al., 2017; Shafiq et al., 2022).

Finally, the impact of digital tools on social interactions and public spaces is evident in the widespread use of smartphones and tablets. These devices have changed how individuals engage with their surroundings and each other, influencing the design and function of public spaces (Smaniotto et al., 2015; Jachna, 2021). Urban planners must consider these new forms of communication and interaction to create spaces that support modern social behaviors and enhance public experiences.

Overall, the digitalization of public spaces presents both challenges and opportunities, highlighting the need for a comprehensive approach to urban design that integrates digital technologies effectively. This transformation requires a thorough understanding of how digital innovations reshape conventional design principles and influence the functionality and experience of public spaces.

1.2. Research Questions

To understand the transformation of public spaces in the digital era, it is essential to examine the key components that define a digitalized public space, such as interactive digital displays, augmented reality, and smart infrastructure. This exploration will help determine whether these elements fundamentally change the nature of public spaces by altering their functions, connectivity, and user experiences, or if they merely add a digital layer without significant impact. The ultimate goal is to assess the long-term effects of this digital integration on urban identity 5and city morphology. In this study, urban morphology will be investigated with the following definition: Urban morphology is the study of urban forms and the agents and processes responsible for their transformation over time. Urban form refers to the main physical elements that structure and shape the city, including streets, squares (public spaces), street blocks, plots, and buildings, among others (Oliveira, 2020). Additionally, it is important to consider whether these digital layers will blend seamlessly with contemporary public spaces or create noticeable contrasts. What objectives will drive the incorporation of these digital layers in public spaces? Understanding these goals is crucial as digital advancements increasingly shape our cities. In the context of urban life's evolution due to digital technology6—ranging

[5] Urban identity, rooted in Tajfel and Turner's (1979) theory, is shaped by social groups and their roles in supporting personal identity. Urban public spaces are crucial for developing this identity and helping citizens connect with their city (Moreno, 2015). Additionally, urban identity influences urban form and placemaking by reflecting personal and social relationships (Butina-Watson & Bentley, 2007).

[6] Digital technologies encompass both specific applications that influence thinking and behavior and the overarching technological paradigm shaping contemporary culture and society. This includes tools for

from computers and smartphones to AI and blockchain—the challenge is not just to integrate these technologies but to evaluate their impact on public spaces. The integration of digital tools in urban planning is reshaping social interactions, mobility, and public space design, emphasizing the need for a comprehensive assessment of these changes. Accordingly, the research questions for this study are divided into the following three sections:

1- What are the components of digital public spaces?

Focus: This question identifies and examines the various elements that constitute digital public spaces, including infrastructure, services, and digital tools.

Purpose: To identify and analyze the essential elements that make up digital public spaces, including technological, spatial, and functional aspects.

2- Does digitalization signify a transformative new era for public spaces, or is it merely a digital layer added to existing environments, and what objectives guide the integration of these digital layers?

Focus: This question explores whether digitalization is fundamentally transforming public spaces or merely overlaying digital elements onto contemporary public spaces.

Purpose: To investigate whether digitalization is creating fundamentally new public spaces or merely adding a digital dimension to existing ones, and to understand the objectives driving the integration of these digital elements.

3- What is the impact of digitalization on urban identity (with a focus on both material and immaterial dimensions) and urban morphology (emphasizing urban form, infrastructure transformation, and physical-digital integration)?

Focus: This question explores how digital technologies influence the character and structure of urban spaces and the identity of cities.

Purpose: To understand how integrating digital technologies into public spaces affects the identity of urban areas and their physical forms. Addressing these questions provides insights into how digital advancements might transform our cities and public spaces in the future, as well as the objectives for integrating digital tools into these environments.

communication, recording and sharing media, data management, task support, interaction mediation, social network management, automation, and information access (Jachna, 2021).

1.3. Aim / Objectives of The Thesis

The primary aim of this thesis is to investigate the transformation of public spaces in the digital age, with a focus on how the integration of digital technologies influences urban identity and morphology. This research seeks to understand the profound shifts that have occurred in the design, function, and experience of public spaces as digital tools and platforms become increasingly embedded in urban environments. By exploring the theoretical and practical implications of digitalization on public spaces, this thesis aims to provide a nuanced analysis of how these changes are reshaping urban landscapes and social interactions. Objectives of this thesis are as follows:

1- To Percept and Analyze Digitalized Public Spaces:

This objective focuses on identifying and examining the key components of digitalized public spaces. This includes understanding the integration of various digital tools, such as interactive displays, augmented reality, and smart infrastructure. By systematically analyzing these components, the research aims to clarify how they contribute to the functionality and experience of modern public spaces. This will involve exploring the theoretical definitions and practical implementations of digital public spaces, as well as assessing their impact on the spatial and social dimensions of urban environments.

2- To Analyze the Role of Digital Technology in Shaping Future Public Spaces:

This objective seeks to investigate the transformative role of digital technology in public space design and usage. It will evaluate how advancements in digital tools—such as artificial intelligence, the Internet of Things (IoT), Wi-Fi as digital connectivity tools—are influencing future public spaces. The research will assess whether these technologies are creating entirely new types of public spaces or merely adding digital layers to existing environments. This involves examining case studies and practical examples to understand the evolving objectives behind the integration of digital elements into public spaces and their implications for urban planning and design.

3- To Understand the Impact of Digitalization on Urban Morphology (emphasizing urban form, infrastructure transformation, and physical-digital integration) and Identity (with a focus on both material and immaterial dimensions):

The third objective is to explore how digitalization affects the physical form and identity of urban spaces. This involves analyzing changes in urban morphology, including the transformation of infrastructure, spatial configurations, and urban form due to digital interventions. The research will also assess how these changes influence the identity of

urban areas, considering both material and immaterial dimensions. By understanding these impacts, the thesis aims to provide insights into how digital technologies are reshaping the character and functionality of cities.

By achieving these objectives, this study will contribute to a deeper understanding of the intersection between digital technologies and urban design. It will also present a proposed model that examines the goals behind the integration of these digital tools into public spaces. The findings will provide valuable insights for architects, urban planners, and policymakers, helping them navigate the complexities of digital transformation in public spaces and design environments that effectively integrate digital and physical realms.

1.4. Significance of the Thesis

In the digital age, the quality and nature of cities, particularly public spaces, have undergone significant changes. Contemporary cities must adapt to digital advancements to provide optimal facilities for their citizens. Public spaces, being crucial urban areas, have always been a focal point for architects and urban planners. Consequently, designing high quality public spaces remains a primary concern for designers. Digitalization offers numerous potential benefits for cities, often supported by governments and industrial stakeholders. Major cities and second-tier cities (mid-sized urban areas with populations of less than one million people) with robust engineering capabilities have likely benefited the most from emerging startups and new investments in industries increasingly reliant on ICT 7skills (van Winden & Carvalho, 2017). The significance of this thesis is in its exploration of the evolving principles of digital public spaces, which can guide architects and urban designers in creating effective future spaces. It examines how the structure of public spaces has changed with the rise of digital technology and considers whether new concepts are emerging in response to these advancements. This research provides insights into improving the quality of digitalized public spaces, contributing to better urban environments. It addresses the potential benefits and limitations of integrating digital technology into public spaces, focusing on their strengths and weaknesses. As digital cities develop, their design must align with the needs of residents (Graham & Peleg,

[7] ICTs are categorized in this study into four elements which are as follows: Wi-Fi networks, digital interactive media façades, interactive public displays, and smartphones' applications in public spaces (Abdel-Aziz et al., 2016).

2017). Public spaces could become central to cities, offering diverse interactions with digital technology to enhance the attractiveness and vitality of urban centers (Korzer et al., 2020). By offering valuable perspectives on the transformation of public spaces in the digital era, this thesis contributes to guiding future urban planning and design practices.

1.5. Thesis Statement

The integration of digital technologies into urban environments, driven by advancements such as artificial intelligence, machine learning, and blockchain (Keseru & Randhahn, 2023; Cohn, 2024), necessitates a profound reevaluation of urban design principles. The Urban Agenda for the EU (European Commission, 2017) underscores the importance of digital transition for urban authorities, highlighting the need for an integrated approach to manage the convergence of physical and digital spaces. As articulated by William Mitchell (1996) in his concept of the "City of Bits," the fusion of digital and physical realms has transformed public spaces, necessitating new theoretical frameworks to understand and design these evolving environments. This transformation is evidenced by practical innovations such as digital displays, interactive installations, and advancements in urban mobility (Menezes & Costa, 2017; Durand et al., 2021; Macharis & Geurs, 2019), which highlight the need for adaptable and responsive urban planning strategies. Furthermore, the application of data-driven tools, including Urban Morphological Artificial Intelligence (Stojanovski, 2021) and Internet of Things (IoT) sensors (Matei & Cocoșatu, 2024), illustrates the imperative to incorporate digital innovations into urban management to enhance functionality and social interaction within public spaces (Smaniotto et al., 2015; Jachna, 2021). Thus, a comprehensive approach to urban design is essential for effectively integrating digital technologies and addressing the evolving needs of contemporary urban environments (Van Winden & De Carvalho, 2017). In summary, embracing a comprehensive approach to urban design that integrates digital technologies is crucial for addressing the evolving demands of contemporary urban environments and ensuring that public spaces remain functional, engaging, and adaptable in the face of ongoing digital transformation.

1.6. Methodology and Plan

This study adopts a multidisciplinary approach to investigate the transformation of public spaces in the digital age. The methodology involves a comprehensive literature

review and case study analysis across several fields, including architecture, sociology, urban studies, and digital sciences. The study explores how digitalization influences public spaces through the implementation of digital tools, urban identity (with a focus on both material and immaterial dimensions), and urban morphology (emphasizing urban form, infrastructure transformation, and physical-digital integration).

1.6.1. VOSviewer analysis

The analysis using VOSviewer revealed a nuanced thematic landscape within research on digitalized public spaces, based on a dataset of 278 articles sourced from Scopus. The co-occurrence network, constructed using keyword occurrences in article titles and abstracts, comprised 62 nodes and 118 edges, highlighting key themes such as "smart cities," "urban design," and "digital technologies." Distinct clusters emerged, including a focus on smart urban technologies integrating IoT and sensor networks, alongside cross-disciplinary topics like urban sustainability and community engagement. Visualization of the network illustrated clear thematic groupings, with node sizes indicating keyword frequency and color-coding emphasizing cluster distinctions. Statistical measures confirmed moderate to high homogeneity within clusters, reinforcing robust thematic coherence. These findings underscore the interdisciplinary nature and evolving trends in digitalized public spaces research, providing insights crucial for advancing urban planning strategies and digital innovation in contemporary urban environments.

Additionally, to ensure comprehensive preprocessing of the data, irrelevant articles were filtered out, and standardization of author names and keywords was conducted. Post-processing, the dataset was enriched with metadata, including author affiliations and citation links, enhancing the dataset's analytical depth. These efforts aimed to guarantee data compatibility and integrity throughout the analysis, facilitating a rigorous exploration of structural patterns and interrelationships within the field of digitalized public spaces. Below, with a focus on the objective of digitalizing public spaces, we delve deeper into these clusters. We will analyze these clusters to understand how they contribute to the overall goal of digitalization in urban environments. Based on the provided cluster information (Figure, 1.2):

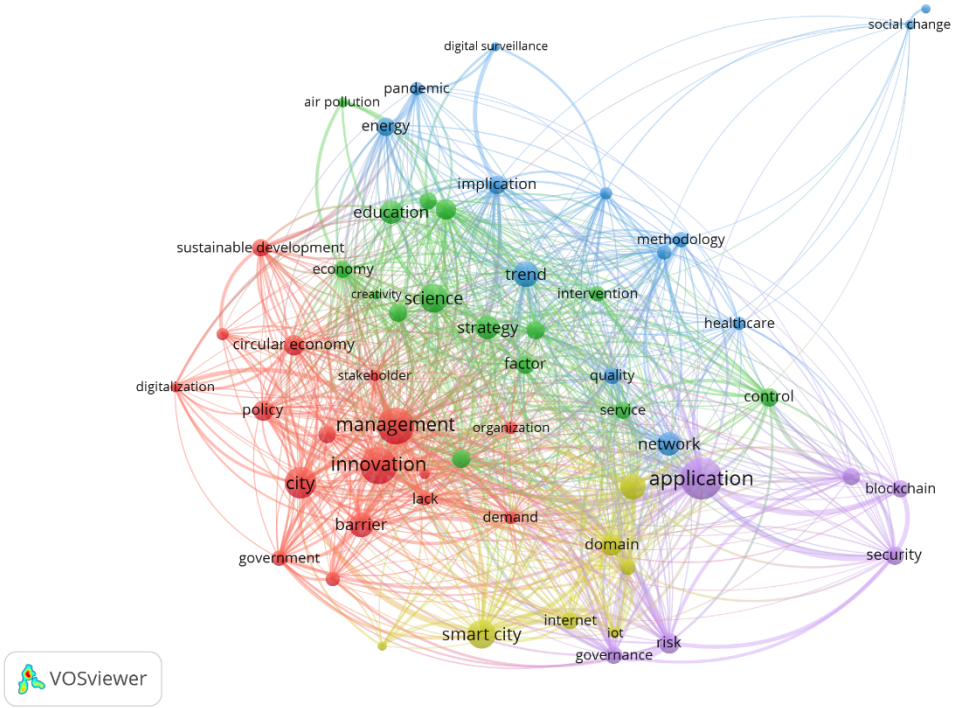


Figure 1.2. *VOSviewer analysis, Source: www.vosviewer.com*

Table 1.1. *VOSviewer Analysis, Source: Author*

Cluster	Terms	Focus
Red	Innovation, management, sustainable development, government, barrier, city, digitalization, policy	Governance and innovation
Green	Strategy, science, economy, education, service	Strategy and economic aspects
Blue	Network, implication, quality, social change, digital surveillance	Social and quality implications
Purple	Application, blockchain, risk, security, IoT (Internet of Things)	Technological and security aspects
Yellow	Internet, domain, smart city	Internet domain and smart city

The Red Cluster focuses on governance and policy, highlighting terms like innovation, management, sustainable development, government, barrier, city, digitalization, and policy. Its purpose lies in establishing effective governance frameworks and policies essential for the equitable, secure, and efficient deployment of digital technologies across public spaces. By integrating these policies, cities can ensure

that technological advancements align with sustainable development goals and enhance overall governance effectiveness.

The Green Cluster centers on strategy and economic aspects, encompassing terms such as strategy, science, economy, education, and service. This cluster aims to leverage digitalization to foster economic growth, improve service delivery, and enhance educational opportunities within urban environments. By prioritizing strategic planning and economic considerations, cities can optimize resource allocation and cultivate innovation hubs that drive economic prosperity and societal advancement.

The Blue Cluster emphasizes social and quality implications, featuring terms like network, implication, quality, social change, and digital surveillance. Its purpose is to harness digital technologies to enhance social connectivity, improve service quality, and promote positive social change within communities. By implementing robust technological infrastructure and monitoring systems, cities can effectively address societal challenges and improve the overall quality of life for residents.

The Purple Cluster highlights technological and security aspects, focusing on terms such as application, blockchain, risk, security, and IoT (Internet of Things). Its purpose is to mitigate risks associated with digitalization, such as cybersecurity threats and privacy concerns, while promoting technological innovation and integration. By prioritizing secure and resilient technological frameworks, cities can safeguard data integrity and ensure the reliability of digital services crucial for urban development.

The Yellow Cluster centers on internet domain and smart city themes, with terms like internet, domain, and smart city. Its purpose is to integrate digital technologies to enhance community engagement, inclusivity, and sustainability within urban environments. By leveraging smart city initiatives, cities can empower residents with access to digital services, promote civic participation, and foster a more connected and responsive urban ecosystem.

In conclusion, these clusters collectively illustrate the comprehensive approach necessary for the digitalization of public spaces. By addressing governance, economic, social, technological, and community engagement aspects, cities can harness the transformative power of digital technologies to create smarter, more sustainable, and inclusive urban environments that enhance the quality of life for all residents (Table, 1.1).

1.6.2. Literature review and multidisciplinary approach

The study involves a comprehensive literature review across several disciplines—architecture, sociology, urban studies, and digital sciences. This review forms the foundation for understanding the interplay between digital technologies and public spaces. This section of the methodology will delve into the transformation of public spaces, starting with a detailed examination of the core concepts of public space—its form, function, and historical transformation. It will then address the impact of the digital age on these spaces, exploring new definitions and functions that emerge as technology integrates with public life. This includes analyzing shifts in social interaction, public participation, and the cultural aspects of these spaces. The study will further compare physical and digital public spaces, addressing the challenges and concerns associated with digitalization and investigating how digital technologies are deployed and layered within these environments.

1.6.2.1. Selection criteria for case studies and analyzing case studies

To investigate successful digital public space projects, cities were selected based on their high rankings in the IMD Smart City Index, which evaluates cities on economic, human, and technological dimensions. The chosen cities—Singapore, Tokyo, Barcelona, and Amsterdam—are among the top-ranked and are exemplary in their integration of digital technologies within urban environments. In this context, efforts were made to select two cities from Asia and two cities from Europe based on these criteria to examine the digital dimensions across different urban environments. Additionally, Istanbul was included as a developing city to assess how the integration of digital layers might influence changes in public spaces within developing urban contexts.

1.6.2.2. Successful case studies and examples of digital public space projects

Singapore: Selected for its extensive smart city initiatives, including digital exhibitions, smart lighting, and advanced waste management systems. These projects illustrate how digital tools enhance urban functionality and public space quality.

Tokyo: Known for its cutting-edge smart infrastructure and real-time environmental data visualization, Tokyo's projects, such as the Tokyo Oasis, provide insights into the transformation of public spaces in a densely populated urban context.

Barcelona: Noted for its robust digital strategy, including smart bike-sharing and citizen engagement platforms, Barcelona serves as a key case study for understanding digital integration into existing public spaces.

Amsterdam: Distinguished by its innovative use of digital platforms and crowd monitoring systems, Amsterdam's projects like Amsterdam Smart City highlight the impact of digital tools on urban management and public space design.

Each city offers a unique perspective on the digitalization of public spaces, contributing to a broader understanding of its effects on urban design and social interactions. This study evaluates the effectiveness of digital solutions, identifies key success factors, and proposes a model for integrating digital tools with specific objectives in public environments.

1.6.2.3. Istanbul case study: examining the impact of Wi-Fi connectivity ıntegration as a digital tool on urban public spaces

The choice of Istanbul as the focal point for this thesis is grounded in its dynamic approach to integrating digital technologies within urban environments, making it an exemplary case for exploring the transformation of public spaces in the digital era. Istanbul's ambitious strategies and extensive implementations of smart city technologies provide a rich context for addressing the research questions and objectives outlined in this study.

Technological Integration: Istanbul has been at the forefront of adopting smart city strategies in Turkey, reflecting a significant push towards digital transformation. The city's Vision 2050 strategy (vizyon2050.istanbul) and its focus on smart planning, inclusive data generation, and transparent digital applications illustrate its commitment to leveraging digital tools for urban development. These strategic goals align closely with the research aim of understanding how digital technologies influence urban identity and morphology. The Istanbul Metropolitan Municipality (IMM) has made substantial progress in integrating digital infrastructure, including the extensive deployment of free Wi-Fi services (wifi.ibb.istanbul). As of June 2024, the city boasts nearly 12,000 access points across a wide array of public spaces, from squares and parks to public transport hubs (Istanbul Metropolitan Municipality, Department of Information Technologies, 2024). This vast network supports the exploration of various aspects of digital public spaces, including connectivity, user experience, and the impact on urban form.

Comprehensive Urban Transformation: Istanbul's smart city initiatives, spearheaded by entities like ISTTELKOM, provide a comprehensive framework for examining the integration of digital technologies. ISTTELKOM's role in developing communication infrastructure—ranging from IoT services to advanced data management—demonstrates a robust approach to urban digitalization (Isttelkom, 2024). This aligns with the study's objective of analyzing how digital technology reshapes public space design and functionality. The free Wi-Fi initiative, exemplified by the IBB Wi-Fi service, not only enhances urban connectivity but also offers insights into how such services affect social interactions, economic activity, and urban planning. The provision of unlimited internet access in key public areas such as Kadiköy Square enables a detailed examination of digital tools' impact on public space dynamics and urban morphology.

Impact on Urban Identity and Morphology: The integration of digital tools and free internet services in Istanbul provides a unique opportunity to investigate their effects on urban identity and morphology. The city's efforts to blend conventional urban environments with modern digital solutions illustrate a critical aspect of this transformation. For instance, the deployment of smart infrastructure and technology-based recreational equipment in Kadiköy Square highlights how digitalization can influence the physical and functional characteristics of public spaces. Additionally, the significant usage statistics of IBB Wi-Fi, including high daily connections and data consumption, reflect the profound impact of digital connectivity on urban life. These statistics (Istanbul Metropolitan Municipality, Department of Information Technologies, 2024) serve as a basis for evaluating how digital tools contribute to social cohesion, economic sustainability, and urban legibility.

1.6.2.4. Methodological framework for evaluating research questions and objectives in Istanbul case studies

Components of Digital Public Spaces: Istanbul's deployment of IBB WiFi, with over 11,954 access points, offers a detailed look into the infrastructure of digital public spaces. This setup is crucial for analyzing how interactive and connected environments are formed through digital technologies.

Transformative Nature of Digitalization: The extensive coverage of free Wi-Fi across public spaces in Istanbul reflects a shift in the needs of individuals in conventional public areas, leading to their evolution into more integrated digital environments. This

transformation allows for an exploration of whether this digital overlay represents a fundamental change or just an enhancement of existing infrastructure.

Impact on Urban Identity and Morphology : By examining the high usage of IBB WiFi in Kadıköy Square, this study investigates the impact of digital connectivity on urban identity and morphology. The integration of such technologies is pivotal in redefining urban dynamics, extending beyond traditional physical infrastructure to reshape the square's character and spatial organization. This approach not only highlights the evolving nature of urban access, which now incorporates digital dimensions, but also offers insights into broader transformations in urban environments. As cities adapt to smart technologies, understanding these shifts in connectivity will be crucial in assessing how digital tools influence urban planning and accessibility.

In summary, Istanbul's forward-thinking digital strategies, especially its free internet initiatives, offer a valuable framework for examining how digital advancements are reshaping public spaces and impacting urban design. This study seeks to explore these technological developments and their broader implications for the city's urban environment.

1.6.3. Data collection and analysis

Data Sources: Data will be collected from various sources, including the IMD Smart City Index reports, city-specific digital public space project documentation, and relevant academic and industry publications.

Evaluation Framework: Each case study will be evaluated based on the following aspects:

Technological Solutions: Analysis of the digital tools and technologies used in public spaces.

Design Principles: Examination of the design strategies and principles that integrate digital technologies.

User Interaction: Assessment of how digital solutions influence user experiences and interactions within public spaces.

Stakeholder Collaborations: Review of partnerships and collaborations between city authorities, technology providers, and other stakeholders.

1.6.4. Comparative analysis

A comparative analysis will be conducted to identify common factors and differences among the case studies. This will include:

Impact on Urban Morphology: Understanding how digital technologies have reshaped urban landscapes and public spaces.

Effectiveness of Digital Solutions: Evaluating the effectiveness of digital tools in enhancing urban environments and user experiences.

Lessons Learned: Identifying best practices and key takeaways that can inform future digital public space projects.

1.6.5. Proposed model

Based on the case study findings, a model will be proposed to outline the objectives and outcomes of integrating digital tools into public spaces. This model will help conceptualize how digitalization influences urban design and public space functionality.

1.7. The Structure of the Thesis

Chapter 1 the first chapter provides a comprehensive overview of the research background and literature on the transformation of public spaces in the digital age. It establishes the research context, introduces key concepts, and outlines the methodology used to address the problem statement and achieve the study's objectives.

Chapter 2 this chapter reviews the concept of public space and digitalized public spaces, examining their definition, functions, and the integration of digital technologies. It compares conventional and digital public spaces, addressing the challenges and impacts of digitalization on public spaces.

Chapter 3 focusing on the evaluation of digital components, this chapter identifies and analyzes the key digital elements in public spaces, including infrastructure, services, and specific digital solutions implemented globally.

Chapter 4 this chapter presents case studies from cities such as Singapore, Barcelona, Tokyo, Amsterdam, and Istanbul. It highlights successful digital public space

projects and examines their impact on urban environments, offering insights into diverse applications of digital technologies in public spaces.

Chapter 5 examining changes in urban morphology (emphasizing urban form, infrastructure transformation, and physical-digital integration) and identity (with a focus on both material and immaterial dimensions) due to digitalization, this chapter analyzes the transformation of physical infrastructure, urban form, and the implications for urban identity. It evaluates both material and immaterial dimensions of urban spaces pre- and post-digitalization[8].

Chapter 6 the final chapter discusses the practical application of the research findings, summarizing the implications of the study. It highlights the potential for digital technologies to reshape public spaces and offers recommendations for future research and urban planning.

[8] In postdigital theorizing, one interpretation views "post" as indicating a stage following the initial novelty of digital technology. Fuller and Jandrić (2019) describe the postdigital as "after the digital has lost its novelty or salience," focusing on the historical phase of digital technology. Cramer (2015) refers to it as the "historicisation of our fascination with ... systems and gadgets."

CHAPTER 2: INTRODUCTION

Chapter 2 aligns with the research question: "Does digitalization signify a transformative new era for public spaces, or is it merely a digital layer added to existing environments, and what objectives guide the integration of these digital layers?"

This question directly addresses the transformation and evolution of public spaces in response to modern technological demands. This chapter explores the evolution of public spaces, tracing their development from their origins in ancient Greek agoras and Roman fora to contemporary urban environments increasingly influenced by digital technologies. It examines how the functions and forms of public spaces have transformed over centuries, reflecting shifts in political, social, and technological contexts. This transformation underscores the need to understand how these spaces are adapting to modern technological demands and the implications for social dynamics, public participation, and cultural expression. Originally central to civic life, public spaces are now challenged by contemporary societal trends and digital advancements, raising questions about their future role and significance.

2. TRANSFORMATION OF PUBLIC SPACES

Public spaces are key to the development of urban settlements. In the particular case of European cities, Greek agora and Roman forums were the core of political, economic, commercial, religious, and social activity. The typologies of public space have evolved over time, partially due to political change, social lifestyle, as well as technological advances. Over the course of several centuries, the activities that were originally concentrated in one place such as the Agora or the Forum have been distributed around various locations, such as banks, shopping malls, markets, temples, public buildings, and all kinds of amenities and services. Paradoxically, even though the creation of new public spaces is among the great achievements of the new era (Madanipour, 2003), the society of the new era – of secular urban culture and the new capitalism – is putting public life at risk (Sennet, 1992), as it is damaging the culture of social interaction thus causing the decline of public life in urban spaces.

Public places preferably in an urban community, are the real image of the variety that the urban community holds and thus perform as “the heart” of that community (Deore & Lathia 2014). In fact, the important role of public spaces in the progress and encouragement of societies has been addressed since a long time. Starting from the Greek

Agora until nowadays contemporary squares, parks, urban public spaces which have a positive impact on cities and towns (Bonilla, 2015). Furthermore, during the 20th century, a redefinition of public space's concept was addressed and a new concept of urban space emerged. The structure of the urban realm transferred due to these conditions and according to critics (Jacobs 1961, Sennett 1987, Madanipour 2003). Nowadays in the contemporary era of digitalization and technology, we are witnessing the emergence of another inconsistency between the way physical space is designed, and the demands of the society that makes use of it. As the world is digitalizing and technology is advancing rapidly, and as social interaction is moving to the sphere of the asynchronous and distributed presence of social media; are public spaces at risk of losing their meaning again?

In recent years, there has been a noteworthy surge in the migration of individuals from rural to urban areas (Figure 2.1), propelled by a heightened emphasis on amenities, social services, and appealing urban facilities. In recent years, there has been a noteworthy surge in the migration of individuals from rural to urban areas (United Nations, Department of Economic and Social Affairs, Population Division, 2018; HYDE, 2023), driven by a heightened emphasis on amenities, social services, and appealing urban facilities . This movement can be viewed through the lens of international migration, where individuals relocate from underdeveloped to developed regions in search of economic opportunities and improved living standards (Mthiyane, Wissink, & Chiwawa, 2022). Population surges often result in urban overcrowding, straining infrastructure, housing, transportation, and public services, leading to pressing issues such as sanitation, waste management, and traffic congestion. These challenges require innovative solutions for sustainable development, as rapid urban migration strains essential services like healthcare, education, and water supply, potentially lowering the quality of life for both migrants and long-term residents (Zahid, 2023). Besides income opportunities, access to urban amenities can also be a significant factor motivating rural-to-urban migration (Selod & Shilpi, 2021). This shift places substantial demands on urban infrastructure, including civic services, health and recreational facilities, and educational resources. To address these needs effectively, urban design must incorporate advancements from the digital revolution, which has transformed urban life through technologies like AI, machine learning, and IoT. As William Mitchell outlines in City of Bits (1995), the integration of physical and digital realms necessitates a reevaluation of urban planning

principles. Innovations such as digital displays, smart mobility solutions, and IoT-driven urban management tools can help cities adapt to increased pressures, ensuring functionality and engagement as urban environments evolve in response to growing population demands. This topic requires suitable infrastructure, taking into account civic services, recreational and health facilities, and enhanced educational services. Otherwise, excessive pressure on urban structures may occur, adversely affecting them (Tacoli et al., 2015).

Additionally, the integration of digital layers in recent years has been considered an intelligent method for controlling urban spaces, providing appropriate urban services, managing municipal waste, controlling energy consumption, and more. Information and communication technology in urban spaces aims to improve quality, citizen satisfaction, and enhance the performance of urban services, also serving as a bridge between users and urban service providers. In addition to traditional public space typologies such as public squares, open spaces, and urban streets, the changing needs and demands of urban dwellers result in emerging typologies of public spaces that reflect contemporary public social life (Oldenberg, 2007; Pittaluga, 2020). The adaptive capacity of a city, crucial for urban dynamics and continuous development, is present as long as people inhabit it (Habraken, 1998). This capacity supports the existing built environment and facilitates adjustments to new technologies, social changes, and trends. However, as noted by Cozzolino (2020), adaptability varies across a city. Traditional and pre-modern environments tend to be more adaptive, whereas modern, planned urban areas exhibit less adaptability (Tsahor et al., 2023).

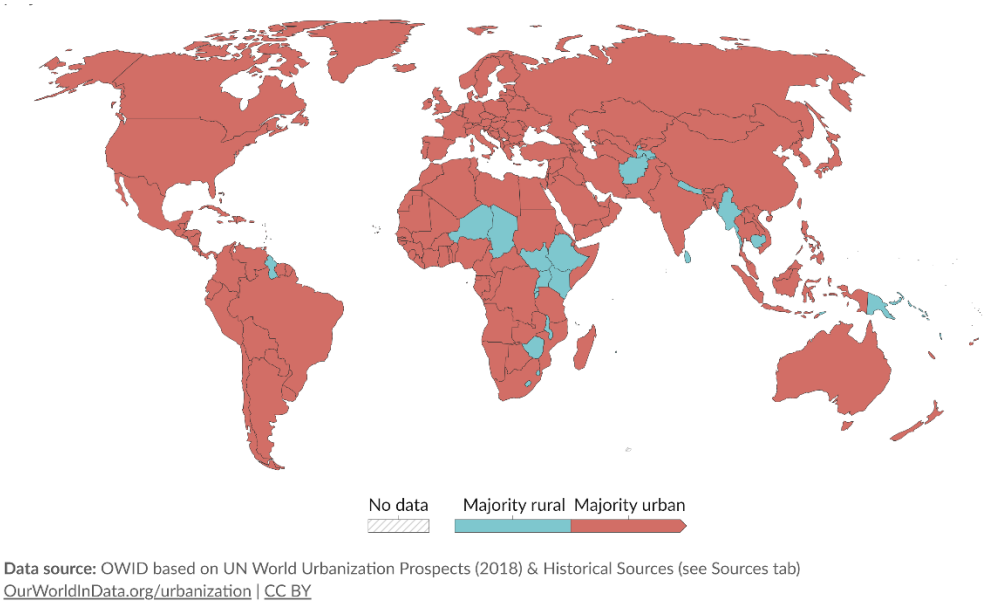


Figure 2.1. *The population living in urban areas, 2050. Source: https://ourworldindata.org/*

2.1. Public Space – Concept, Form, Function, Transformation

Investigating the historical and conceptual transformations of public spaces is fundamental for understanding how shifts in their definitions, forms, and functions influence the social and spatial structures of society. A comprehensive analysis of these transformations offers critical insights into the social and spatial dynamics that shape contemporary public spaces. This examination generally encompasses several key components:

1- Definitions and Concepts of Public Space

2- Forms of Public Space

3- Functions of Public Space

1- Definitions and Concepts of Public Spaces: Public spaces, viewed through the lenses of architects, urban planners, and philosophers, have evolved with various interpretations over time. To explore this multifaceted concept, it is essential to consider different theoretical perspectives. The table below summarizes definitions from prominent scholars, each offering a unique viewpoint on public space. This synthesis aims to integrate these insights into a unified definition, providing a comprehensive understanding of the concept. (Table 2.1).

Table 2.1. *Different definitions of public space, public sphere, space.*

Juergen Habermas (1991)	**Public Sphere** -The public sphere as the realm of conversation and discussion by private individuals on matters of public interest. -Made up of private people gathered together as a public and articulating the needs of society with the state	**BOOK:** The Structural Transformation of the Public Sphere
Jane Jacobs (1961)	**Public and Private Space** -First, there must be a clear demarcation between what is public space and what is private space. -Public and private spaces cannot ooze into each other as they do typically in suburban settings or in projects.	**BOOK:** The Death and Life of Great American Cities
Jan Gehl (2013)	**Public Space** -The charm of a city can be identified by the large number of people who gather in its public spaces and spend their time there. -Public space is understood as streets, alleys, buildings, squares, bollards; everything that can be considered part of the built environment.	**BOOK:** How to Study Public Life
Ali Madanipour (2003)	**Public Space** He defines public space as a "space that allows all the people to have access to it and the activities within it, which is controlled by a public agency, and which is provided and managed in the public interest".	**BOOK:** Public and Private Spaces of the City

Table 2.2. *(Continued) Different definitions of public space, public sphere, space.*

Henri Lefebvre (1992)	**Space** The Production of Space is that space is a social product, or a complex social construction (based on values, and the social production of meanings) which affects spatial practices and perceptions. Space= Product & Production, Collection of Relations	**BOOK:** The Production of Space
Richard Sennett (1987)	**Public Space** The public space is composed of people who differ racially, ethnically, religiously, economically. Who do not know each other; nonetheless interact.	**BOOK:** The Fall of Public Man

Based on the definitions summarized in the table above, it can be concluded that public space is a dynamic and inclusive realm that functions as both a physical and social venue for community interaction and engagement. It is characterized by:

Accessibility: It is open to all individuals, ensuring equitable access and management in the public interest (Madanipour, 2003).

Social Interaction: It facilitates diverse social interactions, allowing individuals from varied backgrounds to connect and communicate (Sennett, 1992; Habermas, 1991).

Physical Environment: It includes various built elements such as streets, squares, and parks, which contribute to its functionality and appeal (Gehl, 2013). A clear demarcation between public and private spaces is crucial, as public spaces should be distinct from private ones to avoid the blurring of boundaries often seen in suburban settings or large-scale projects (Jacobs, 1961).

Social Construction: It is shaped by societal values and practices, influencing how the space is perceived and utilized (Lefebvre, 1992).

This integrated definition captures the critical aspects of accessibility, social engagement, physical characteristics, and social context, offering a comprehensive understanding of public space.

2- Different Types of Public Space: Public spaces encompass various types that shape urban environments based on the citizens' needs and impact human interactions. These types are designed in response to the unique physical characteristics of their surroundings in urban areas. For instance, open public spaces like parks enhance a sense of freedom for citizens (Figure 2.2). Conversely, closed public spaces emphasize the sheltered nature of these space. Intermediate spaces provide a penetrable spatial experience. Each of these types possesses multifaceted qualities and is designed to address social needs and specific functions within the urban context.

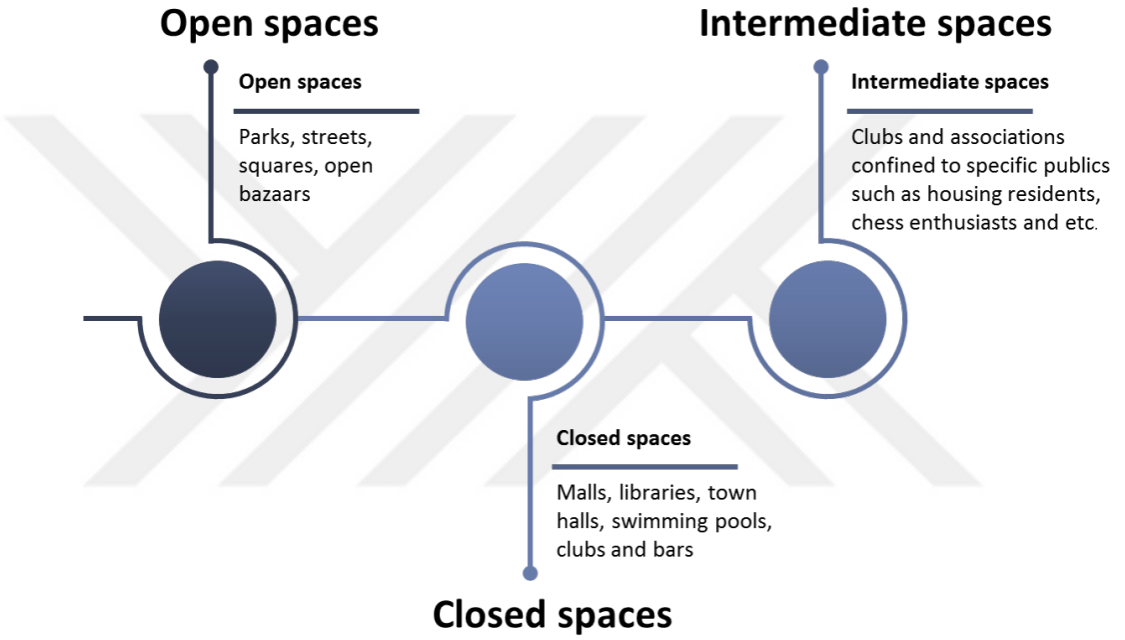


Figure 2.2. *Types of Public Space, Source: (Amin, 2008).*

3- Functions and Transformation of Public Space: Richard Sennett (1987) emphasized that urban public spaces are central to urban life, embodying political, socio-economic, and historical dimensions. Historically, public spaces have served diverse purposes, from business and commerce to political events, voting, and cultural activities. They have functioned as venues for political protests and social gatherings, evolving beyond mere recreational areas to become vital forums for political, social, and cultural expression (Sennett, 1987). Public spaces are crucial for fostering community interaction and social cohesion. They provide a platform for diverse individuals to connect, promoting inclusivity and a sense of belonging. Sennett argues that the design and accessibility of these spaces significantly influence social interactions and the vibrancy of urban life (Wade, 2010). Well-designed public spaces can encourage spontaneous encounters and

dialogues, enhancing democratic engagement (Chandler, 2017). Moreover, these spaces are essential for the cultural life of a city, hosting cultural performances, festivals, and public art, which contribute to the community's cultural identity and heritage (Perfas, 2024). This cultural dimension is crucial for a dynamic urban environment (Sennett, 1987).

Additionally, public spaces impact the physical and mental well-being of urban residents. Access to green spaces and recreational areas is linked to numerous health benefits, including reduced stress, improved mental health, and increased physical activity. Sennett highlights that natural elements in urban spaces create a more pleasant environment, essential for overall quality of life. Public spaces also play a key role in shaping the political landscape, providing a stage for public discourse, protests, and civic engagement. Their historical significance as arenas for political action underscores their role in the democratic process (Sennett, 1987).

The transformation of public spaces reflects changing societal needs and historical contexts. According to Ariés (1973), the boundaries between private and professional life were blurred from the 5th to the late 15th century, and public spaces were multifaceted, serving purposes such as communication, entertainment, religion, and politics, rather than solely commercial activities. The Renaissance and the Industrial Revolution brought significant changes, with public spaces adapting to new social and technological contexts. In the modern era, the rise of digital technology and consumer culture has reshaped the role of public spaces. As private and virtual domains have increasingly supplanted physical spaces, the functions of public spaces have transformed. The integration of technology into public spaces has become essential, as these areas adapt to new forms of interaction and engagement. Henri Lefebvre’s concept of the "production of space" is relevant here, emphasizing that the role of public spaces evolves with societal changes (Lefebvre, 1991) and technological advancements. This evolution reflects a shift from traditional uses to more diverse functions influenced by digitalization and consumer culture.

In summary, understanding the functions and transformation of public spaces is crucial for grasping their role in contemporary urban life. The integration of historical and modern perspectives, will strengthen the dynamic nature of public spaces in response to changing societal needs.

2.2. Public Space in Digital age – Definition and Functions

The digitalization of urban spaces, particularly public spaces, is a long-run process that began to take shape in the 2000s, although its origins trace back to the early days of cybernetics in the 1970s. The interplay between cyberspace and physical space enables the creation of new, synthetic spaces that were previously nonexistent (Mitra & Schwartz, 2001). Foucault (1986) argued that the relations between spaces and "sites" are fundamental to the construction of place in any community and the exercise of power within the community, arguing that "we live inside a set of relations that delineates sites." Recent advancements in technology, including telecommunications, digital tech, electronics, social media, Wi-Fi, and sensors, have rapidly evolved. These innovations are facilitating interactions between two distinct environments: (1) the physical world with its local identity, and (2) the digital realm of virtual reality (Albeera, 2019). With the increasing reliance on digital networks in daily life, a new digital layer is being integrated into the existing urban landscape (López Baeza, 2021). The emergence of a fifth dimension in space is creating a fluid environment where traditional spatial boundaries are giving way to more complex and fragmented situations. Public and private spaces are blending together, fundamentally transforming their original identities (Ampanavos & Markaki, 2014). Since the Industrial Revolution, technology has dominated society and culture. Today's designers face the crucial challenge of making technology serve culture and society instead (Bagdikian, 1992).

Hybrid Spaces: Integrating Physical and Digital Realms

In City of Bits: Space, Place, and the Infobahn, Mitchell (1996) poses the question, "How should virtual and physical public spaces relate to each other?" He explores the idea that contemporary public spaces need to evolve in response to the transformations in social relations brought about by technological advancements. According to Mitchell, modern public spaces must adapt to integrate and reflect the changes driven by the digital age, bridging the gap between virtual and physical realms to meet the evolving needs of society. In fact, the digitalization of public spaces should be more than just adding the free city internet and online information kiosks. The digitalization of public spaces should be able to create a hybrid space; physical and digital. Procedural urbanism theories defend that successful public spaces are flexible and evolve over time according to the needs and wants of citizens (Badel & López Baeza, 2021), which aligns with the concept of hybrid

spaces that integrate physical and digital realms. Following the recent advances in immersive technologies, such as mixed reality (MR) and virtual reality (VR), human senses have been introduced to new forms of interactions with physical and digital realms (Gulay & Lucero, 2019). This overlaying of digital infrastructure and digitally mediated spatial practices onto the physical spaces of the world creates a phenomenon that has variably been referred to as “hybrid spaces” (De Souza e Silva, 2006) or “virtual co-emplacement” (Moores, 2006). In this thesis, a 'hybrid space' is defined as a novel framework where physical public spaces and digital environments are seamlessly integrated, transcending traditional spatial boundaries and enabling dynamic interactions between physical and digital realms. Case studies of hybrid public spaces, such as the City Fireflies at Medialab-Prado’s digital facade in Madrid (2013), demonstrate how digital technologies can enhance physical environments, making public spaces more engaging and multifunctional.

2.2.1. New definitions of public spaces in the digital age

The definition of the place has undergone many changes throughout human history, right up to the technology era of today, which has affected the definition of the place dramatically. Nowadays, technology has become an intrinsic part of our daily lives; it has changed the way we live and work. This effect will continue to change the concept of place in the future. Society has developed through industrial revolution reaching today’s technology revolution, which affects its social hierarchy. Time is an important aspect of the metropolis, where it became intelligible life (Younes & Al-Zoubi 2015).
Today, as in the past, talking about public space is no longer just a physical urban space (Figure 2.3). After the digitalization of public spaces and the transfer of social interactions to the digital world, different meanings for public space became apparent. The addition of digital layers has also had a tangible impact on the new definitions of this place. Digitalized physical public space, public hybrid spaces, smart public spaces, digital public spaces, augmented public spaces, mixed-reality public spaces as new definitions of public spaces which are used in digital age. The digitalization of these spaces and the shift of social interactions also to the digital realm have introduced new meanings and definitions. This section explores the various modern interpretations of public space:

1- Digitalized physical public space (Digitalized public space): It refers to traditional public spaces such as parks, squares, and streets that have been enhanced with digital technologies. These technologies may include Wi-Fi, interactive kiosks, digital signage, and sensors that collect data to improve user experience and manage the space more efficiently.

2- Public hybrid spaces: It refer to areas that combine various functions such as social, recreational, and commercial uses within a public environment. In the context of this thesis, which deals with public spaces in the digital age, these hybrid spaces can be defined as areas that integrate physical and digital elements, enabling both in-person and virtual interactions.

3- Smart public spaces: It refers to urban areas like streets and parks that use technology to enhance community quality of life. This technology boosts accessibility, engagement, sociability, and comfort. It also generates data to improve visitor experiences, inform planning, and optimize management and maintenance (Transport for NSW, 2023).

4- Digital public spaces: It is a concept that envisions a future internet where technology enables unrestricted access to cultural and knowledge resources for everyone. It represents a shift towards an open, collaborative digital environment that integrates technical infrastructure and standards to enhance engagement, sharing, and accessibility across various platforms and communities (Hemment et al., 2013).

5- Augmented public spaces: It refers to physical locations enhanced with augmented reality (AR) technology, transforming them into interactive, immersive experiences. This integration allows users to engage with digital content—such as historical information, art, or holograms—layered over real-world environments, enriching their interaction with the space and its stories (Hoverlay, 2024).

6- Mixed-reality public spaces: It refer to physical environments enhanced with mixed reality technology, which integrates digital and physical elements in a way that they interact seamlessly. This technology allows users to experience and interact with virtual objects and information as if they coexist with the real world, creating immersive and intuitive experiences for urban planning and public engagement. Mixed reality can transform urban design by enabling stakeholders to visualize and interact with future developments in a realistic, interactive manner (Nyberg, 2019).

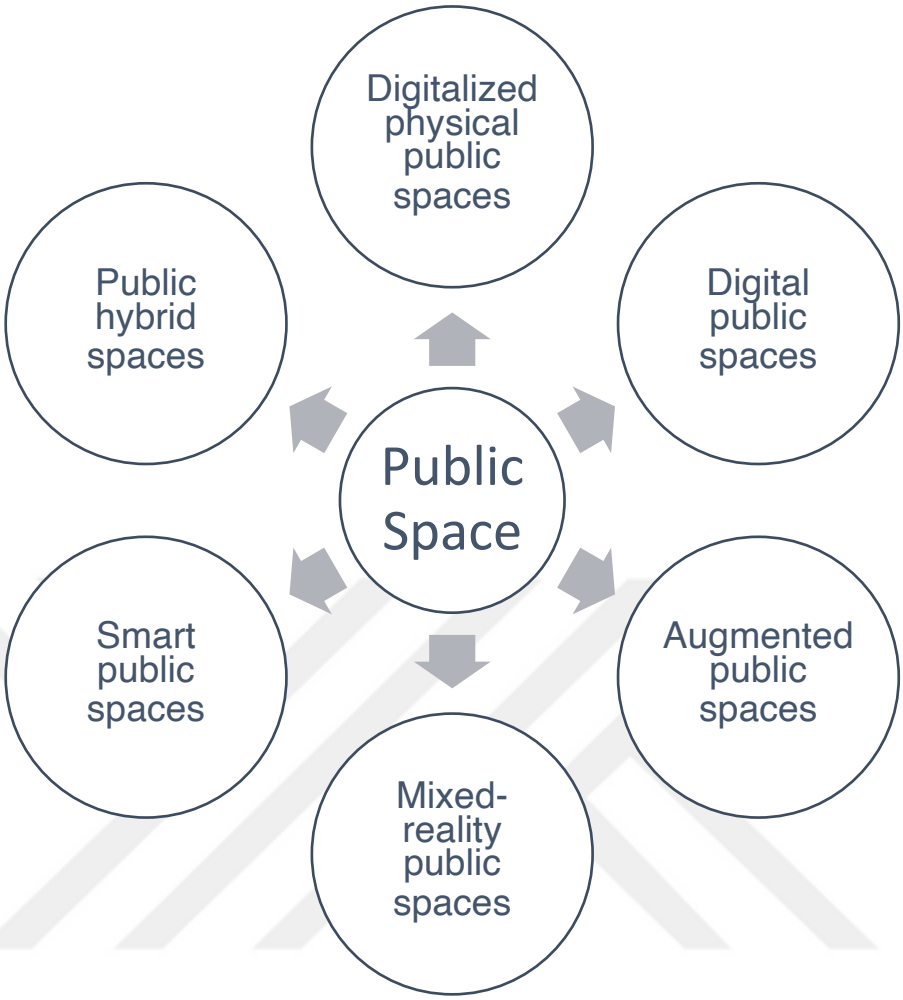


Figure 2.3. *New definitions of public spaces in digital age, Source: Author*

The focus of various concepts in the evolution of public spaces differs significantly, each offering unique enhancements and interactions. Digitalized Physical Public Space (Digitalized public space) centers on embedding digital technologies like Wi-Fi, interactive kiosks, and sensors into traditional public spaces—such as parks and streets—to improve their functionality and user experience. Public Hybrid Spaces shift the emphasis to creating environments that seamlessly integrate physical and digital elements, facilitating a blend of social, recreational, and commercial activities both online and offline. Smart Public Spaces focus on utilizing technology to enhance urban living through improved accessibility, engagement, and comfort, driven by data for better management and operational efficiency. In contrast, Digital Public Spaces envision a collaborative digital realm that enhances access to cultural and knowledge resources via the internet, promoting information sharing and engagement without altering physical environments. Augmented Public Spaces leverage augmented reality (AR) to overlay digital content onto physical locations, providing interactive and immersive experiences

that enrich real-world interactions. Lastly, Mixed-Reality Public Spaces aim to integrate digital and physical elements so they interact seamlessly, creating immersive environments where virtual and real-world elements coexist, thus offering a dynamic and intuitive user experience. Each concept represents a distinct approach to enhancing public spaces, highlighting the diverse ways in which technology can transform urban environments.

The term "digitalized public space" or "digitalized physical public space" was chosen for this thesis because it precisely aligns with the aim of investigating how digital technologies are transforming public spaces and influencing urban identity and morphology. As the primary focus is on understanding how digital tools and platforms, such as interactive displays, augmented reality, and smart infrastructure, are integrated into existing public spaces, "digitalized public space" encapsulates the essence of this transformation. This term allows for a nuanced analysis of how digitalization impacts both the functionality and the user experience of public spaces, reflecting the thesis's objectives to analyze key components of digitalized spaces, evaluate the role of technology in future public space design, and explore the effects of digitalization on urban morphology and identity.

2.2.2. New function of public spaces in the digital age

As depicted Image 2.1, the utilization of public spaces varies across different regions, contingent upon their historical and geographical context. Public spaces serve various functions encompassing social, cultural, recreational, political, and commercial dimensions. However, in recent years, a novel dimension of usage has emerged in public spaces, namely "digital connectivity". Citizens exhibit increasingly diverse preferences, with one notable inclination being towards public spaces equipped with Wi-Fi access and internet connectivity. Evidently, internet accessibility has become integral to the fabric of modern urban spaces. In their examination of urban space evolution in the digital age, Hampton, Livio, Trachtenberg, and McEwen (2010) offer valuable insights derived from their research, observations, and interviews. In their article "The Social Life of Wireless Urban Spaces: Photo Essay," they delve into the multifaceted interactions facilitated by Wi-Fi-enabled public domains. Their inquiry reveals how individuals in selected public spaces find solace amidst urban hustle and bustle through internet connectivity. As depicted in Image 2.2, interviewees have indicated their sole purpose of visiting such

locations being internet connectivity. This discussion illustrates that individuals' preferences for choosing public spaces to linger in have shifted compared to before, when such places were primarily chosen for socializing. Now, a space is needed primarily for connectivity!

Image 2.1. *Union Square (San Francisco) Photos by C.T., Source: (Hampton et al., 2010)*

Image 2.2. *Rittenhouse Square (Philadelphia) Photo by O.L. Urban public spaces are increasingly places for the use of mobile phones (left), computers (right), and other devices connected to the wireless Internet (middle). Twenty-five percent of the people we interviewed reported that they hadn't ever visited the space where they were observed before wireless Internet was available. Source: (Hampton et al., 2010)*

As previously noted, humans gradually shape their environment based on their evolving needs, necessitating corresponding adjustments in urban public spaces. While internet access is not the sole transformative element in urban spaces, it stands as one of the foundational services garnering recent attention in advanced nations. Changes in cultural, social, and collective participation activities in the digital age have also been further addressed in subsequent chapters.

2.2.2.1. Social interaction in digital age

The Internet is a tool to connect people with each other to make life more productive and easier. Nowadays technology has become part of our daily activities and changed people's attitude and their behaviors in the place on different scales. It has also reduced the crowdedness in some places, such as online banking, booking tickets and shopping, or by increasing the connection between the local and the global (Castells 2011).

Increasing social interaction between citizens is one of the main goals of public spaces, with a direct impact on their quality. Nowadays, communication no longer needs to happen in the same place, or at the same time. The possibility of socializing through digital social media and messaging platforms has relieved us from the necessity of using physical space for co-presence, face-to-face interaction and direct synchronous communication. Regardless of their physical environment, people are in contact. Again, keeping public spaces in sync with the digital era needs to consider contemporary ways of socializing. For example, the use of open internet access points next to sitting places (including restaurants or cafés) points towards the need for a digital infrastructure to be established as a key aspect of public spaces, similarly to traditional benches and fountains.

2.2.2.2. Public participations in digital age

In his milestone book, The Structural Transformation of the Public Sphere, Habermas (1991) develops the normative notion of the public sphere as a part of social life where citizens can exchange views on matters of importance to the common good so that public opinion can be formed. This public sphere comes into being when people gather to discuss issues of political concern (Velibeyoglu, 1999). Public spaces that have a platform for various social activities are often used by citizens. In the past, these spaces have witnessed a variety of political activities, including collecting votes for decision-making and forming government courts. Today, with existing digital media, political activities, civic movements and street protests have changed their forms.

In recent years, citizen participation through digital platforms has been widely welcomed by municipalities (Table 2.3). The establishment of digital public space to facilitate community engagement is a significant international development in urban planning and governance (Aicholzer et al. 2016). The use of digital public spaces for engagement and deliberation is seen by municipal governments as accessible and efficient, convenient and cost-effective ways to consult with citizens or undertake more participatory processes involving citizens in decision-making (Deseriis 2021).

Table 2.2. *Tools based on information and communication technology for public participation, Source: Relhan, Ionkova, and Huque 2012*

Tool	Uses and characteristics

Surveys (forecast and retrospective)	Citizen surveys are investigations of the behavior, preferences, attitudes, or opinions of a target group sample collected through online questionnaires. Ex ante (or forecast) surveys can help governments and utilities to shape future plans, such as investment or infrastructure plans to expand services, institutional changes, and tariff changes. Ex post (or retrospective) surveys can constitute effective mechanisms for conveying citizen's viewpoints and reviews of public projects and services to authorities. Surveys may cover particular subgroups or geographical communities within the service area or the service area as a whole. Ex ante surveys may measure willingness to pay or preferences, for example, such as service levels and tariff structures. Ex post surveys can be used to evaluate and monitor the performance of urban projects and services from the point of view of the citizenry.
Digital publication	An effective way of ensuring the accountability of local governments is by making important documents (designs, plans, and maps) available through online publishing or disseminating relevant information using SMS messages. Such reports provide a mechanism for public review, and a tool to monitor performance.
E-participation	E-participation mediums such as blogs, citizen forums, on-demand information channels (for instance, YouTube, Facebook), online chat rooms, and so on render a virtual feedback, review, critique, and complaint loop between citizens and the concerned authorities and service providers. The goal of such mechanisms in governance is to enable greater citizen participation in the decision-making process. Through e-participation, people can interact with local officials and make their voices heard. It allows citizens to immediately see how and why their representation is functioning the way it is. In addition, it enables citizens to share their comments and views about the functioning and performance of local agencies. Public officials or agencies can judge the prevailing mood of citizens and take a corresponding course of action based on popular sentiment.

2.2.2.3. Cultural dimension of public space in digital age

The digitalization of public spaces should be able to create a hybrid space; physical and digital. Procedural urbanism theories defend that successful public spaces are flexible and evolve over time according to the needs and wants of citizens. In this context, we have witnessed various exhibitions of digital art in public spaces in recent years. People's acceptance of such digital exhibitions can indicate a change in their preferences. Data walls, digital signage, digital games in public spaces, and digital public art have updated the look and feel of many public spaces. For example, artists do not just

present their artwork in a small frame in an exhibition, but they can project their work in large-scale digital art formats.

Since time immemorial location has been used to consecrate objects and people. The religious and power centers of the world maintain sacred spaces where only the chosen elect are allowed to enter. In the art world too, access to a location – a gallery, a museum or other curatorially closed space – is tightly controlled to confer value and thus, via this exclusivity, to canonize the works shown there as "high art." What does it mean however to control physical space when in geolocated virtual space anyone can place whatever they want? (Aceti, 2008) Augmented reality artists require no permission from government or artistic authorities to place their works at a specific site. They merely need know the GPS coordinates of the location – and unlike Street Art or other physical art interventions, the infiltrated institutions cannot remove the works, which remain on site as long as the artist wishes (Thiel, 2014).

"In the 21st Century, Screens are no longer Borders. Cameras are no longer Memories. With AR the Virtual augments and enhances the Real, setting the Material World in a dialogue with Space and Time." (Manifest.AR 2011). In 2011, using the recently developed mobile technology of geolocated augmented reality (AR), the author was the primary organizer of two interventions into art biennials: in Venice together with Sander Veenhof and Mark Skwarek for our cyberartist group Manifest.AR, (Manifest.AR blog 2013) and in Istanbul in collaboration with the Istanbul design team PATTU (PATTU 2013). With geolocated AR artists can place virtual computer graphic artworks at specific locations via the site's GPS coordinates. The artwork can then be viewed by anyone on site in the display of a smartphone or mobile enabled tablet as an overlay on the live camera view, merged with the surroundings as if the artwork was there in real life (Thiel, 2014).

Image 2.3. *The Crystal Coffin, Giardini, Lily & Honglei, 2011. Augmented Reality. Artwork inspired by the crystal coffin in the Mausoleum of Mao Zedong in Tienanmen Square, seen here in front of the Giardini Central Pavilion.*

The augmentation is inspired by the crystal coffin (Image 2.3) displayed in Mausoleum of Mao Zedong on Tiananmen Square since 1977, a year after Mao's death. In the twenty first century, while China has been transforming itself into a modern society in many ways and gaining more influences economically and politically around the globe, Mao's crystal coffin, the immortal-looking shell, remains exist as a symbol of authoritarian ruling system. During spring 2011, a crackdown on dissent – including detaining many intellectuals and members of religious group – followed by distinct signs of revival of Maoist policies, has left people baffled about the future direction of China. They therefore used Crystal Coffin of Mao as main body of the virtual China Pavilion, which is topped with a tower and roof with ancient Chinese looking, as regulated by Ministry of Construction of China: architectural 'designs must reflect traditional Chinese building styles.

2.3. Challenges and Concerns of Digitalized Public Spaces

Public spaces, which in the past played a significant role in the social life of individuals with various purposes such as social and political participation, have declined in the eyes of experts in recent years. Since the second half of the twentieth century, the digital revolution has taken place, and because existing public spaces have been shaped by old patterns, they need to be updated. The digital revolution is known as the third

industrial revolution that has led to progress in the public sphere as well. Digital technologies have evolved over time to change the lifestyle of contemporary humans. The new public spaces design has been developed all over the world, and the traditional concept of public space is being modified based on the contemporary needs (Albeera, H. A. 2019) If we cannot provide a proper public space system in the digital age, there is doubt as to whether we will have urban public space in future cities that can move forward with their contemporary technology and meet the needs of citizens in accordance with advances in technology. These places need to be flexible so that they can keep pace with technological advances and respond to changes in the digital age.

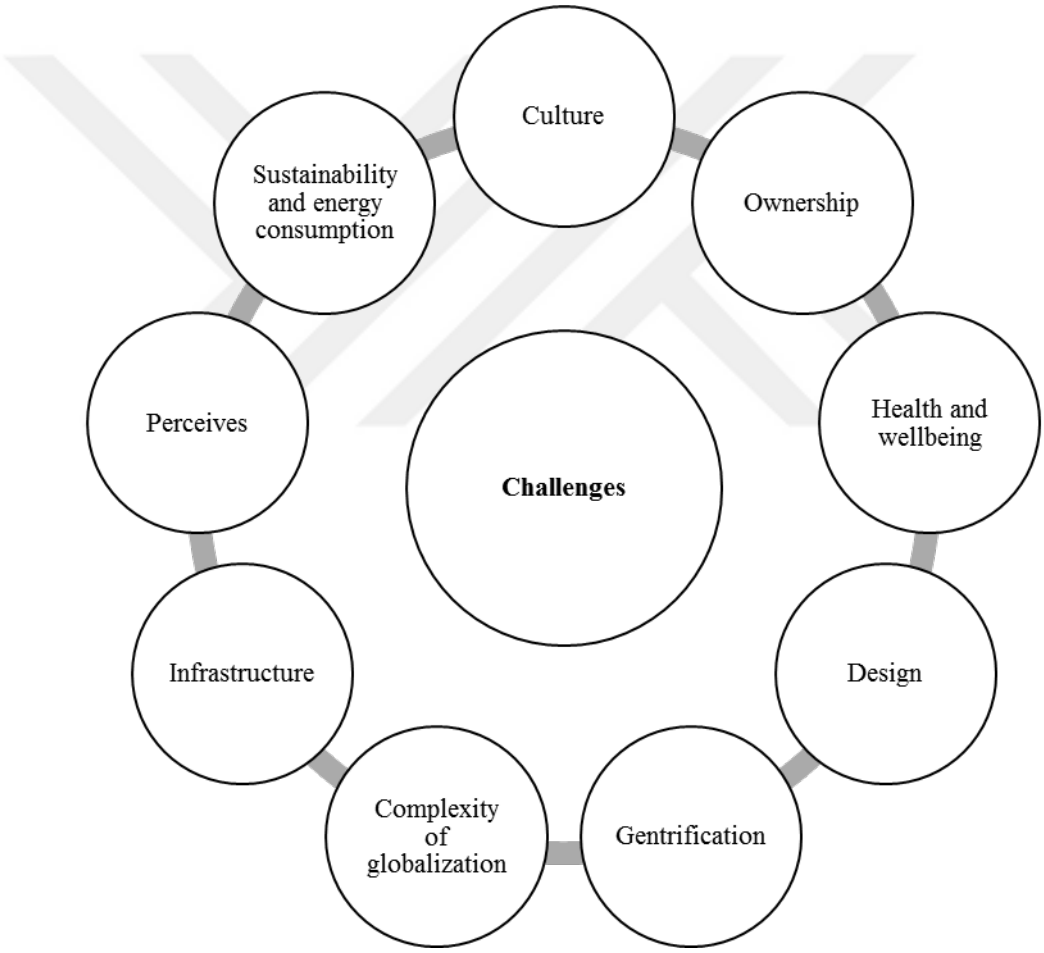


Figure 2.4. *Challenges and concerns of digitalized public spaces, Source: Author*

There are always challenges and concerns in the process of digitalization of public spaces. This is a new way of designing and of course it opens new ways of challenging. The figure 2.4 above demonstrates the challenges to digitalizing public spaces. For instance, in the process of digitalizing the public spaces, the matter of data and the ownership of that is always one of the important subject of discussions. And also most of

our digital spaces are privately owned by companies. Therefore, these are the concerns and challenges we face in this process. Another challenge that we have is Well-off people will have access to these kind of technologies, we are automatically possibly leaving out a large section of the population so we need to find ways of dealing with this.

2.3.1. Examining the challenges and dynamics of physical and digital public spaces

While physical public spaces are upheld by a social contract, there is no such social contract which provides the foundation for designing, building, managing, and protecting public values in our shared digital spaces. Some spaces do indeed come close to resembling digital public spaces, like certain online government portals, open forums, and publicly-funded tech. But there are various ways in which these spaces fall short of being truly open digital public spaces: the lack of applied and foundational public values with regard to tech; the private infrastructures which permeate various other spaces often without knowledge or consent of citizens. Since many services, and especially social platforms, offer their services free of any direct charge, they are easily and erroneously seen as forming a digital public space (a narrative which is central to their business model). In actuality, these companies offer a service or product from the context of a strictly private space where the rules are theirs – not subject to social or democratic accountability. On Facebook, for example, you do not have a right to free speech but rather are a consumer of a commercial platform and bound to the rules it sets for you. Still, users of commercial platforms like Facebook and Twitter argue that rights such as freedom of speech ought to apply. This friction plays out when, for example, a platform marks a post as 'fake news', bans a user, or utilizes black-boxed algorithms to manage what users do or do not see (van der Waal et al. 2021).

When discussing digital public spaces such as Facebook, it is important to recognize that these platforms operate on a global scale. In contrast, physical public spaces are typically localized. Table 2.3 illustrates that public spaces are no longer confined to specific locations; rather, they can be accessible to people worldwide. Table 2.3 provides a clear comparison between physical and digital public spaces, highlighting their distinct characteristics (This explanation is provided by the author of this thesis):

-Place versus Space:

Physical Public Spaces: These are tangible locations where people gather and interact, such as parks, squares, and streets.

Digital Public Spaces: These are virtual environments where interactions occur, like social media platforms, forums, and online communities.

-Local versus Global:

Physical Public Spaces: Typically localized, serving the immediate community or neighborhood.

Digital Public Spaces: Have a global reach, allowing people from all over the world to connect and interact.

-Live versus Archive:

Physical Public Spaces: Experiences are live and real-time, with interactions happening in the moment.

Digital Public Spaces: Interactions can be archived, allowing for the storage and retrieval of past communications and content.

-Private versus Public:

Physical Public Spaces: Often have elements of privacy, with certain areas or interactions being more secluded.

Digital Public Spaces: Generally more public, with content and interactions often accessible to a wider audience.

This comparison underscores the fundamental differences in how public values and interactions are managed in physical versus digital environments. It also raises important questions about privacy, accessibility, and the nature of public engagement in these two types of spaces.

Table 2.3. *The Comparison Between Physical and Digital Public Spaces, Source: Salinas, L. (2014).*

Physical public spaces	Digital public spaces
Place	Space
Local	Global
Live	Archive
Private	Public

2.4. Deployment of Digital Technology in Public Spaces

For deployment of digital technology, we can point to digital tools which has been used for safe distancing. Technology has been used to help public spaces in safe distancing work. The safe distance parks portal safedistparks.nparks.gov.sg, for instance, was developed by NParks to allow the public to look for a park near them and check

visitorship levels before leaving their house. A total of 30 drones are also being deployed in selected parks (in Singapore) and nature areas to provide officers with a high vantage point to obtain visitorship updates quickly, complementing ground observations, as well as give them a better sense of the density of visitors in a specific area. The implementation of digital technology in public spaces extends beyond the aforementioned examples and includes various innovative solutions as depicted in the table 2.4 below:

Table 2.4. *Deployment of Digital Technology and their Functions, Source: www.nparks.gov.sg*

Deployment Of Digital Technology	Functions
Drones	• Fire Monitoring System • Delivery during pandemic • To monitor quarantine measures, to facilitate aerial broadcasting, to spray disinfectant, conduct aerial thermal sensing, monitor traffic
CCTV's	• Accelerated deployment and integration with video analytics • People counting for restricted entrances
Robots	• Surveillance and SDM announcements
Sensors	• Bin: Measure Bin fullness • Toilet: Measure Ammonia Level • Electricity - Water Meter: Real-time readings • Sensors measuring body temperature to identify infected individuals in the crowd

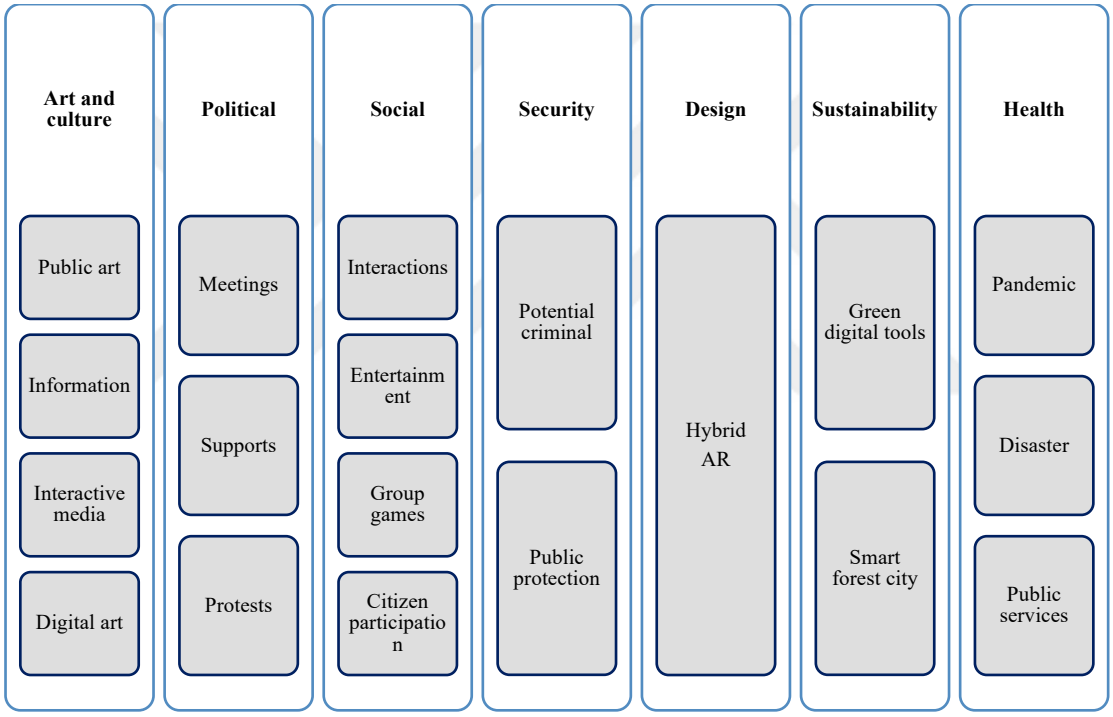
These technologies collectively contribute to the enhancement of safety measures and operational efficiency within public spaces, particularly during challenging circumstances such as pandemics.

2.4.1. Adding new digital layers

Our public spaces are being digitalized from different perspectives (Table 2.5). Surveillance systems play a role in protecting the public and increase the security of public spaces. Digital technology could also enable the use of open data platforms and more public engagement. Planners could collect various perspectives from the general population using an app, for instance, while also using digital technology to map and boost urban biodiversity and to ensure that green areas are placed where they will achieve maximum efficiency. For urban designing Augmented reality (AR) offers great potential as a visual tool to engage and encourage participation in shaping public spaces. The

combination of AR with the smartphone and tablet creates new and accessible design and artistic possibilities in spatial development. AR allows the combination of physical reality with digital content and thus enables hybrid and spatial experiences. On the one hand, AR visualizations have the potential to visually close the abstraction gap between planning (plans, visualizations, diagrams) and implementation (space, material, function). On the other hand, AR offers a promising opportunity to encourage more (and different) people (especially younger ones) to actively participate in planning and participation processes in a vivid way with an extended virtual method setting.

Table 2.5. *The purposes of adding digital tools, Source: Author*



CHAPTER 2: SUMMARY

Chapter 2 explores the evolution of public spaces from their historical roots to their contemporary forms. Originally, European public spaces like the Greek Agora and Roman Forum were central to political, economic, and social activities. Over time, the functions of these spaces have expanded and dispersed into various types of locations, including shopping malls and public buildings, reflecting changes in political, social, and technological contexts. This transformation underscores both the advancements and challenges faced in maintaining vibrant public life amidst evolving societal needs.

The chapter also addresses the dual nature of modern public spaces, which are increasingly influenced by digital technology. With the rise of digitalization, traditional public spaces are being integrated with digital layers, creating hybrid environments that blend physical and virtual realms. This shift presents both opportunities for enhancing urban functionality and risks of diminishing the cultural and social significance of public spaces. The chapter examines how these changes affect the design and use of public spaces, highlighting the need for innovative solutions to preserve their role in fostering community interaction.

Additionally, the chapter considers the implications of rapid urban migration on public spaces. As more people move to cities in search of better amenities and opportunities, urban areas face increased pressure on infrastructure and services. The integration of technology, such as smart urban management tools and digital enhancements, is proposed as a way to address these challenges and adapt to the evolving needs of urban populations. This evolving landscape underscores the importance of rethinking urban planning to ensure that public spaces continue to serve their essential functions in contemporary society.

In the context of digital technology in public spaces, several key themes emerge from the text. First, there's a significant shift in how public spaces are utilized, with digital connectivity becoming a primary draw for many individuals, as seen in the preference for Wi-Fi-enabled areas. This shift highlights the growing importance of integrating digital infrastructure into public spaces to meet contemporary needs. Furthermore, the text addresses how digital platforms are reshaping social interactions and civic participation, allowing for remote engagement and changing the dynamics of public discourse. However, challenges such as data ownership, digital inequality, and the need for adaptable public spaces are crucial considerations. Balancing the benefits of digital tools with these challenges is essential for developing public spaces that are both functional and equitable in the digital age.

CHAPTER 3: INTRODUCTION

Chapter 3 investigates the evaluation of public spaces in the digital age, focusing on the integration and impact of digital technologies. This chapter directly addresses the research questions posed in the thesis by examining the components of digitalized public spaces, assessing whether these components signify a transformative shift or merely add a digital layer, and understanding the effects of digitalization on urban spaces. Through a detailed analysis of data collection methods, the implementation of smart technologies, and their role in reshaping urban spaces, the chapter aims to provide a comprehensive understanding of how digital advancements influence public space design, functionality, and urban form.

3. EVALUATION OF PUBLIC SPACES IN DIGITAL AGE

In the digital age, the evaluation of digitalized public spaces is considered from multiple perspectives. Digital solutions and various components are evaluated with the aim of efficiency, quality enhancement, and usability in these spaces. The evaluation process of urban public spaces in the digital age involves several stages, beginning with the systematic collection of data using advanced data collection tools. Subsequently, these data are analyzed using algorithmic methods to gain insights into the specific challenges and needs of public spaces, ranging from environmental concerns to traffic flow dynamics. Following this, digital solutions based on the acquired data are implemented to improve the quality of life for citizens and address identified issues and problems. These solutions encompass a wide range of smart technologies such as smart city parking solutions, online traffic maps, weather reports, pollution alerts, and online routing (detailed in later sections). Furthermore, urban network infrastructures supporting public spaces play a crucial role in facilitating connectivity and access for all segments of society, thereby preventing potential digital divides. Overall, the evaluation of public spaces in the digital age involves the integration of technologies and the implementation of digital solutions to optimize usability, public space management, and sustainability, paving the way for continuous advancements in urban development and citizen services.

3.1. Digital Components in Digitalized Public Spaces

The process of digitalizing public spaces consists of several important stages. Initially, data is systematically collected from the designated public space using data

collection tools. These data are identified with various objectives that fall within the purview of governments and municipalities. The aim is to address urban life and infrastructure challenges as a precursor to subsequent steps. During the data identification stage, the use of data analysis and algorithmic methods can offer a detailed understanding of the issues in the target public space, spanning challenges specific to the area, as well as matters related to traffic flow and environmental concerns. This information is then presented as a foundation for the following stages. In the next stage, the proposed digital solutions based on the acquired data are implemented to address the identified problems, enhance the quality of citizens' lives, and achieve other specified objectives. These solutions encompass a broad spectrum of technologies, including IoT devices, data visualization tools, and other tools employed for the smartification of public space infrastructures. The implementation of these digital solutions marks a crucial point in the management of public spaces (Figure 3.1) . All these efforts are geared towards creating digitally transformed public spaces that prioritize functionality and responsiveness to citizens' needs, aiming to provide a citizen-centric public space. By seamlessly integrating technology, this evolving process actively addresses urban challenges and meets citizen needs, ultimately enhancing the quality, efficiency, and sustainability of public spaces (Figure 3.2).

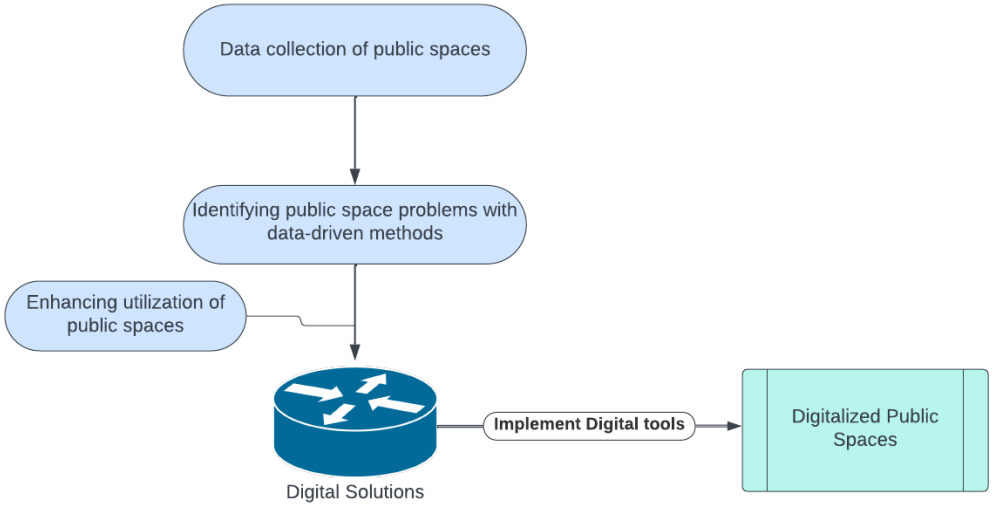


Figure 3.1. *Digitalization of Public Spaces: A Process from Data Collection to Implementation, Source: Author, 2024.*

The Process of Digitalizing Public Spaces	
1. Data Collection	1- Data Collection Tools: Systematic collection from designated public spaces. 2- Objectives: Aligned with governmental and municipal goals. 3- Purpose: Addressing urban life and infrastructure challenges. 4- Analysis and Algorithms: Detailed understanding of specific challenges
2- Data Identification	1- Information Presentation: Data becomes a foundation for subsequent stages. 2- Focus: Providing insights into challenges and shaping the course of action.
3- Implementation of Digital Solutions	1- Proposed Solutions: Based on acquired data. 2- Objectives: Addressing identified problems, enhancing citizen lives, and achieving specified goals. 3- Technological Tools: Involves IoT devices, data visualization tools, and smartification technologies.
4- Utilization and Goals	1- Utilization: Through networks, systems, and solutions. 2- Priority: Creating digitally transformed public spaces. 3- Purpose: Increasing access, enhancing performance, protecting public spaces, improving quality, aiding in maintenance, ensuring sustainability, increasing citizen satisfaction, and assisting in management.

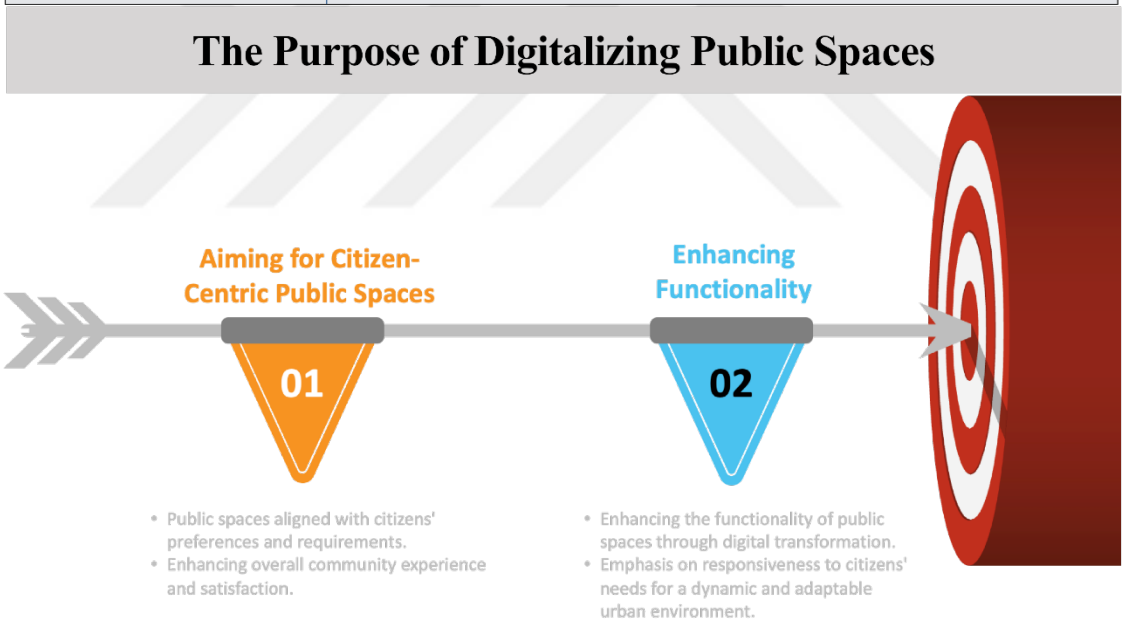


Figure 3.2. *The Process and Purpose of Digitalizing Public Spaces (Source: Author, 2024).*

Digital technologies in public spaces encompass tools and solutions that are used for various purposes. The utilization of these technologies is carried out through networks, systems and solutions with goals such as increasing access, enhancing performance, protecting public spaces, improving the quality of public spaces, aiding in the maintenance of public space health, ensuring sustainability, increasing citizen satisfaction, and assisting in the management of public spaces.

Some of the tools used for designing digital public spaces include controllers, sensors, monitors, detecting devices, digital mapping tools, alert systems, navigation systems, and transportation systems. These are deployed by stakeholders, municipalities, and governments in cities. This section explains the digital technologies used in public spaces and their roles in increasing access, performance, and user experience (Figure 3.3).

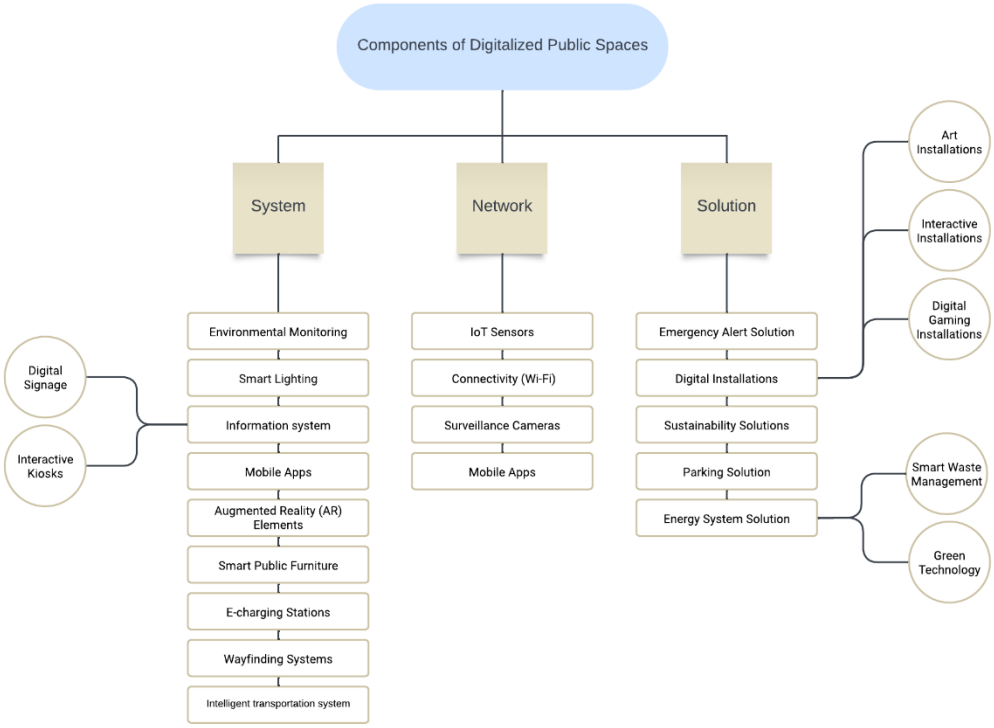


Figure 3.3. *Digitalized Public Spaces Framework (Source: Author).*

3.1.1. Defining the digital systems involved in public spaces

Internet of Things (IoT): The definition of Internet of Things is developing according to the time, and whenever there is a discussion about digitalization, it can be started from the topic of Internet of Things.

The term Internet of Things refers to the networked interconnection of objects of diverse nature, such as electronic devices, sensors, but also physical objects and beings as well as virtual data and environments (Kosmatos et al., 2011). The Internet of Things can also be considered as a global network which allows the communication between human-to-human, human-to-things and things-to-things, which is anything in the world by providing unique identity to each and every object (Aggarwal & Das, 2012). It may not be an exaggeration to consider IoT as the cornerstone of the digitalization of public spaces, as both wired and wireless devices can be interconnected through IoT. Numerous IoT sensors deployed in public spaces gather data for a variety of purposes. For example, environmental sensors within urban areas provide urban planners with essential information regarding pollution levels, air quality, temperature variations, ambient noise levels, and humidity measurements.

3.1.2. Exploring the network infrastructure supporting digital public spaces

If we consider the public space as the central heart of the city, its connecting networks can be the vessels of public spaces. Since the survival of a city is closely related to the increase in livability of its public spaces, maintaining services that increase this livability is on the agenda. Networks also increase the role of connectivity and access in today's modern and smart world. These networks aim to increase the use of public spaces, integrate users, support public life and respond to social needs of an urban space.

Networks play a crucial role in facilitating connections in digitalized public spaces. Communication networks enable the establishment of infrastructure for digital devices and systems, offering services for specific purposes. These networks encompass the Internet, local networks, intranet, as well as mobile and fixed broadband networks. Official statistics reveal significant disparities in the availability and accessibility of internet connection networks worldwide. In a global survey, participants expressed negative feedback regarding the coverage and quality of connection networks currently serving cities. Almost 20% of survey participants highlighted the absence of network infrastructure as a hindrance to progress in the development of smart cities (Beckers et al., 2023).

Throughout the world, urban governments, with the help of network providers and local stakeholders, strive to provide the best citizen services. These communication networks must be usable by any group of people to prevent digital divides. Furthermore, these

networks should cover public spaces in all urban areas, as establishing connectivity networks in public spaces is one of the most crucial steps towards digitalizing urban public spaces so that all citizens can equally benefit from them. This can be the first step in preventing the digital gap. For example, free internet networks can elevate digital literacy in deprived or low-income areas and help embrace digital layers across all segments of society.

3.1.3. Analyzing the specific digital solutions implemented in public spaces

When it comes to solutions in digitalized public spaces, it may seem that surveillance cameras and facial recognition technology are the only options for protection. However, the digital revolution that has influenced urban spaces goes beyond technologies limited to surveillance control. Monitoring systems are one of the tools used for the management of public spaces, including environmental monitoring, traffic management, citizen surveillance systems, and security systems.

In digitalized public spaces, other layers are in place to provide services to citizens in solving urban and social problems. Technological innovation serves as an interface between citizens and the city, aiming to raise the quality of public spaces and improve the management of public areas. Among the digital solutions implemented by municipalities in public spaces are smart city parking solutions, addressing issues such as urban traffic, payment problems, and finding parking spaces. These technologies have transformed how cities manage infrastructure related to city parking. Additionally, the management of waste disposal and recycling through applications and digital sensors can be counted as practical solutions in these digitalized spaces. This approach optimizes waste collection activities and plays an effective role in the cleanliness of public spaces, reducing energy consumption and pollution generated by waste collection.

In crisis and emergency conditions, digital technologies serve as tools for awareness and deployment of critical service tools. Examples include citizen status announcements during emergencies like terrorist attacks, street conflicts, and even natural disasters. Other digital solutions for public spaces include the use of navigation applications, contributing to uniform traffic distribution in urban spaces, and providing adaptable accessibility features to users for optimal use of public spaces. Digital technologies in public spaces, with the help of electronic charging tools for electronic devices, can increase environmental sustainability. For example, the deployment of these tools makes it easier

for citizens to use electronic transportation with reduced pollution, contributing to the improvement of regional air quality.

In essence, there is a diverse array of digital solutions aimed at increasing the usability of public spaces and optimizing these spaces. With the advancement of technology, this subject will continue to evolve.

CHAPTER 3: SUMMARY

Chapter 3 explores the evaluation and integration of digital technologies in public spaces, focusing on how these innovations are transforming urban environments. In the digital age, the process of evaluating and improving public spaces involves multiple stages, starting with the collection of data through advanced tools. This data is then analyzed using algorithmic methods to identify specific challenges such as traffic flow and environmental issues. Based on these insights, various digital solutions are implemented to enhance the quality of life for citizens. Technologies like smart city parking solutions, online traffic maps, and pollution alerts are among the key innovations used to address these challenges and improve urban living conditions.

The chapter further delves into the digital components that facilitate the transformation of public spaces. Initially, data collection tools are employed to gather information, which is then analyzed to address urban infrastructure challenges. The integration of technologies, such as IoT devices and data visualization tools, plays a critical role in this process. These digital solutions are designed to make public spaces more responsive to citizens' needs and to enhance overall functionality and sustainability. The use of these technologies is aimed at creating a citizen-centric environment that effectively manages urban challenges and promotes a higher quality of life.

Additionally, the chapter examines the essential network infrastructure supporting digital public spaces. Communication networks, including the Internet, local networks, and broadband connections, are crucial for enabling the functionality of digital solutions. The chapter highlights the disparities in network availability and quality globally and underscores the importance of inclusive connectivity to prevent digital divides. It also discusses various digital solutions implemented in public spaces, from environmental monitoring and traffic management to emergency response systems and waste management. These innovations aim to improve public space usability and sustainability, reflecting the ongoing evolution of urban digitalization.

In the upcoming chapters (Chapters 4 and 5), we will delve deeper into how the components mentioned in this chapter—digital tools and technological advancements—affect future public spaces and urban morphology (emphasizing urban form, infrastructure transformation, and physical-digital integration). This exploration will highlight the transformation of urban form and infrastructure and the integration of physical and digital realms. By connecting these elements, our goal is to provide a nuanced analysis of how digitalization shapes urban identity (with a focus on both material and immaterial dimensions), encompassing both material and immaterial dimensions as well as spatial dynamics.

CHAPTER 4: INTRODUCTION

This chapter examines the role of digital technologies in transforming public spaces and sets the groundwork for Chapter 5, which will explore how the installation and deployment of these technologies impact urban identity (focusing on both material and immaterial aspects) and urban morphology (emphasizing urban form, infrastructure evolution, and physical-digital integration).

Singapore, Barcelona, Tokyo, and Amsterdam are used as case studies in this analysis. Each city employs digital tools to enhance urban services and improve quality of life, illustrating various approaches to smart city development. At the end of each case study, a table will analyze the impacts, user experience, design principles, technological solutions, engagement strategies, and stakeholder collaborations of these technologies, thereby contributing to understanding the objectives behind their installation.

Singapore's initiatives, such as the Garden Management System and smart waste monitoring, exemplify how technology can optimize urban services and sustainability. Barcelona’s IT strategy, featuring programs like the Bicing bike-sharing and Decidim platform, highlights a comprehensive approach to improving urban functionality and stakeholder engagement. Tokyo's integration of real-time data through platforms like TOKYO OASIS and spatial soundscapes demonstrates the impact of digital tools on urban life and tourism. Amsterdam’s use of platforms such as Amsterdam Smart City and Data Amsterdam reflects a commitment to real-time data management and environmental monitoring.

These case studies align with the thesis's aim to explore how digital tools transform public spaces. They provide insights into digital public space components, the potential for digital transformation, and its effects on urban identity and morphology. The study seeks to understand whether digital advancements fundamentally change public spaces or merely add new layers of functionality and to assess their long-term impact on urban forms and identities.

This chapter will also examine the objectives behind the installation of digital tools in public spaces by introducing those that have been deployed or established. The study will identify the specific purposes these tools serve in urban environments. This process will contribute to the development of a comprehensive model that includes both the digital tools and their installation objectives, which will be presented in the final chapter.

The chapter also explores Istanbul's evolution through smart city initiatives like Vision 2050, focusing on how digital tools such as free Wi-Fi transform urban morphology and identity. The extensive IBB Wi-Fi network and ISTTELKOM's smart infrastructure signify a major shift, altering urban forms and integrating physical and digital elements in public spaces. This transformation impacts the city's physical layout—streets, squares, and public areas—and generates new demands for spaces reflecting modern social life (Oldenburg, 2007; Pittaluga, 2020).

At the end of this chapter, the expansion of free internet access in Istanbul and its impacts on the urban structure and identity of Istanbul, specifically in Kadıköy Square (selected due to its high usage of free internet), will be examined. From a material perspective, digital infrastructure reconfigures urban spaces, while digital tools alter residents' needs from the city and public spaces. This analysis will help determine whether these digital advancements fundamentally change the urban identity and morphology of Istanbul or simply add new layers to the existing landscape.

4. CASE STUDIES AND URBAN ANALYSIS: DEVELOPING A MODEL FOR ISTANBUL'S CITY DYNAMICS WITH EMPHASIS ON DIGITALIZATION

This section examines successful case studies of digital public space projects to provide insights into how digital technologies impact urban environments. By evaluating examples from leading smart cities, the study aims to understand how digital tools transform public spaces, contributing to a comprehensive analysis of digital transformation in urban settings. Based on the information gathered from these case studies, this section will develop a model to analyze the dynamics of Istanbul, a developing city, with a focus on the impact of digitalization.

4.1. Selection Criteria for Case Studies/Successful Case Studies and Examples of Digital Public Space Projects

In this section, the selection criteria for case studies examining successful digital public space projects are outlined. Among the smart cities referenced by the Institute for Management Development (IMD) Smart City Index—published by an organization based in Sweden to evaluate and rank cities worldwide based on criteria related to the development and initiatives of smart cities—successful examples such as Singapore, Tokyo, Barcelona, and Amsterdam were selected for this study (Figure 4.2).

The IMD Smart City Index evaluates cities based on economic, human, and technological aspects, focusing on quality of life, the environment, and inclusiveness. Since 2019, it has surveyed citizens and collected data from 142 cities worldwide. The index is on track to becoming an internationally recognized tool for policymakers and is attracting global media attention. It assesses structures and technology across five criteria: health and safety, mobility, activities, opportunities, and governance. Cities are rated from AAA to D based on perceptions, using the Human Development Index (HDI), with recent years weighted more heavily (Figue 4.1).

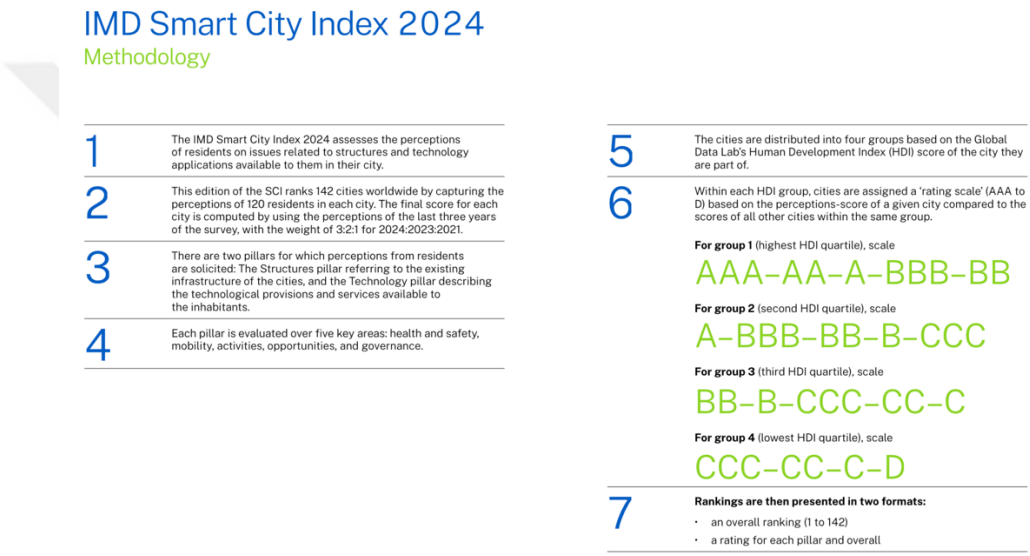


Figure 4.1. IMD Smart City Index 2024 Methodology Overview
For detailed, visit: IMD Smart City Index 2024 Methodology, www.imd.org

IMD Smart City Index 2024: Results

In 2024 City Ranking Order and 2023 Ranking Comparison

City	Smart City Rank 2024	Smart City Rating 2024	Structure 2024	Technology 2024	Smart City Rank 2023	Change
Zurich	1	AAA	AAA	AA	1	—
Oslo	2	AA	AA	A	2	—
Canberra	3	AA	AAA	A	3	—
Geneva	4	AAA	AAA	AA	9	+5▲
Singapore	5	A	A	A	7	+2▲
Copenhagen	6	AA	AA	A	4	-2▼
Lausanne	7	AA	AA	A	5	-2▼
London	8	A	BBB	AA	6	-2▼
Helsinki	9	AA	AA	A	8	-1▼
Abu Dhabi	10	BB	BB	BB	13	+3▲
Stockholm	11	A	A	A	10	-1▼
Dubai	12	BB	BB	BB	17	+5▲
Beijing	13	BB	BB	BB	12	-1▼
Hamburg	14	BBB	BBB	BBB	11	-3▼
Prague	15	A	A	A	14	-1▼
Taipei City	16	A	BBB	A	29	+13▲
Seoul	17	AA	BBB	AAA	16	-1▼
Amsterdam	18	A	BBB	A	15	-3▼
Shanghai	19	BB	BB	BB	25	+6▲
Hong Kong	20	A	BBB	AAA	19	-1▼
Munich	21	A	A	A	20	-1▼
Sydney	22	A	BBB	A	18	-4▼

City	Smart City Rank 2024	Smart City Rating 2024	Structure 2024	Technology 2024	Smart City Rank 2023	Change
Chicago	67	BB	BB	BB	61	-6▼
Los Angeles	68	BB	BB	BB	50	-18▼
Dublin	69	BB	BB	BBB	63	-6▼
Bordeaux	70	CCC	CCC	CC	78	+8▲
Manchester	71	BB	BB	BB	73	+2▲
Leeds	72	CC	CCC	CC	76	+4▲
Kuala Lumpur	73	B	B	CCC	89	+16▲
Medina	74	CCC	B	CCC	85	+11▲
San Francisco	75	BB	BB	B	68	-7▼
Krakow	76	CCC	CCC	CC	79	+3▲
Newcastle	77	CC	B	CC	77	—
Bologna	78	BB	BB	B	51	-27▼
Kiel	79	BB	BBB	CCC	81	+2▲
Montreal	80	BB	BB	B	69	-11▼
Barcelona	81	BB	BB	BB	75	-6▼
Chongqing	82	CCC	CCC	CCC	86	+4▲
Birmingham	83	BB	BB	BB	74	-9▼
Bangkok	84	CCC	CCC	B	88	+4▲
Lille	85	CCC	CCC	CC	84	-1▼
Tokyo	86	BB	BB	BB	72	-14▼
Glasgow	87	B	BB	B	80	-7▼
Muscat	88	B	B	CCC	96	+8▲

Figure. 4.2. IMD Smart City Index 2024 Results, City rankings for 2024, including a comparison with 2023. For details, visit: IMD Smart City Index 2024 Results, www.imd.org

In alignment with the primary aim of this thesis—to investigate the transformation of public spaces in the digital age and how digital technologies influence urban identity and morphology—the selected cities of Singapore, Tokyo, Barcelona, and Amsterdam offer compelling case studies due to their exemplary integration of digital technologies in their public spaces. These cities have been chosen to address the thesis's objectives, providing diverse and insightful examples of digitalization's impact on urban environments.

Singapore was selected for its extensive and comprehensive approach to smart city development. Singapore's initiatives, such as digital exhibitions, smart lighting, and advanced waste management systems, reflect a commitment to embedding digital tools deeply within public spaces. These examples are instrumental in analyzing how digital technologies contribute to modern urban functionality and public space enhancement, thereby addressing the objective to perceive and analyze digitalized public spaces.

Tokyo is renowned for its cutting-edge smart infrastructure and real-time environmental data visualization, as seen in projects like the Tokyo Oasis. Tokyo's integration of digital technologies in a densely populated urban context provides a valuable perspective on the transformative role of digital tools in shaping future public spaces. This aligns with the objective of analyzing how advancements in digital technologies, such as AI and IoT, influence public space design and usage.

Barcelona offers a robust digital city strategy with initiatives like smart bike-sharing and citizen engagement platforms. Barcelona's efforts in leveraging digital technologies for urban innovation make it a key case study for understanding how digital elements are integrated into existing public spaces, thus fulfilling the objective of exploring the evolving objectives behind digital integration and its implications for urban planning.

Amsterdam stands out for its innovative use of digital platforms and crowd monitoring systems. The city's pioneering projects, such as Amsterdam Smart City, illustrate how digital tools can enhance urban management and transform public spaces. This makes Amsterdam an ideal example for investigating the impact of digitalization on the physical form and identity of urban areas, addressing the objective of understanding changes in urban morphology due to digital interventions.

Together, the cities examined in this study showcase a diverse array of successful digital public space projects, providing valuable insights into the interplay between digital technologies and urban design. Additionally, although Istanbul does not rank as highly on the IMD Smart City Index as the other selected cities, its inclusion offers valuable insights into how digital solutions are implemented in a developing urban context. The city's dynamic approach to integrating digital technologies and its ambitious smart city strategies, including the extensive deployment of free Wi-Fi services, make it an exemplary case for exploring the transformation of public spaces. The author's personal visit to Istanbul facilitated access to municipal data and resources, which supported the collection and preparation of relevant materials for the study. Including Istanbul allows for an assessment of how digital integration might influence public spaces within developing cities, providing a comparative perspective that enhances the overall analysis of urban digital transformation.

This thesis explores these case studies to understand the outcomes, impacts, and user experiences related to the digitalization of public spaces. It investigates how digitalization reshapes urban landscapes and influences social interactions. The study focuses on identifying key factors that contribute to the success of digital public space projects, including design principles, technological solutions, user interaction strategies, and stakeholder collaborations. By analyzing exemplary projects from Singapore (4.3) and other selected case studies, the research assesses the implementation and effectiveness of digital solutions in enhancing urban environments.

Additionally, after identifying the digital tools used in these public spaces, the study proposes a model to outline the objectives pursued through the integration of these tools into public environments. This comprehensive analysis contributes to a deeper understanding of the transformation of public spaces through digitalization and its impact on urban living.

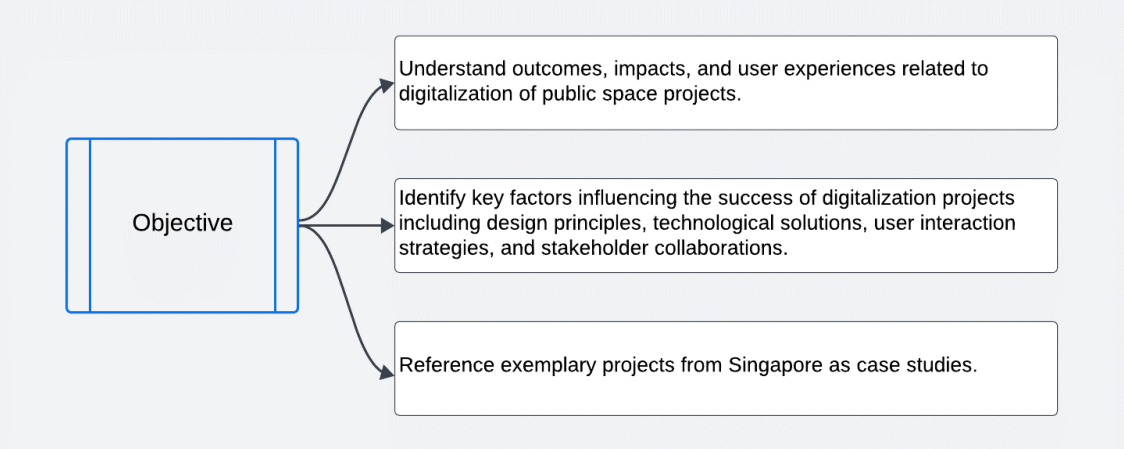


Figure 4.3. *The purpose of examining case studies, Source: Author*

4.2. Case Study 1: Singapore

The cities of the world are constantly undergoing changes and transformations with the advancement of technology. Technologies are being used in various aspects of urban services. These urban services include energy management, transportation, waste management, security, and healthcare services in public spaces. The use of the latest technologies in providing urban services has enabled cities to align with the goals set by smart cities. Among them, Singapore has become one of the smartest cities in the world by adopting intelligent strategies for itself. Despite having limited natural resources, Singapore has managed, with the help of technology on a global scale, to become a model for utilizing technology to improve the overall quality of life for its citizens.

What Singapore strives to be is a digital-first – and not a digital-only – society. Digitalization is not an end in itself, but a means to enrich quality of life. Putting people first in Singapore's digital transformation journey is vital, as this directs our focus towards building a digitally inclusive society and future where no one is left behind (Hee et al., 2023).

In recent years, Singapore (Figure 4.4), once perceived as a resource-scarce island, has embarked on a transformative journey guided by the government's vision of 'Smart Nation

Singapore.' The ultimate objective, extending beyond economic growth, is to enhance the quality of life for all residents and elevate the city-state to the status of a Smart City (Mahizhnan, 1999). In Singapore's urban design, key elements are prioritized and formalized in government guidelines. These elements, integral to urban development, shape the city. Singapore's urban framework includes 9 core components: urban pattern, open space, pedestrian network, vehicular access, building form, streetscape, roofscape, greenery, and night lighting (See, www.clc.gov.sg).

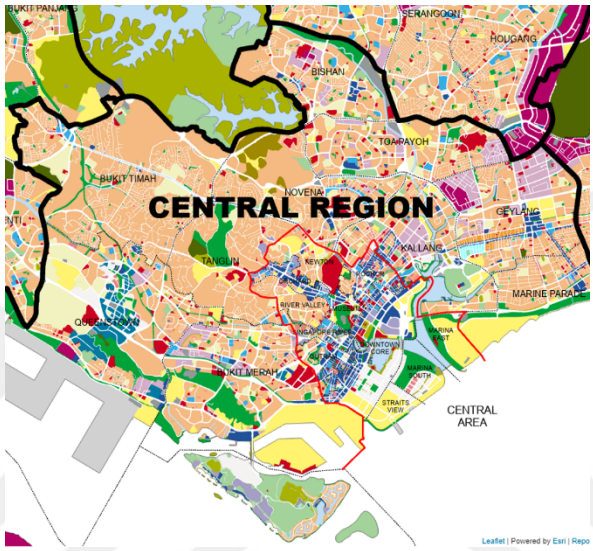


Figure 4.4. *Singapore map Source: www.Esri.com*

4.2.1. Digital exhibitions for promoting urban digital technologies and public education (fostering singapore's smart nation: focus on 'smart nations' exhibition and ınitiatives)

The city of Singapore strategically employs the hosting of digital exhibitions as a means to promote and showcase the latest urban digital systems. This city invests in cutting-edge technologies to enhance urban sustainability and efficiency for its residents. These exhibitions serve the purpose of raising public awareness about the advantages of digital technologies in everyday urban life. They educate the populace on how digital technologies and their applications, ranging from waste management to public transportation, can improve urban living.

Digital exhibitions and technology, by providing digital services tailored to every segment of society, possess the potential to elevate general awareness of the burgeoning smart world. They familiarize citizens with urban digital infrastructures and the concept of a smart city, imparting guidelines for the utilization of forthcoming digital tools. In this

regard, the organization of such exhibitions contributes to citizen engagement in the process of urban digitalization and reinforces a sense of ownership and participation in the development of digital urban environments.

The Smart Nation and Digital Government Office (SNDGO), operating under the Prime Minister's Office (PMO), leads strategic planning, fosters digital innovation, and promotes tech adoption in the public sector to collectively advance Singapore's nation towards a Smart Nation. Working closely with the Government Technology Agency (GovTech), these entities form the Smart Nation and Digital Government Group (SNDGG), ensuring a united effort for a technologically advanced and digitally empowered nation. The city of Singapore has implemented a multifaceted approach aimed at facilitating the integration of its citizens into the process of urban digitalization. This strategy encompasses a range of initiatives, including permanent and temporary digital exhibitions, science expansion programs, competitive events, volunteer opportunities, and civic engagement programs. Of note, among the permanent exhibitions curated by the Singaporean government, the "Smart Nations" exhibition stands as a prominent example. This report will delve into the diverse strategies employed by Singapore to enhance citizen engagement and participation in the ongoing digitalization of urban environments, with a particular focus on the "Smart Nations" exhibition. The Smart Nation Builder (Figure 4.5) is an exhibition with interactive games that educate the public about Singapore's tech initiatives and digital government services. It's also a platform for citizens to share feedback and ideas for product and service enhancements (Smart Nation) (Figure 4.6).

Smart Nation Builder	Who is it for: Everyone. Families welcome
Project Pensive: Detecting Dementia early	Project Pensive, from Singapore's Ministry of Health, uses AI to detect dementia risk in seniors through a 10-minute digital drawing analysis.
Keeping your Singpass account secure	Learning practical tips to protect your personal information and navigate the digital landscape with confidence.
Ageing well at the Smart City Technology Booth	Find out how Singapore is using tech solutions to ensure our elderly (and our future elderly – present company included) can live independently in their silver years.
Avoid taking the bait as a phishing victim	You can gain valuable insights into identifying and preventing phishing attempts, equipping yourself with essential skills to stay safe online.
Fun for the whole family	you can test your luck and win exclusive Smart Nation swag using the points collected from the game stations.
Calling all problem solvers	Sign up to be part of Tech Kaki, and actively contribute to improving our government digital products and services.

Figure 4.5. *The services provided to citizens by the 'Smart Nation builder' project at roving exhibition. Source: (https://www.tech.gov.sg/media/technews/look-forward-to-fresh-new-experiences-at-smart-nation-builder)*

Figure 4.6. *Fostering Citizen Engagement and Innovation Through the 'Smart Nation Builder',*

Source: (https://www.tech.gov.sg/products-and-services/smart-nation-showcases/)

Smart Nation Showcases: The Smart Nation Showcases (Figure 4.7) are a series of exhibitions that provide a comprehensive overview of Singapore's Smart Nation initiatives, each with its unique focus and approach to engaging the public (Smart Nation).

Figure 4.7. *Overview of Singapore's Smart Nation Showcases, Source: (https://www.tech.gov.sg/products-and-services/smart-nation-showcases/)*

4.2.2. Singapore's Garden Management System (GMS) - Digitalizing Public Parks

In the park management system, Singapore uses digital technologies for monitoring, maintenance, irrigation and transportation (Figure 4.8).

Jurong Lake Gardens has implemented an integrated Garden Management System (GMS) covering its extensive 90-hectare landscape. The GMS centralizes monitoring and control, integrating various environmental and facility sensors. This pioneering system allows staff to remotely monitor park operations, from building equipment to transportation, providing real-time oversight. Notably, the GMS contributes to sustainability by making data-driven decisions on irrigation, monitoring resource usage, and alerting staff to potential leaks. This innovative approach marks a significant advancement in park management, offering efficiency and sustainability benefits (Source: https://www.jld.gov.sg/events-and-resources/places/smartjlg).

Figure 4.8. *A close-up of one of the Interactive Kiosks. Source: https://www.nparks.gov.sg/juronglakegardens/who-we-are/jurong-lake-gardens*

4.2.3. Smart Lighting (Agil, LaaP)

LaaP (Lamppost-as-a-Platform) employs environmental sensors to gather specific local data related to factors such as temperature, humidity, gas concentration, air quality, and rainfall. This data, pertaining to the immediate environment, equips agencies with valuable insights for the design of improved living and work environments, considering

critical environmental parameters, thereby fostering advancements in public health and environmental sustainability.

Image 4.1. *Smart lampposts fitted with different sensors, Source: https://www.bivocom.com/solutions/smart-pole*

Singapore city has harnessed the potential of its streetlight poles (Image 4.1), which are a common sight throughout the urban landscape, not only providing illumination but also contributing to the city's aesthetic appeal. In the context of Singapore's smart city initiatives, these streetlight poles have been reimagined as Smart Poles, serving as essential components of the city's digital infrastructure. By integrating advanced technologies like 5G/4G, IoT, AI, and big data, Singapore's Smart Poles offer modular and scalable solutions, enabling diverse applications for the city's smart initiatives. These systems can be managed individually or integrated into a unified management framework, allowing Singapore to efficiently realize its vision of a smarter and more sustainable city. Smart Poles in Singapore play a crucial role in enhancing safety, energy efficiency, and the city's readiness for future growth and development (Figure 4.9).

Smart Poles (Figure 4.10) in Singapore play a crucial role in enhancing safety, energy efficiency, and the city's readiness for future growth and development, underscoring their significance in the construction of a smart city. Below (Table 4.1) are some of the key systems that have been installed on today's Smart Poles in Singapore to support the city's digitalized urban development.

Table 4.1. *Key Systems Integrated into Smart Pole Infrastructure for Smart Cities, Source: (https://www.bivocom.com/solutions/smart-pole)*

System	Functions and Applications
1. Intelligent Street Light	-Remote LED light control
	-Automatic light adjustment
2. Environment Monitor	-Weather information
	-Air quality
	-Noise
3. Video Surveillance	-Security monitor
	-Face ID recognition
4. Emergency Call	-SOS button
	-Video and audio intercom
5. Small Cell	-WIFI hot spot
	-5G base station
6. Smart Traffic Light	-Traffic flow monitor
	-Traffic management
7. Led Display	-Advertisement
	-Political news
	-Information delivery
8. Water Level Monitor	-City lake or river
	-Tunnel
9. Public Broadcast	-Audio broadcasting
10. Ev Charger	-Electronic vehicle charging

Item	Modular System Description	Smart Pole IoT Platform Function	Specification	Picture
1.IoT Edge Gateway	Connect, communicate and control all modular system	1. Establish a reliable and stable connectivitiy between field sensor and equipment 2. Covert the field data to certain protocols and transfer over 5G/4G/Fiber/Ethernet cables	1.5G/4G+Fiber cable redundancy, Dual SIM 2.Gigabit, PoE, RS232, RS485, DI, DO, ADC, GPS, WiFi (Please refer to data sheet)	
2. LED Single Lighting Controller	1. Remote control the LED light on and off 2. Automatical adjust the lighting	1. Remote control single and group light on, off, dimming 2. Energy usage data collection: voltage, current power 3. Light failure alarm, historical data records, etc.	1. IP67 protection 2. Communication port and protocol: RS485, Modbus RTU 3. Dimension: 175.5mm ×56mm ×41mm 4. Working Temperature: -40 °C~ +70°C	
3. IP Camera	1.Smart pole surrounding video surveillance, 2.hostorical video checking	1. Real-time video viewing, split-screen preview, PTZ control, variable zoom, preset point setting; 2. Video playback	1. 2 Mega pixel resolution 2. RJ45 Ethernet port 3. Movement Range (Pan) : 0-360°; Movement Range (Tilt): 0-90° 4. Dimension: :Φ179.4×239.5mm	
4. Environment Sensors	Surrounding environment monitor: temperature, humidity, air pressure, wind speed, wind direction, noise, PM2.5, PM10, CO	1. Configure monitoring factors and alarm settings 2. View the real-time data of the surrounding environment monitoring, historical data, threshold alarm records, etc.	1. IP Rating: IP65 2. Communication port and protocol: RS485, Modbus RTU 3. Dimension: Inner diameter: 49.8mm，Outer diameter: 70mm	
5. Digital Signage	1. Information release, advertisement(text, video, picture all support) 2. Environment data display	1. Configure parameters of the screen 2. Remotely manage the content of the screen 3. Schedule the time to publish content, turn on or off the screen, etc.	1.Housing: fully cast aluminum structure 2.Overall size: 502mm*706mm*95mm 3.Display size: 400mm*600mm 4.Resolution: 168*252 5.Brightness: >=7000CD/m2 6.Viewing distance: >=3 meters	
6. Public Address Loudspeaker	Real-time broadcast, or timing audio play	1. Manage the audio contents 2. Setting time of audio play	1. Built-in power amplifier, output power: 40W, sound quality reaches CD level 2. RJ45 10/100M network interface 3. Volume can be adjusted remotely 4. Built-in 4 inch bass *3+ tweeter unit 5. Dimension: 100×493×152mm	
7. Emergency Call System	SOS button, video and audio intercom	1. Preview alarm monitoring 2. View alarm records	1. 2 mega pixel video capture, support infrared light 2. Audio intercom, broadcast 3. Dual Ethernet ports 4. Dimension(mm): 518*128*58(LxWxH)	
8. WiFi Hot Spot	Share WiFi hotspot	Access point configuration and management	1. IP68 protection 2. Dual band 2.4G/5G WIFI, supports 802.11 a/b/g/n/ac 3. Up to 128 users 4. POE power supply module 5. 4 External N-type interfaces 6. Dimension: 216mm x216mm x 67(L×W×H)	

Figure 4.9. *The functions and applications of Smart Pole systems in smart cities*

Source: https://www.bivocom.com/solutions/smart-pole

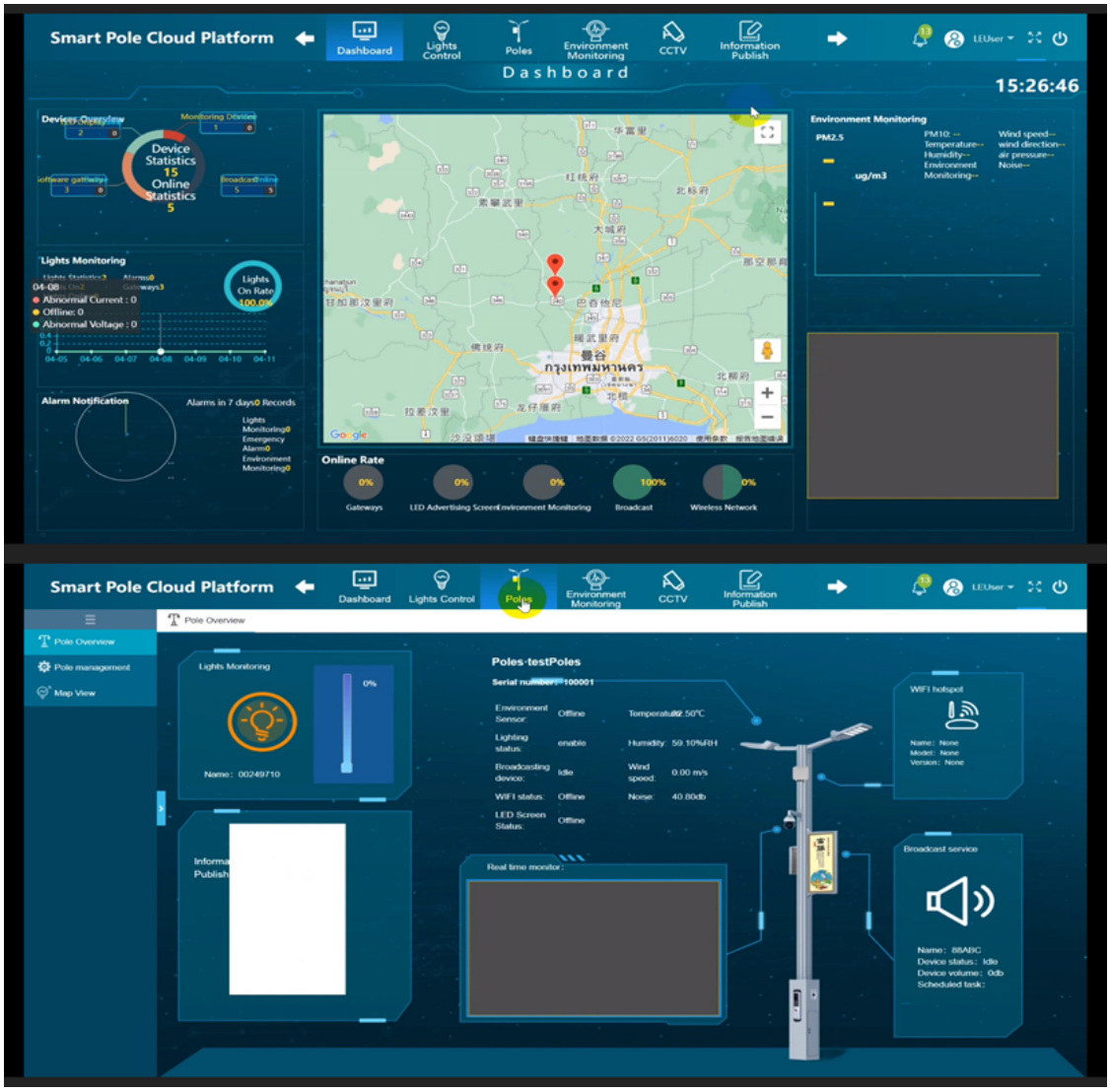


Figure 4.10. *The functions and applications of Smart Pole systems in smart cities*

Source: https://www.bivocom.com/solutions/smart-pole

4.2.4. The AGIL Smart Waste Monitoring Solution: Transforming Waste Management with IoT and Data-Driven Insights

The AGIL Smart Waste Monitoring Solution stands as a testament to innovation, harnessing cutting-edge technology, Internet of Things (IoT) capabilities, analytics, and intelligent sensors to revolutionize waste management. This sophisticated system empowers operators to optimize their route planning, track bin statuses and waste collection progress in real-time, and bolster their operations with data-driven insights. At its core, this versatile solution offers a unified dashboard and centralized management system, accommodating a range of network connectivity options and seamlessly integrating with diverse waste detection and monitoring sensors, independent of vendors,

all within a common IoT platform. Furthermore, the solution extends its functionality through a user-friendly mobile app (Figure 4.11), enabling real-time job and route guidance for mobile cleaning teams and facilitating instantaneous updates on task completion, fostering efficiency and transparency in waste collection processes (Figure 4.12).

Figure 4.11. *Smart Waste Management Solution, Source: https://www.stengg.com/en/smart-city/urban-solutions/smart-utilities-and-infrastructure/smart-waste-monitoring/*

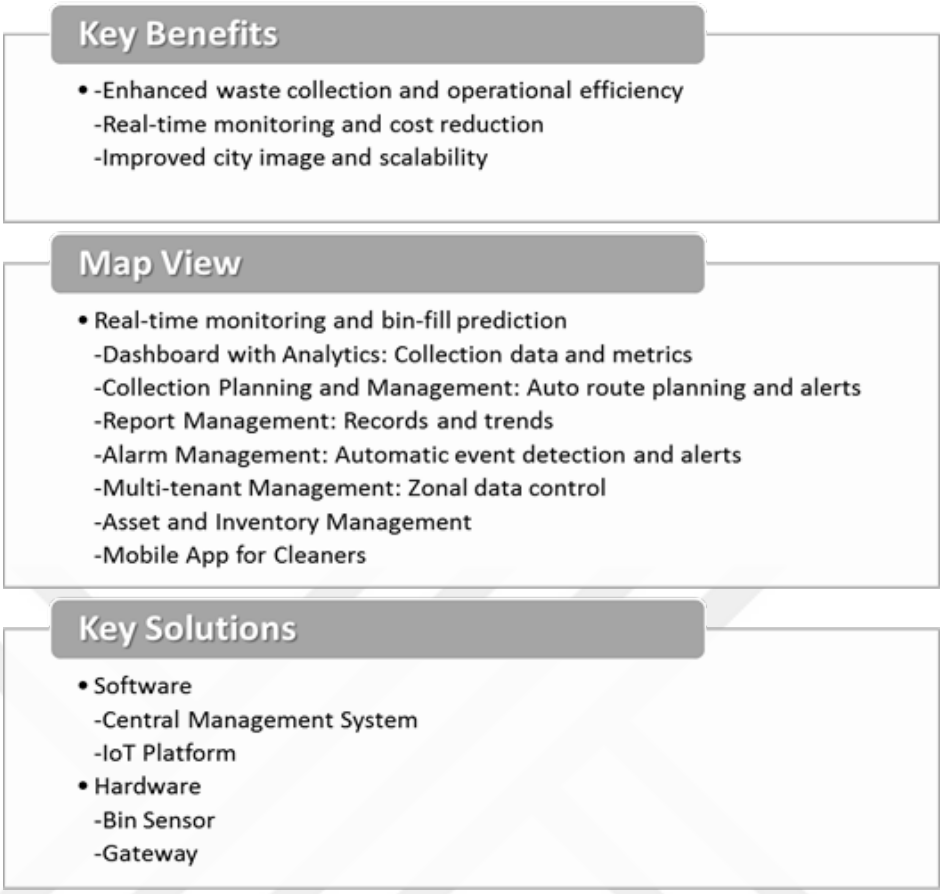


Figure 4.12. *Smart Waste Management Solution, Source: https://www.stengg.com/en/smart-city/urban-solutions/smart-utilities-and-infrastructure/smart-waste-monitoring/*

To conclude on the impacts of the examined projects in this section, user experiences with these projects, design principles, technological solutions, and stakeholder collaborations, the following table has been arranged (Figure 4.13):

Project	Impact	User Experiences (Ux)	Design Principles	Technological Solutions	Stakeholder Collaborations
1- Exhibition	-Increased public engagement -Enhanced civic education -Promotion of innovation -Fostering digital inclusivity -Gathering feedback -Community building	-Accessible Information -Interactivity: Visitors engage with hands-on displays to understand technology. Visitors interact and provide feedback. -Tech Showcases: Innovative projects on display, like smart city solutions.	-Clarity and Accessibility: Prioritize clear and accessible content for all visitors (regardless of their background or level of familiarity with technology). -Engagement: Engaging visitors with interactive displays and multimedia. -User-Centric Design: Making complex concepts relatable to a broad audience. -Storytelling: Using design to convey the initiative's narrative and impact. -Accessibility: Ensuring inclusivity, even for individuals with disabilities.	-AR/VR Experiences: Exploring projects in virtual or augmented reality. -Data Visualization: Real-time data showcases Smart Nation impacts. -Smart City Simulations: Offer a comprehensive view of urban initiatives. -Info Kiosks: Providing project and service details. -AI Chatbots: Answering questions conversationally.	-Government Agencies: such as the Infocomm Media Development Authority (IMDA) and the Smart Nation and Digital Government Office (SNDGO). -Local Businesses: Including tech companies. -NGOs: Focusing on technology and community development. -Community Groups: Ensuring alignment with community needs. -Experts: Providing insights and presentations. -Sponsors: Offering funding and support.
2- Garden Management System (Gms)	-Expected cost savings of $2.3 million a year. -Productivity improvement with savings of about 14,700 man-days. -Reduced reliance on foreign labor through automation. -Enhanced visitor experience	-The goal of Smart Gardens is to improve the overall park experience for visitors. -Smart Gardens aims to streamline processes and improve service quality.	-Implementation of digital tech in plant, irrigation, lake, security, lighting, and facilities. -Employing autonomous drones for inspections. -Creating a central security control center. -Utilizing AI and ML for data-driven improvements.	-Smart Lampposts for Lighting -Autonomous Drones -Automated People Counting Sensors: -Placing sensors at entrances for crowd management -Centralized Command and Control Center	-Government Authorities -Municipal Authorities -Technology Providers -Environmental and Conservation Organizations -Educational and Research Institutions
3- Smart Lighting (Agil, LaaP)	-Optimize cost saving -Remote control and monitoring -Optimize resources with data analytics -Increase efficiency and productively	-Enhancing the legibility of public spaces -Making the street safer - Increasing the attractiveness	-Ease of Installation -Regular Checks & Periodic Servicing -Real-time Status Alerts -Remote Access Lower Maintenance & Labour Costs	-Centralized control -Wireless mesh communication network -Data analytics	-Government Authorities -Technology Providers: -Residents and Local Communities -Energy Providers -Innovative Technology Companies
4- Smart Waste (Agil)	-Reduce operational costs -Reduce carbon footprint -Improve city image with better managed waste collection	-Convenience -Reduced Environmental Impact -Cleaner and Healthier Environment	-Sustainability -Cost Optimization -Sensor integration -Predictive Maintenance	-Flexible deployment to support multi-device providers -Future-ready and scalable platform to support smart city applications -Map view	-Municipalities and Town Councils -Technology Providers -Environmental and Sustainability Groups -Transportation and Logistics Providers -Waste Collection and Disposal Contractors

Figure 4.1. *Digital initiatives project in Singapore's urban environment, Source: Author*

Additionally, an overview of the objectives for implementing these projects in public spaces is summarized as follows (Figure 4.14). Based on these specified objectives for each examined project, a proposed model will be presented at the end of the thesis.

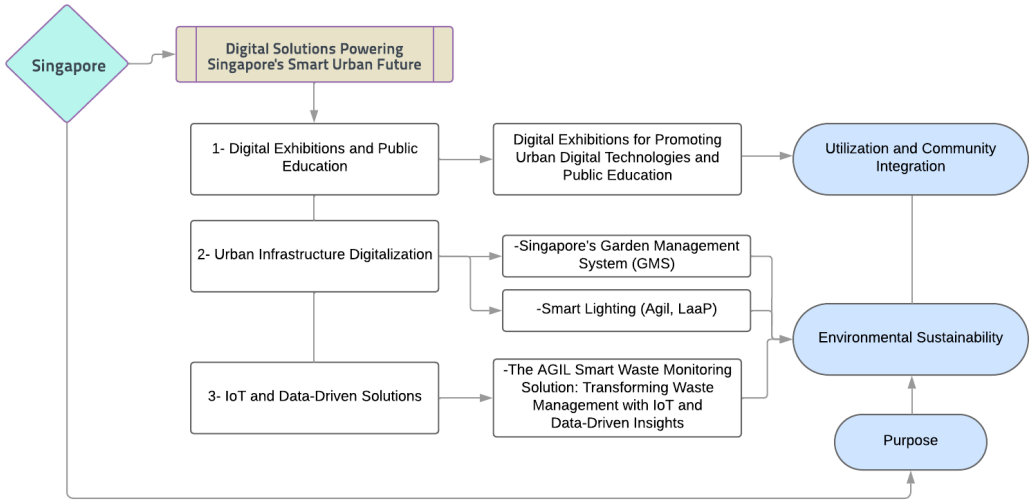


Figure 4.14. *Digital Solutions Powering Singapore's Smart Urban Future, Source: Author.*

4.3. Case Study 2: Barcelona

In 2011, Barcelona City Council (Figure 4.15) launched a new IT strategy as part of a comprehensive transformation plan. This initiative aimed to creatively combine new technologies to improve the city's performance and overall management, with the dual goals of stimulating economic growth and improving the well-being of city residents. This strategy was in line with the objectives set out in Horizon 2020, the EU's strategy to reform the growth model over the next decade by strengthening sustainability, smartness and inclusiveness in development. The Barcelona strategy also addresses the city's unique challenges in terms of internal organization, citizen participation, cooperation with private companies and coordination with local government (Ferrer, 2017).

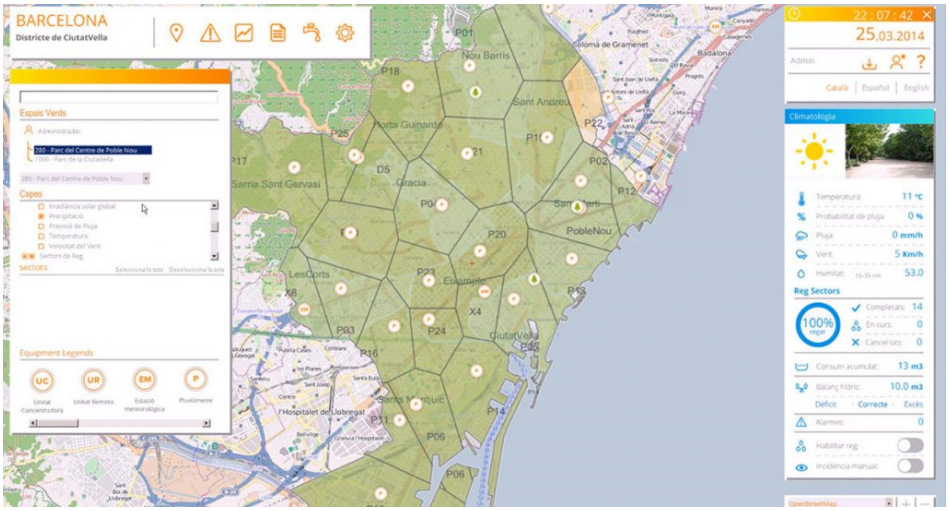


Figure 4.15. *Barcelona smart city, Source: AVEVA-Wonderware System Platform*

4.3.1. Barcelona's Smart City Vision and Strategy

In Barcelona, the transformative urban landscape is driving the comprehensive development of a smart city. This forward-looking strategy is based on a holistic approach that takes into account every aspect and corner of the city. At its core are 22 different programs covering a range of initiatives, projects and strategies, each aimed at addressing different urban challenges. What distinguishes Barcelona's approach is its commitment to the participation of all stakeholders: the public sector, private companies and, above all, the citizens themselves. This inclusive model, with its emphasis on collaboration and innovation, supports Barcelona's digital transformation and makes it a blueprint for future smart cities (Ferrer, 2017) (Figure 4.16).

Figure 4.2. *Barcelona Smart City's 22 programs, Source: (Ferrer, 2017)*

4.3.2. Barcelona's Digital City Strategy: Seizing the Information Revolution

The idea of the "smart city" is not a temporary trend, but rather a manifestation of the information revolution initiated by the Internet. This revolution goes beyond technology and focuses on how Internet-based technologies can be used to redesign cities holistically, economically, socially, culturally and politically. Twenty-first century technology provides a unique opportunity to build equitable and sustainable cities where innovation supports economic growth and resource efficiency. But it's not just about technology. This is a strategic and political effort. Barcelona recognized this potential and took a holistic approach, using the internet and technology to transform logistical and energy elements into public spaces, housing and more. Barcelona's vision embodies the transformative power of digital cities (Ferrer, 2017).

This study examines some of the programs mentioned above and examines how the city of Barcelona is using technology to improve the quality of urban life in digital public spaces.

4.3.3. Bicing Bike Sharing

Barcelona has a popular bike-sharing program called Bicing, (Figure 4.3) exclusively designed for the residents of the city. Bicing has steadily grown, boasting more than 500 docking stations housing around 7,000 operational bicycles to serve approximately 130,000 users (for more details, visit http://bicing.barcelona) (Bustamante et al., 2022).

Features of the Bicing bike-sharing service in Barcelona:

Providing 24/7 Service: Bicing offers around-the-clock bike-sharing.

Expanding the Fleet: Users can choose from 4,000 mechanicals and 3,000 electric bikes.

Offering Bike Options: Users have the flexibility to select either electric or mechanical bikes.

Extending the Station Network: Access is available at 519 mixed stations.

Ensuring User-Friendly Access: Easy access is facilitated through smart cards, the Smou app, or NFC-enabled smartphones.

Implementing Flexible Pricing: Options cater to both regular and occasional users.

Promoting Sustainability: The fleet includes eco-friendly vehicles for bike distribution.

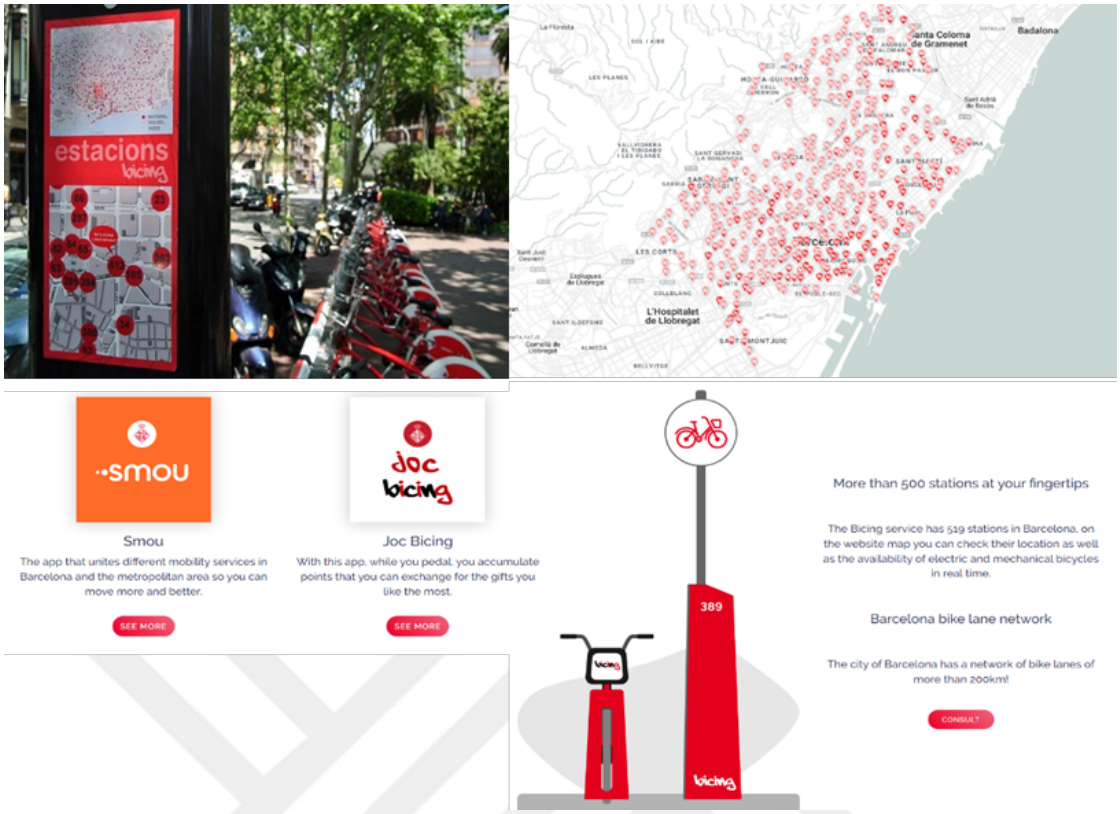


Figure 4.4. *Bicing bike-sharing service in Barcelona. Source: https://bicing.barcelona/mapa-de-disponibilitat*

4.3.4. Smart Bins (cuidembarcelona) - Digitalizing Urban Waste Management

Urban waste management is undergoing a significant transformation as cities worldwide embrace digitalization to optimize resource allocation and reduce environmental impact. The smart waste management market's remarkable growth, valued at $1.41 billion in 2018 and projected to exceed $5.19 billion by 2025, highlights the increasing interest in smart city initiatives. This digital revolution transcends technology, focusing on data-driven insights that streamline waste collection and resource allocation efficiently. IoT devices, equipped with predictive analytics and machine learning, empower cities to enhance waste management operations. In this context, Barcelona serves as a compelling case study. Barcelona's digitalization efforts have prioritized waste management, ensuring efficient service provision and worker safety. They have adopted IoT solutions for real-time data updates and agile, data-driven decision-making. This approach optimizes garbage pickup activities, reduces fuel consumption, and enhances route efficiency, resulting in an eco-friendly and cost-effective waste management process. The Barcelona case study exemplifies the benefits of embracing digitalization in

urban waste management, setting the stage for intelligent, sustainable, and efficient waste management practices in cities worldwide (Haugaard, 2018) (Table 4.2).

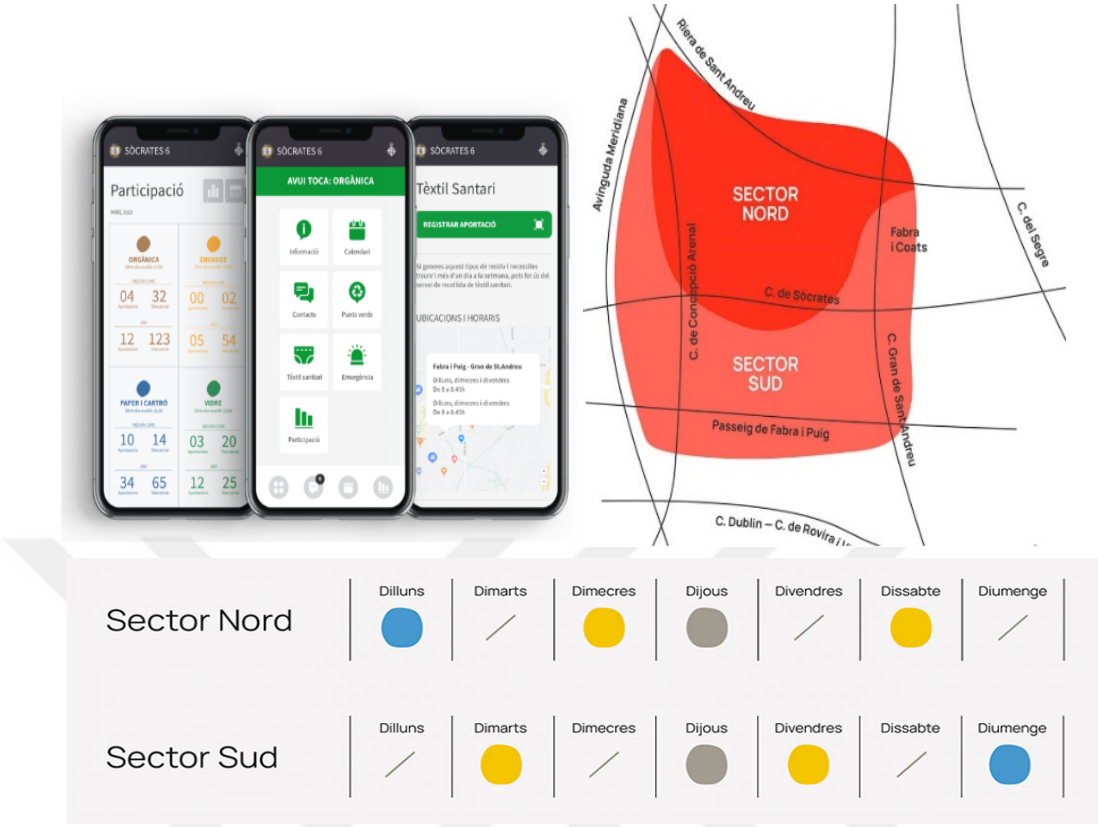
Smart Waste Management and Increasing Adoption of IoT Solutions

In the digitalization of public spaces, advanced tech like AI, machine learning, and IoT has revolutionized waste management. It monitors workloads, uncovers inefficiencies, and offers real-time data to optimize container placement and routes. This boosts efficiency, cuts costs, and reduces the environmental impact in our digitalized public areas (Haugaard, 2018) (Figure 4.18).

Sant Andreu de Palomar

In the era of digital transformation in public spaces, Sant Andreu de Palomar introduces a groundbreaking waste collection system. This progressive model includes door-to-door collection for most waste types, which have specific collection methods. The neighborhood operates with two distinct collection calendars and offers a user-friendly web app for residents to access information and track their participation. Supported by funding from the European Union and the Spanish government, this initiative aligns with Barcelona's digital strategy to combat climate change and enhance recycling efforts. Additional services, such as more frequent commercial collections, an emergency vehicle, and a dedicated support office, contribute to greater transparency and collective responsibility in waste management, promising a more efficient and sustainable future for public spaces in Sant Andreu de Palomar (Figure 4.19).

Figure 4.5. *Revolutionizing Waste Management with IoT: Smart Bin Sensors by WoMaster, Source: https://trends.directindustry.com/womaster/project-192288-1116255.html*



Each organics bin, recyclables, and waste bags come with a unique code. It's important to emphasize that this code is exclusively used for statistical purposes and does not involve the collection of any personal data from citizens. During the waste collection process, the code is scanned and logged, serving as a means to track and record participation.

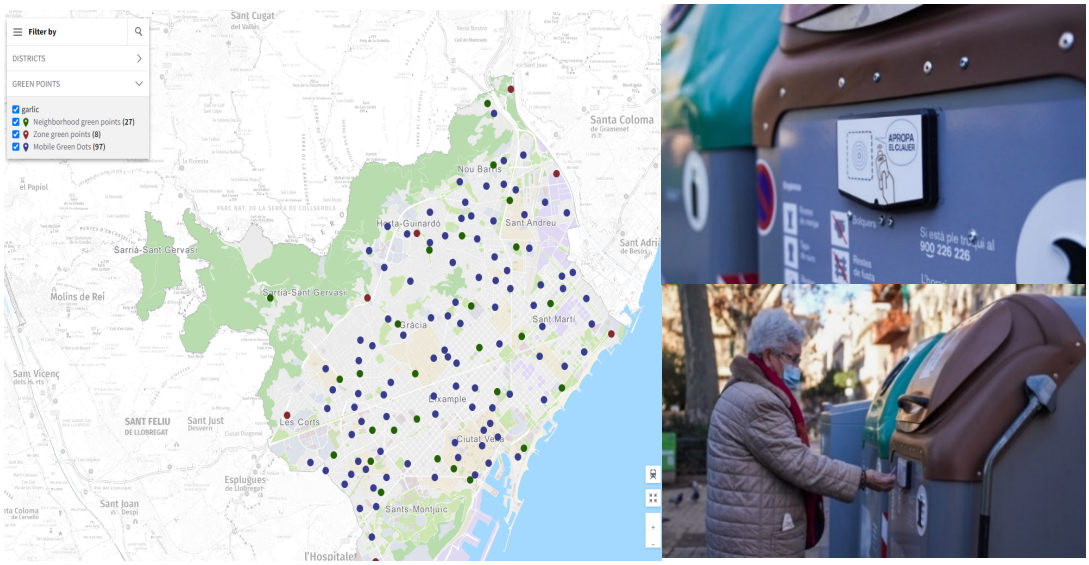


Figure 4.19. *Digitalizing Waste Collection: Sant Andreu de Palomar Smart Solution, Source: https://barcelonaportaaporta.wcity.app/*

Table 4.2. *Digitalizing Waste Collection: Smart Containers in Sant Andreu del Palomar, Source: https://www.barcelona.cat/infobarcelona/en/tema/environment-and-sustainability/smart-recycling-deposits-and-waste-containers-for-selective-waste-collection-in-*

Digitalization Initiatives in Waste Management
1. Flexible Waste Collection
- Proposals aim to enhance organic waste collection through digital solutions.
2. Smart Recycling Containers
- Fifteen smart containers are replacing traditional bins, marking a shift towards digital waste collection.
3. Digital Recycling Deposits
- Introduction of 48 digital recycling deposits for streamlined waste separation.
4. Digital Incentives
- A 30% tax discount, tracked digitally, encourages responsible organic waste disposal.
5. Eco-Friendly Collection
- Noise reduction and eco-friendly transportation through natural gas and electric vehicles.
6. Interactive Information Hub
- An information point equipped with digital tools like key fobs and a website for public education, promoting sustainability and engagement.

4.3.5. Smart Parking (urbiotica, Fiwoo)

Smart Parking Solutions Transform public urban spaces: Smart parking solutions offered by companies like Urbiotica and FIWOO represent a significant advancement in the digitalization of public spaces. Urbiotica's intelligent sensor systems and FIWOO's real-time management platform have revolutionized the way cities manage their parking infrastructure. These technologies make parking more efficient by providing real-time data on available spaces, reducing the time and stress associated with finding parking spots. This not only enhances the convenience for drivers but also reduces traffic congestion, leading to greener and more accessible cities. By leveraging smart parking innovations, cities can optimize their resources, decrease pollution, and improve the overall urban experience for residents and visitors (www.fiwoo.eu) (Figure 4.20).

Figure 4.20. *Smart Parking Solutions Transform public urban spaces, Source: www.fiwoo.eu*

4.3.6. Digital Citizen Engagement (Decidim)

Decidim (Figure 4.22), the digital platform for citizen participation, is a powerful tool designed to foster participatory democracy at all levels, embracing open-source principles and dedicated to promoting democratic engagement. Conceived in collaboration with Barcelona City Council and the Decidim community in 2016, it has found adoption not only in Catalonia but also globally, with over 400 active instances and implementations in 20 countries. Notable adopters include the governments of Mexico City, Helsinki, New York, Kakogawa (Japan), and the National Assembly of France. It

earned recognition from the European Commission as one of Europe's most innovative open-source projects in 2019. Decidim's success is underpinned by its modularity, accommodating a wide array of participants and enabling tailored participatory processes. The platform's features, ranging from proposal formulation to voting and result publication, ensure a comprehensive participatory experience. An open governance model, facilitated by its community-driven structure, supports its continuous enrichment and adaptability. Decidim stands as a testament to the power of open-source collaboration in shaping participatory democracy in the digital age, with a commitment to transparency, inclusivity, and responsive governance at its core (Figure 4.21, Table 4.3) .

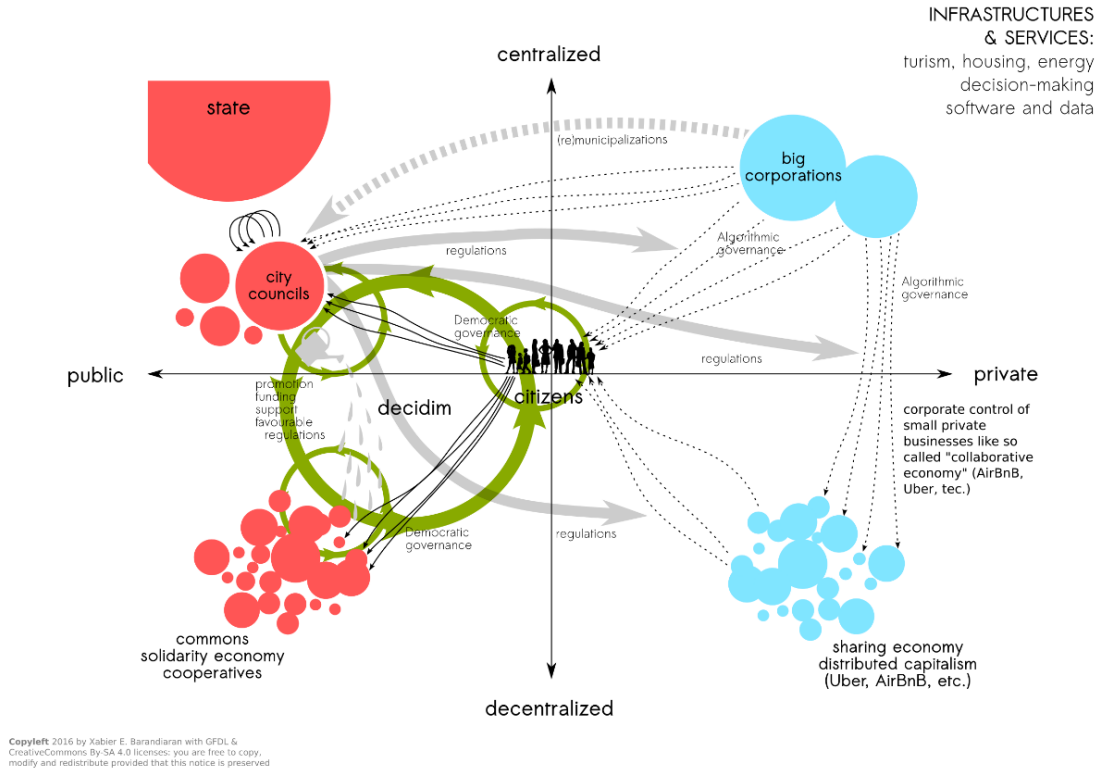


Figure 4.21. *what is Decidim, Source: https://xabier.barandiaran.net/2018/04/24/what-is-decidim/*

Table 4.3. *Overview of Decidim, Source: https://xabier.barandiaran.net/2018/04/24/what-is-decidim/*

Title	Description
Definition	Decidim, a collaborative, open-source digital platform, empowers participatory democracy by connecting traditional meetings with online engagement.
Platform Features and Functional Architecture	Decidim offers a range of components for creating different types of participatory spaces, allowing organizations to design custom democratic systems.

Table 4.4. *(Continued) Overview of Decidim, Source: https://xabier.barandiaran.net/2018/04/24/what-is-decidim/*

The Social Contract	Decidim adheres to a social contract that emphasizes principles like free software, transparency, equal opportunities, and democratic quality.
Instances	Decidim serves public institutions, cooperatives, associations, and more, fostering sustainability and collaboration through multiple instances.
A Sustainable Ecosystem	The project relies on a sustainable ecosystem of collaborating entities and open-source code on GitHub.
Democracy and Social Empowerment	Decidim empowers social processes and provides an alternative to private platforms, emphasizing common, open, and democratic values.
The Political, The Technical, and The Techno political	Decidim encompasses political, techno political, and technical dimensions, impacting local governance, architectural design, and overall success.

Figure 4.22. *Decidim platform, Source: https://www.decidim.barcelona/15*

To summarize the impacts of the projects reviewed in this section, including user experiences, design principles, technological solutions, and stakeholder collaborations, the following table (Figure 4.23) has been created:

Project	Impact	User Experiences (UX)	Design Principles	Technological Solutions	Engagement Strategies	Stakeholder Collaborations	Application
1- Bicing Bike Sharing	-Reduced Traffic Congestion -Environmental Benefits -Improved Public Health -Reduction in Parking Demand -Economic Benefits -Reduction in Noise Pollution -Social Equity	-Convenience -Easy Registration -Availability of Bikes -Navigation Assistance -User Support -Feedback and Ratings	-User-Centric Design -Intuitive User Interface (UI) -Map Integration -Real-Time Updates -Bike Reservation -Payment and Billing -Accessibility -Multi-Language Support -Feedback Mechanisms -Security and Privacy	-Payment Gateways -QR Code Scanning -Multi-Language Support -User Analytics	-Educational Content -Gamification -Community Building -Localized Content -Feedback Channels	-Ajuntament de Barcelona -Autoritat del Transport Metropolità, ATM	https://www.bicing.barcelona/es/mapa-de-disponibilidad
2- Smart Bins (cuidembarcelona)	-Reduced Carbon Emissions -Cleaner and More Attractive Urban Environment -Improved Public Health -Sustainability and Environmental Goals	-Reduced Odors and Pests -Cleaner Environment -Convenience (provide a more convenient waste disposal experience)	-Remote Management -improve waste management -Durability -User-Friendly Interface -Sustainability	-Fill-Level Sensors -Wireless Connectivity -RFID Tags -Mobile Apps	-Public Awareness -Recycling Promotion -Community Engagement	-Ajuntament de Barcelona -Waste Management Companies -Transportation and Logistics Providers	https://barcelonaportaaporta.wcity.app/ https://www.barcelona.cat/cuidembarcelona/en/reciclar
3- Smart Parking (urbiotica, Fiwoo)	-Reduced Traffic Congestion -Lower Emissions -Time Savings -Reduced Illegal Parking -Reduced Fuel Costs	-Easy Reservation -Convenient Payment -Digital Wayfinding -Navigation Assistance -Real-Time Information	-user-friendly -Efficient Space Utilization -User-Centric Design -Real-Time Data	-Real-Time Sensors -Wireless Communication -License Plate Recognition (LPR) -Security Cameras (to enhance safety and security for users)	-Mobile Apps and Digital Platforms -Environmental Initiatives (electric vehicle charging stations)	-Ajuntament de Barcelona -Parking Operators -Technology Providers -Mobile App Developers	https://urbiotica.com/ https://barcelona.wesmartpark.com/es
4- Decidim Citizen Engagement	-Enhance Decision-Making -Promote Participatory Democracy -Increase Transparency -Support Local Initiatives	-Accessibility (disability) -Voting and Decision-Making -Feedback Mechanisms -Privacy and Data Security -Information Sharing	-User-Centric -Flexibility (to be flexible and adaptable for different communities or organization) -Inclusivity	-Proposal Submission Tools -Discussion Forums -Openness -Customization for needs	-User-Friendly Interface -Community Building (build a sense of community and collaboration among users) -Education and Outreach -Community Moderation	-Ajuntament de Barcelona -Civic Tech Developers -Local Government Authorities	https://www.decidim.barcelona/

Figure 4.6. *Digital Initiatives project in Barcelona's Urban Environment, Source: Author*

Furthermore, the objectives behind implementing these projects in public spaces are summarized as follows (Figure 4.24).

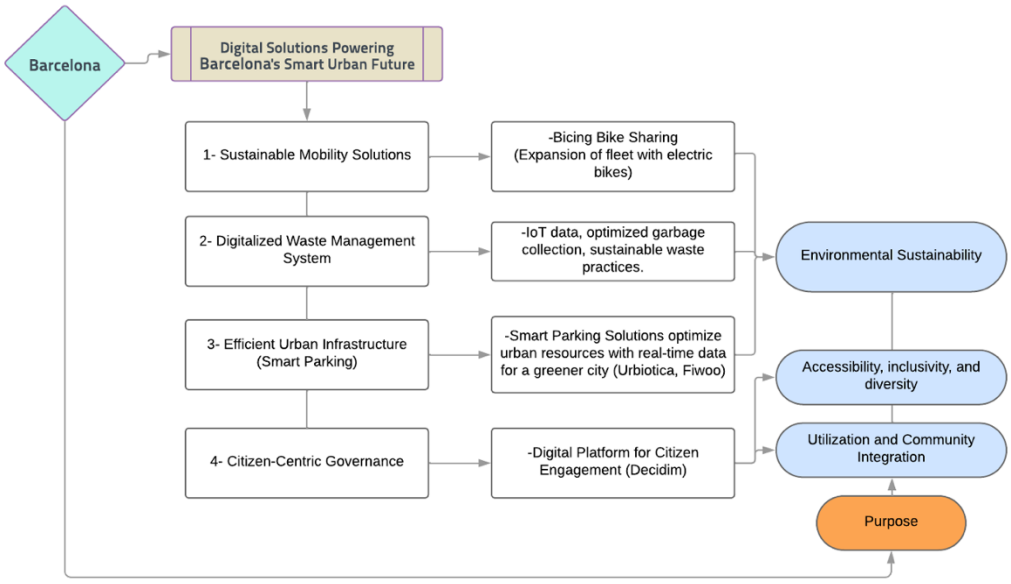


Figure 4.24. *Digital Solutions Powering Barcelona 's Smart Urban Future, Source: Author.*

4.4. Case Study 3: Tokyo

With the implementation of the smart city, which is a combination of physical and digital cities, there is a change in the decision-making process using real-time data, which leads to various changes that can be considered the characteristics of a smart city. The value of the city will increase dramatically through the results created as a result of these changes. On Tokyo's path to becoming a smart city, digital public spaces serve as critical online hubs that connect residents to information, services, and social engagement. These platforms streamline government transactions, enable civic engagement, and promote city transparency while supporting robust cyber security measures. Tokyo ensures inclusiveness, bridges the digital divide and seamlessly integrates these digital spaces into its broader smart city vision, thus creating a dynamic, interconnected and secure urban environment where the world digital and physical converge, facilitates (Figure 4.25).

Figure 4.25. *3D Tokyo, Source: OpenStreetMap*

4.4.1. Tokyo's Dominance in Smart Infrastructure

In terms of smart infrastructure, Tokyo is the undisputed winner. It has the largest number of train stations and the longest operating hours, the second (relatively) longest railway line (after Osaka), the highest public transport use, and private spending (percentage) on communication and transport. is the highest. Second lowest level (after Kyoto). Tokyo has an impressive knowledge infrastructure. It is a vibrant city as a center for intellectual and innovative activities. Tokyo is trying to become a smart energy city. The Tokyo Metropolitan Government Strategy, introduced in 2012, emphasizes energy efficiency, low-carbon resources, and smart energy management (Fietkiewicz & Stock, 2015). The Tokyo Metropolitan Government is committed to realizing the "Smart Tokyo" vision of convenience and improving the quality of life through the integration of advanced technologies. The main goal of this project is the rapid development of innovative services that increase the level of comfort and well-being for Tokyo residents. To achieve this goal, the government is promoting joint partnerships with startups and other dynamic stakeholders, known for their creativity and agility, in various regions. By uniting these entities, the goal is to harness their collective potential to deliver cutting-edge solutions and initiatives that meet the growing needs of city residents.

4.4.2. Georeferenced, Real-Time Spatial Soundscape Platform

A new innovation has emerged using digital tools to enhance and develop public spaces with an auditory perspective. This innovation provides a better understanding of the acoustic environments and urban landscapes. It leverages technology to create a more immersive and informative experience, offering a unique way to interact with and

appreciate the auditory aspects of public spaces. This can have applications in urban planning, art installations, environmental monitoring, and more, enriching the way we engage with and design public areas (Image 4.2, Image 4.3, Image 4.4).

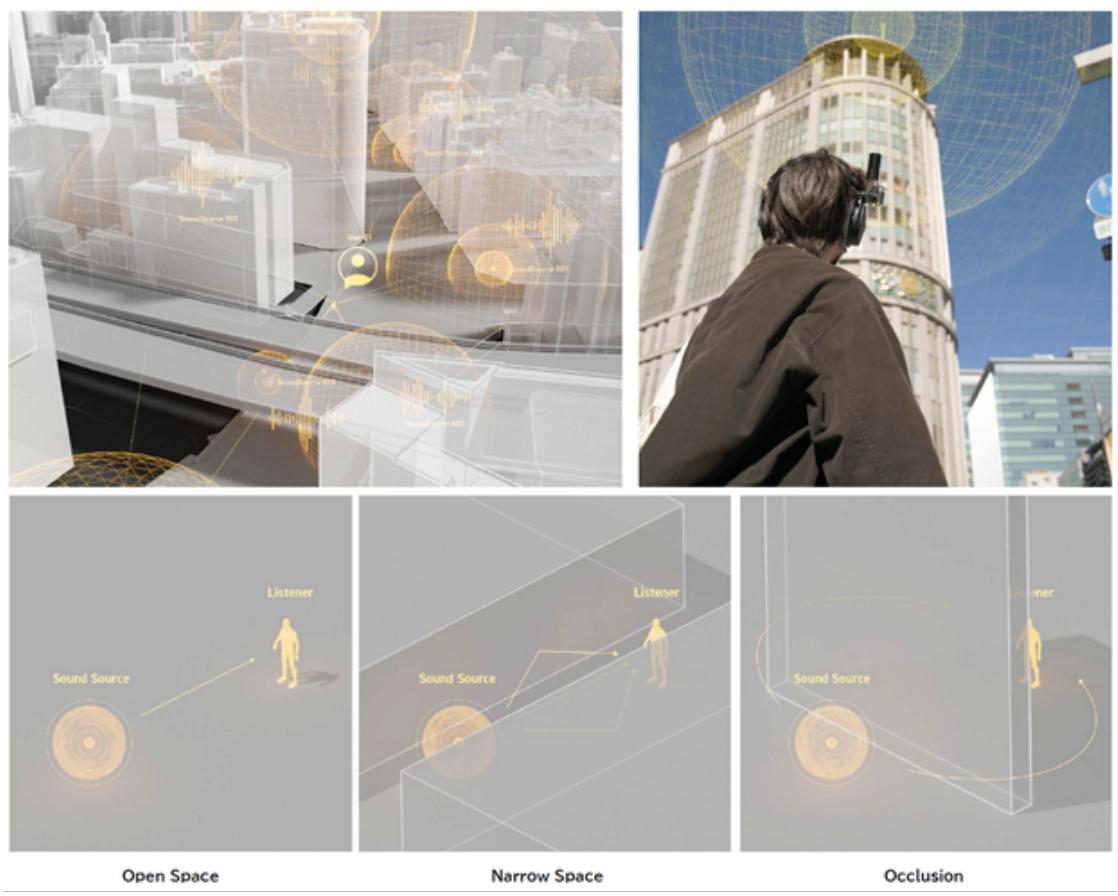


Image 4.2. *Soundscape platform, Source: www.mlit.go.jp*

Image 4.3. *Soundscape platform, outdoor position,*

Source: www.mlit.go.jp

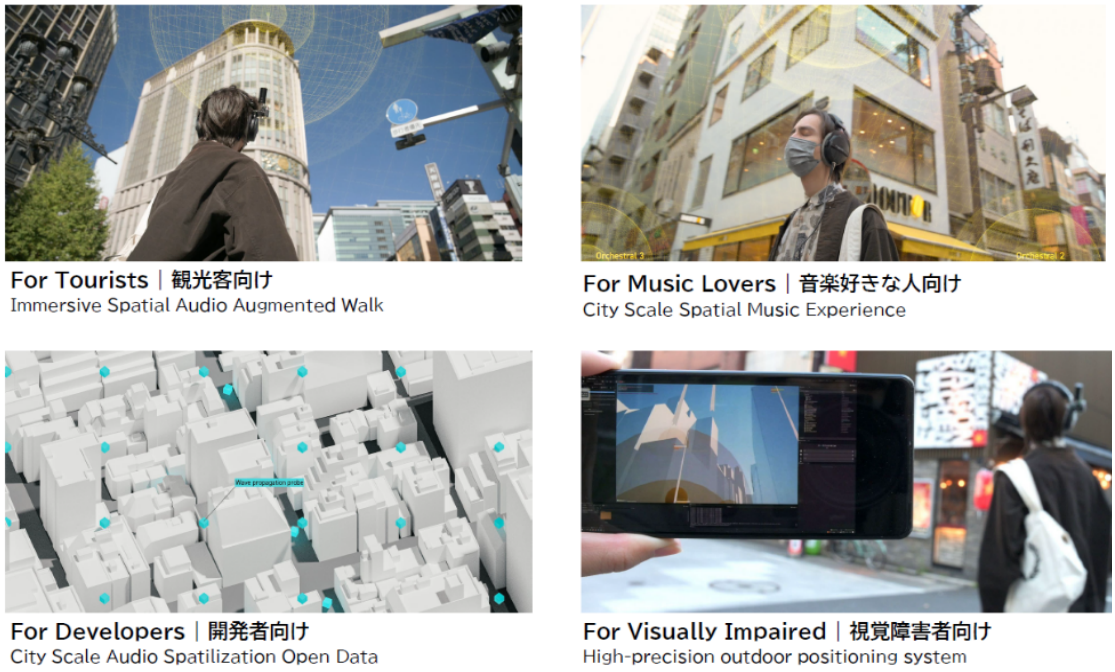


Image 4.4. *A platform that audibly expands physical space, Source: Geosimulation.org*

4.4.3. Digitalizing Public Spaces: Urban Environments with the Power of Environmental Data Visualization- TOKYO OASIS

An innovative approach to enhancing the quality of urban life through the visualization and simulation of environmental data is presented by the TOKYO OASIS web service (Figure 4.26). This unique tool is not only provided as a means for experiencing comfortable strolls through the city but also positioned as a catalyst for collective contemplation on the concepts of "comfort" and "attractiveness" within an urban setting. Through active engagement and the incorporation of diverse community perspectives, the objective is to uncover and communicate fresh facets of a city's appeal and values, which can be instrumental in shaping the trajectory of future urban development. Valuable insights and opinions through the survey are eagerly awaited and welcomed, as they play a pivotal role in shaping the future of towns and the experiences they offer. At its core, TOKYOOASIS is a web service that fosters a more comfortable and vibrant urban landscape through the integration of cutting-edge environmental data. This real-time visualization and simulation platform redefines city exploration, offering "OASIS SPOTS," route customization based on weather and mood, and various other services. Responding to user feedback, this update introduces a broader selection of "Comfortable Spots for Relaxation (OASIS SPOTS)" and novel urban walking paths that

seamlessly blend above-ground and underground areas. The Tokyo Green Studies Group remains committed to connecting the city with its residents, unveiling hidden charms, and fostering a more vibrant urban landscape.

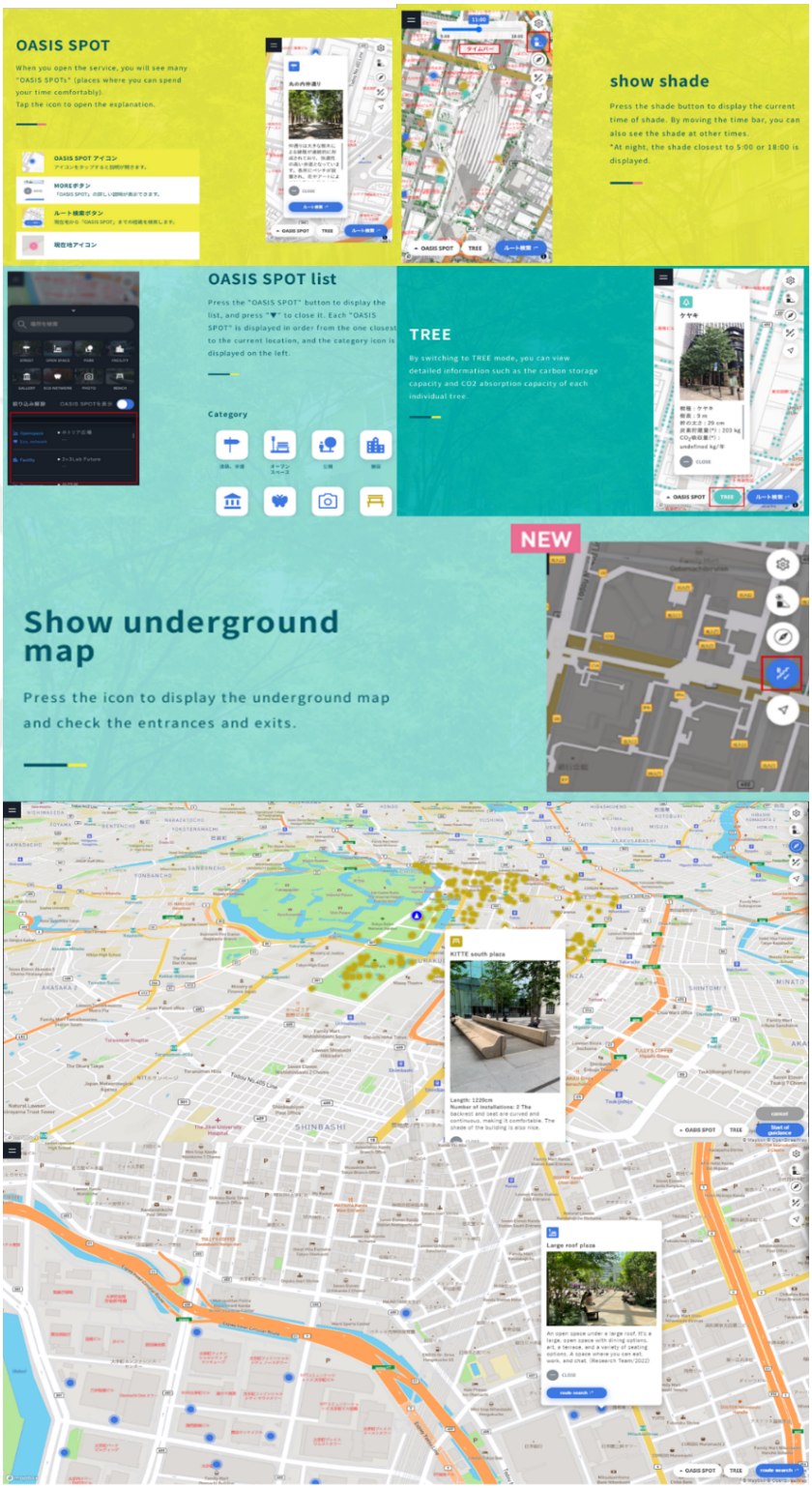


Figure 4.26. *Exploring Urban Comfort: TOKYO OASIS, Source: https://tokyooasis.com/*

4.4.4. Tourist Information Digital Signage Features

These high-performance tourist guidance signs, equipped with outdoor LCD displays and touch panels, are strategically placed at key locations in Tokyo, including the Tokyo Metropolitan Government Office and Keio Plaza Hotel (Image 4.5). The system captures attention with vivid imagery and user-friendly icons for content switching. It provides disaster information during emergencies and can be accessed via smartphones. This interactive outdoor signage system has not only improved the tourist experience but also attracted attention from other regions and businesses. The Tokyo Convention & Visitors Bureau aims to continually enhance the system's user-friendliness and promote Tokyo as a global tourism destination. This innovative digital signage system offers users a seamless connection to valuable information. By scanning QR codes or utilizing NFC technology, visitors can effortlessly transfer content to their smartphones, gaining immediate access to directions and other relevant details. These high-performance tourist guidance signs stand out with captivating imagery that naturally draws the attention of passersby. Additionally, their user-friendly design, featuring icons for easy content switching at the screen's base, ensures accessibility for all, making them a valuable asset for both tourists and locals alike (Table 4.4, Image 4.6).

Image 4.5. *Digital signage system Tokyo, Source: https://panasonic.net/cns/prodisplays/casestudies/035*

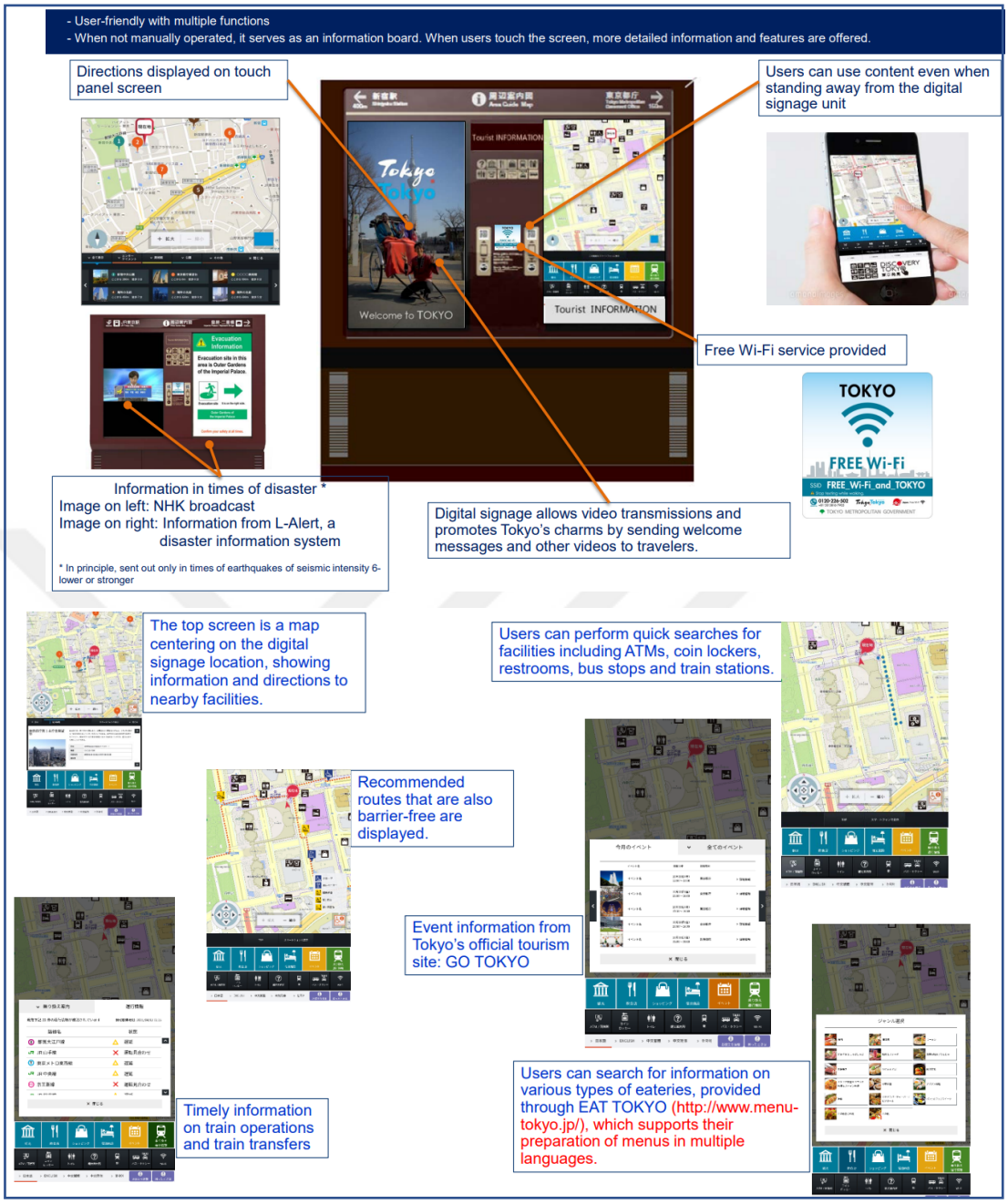


Image 4.6. *Digital signage Tokyo, Source: https://www.metro.tokyo.lg.jp/*

Table 4.5. *Content provided by digital signage Tokyo, Source: Digital signage Tokyo, Source: https://www.metro.tokyo.lg.jp/*

Content provided by digital signage		
Search for locations	Sightseeing	Nearby sightseeing spots
	Eateries	Search for information on various types of eateries that have menus in foreign languages, provided through EAT TOKYO (http://www.menu-tokyo.jp/)
	Shopping	Location of nearby department stores and duty-free stores
	Accommodations	Information on nearby hotels and *ryokans*
Search for events (train transfers and operation information)	Events	Search for "This month's events" or "All events" happening nearby
	Train transfers/operations	Information on train transfers and train operations
Quick search	ATMs and currency exchange locations	Locations of ATMs that take international bank cards and foreign currency exchange locations
	Coin lockers	Location of coin lockers
	Restrooms	Restroom locations, along with displays of whether ostomy/wheelchair support or changing tables, etc. for small children are available
	Sightseeing guidance	Locations where multi-lingual sightseeing guidance is provided
	Train and subway stations	Nearby stations
	Buses and taxis	Local bus and highway bus stops and taxi stands
	Wi-Fi	TOKYO FREE Wi-Fi spots
Useful information	Smoking areas	Warnings on smoking on the streets in Tokyo and locations of nearby smoking areas
	Using the Wi-Fi service	How to use the free Wi-Fi service, Tokyo FREE WI-FI
When help is needed	Lost items	Where to make inquiries if an item has been left at a train station/on the train, on a Toei subway/bus, in a taxi, at the airport, accidentally dropped on the street or lost somewhere unknown
	Illnesses and injuries	Minor illnesses and injuries, illnesses and injuries requiring urgent care, traffic accidents, location of AED devices, and others
	Fires and earthquakes	Initial response if a fire or earthquake occurs

To outline the impact of the projects examined here, including user experiences, design principles, technological solutions, and stakeholder collaborations, the summary table (Figure 4.27) has been provided.

Project	Impact	User Experiences (UX)	Design Principles	Technological Solutions	Engagement Strategies	Stakeholder Collaborations
1- Soundscape Platform	-Improved Urban Landscape Development -Immersive and Informative User Experience -Innovative Interaction with Auditory Aspects of Public Spaces -Potential Applications in Urban Planning, Art Installations	-Immersive and Informative -Enhanced Interaction with Auditory Aspects -Unique Way to Experience Public Spaces	-Utilizing Digital Tools -Enhancing Urban Auditory Perspective -Immersiveness and Interactivity	-Digital Tools for Urban Auditory Enhancement -Innovative Technology Integration	-Collaboration with Artists and Urban Planners -Integration into Public Space Design	-Urban Planners and Designers -Artists and Creative Professionals -Local Communities -Government Agencies and Municipalities
2- TOKYOOASIS	-Enhanced urban life quality -Collective contemplation on "comfort" and "attractiveness" -Shaping the future of urban development	-Comfortable city strolls -Active engagement and community incorporation -Fresh perspectives on city appeal and values -Interactive and informative experiences	-User-centric design -Integration of cutting-edge environmental data -Seamless blending of above-ground and underground areas	-Real-time visualization and simulation platform -Customized route planning based on weather and mood	-Broadened selection of Comfortable Spots -Novel urban walking paths	-Tokyo Green Studies Group -Local Residents -Tourists and Visitors -Local Businesses and Organizations
3- Information Digital Signage (Tourist)	-Enhanced tourism experience -Improved accessibility to information -Increased interest from other regions and businesses	-Connection to valuable information -Effortless access to directions and relevant details -Inclusive and positive user experience	-User-friendliness -Accessibility -Attention-grabbing information -User-centered design	-Outdoor LCD displays and touch panels -QR codes and NFC technology	-Captivating visuals -User-friendly features -Easily accessible information -Disaster alerts	-Involvement of the Tokyo Convention & Visitors Bureau -Collaborative efforts to enhance the system -Positive impact on Tokyo's reputation as a global tourism destination

Figure 4.27. *Digital Initiatives project in Tokyo's Urban Environment, Source: Author.*

Additionally, the goals for implementing these projects in public spaces are summarized below (Figure 4.28).

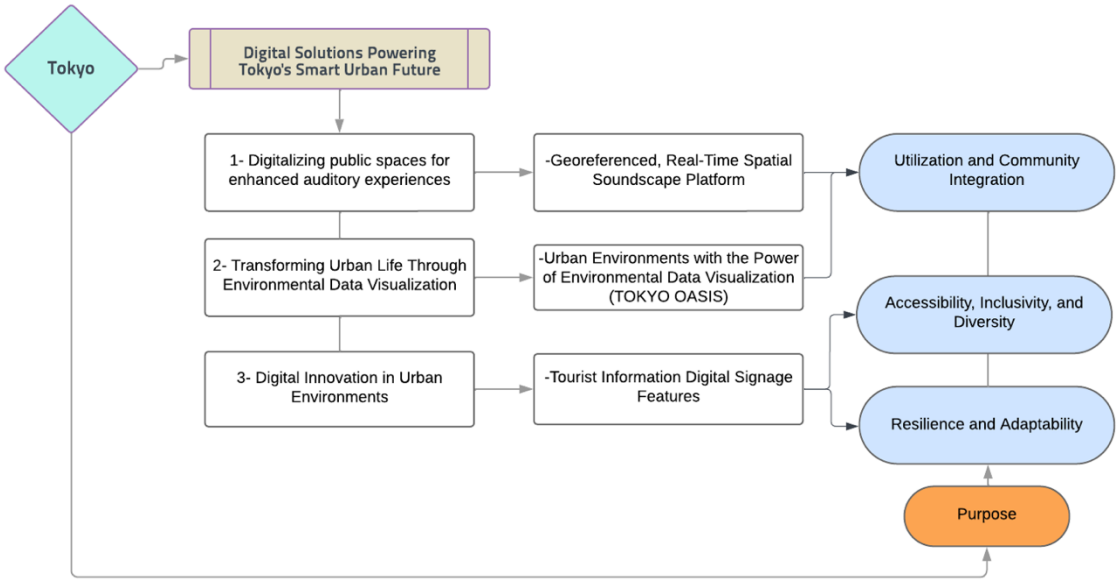


Figure 28. *Digital Solutions Powering Tokyo's Smart Urban Future, Source: Author*

4.5. Case Study 4: Amsterdam

With a population of about 918,194 people, Amsterdam is classified as a large city (Gemeente Amsterdam 2023) and its success in the field of smart cities makes its strategy an ideal model for analysis (Figure 4.29). This success is evidenced by the numerous awards the city has received in recent years and its international status as a smart city (I Amsterdam 2011, 2012, 2013; Collins 2013; Cohen 2012, 2014). One of the most important awards comes from the European Parliament, which placed the Dutch capital among the six successful smart cities in Europe (Manville et al. 2014).

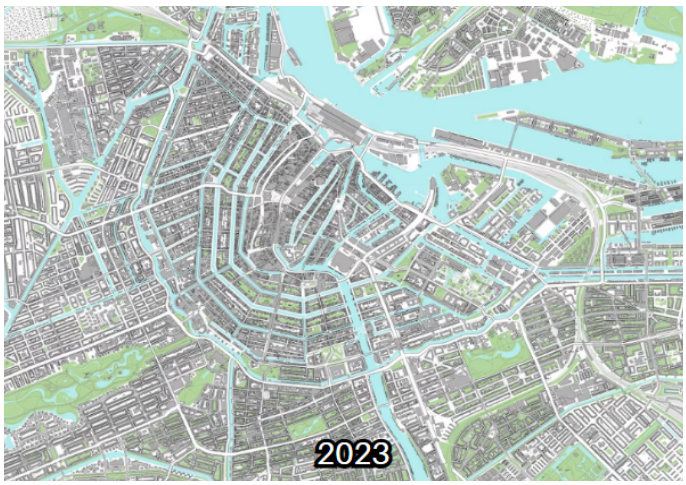


Figure 4.7. *Amsterdam map, Source: Googlemap*

4.5.1. Online Platforms

This section examines online platforms that contribute to the digital evolution of urban landscapes. These platforms serve as hubs for collaboration and participation, providing access to data and real-time management, enhancing innovation and sustainability in smart cities such as Amsterdam. Through platforms such as Amsterdam Smart City, Data Amsterdam, and Geodan, Amsterdam utilizes digital technologies to address complex challenges and improve the quality of life for its residents, as well as to facilitate citizen participation. From facilitating collaborative partnerships to opening access to data and enabling real-time monitoring and optimization, these online platforms play a significant role in shaping the future of urban environments.

4.5.1.1. Amsterdam Smart City

Because the belief that challenges for now and the future can only be addressed through collaboration is held by Amsterdam Smart City, a public-private partnership was initiated (Image 4.7, Image 4.8). The partnership is comprised of twenty permanent partners who enable Amsterdam Smart City, governments, knowledge institutions, social organizations, and innovative companies active in the Amsterdam Metropolitan Area. Complex issues that hold a high position on their respective agendas but are beyond individual resolution are collectively addressed. Challenges are acquainted with, support is provided through inspiring conversations and workshops, masterclasses are organized, mutual learning takes place, and joint projects are undertaken.

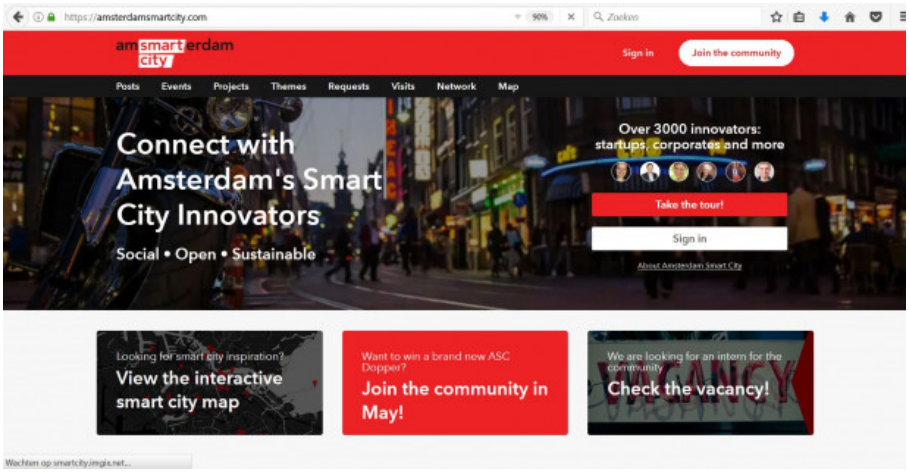


Image 4.7. *Amsterdamsmartcity.com*

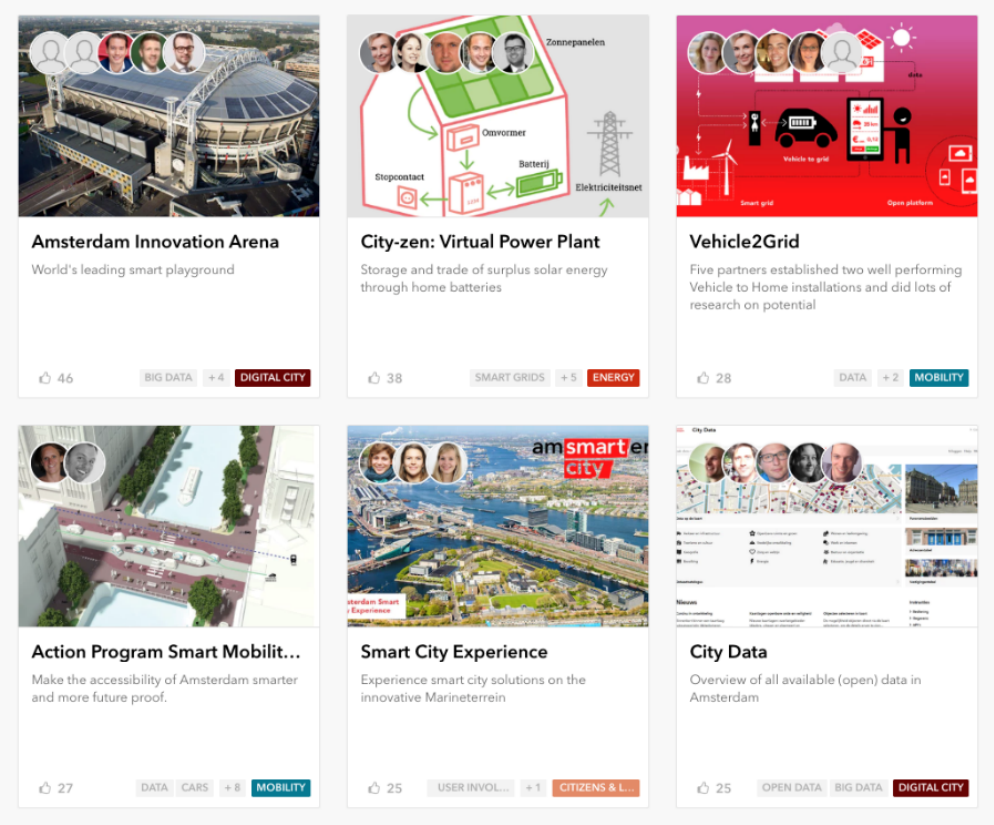


Image 4.8. *Project overview on the ASC community, Source: amsterdamsmartcity.com*

4.5.1.2. Data Amsterdam

One remarkable aspect of Amsterdam is its decision to make City Data (Figure 4.30) openly accessible. This means that the data is available to everyone, and individuals can contribute additional datasets to this repository. The City Data is conveniently accessible online in Dutch, making it effortless to search, download, or integrate into your own system (Macpherson, 2017).

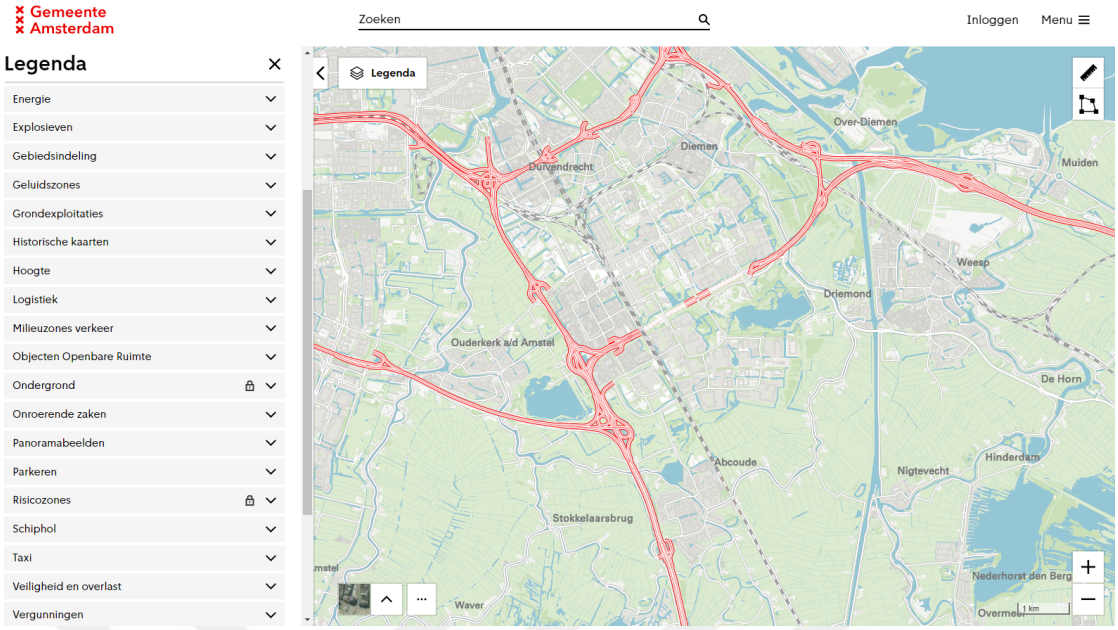


Figure 4.30. *Data Amsterdam, Source: https://data.amsterdam.nl/*

4.5.1.3. Geodan

Geodan Image 4.9, in collaboration with partners such as Huawei, the Johan Cruijff ArenA, and the City of Amsterdam, has introduced the Amsterdam Smart City Dashboard, a key player in the digital transformation of public spaces. This innovative tool, unveiled during the WeMakeThe.City event, represents a pivotal step toward real-time data-driven management of urban areas. It effectively addresses pressing issues related to the energy transition, traffic management, and urban development, aligning with the growing trend of digitalization in public spaces. By seamlessly integrating data sources and providing real-time visualizations, the Dashboard empowers city officials and the public to monitor, optimize, and enhance essential processes concerning energy, quality of life, and transportation, thereby advancing the smart, sustainable evolution of Amsterdam's urban landscape through digitalization. It has three vital themes: 1- Energy transition, 2- Human Environment, 3- Mobility

Image 4.9. *Geodan dashboard, Source: www.geodan.com*

4.5.2. CMSA, Crowd Monitoring System Amsterdam

The Crowd Monitoring System Amsterdam (CMSA) (Figure 4.31) is designed to enhance urban safety and efficiency through crowd monitoring solutions. Public Eye, one of the systems of this project, provides real-time predictions of population counts without storing images or videos of individuals (to preserve privacy). During the COVID period, the Municipality of Amsterdam used this system to prevent gatherings of specified numbers of people. While this system also provides valuable insights into population dynamics, such as size, density, direction, and speed, and offers effective data analysis for managing public spaces. For example, the Amsterdam municipality measures excessive crowding through this system and takes action if it detects unsafe situations (contagious diseases, terrorist attacks, etc.) (Figure 4.32, Figure 4.33).

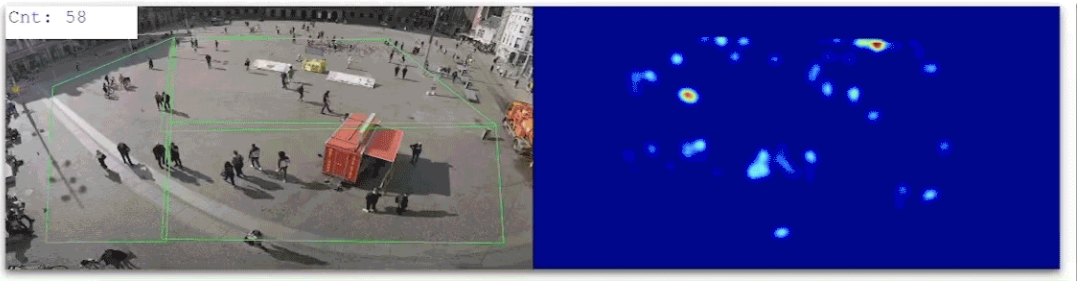


Figure 4.31. *Crowd Monitoring System Amsterdam, https://www.tapp.nl/project-overview/public-eye*

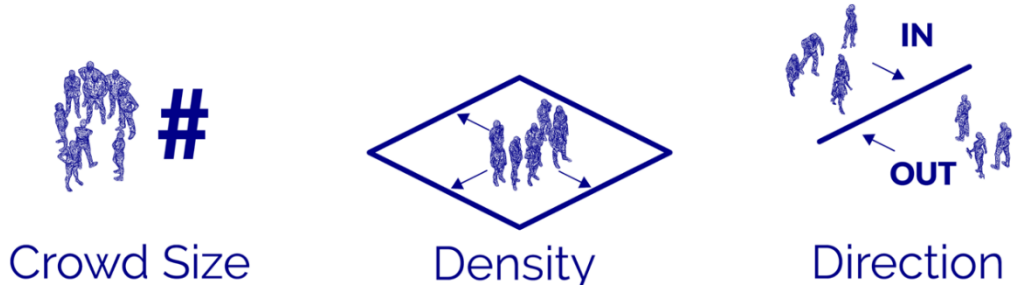


Figure 4.32. *Crowd size, density, direction model of CMSA, Source: https://www.tapp.nl/project-overview/public-eye*

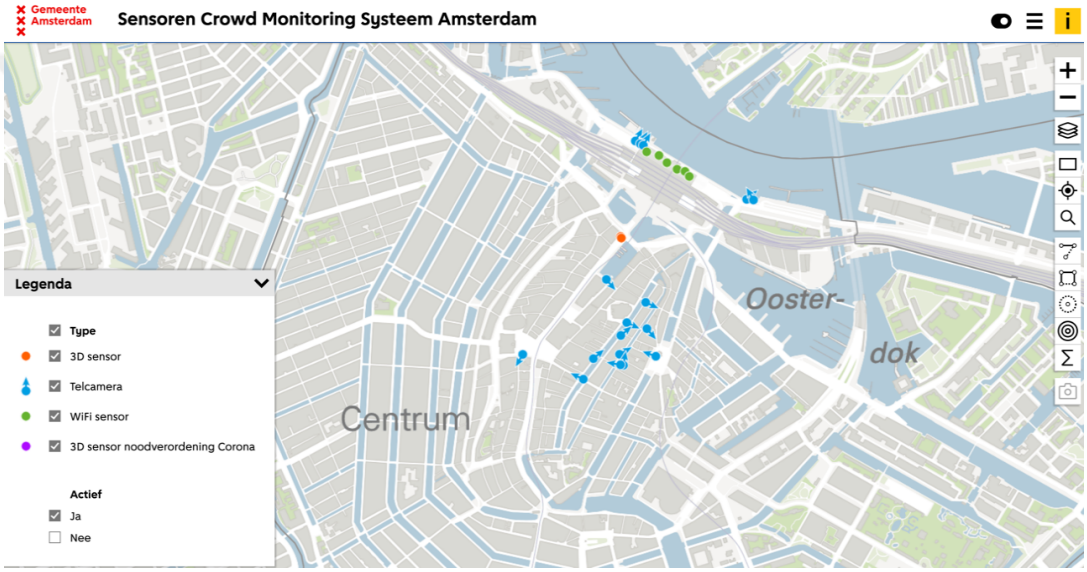


Figure 4.8. *Sensors of CMSA, Source: https://www.tapp.nl/project-overview/public-eye*

4.5.3. The Green Mile Amsterdam, Measuring Street Transformation

Measuring Street Transformation-The Green Mile Amsterdam- evaluating air quality and sound levels, crucial for human, plant, and animal well-being. During the closure of a segment in June and July 2023, they initiated assessments, comparing pre- and post-closure data. Tapp - Smart City Architecture conducts benchmarking with environmental sensors, measuring sound levels, CO2, air quality index (AQI), and particulate matter. This data can be viewed on a public dashboard, fostering awareness and support for The Green Mile. Tapp collaborates with local teams to design citizen-centric solutions, enriching the living environment (Figure 4.34-39).

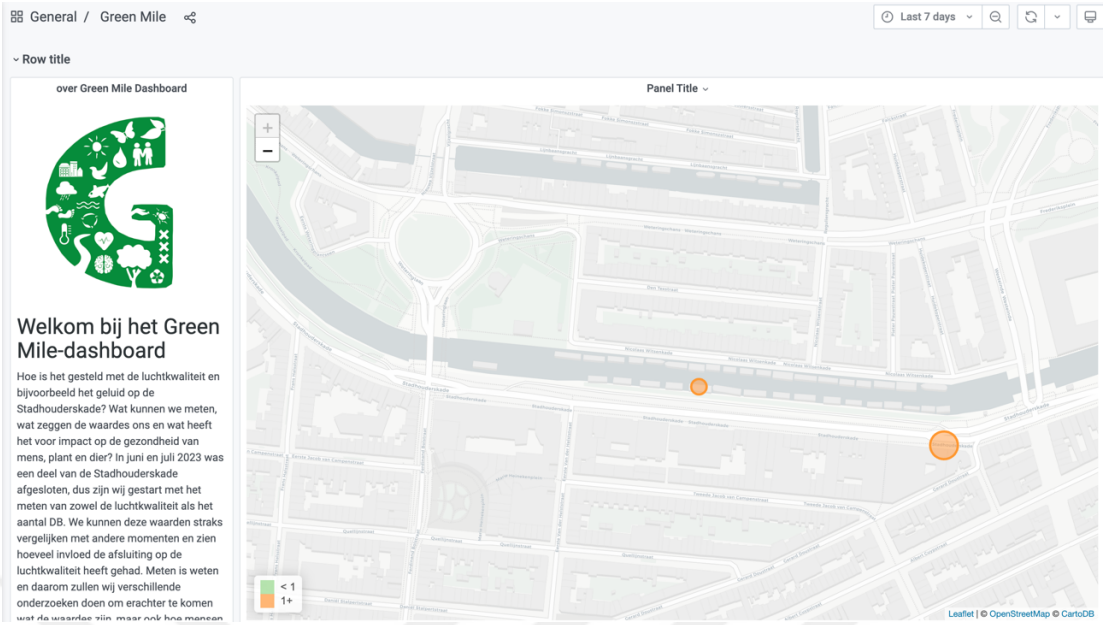


Figure 4.34. *The Green Mile dashboard, https://www.tapp.nl/project-overview/measuring-street-tranformations*

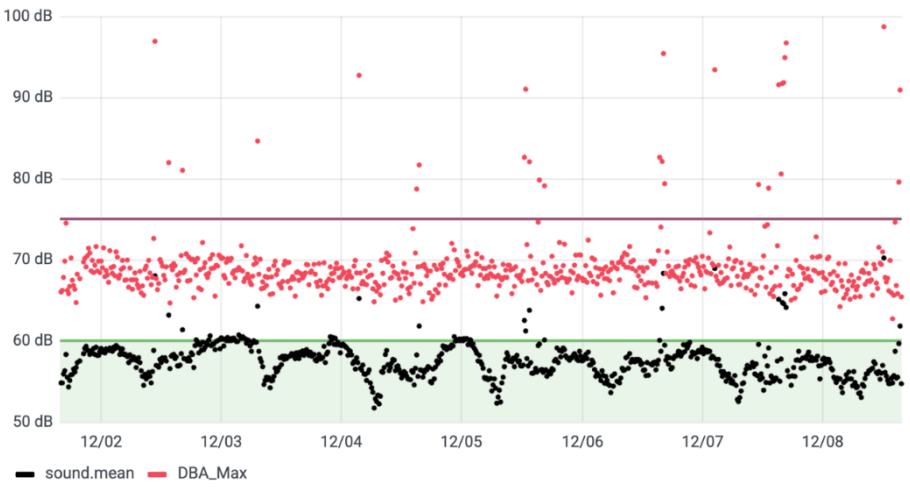


Figure 4.9. *Noise level*

https://www.tapp.nl/project-overview/measuring-street-tranformations

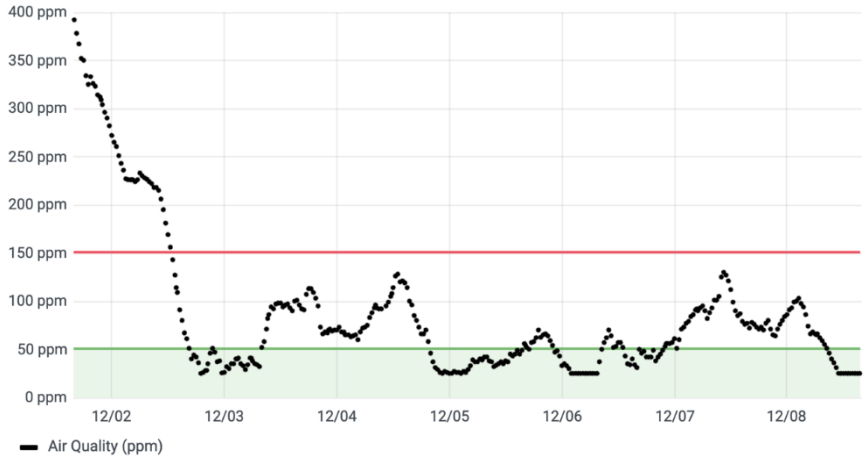


Figure 4.10. *Air Quality (AQI Index), Source: https://www.tapp.nl/project-overview/measuring-street-tranformations*

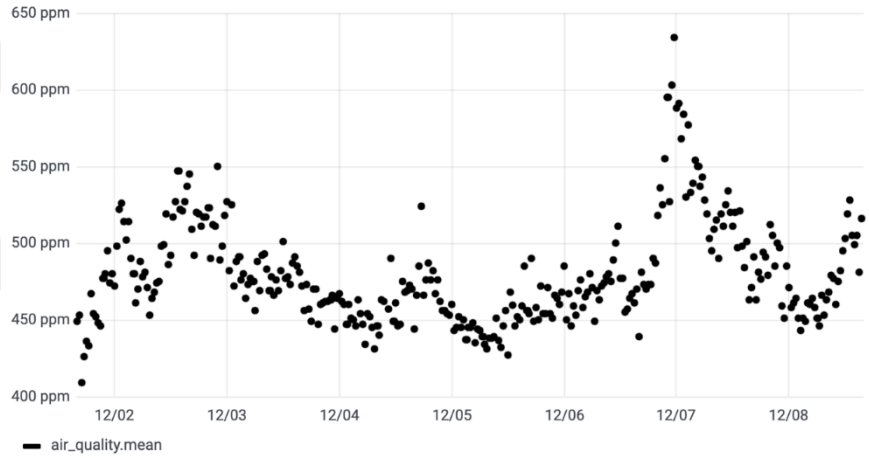


Figure 4.11. *Co2 (historic), Source: https://www.tapp.nl/project-overview/measuring-street-tranformations*

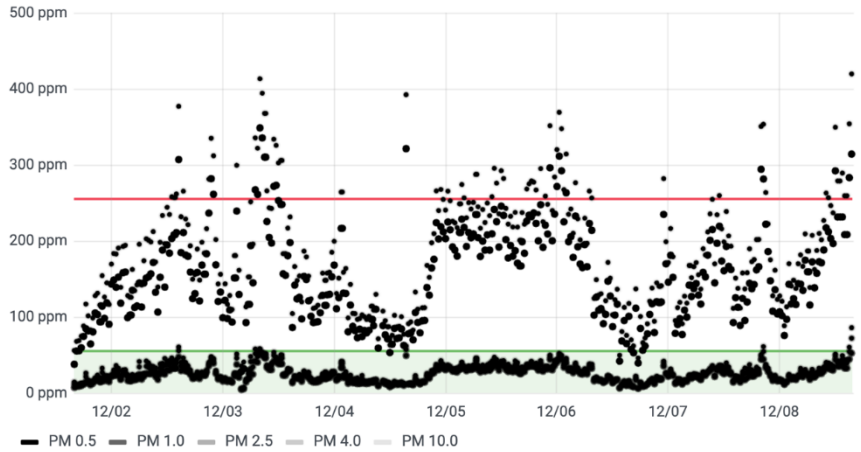


Figure 4.12. *Particulate matter, Source: https://www.tapp.nl/project-overview/measuring-street-tranformations*

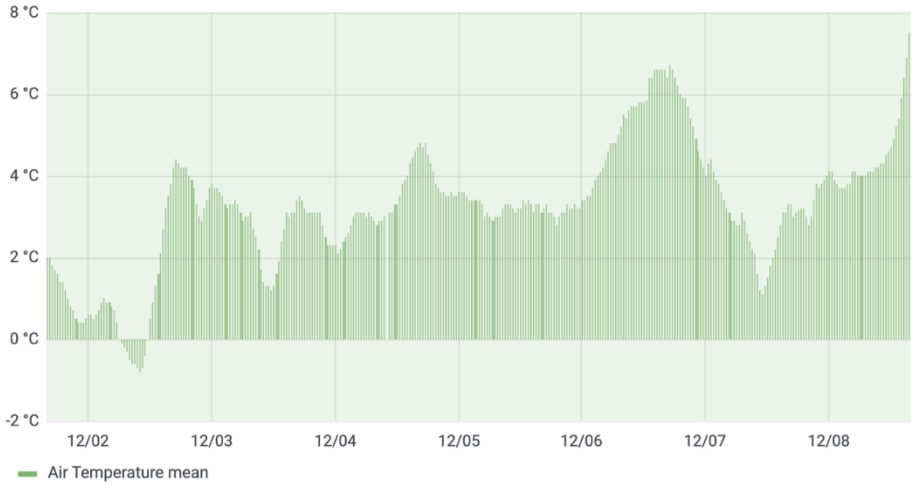


Figure 4.13. *Air temperature, Source: https://www.tapp.nl/project-overview/measuring-street-tranformations*

Overall, the impacts of the projects examined, including user experiences, design principles, technological solutions, and stakeholder collaborations, are presented in the summary table (Figure 4.40).

Project	Impact	User Experiences (UX)	Design Principles	Technological Solutions	Engagement Strategies	Stakeholder Collaborations
1-Platforms						
Amsterdam Smart City	Facilitates collaboration among stakeholders, addresses urban challenges, improves quality of life, and enhances citizen participation.	Provides a platform for collective problem-solving, workshops, and joint projects.	Collaboration, innovation, sustainability	Online platforms for requests and opportunities, Smart updates	Workshops, shared learning processes	Public-private partnership involving various entities in the Amsterdam Metropolitan Area.
Data Amsterdam	Opens city data, encourages contributions, and provides accessible online access.	Enables easy search, download, and integration of city data.	Open data, accessibility, transparency	Online platform for sharing city data	Making city data openly accessible; providing easy online access	Collaboration with the City of Amsterdam to share city data
Geodan	Introduces the Amsterdam Smart City Dashboard for real-time urban management.	Empowers city officials and the public through real-time visualizations.	Real-time monitoring, data integration, visualization	Amsterdam Smart City Dashboard empowers city officials and the public to monitor, optimize, and enhance essential processes.	Integrating data sources, providing real-time visualizations	Collaboration with partners such as Huawei and the City of Amsterdam.
2- CMSA, Crowd Monitoring System Amsterdam	Enhances urban safety through crowd monitoring solutions while preserving privacy.	Provides insights into population dynamics and effective data analysis.	Urban safety, privacy preservation, efficiency	Crowd monitoring solutions including Public Eye	Providing real-time predictions while preserving privacy; analyzing population dynamics	Collaboration with the Municipality of Amsterdam for crowd monitoring.
3- The Green Mile Amsterdam	Measures street transformation by evaluating air quality and sound levels.	Provides public access to environmental data and collaborates on citizen-centric solutions.	Environmental awareness, citizen-centric design	Environmental sensors measuring various factors such as sound levels, CO2, air quality index (AQI), and particulate matter	Providing public dashboards; collaborating on citizen-centric solutions	Collaboration with local teams and stakeholders for street transformation.

Figure 4.40. *Digital Initiatives project in Amsterdam's Urban Environment, Source: Author*

Moreover, the goals for executing these projects in public spaces can be outlined as follows (Figure 4.41).

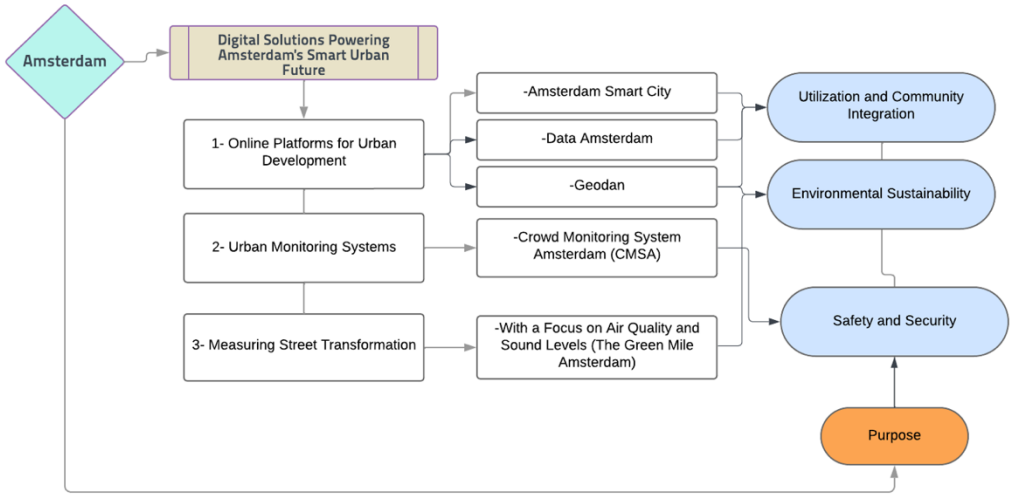


Figure 4.41. *Digital Solutions Powering Amsterdam's Smart Urban Future, Source: Author*

4.6. Case Study 5: Istanbul

Istanbul's Historical and Cultural Significance: Istanbul, with a history spanning over 8500 years, stands as Turkey's largest city and principal port, having served as the capital of the Roman, Byzantine, and Ottoman empires. This ancient city is strategically located on a triangular peninsula between Europe and Asia (Ehrlich, B., 2024). Istanbul's Asian section lies to the east, while its European section is situated to the west, separated by the Bosphorus Strait (Figure, 4.42). Throughout history, Istanbul has served as a bridge between diverse cultures, religions, and ethnicities. With a population of approximately 16 million people, the city comprises 39 districts and 40 municipalities, all governed by the Istanbul Metropolitan Municipality (IBB). In 2019, Istanbul boasted 1796 historical sites, 28 palaces, and 91 museums, making it the top destination for international tourists (Source: http://www.istanbul.gov.tr/bir-bakista-istanbul).

Istanbul, distinguished by its strategic position at the junction of key maritime routes and transportation corridors spanning Europe, Eurasia, and the Middle East, is a cosmopolitan city that demands comprehensive examination across various disciplines such as geography, history, collective memory, sociology, cultural heritage, and economy. Moreover, Istanbul holds the potential to emerge as a leading global metropolitan area (Çelikyak, 2013). Given its significance, this city necessitates a

coherent strategy for future development to effectively meet the needs of both residents and visitors. Urban services, among other requirements, are consistently scrutinized and evaluated by municipalities and relevant organizations.

Figure 4.42. *The location of the Asian and European parts of Istanbul, Source: earth.google.com*

4.6.1. Smart city strategies in Istanbul

In recent years, Turkey has taken significant steps towards implementing smart city technologies. Istanbul, as Turkey's largest city, has been striving to develop smart infrastructures. These infrastructures aim to support digital systems that facilitate city smartification, enabling urban environments to evolve through intelligent solutions to enhance service quality.

The Vision 2050 strategy for Istanbul outlines a comprehensive plan aimed at (Istanbul Metropolitan Municipality, 2024):

1- Comprehensive Development Goals: The strategy outlines more than 38 goals across seven key areas to enhance the city's development and quality of life.

2- Smart Planning and Collaboration: Emphasizes smart planning and collaboration based on extensive cooperation and reliable data from Istanbulites.

3- Inclusive Data Generation: Aims for inclusive data generation that safeguards personal data for all city residents, including disadvantaged groups.

4- Unified Data Tools: Develops unified tools for data collection, monitoring, and evaluation across urban services.

5- Transparent Digital Applications: Promotes transparent digital city applications to ensure fair data sharing.

6- Ethical Data Use: Focuses on using data ethically and adhering to social justice principles.

7- Information and Communication Technology Infrastructure: Enhances ICT infrastructure and expands free internet access to bridge digital divides.

Due to the widespread adoption of smartphones, data collection through IBB Wi-Fi in public areas is prevalent. However, the primary use of smart devices for social media and other functionalities such as mobile payments limit widespread two-way communication for city services. By the end of 2021, Istanbul Metropolitan Municipality (IMM-IBB) offered free Wi-Fi service at 8,743 access points across 4,089 locations, including squares, parks, buses, and metrobuses. This number continues to increase as part of the municipality's strategic objectives. In the 2030 Strategic Plan of Istanbul Municipality, under Initiative 2 - Strengthening Smart City Infrastructure and Establishing a Unified Communication Backbone, projects covering connectivity networks are described as follows:

The aim of this initiative is to enrich the city's wired and wireless communication infrastructures and establish a unified communication backbone. The goal is to design a common communication backbone where sensor infrastructures and communication nodes (gateways) are deployed and proliferated throughout the city, converging and optimizing them.

• Project 1: Designing a Unified Metering Infrastructure and Conducting Pilot Implementation

• Project 2: Istanbul Metropolitan Municipality Wi-Fi

This initiative underscores strategic efforts to integrate and optimize communication networks across urban spaces, emphasizing enhanced connectivity and operational efficiency. (Istanbul Metropolitan Municipality, 2021).

4.6.2. Istanbul’s smart city infrustructure by Isttelkom

The Istanbul Metropolitan Municipality meets its information and communication technology (ICT) needs through its subsidiary, ISTTELKOM, which plays a crucial role in constructing the communication infrastructure essential for Istanbul's smart cities and integral to the city's digital transformation. ISTTELKOM offers a diverse range of services and solutions to the municipality, including:

• Digital transformation services

• Information services

• Information technology security solutions

• Data center solutions
• Communication infrastructure management services (fiber)
• Internet Service Provider (ISP) services
• Wireless services
• Wireless network services
• Internet of Things (IoT) services
• Communication solutions with smart city furniture

Given that city services must comply with national laws and regulations, ISTTELKOM adheres to the following regulations in its service delivery: Municipal law, Metropolitan Municipality Law, Electronic Communications Law, Labor Law, Turkish Commercial Code, Public Procurement Law, Environmental Law, Occupational Health and Safety Law. ISTTELKOM also provides wireless services for designing Wi-Fi network structures (Isttelkom, 2024).

4.6.3. Free Internet access initiative by Istanbul metropolitian municipality

IBB WiFi (İstanbul Büyükşehir Belediyesi- Istanbul Metropolitan Municipality) is a system of free internet services provided by the Istanbul Metropolitan Municipality, covering public spaces such as squares, streets, parks, sports and cultural centers, as well as social venues including universities, hospitals, and public transportation (Figure, 4.43). The aim of this project is to integrate free internet services with the latest solutions, improve their quality, and expand coverage throughout Istanbul, particularly in public spaces (ISTTELKOM, 2024).

4.6.3.1. Distribution systems of IBB Wi-Fi network

As of June 2024, a total of 11,954 (Figure, 4.46) access points have been deployed across Istanbul. The diagram below illustrates the distribution of the Wi-Fi networks carried out by the Istanbul metropolitan municipality (Figure, 4.44). Additionally, the network distribution groups, the number of locations, and access points are detailed in the diagram 4.46. Free internet network distribution groups include service building, district municipality building, student dormitory, Ismek (Istanbul metropolitan municipality art and vocational education courses), villages, library, bus stop, metrobus stop, city lines pier, culture and social and sports facility, tram station, green area, metrobus, metro, city lines ferry, mobile. Furthermore, this diagram categorizes locations into fixed and mobile categories (Figure, 4.45).

Figure 4.14. *Unlimited free Internet Website (IBB Wi-Fi), Source: wifi.ibb.istanbul*

Figure 4.15. *Free Internet location board, Source: www.ekremimamoglu.com*

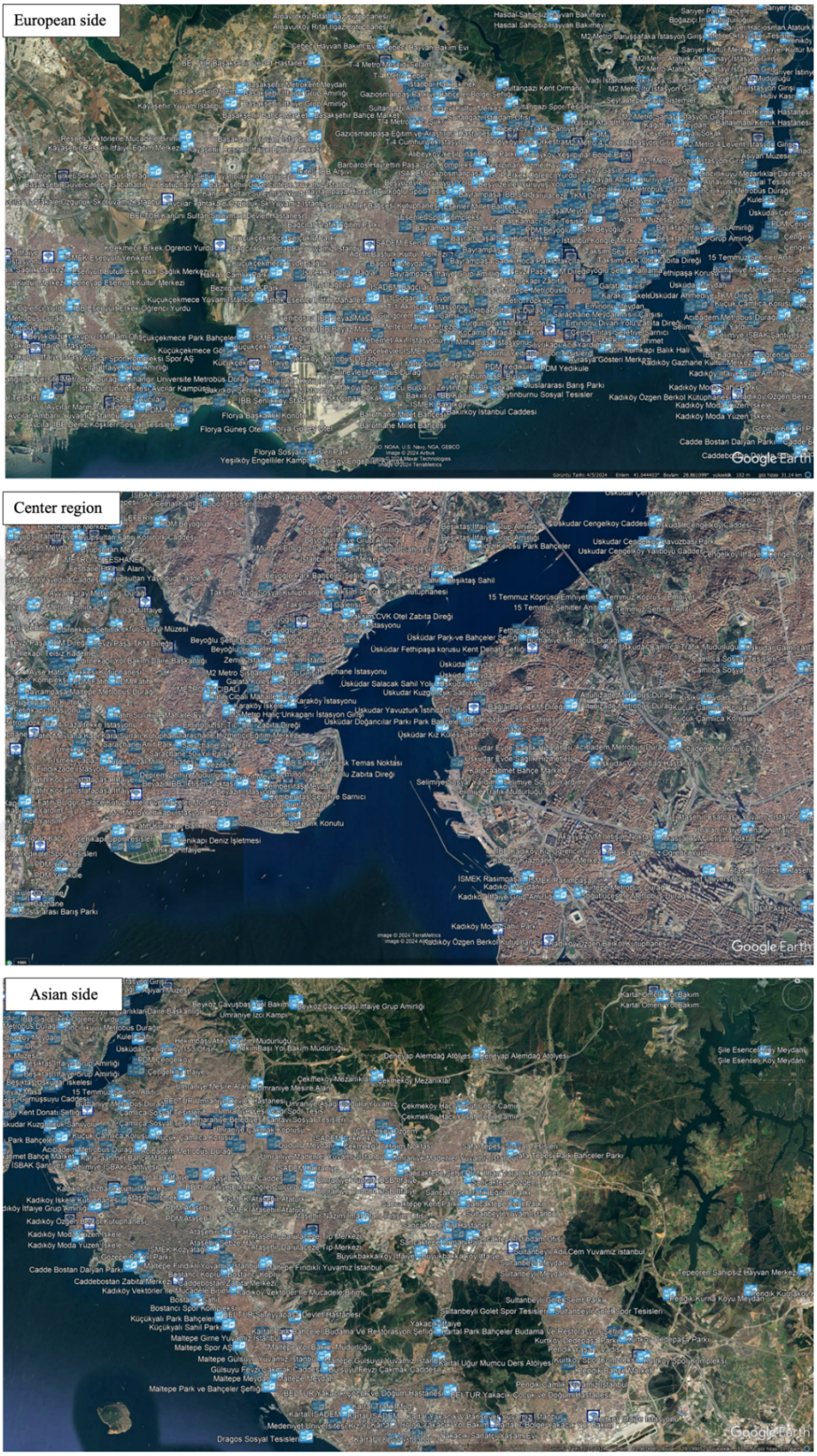


Figure 4.16. *The location of the free Internet masts of IBB Wi-Fi, (Source: Istanbul Metropolitan Municipality, Department of Information Technologies, 2024)*

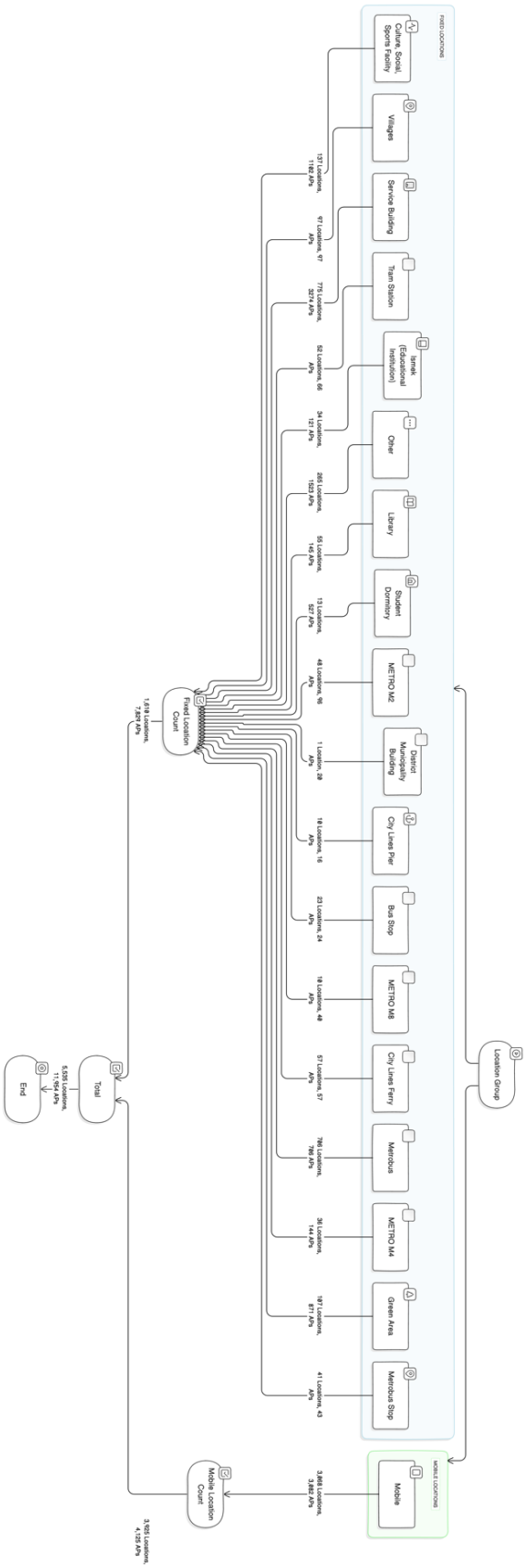


Figure 4.46. *The distribution of the number of locations and access points to free internet in Istanbul.*

(Source: Istanbul Metropolitan Municipality, Department of Information Technologies, 2024)

4.6.3.2. How to use IBB free Wi-Fi service

Residents of Istanbul can utilize the IBBWiFi service by downloading the 'Istanbul Sennin' app on their smartphones and entering their mobile phone number to gain access. The app then identifies nearby service points on a map, enabling users to connect by selecting them for additional information or a password. Initially limited to 30 GB, the service was upgraded to 60 GB in the first half of 2024. Subsequently, the Istanbul municipality decided to remove this cap, offering unlimited internet capacity to citizens (Isttelkom, 2024).

- General Information

The IBBWiFi service boasts an extensive infrastructure comprising 11,954 access points spread across 5,535 locations. It supports 4,125 mobile vehicles equipped with 4G connectivity, providing a total internet capacity of 5 Gbps. Users benefit from unrestricted access, with a speed cap set at 5 Mbps. As of the latest count, the service has amassed a subscriber base of 5,738,504 users, including 794,177 foreign subscribers.

- Daily Usage Statistics

On average, the service registers 19,000 local users and 235 foreign users daily, resulting in approximately 38,000 daily connections. The system handles an average of 22 TB of data per day (Figur, 4.47, 4.48)(Istanbul Metropolitan Municipality, Department of Information Technologies, 2024).

The IBBWiFi service represents a new frontier in urban services for citizens. The digitalization of urban services has the potential to reduce the necessity for physical presence of citizens and influence urban traffic patterns.

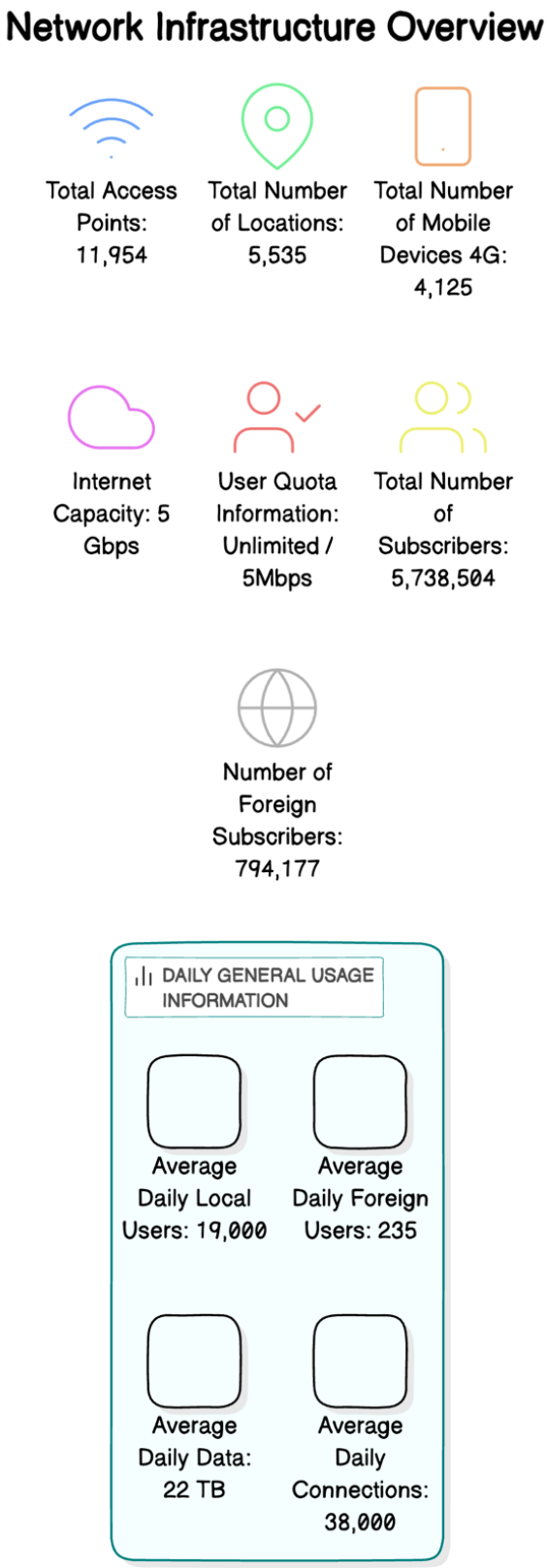


Figure 4.47. *Current Infrastructure Details of IBBWiFi Service (July 16, 2024)*

(Source: Istanbul Metropolitan Municipality, Department of Information Technologies, 2024)

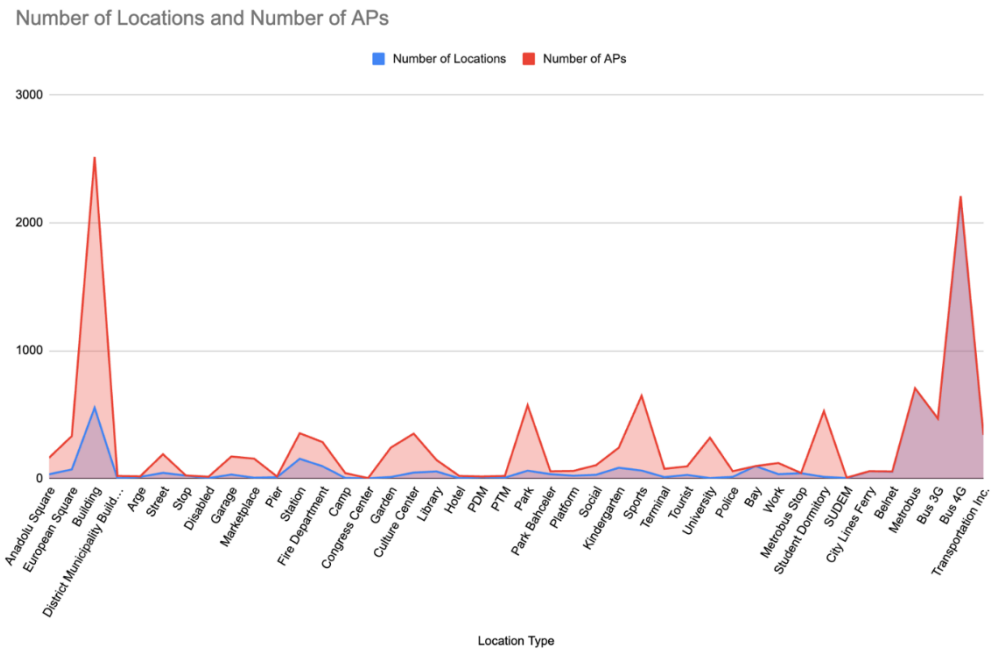


Figure 4.17. *The number of locations and number of Aps of IBB Wi-Fi in Istanbul, (Source: Istanbul Metropolitan Municipality, Department of Information Technologies, 2024)*

Location Type	Number of Locations	Number of APs
Anadolu Square	33	162
European Square	71	332
Building	553	2515
District Municipality Building	1	20
Arge	13	17
Street	44	190
Stop	23	24
Disabled	3	14
Garage	31	172
Marketplace	6	155
Pier	10	16
Station	154	354
Fire Department	96	285
Camp	4	42
Congress Center	1	3
Garden	12	242
Culture Center	46	351
Library	55	145
Hotel	2	20
PDM	12	16
PTM	7	20
Park	61	573
Park Bahceler	34	56
Platform	22	59
Social	29	104
Kindergarten	84	241
Sports	62	647
Terminal	11	76
Tourist	28	95
University	3	319
Police	13	57
Bay	97	97
Work	34	121
Metrobus Stop	41	43
Student Dormitory	13	527
SUDEM	3	7
City Lines Ferry	57	57
Belnet	53	55
Metrobus	706	706
Bus 3G	470	469
Bus 4G	2,196	2,209
Transportation Inc.	341	341
Total	**5,535**	**11,954**

Figure 4.18. *The location type and number of locations and Aps of IBB Wi-Fi in Istanbul, (Source: Istanbul Metropolitan Municipality, Department of Information Technologies, 2024)*

There is a wide range of locations and facilities offering free Wi-Fi access in Istanbul. Anadolu Square is home to 33 locations with a total of 162 free Wi-Fi access points (APs), while European Square has 71 locations with 332 APs. Buildings are the most numerous in the city, with a total of 553 locations and 2,515 APs. District Municipality Buildings and R&D Offices have only one and thirteen locations, respectively, and each provide a limited number of free Wi-Fi APs. Streets, bus stops, and garages are more numerous, spread across 44, 23, and 31 locations, respectively, and each equipped with a different number of free Wi-Fi APs. The city's cultural and entertainment centers, including gardens, cultural centers, and parks, are home to a large number of APs, reflecting the commitment to connectivity in public spaces (Figure, 4.49).

4.6.3.3. Istanbulsenin App: Empowering citizens with digital solutions

The 'Istanbulsenin' Application is a citizen-centric free application for smart cities that Istanbul residents can utilize. This application provides various solutions including bill payments, transportation information, social assistance, shopping, and access to city-wide internet service, IBB WiFi. All user information is securely stored in the Istanbul Metropolitan Municipality's secure data center and is not shared with any third parties without citizens' permission (Istanbulsenin, 2024) (Figure, 4.50) (Table, 4.5).

Figure 4.50. *Istanbulsenin Application, Source: Istanbulsenin.istanbul*

Table 4.6. *The Istanbulsenin Application (Challenges, solutions and participations), Source: www.bable-smartcities.eu*

Challenge/Goal	Streamlining interaction between 40 subsidiaries and citizens	Difficulty accessing municipal information across multiple platforms	Enhance direct communication and citizen involvement

Table 4.7. *(Continued) The Istanbulsenin Application (Challenges, solutions and participations), Source: www.bable-smartcities.eu*

Solution	Deployed City SuperApp	Unified platform with secure digital identity	Direct access via broadcast messages, push notifications, polls
Citizen Participation	Downloaded over 3 million times	150,000+ active users daily	Successful adoption and democratic participation

4.6.4. The Impact of Free Internet Access on Urban Identity

Physical and non-physical features such as architecture, urban fabric, social interactions, sense of belonging, and economic and social conditions distinguish each city from another. These dimensions of structures create the identity of cities. Additionally, each city possesses its own unique material and immaterial dimensions (which will be detailed in the next chapter).

Technology-Centric Urban Identity: The impacts of free internet on urban identity (Figure 4.51) and public spaces can be examined from several perspectives. These include access to information, development of communications and social interactions, economic sustainability, social equality, and urban interpretation. Assuming that all socio-economic groups, along with age groups eligible for mobile phone use, can access mobile phones and subsequently connect to free mobile internet provided by municipalities, based on existing studies, the following conclusions are drawn (Table, 4.6):

Table 4.8. *Impact of free Internet access on urban identity: Enhancing connectivity, sustainability, and urban planning efficiency. Source: Author*

Objectives	Impacts
Transformation in access to urban information and services	Increase in access to information: Citizens can easily access urban information, public transportation services, locations of cultural events, recreational facilities, healthcare services, and municipality performance. They can also provide feedback and suggestions to urban services and municipalities. This convenient and cost-effective access to urban services and amenities can enhance citizens' quality of life by keeping them informed and improving their connection with urban resources. Additionally, citizen participation in society and the sharing of information and experiences among residents strengthen cultural exchanges, contributing to social cohesion.
Development of communications	Social connectivity: Citizens can use free internet and unlimited city-wide networks through social media, messaging apps, and other digital platforms to communicate

and social interactions	with friends, family, local community members, and individuals across the globe. These connections foster social cohesion and contribute to social sustainability.
Economic sustainability	Unlimited internet access can help local businesses utilize digital opportunities for advertising, sales, and customer interaction, thereby increasing economic activity and contributing to local employment and economic sustainability.
Promoting equality (reducing socioeconomic disparities)	As depicted in Figure 4.42, free unlimited internet access ensures that all city residents have online connectivity, regardless of their economic status. This initiative significantly contributes to bridging the digital divide in the city. Moreover, free internet access enhances digital literacy by facilitating access, thereby preventing societal stratification.
Enhancing urban legibility	As argued by Lynch (1960), in urban design, readability refers to how easily people can navigate and understand the layout of a city, including landmarks, areas, and routes that facilitate efficient movement and improve the overall urban experience. In this context, free internet access and applications that define paths, roads, buildings, and locations can significantly contribute to urban legibility. Navigation systems, location services, and search functionalities for attractions and city services aid residents in better understanding their city. In a study conducted in central Ankara (Barlas & Şentürk, 2011), it was found that the use of mobile phones led to a noticeable increase in meeting places and diversity of meeting locations, with a decrease in concentration in central points shifting towards streets and neighborhoods. The dispersion of meeting places means that the entire physical area of the city is used for social interaction, potentially benefiting the local economy by boosting local commerce and income. Access to navigation systems has enabled residents to better understand their cities and promote decentralization. When residents are more familiar with their cities, they can choose a wider variety of locations for social interactions, which can help alleviate urban traffic congestion.
Tourism Development	Facilitating easy access to landmarks and city information for tourists and foreigners can enhance the city's appeal and contribute to the growth of the tourism sector. Providing online access to digital platforms that share information about tourist attractions also greatly helps in attracting regional tourists.
Efficient Urban Planning	Municipalities and relevant organizations can enhance urban planning by leveraging data-driven insights obtained through digital public participation facilitated by internet access. This approach allows them to more accurately address citizens' needs. Additionally, digital platforms can facilitate communication between citizens and relevant organizations, fostering information exchange towards achieving sustainable goals.

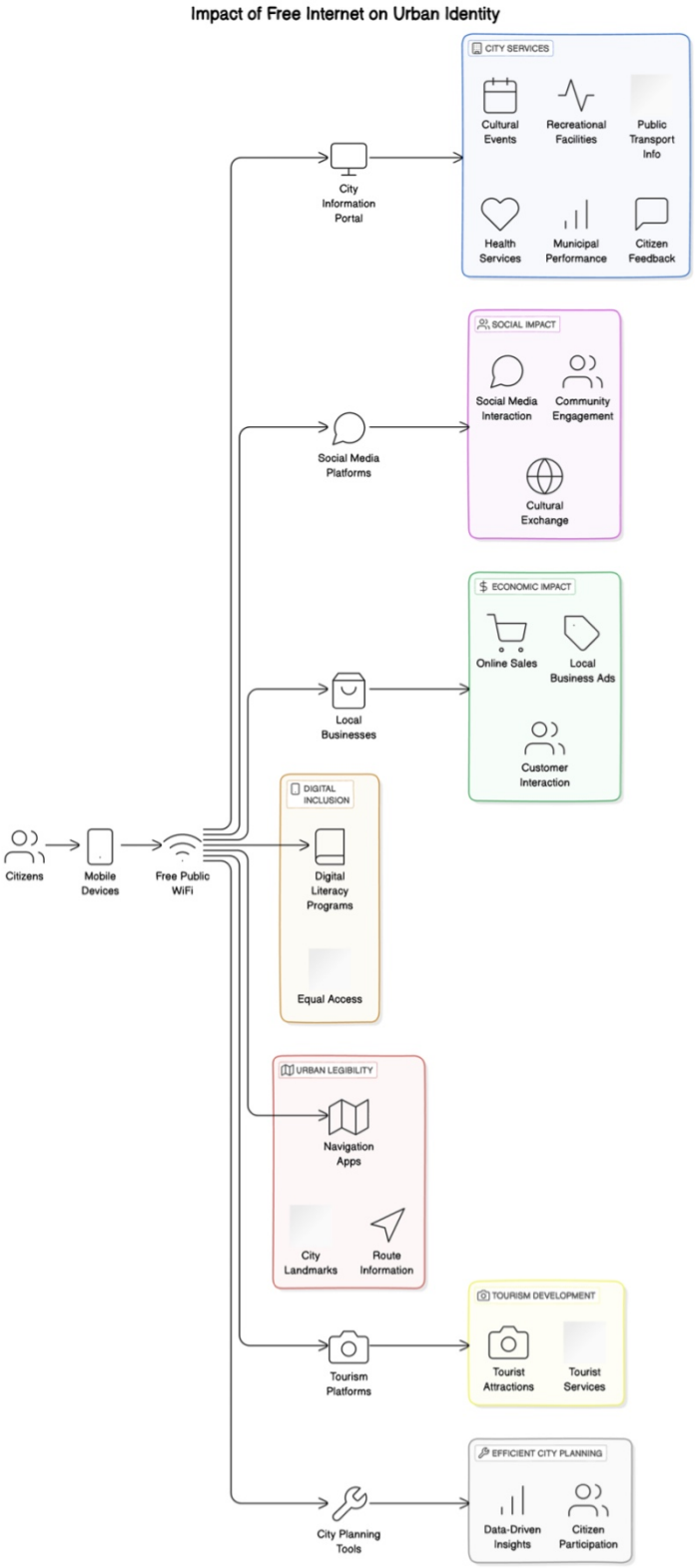


Figure 4.51. *Impact of free Internet on urban identity, Source: Author*

While the topic of free, unlimited internet in Istanbul is relatively new and specific research on its impacts is currently lacking, insights from studies conducted in other cities can provide a basis for predicting potential effects. For example:

The UNDP's Accelerator Lab in El Salvador collaborated with the Salvadoran Tourism Institute to introduce Wi-Fi in Balboa Park, a popular destination. Although the increase in visitor numbers was not as significant as anticipated, free internet access became highly valued among park visitors, enhancing their overall experience and leaving them with positive impressions. A related study indicated that promoting internet services extended visitor durations and increased recommendations for local businesses. These findings underscore the potential of internet access to foster community engagement, support local economies, and highlight the importance of ongoing efforts in digital literacy and evidence-based strategies in public spaces (Tablas, 2023).

4.6.5. The Impact of Free Internet Access on Urban Morphology

For nearly two decades, the discourse surrounding smart cities and the integration of digital tools within urban environments has been prominent. However, comprehensive studies defining a unified framework and distinctive features for smart city development are still ongoing. Smart cities encompass various definitions, yet they share common objectives in leveraging digital technologies.

Historically, the Industrial Revolution brought about profound changes in urban landscapes. Since then, the focus has shifted towards augmenting cities with digital layers. The rapid evolution of technology and the adoption of smart digital tools aimed at enhancing citizen convenience have posed challenges for urban planners and policymakers in aligning city needs with technological advancements. Effective urban development strategies necessitate a technology-centric approach to keep pace with these advancements. While standardized frameworks for smart cities are still evolving, equitable distribution of technology remains essential for improving urban quality of life. In smart cities, data plays a foundational role, serving as the bedrock for planning and progress. Both municipalities and citizens contribute to and benefit from urban data, fostering mutual growth and development.

For instance, municipal initiatives providing city-wide internet facilitate the collection of diverse data from citizens, such as internet usage patterns and location-based information. This access also empowers citizens by providing insights into their

geographical context, municipal services, and operational dynamics, thereby fostering a reciprocal cycle of needs and advancements between residents and city administrations. Cities continue to evolve dynamically to meet emerging challenges and opportunities, driven by technological advancements. The deployment of free municipal internet infrastructure typically involves the installation of access points, modems, routers, connectivity equipment, cables, signal boosters, traffic analysis tools, security apparatus (e.g., firewalls, intrusion detection systems), network management devices, and backup systems.

4.6.5.1. Transformative impacts of free unlimited internet access with digital tools on Kadikoy square: Challenges and planning consideration in public space

As shown in the figure below, Kadikoy Square, located in the Asian part of Istanbul, had the highest usage of the municipality's free internet in June 2024 (Figure, 4.53).

Kadıköy Square, İskele Square or Rıhtım Square, is a square located in the Kadıköy district of Istanbul province. Located on Istanbul's Asian side, Kadıköy Rıhtım Square, also known as Kadıköy Iskele Square, extends in a "C" shape along the Marmara Sea between Haydarpaşa Train Station and İnciburnu Lighthouse (Figure, 4.52). It is intersected by Söğütlüçeşme Avenue, a major thoroughfare in Kadıköy. Today, Kadıköy Rıhtım Square functions as a crucial transportation hub, providing connections to City Lines ferries, Istanbul Sea Buses, Turyol sea motors, and the Kadıköy-Kartal Metro line. This vibrant public space facilitates access to various districts and neighborhoods on the Anatolian side (Göllü & Türkyılmaz, 2019).

Figure 4.52. *The location of Kadikoy square, Source: (Ender Altay, Pırselimoğlu Batman, & Acaray, 2023)*

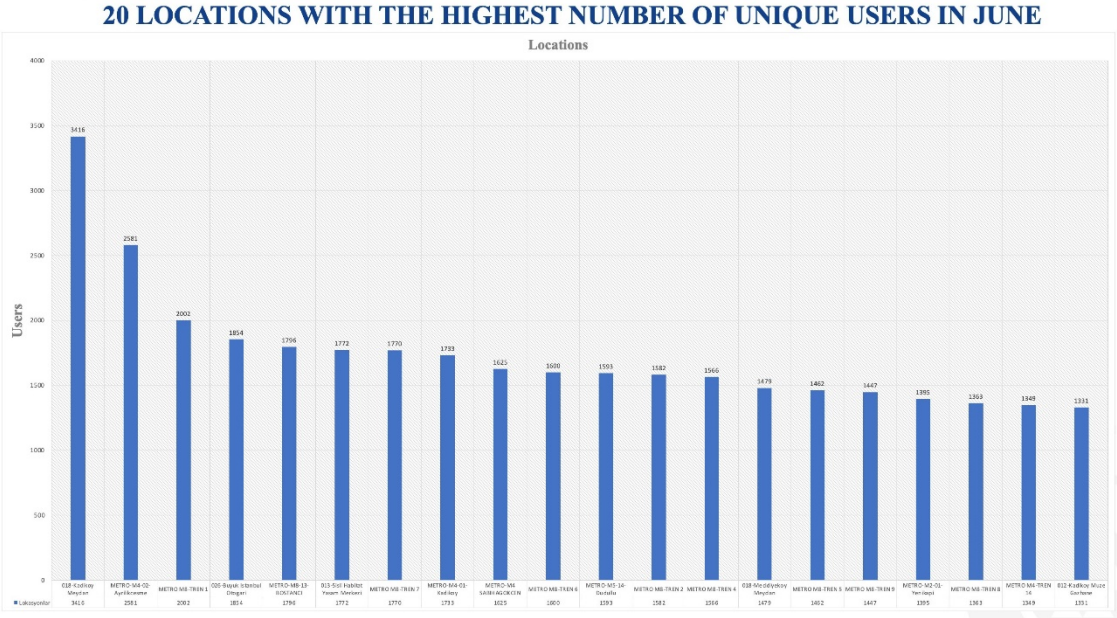


Figure 4.19. *20 locations in Istanbul with the highest number of IBB Wi-Fi users in June, 2024. (Source: Istanbul Metropolitan Municipality, Department of Information Technologies, 2024)*

In this regard, the physical presence of people in squares necessitates urban infrastructures that cater to connected citizens with diverse needs. Equipment for a public space that can support unrestricted free internet includes (Table, 4.7):

- Seating areas with shaded canopies
- Mobile phone charging stations
- Spaces for placing tablets and laptops
- Facilities for catering services
- Installation of security enhancement equipment such as security sensors for improved square safety
- Increased number of communication poles and stands
- Installation of technology-based recreational equipment
- Digital displays for city information and cultural/educational programs

Table 4.9. *Equipment for a public space that can support unrestricted free internet, Source: Author*

Category	**Equipment**	**Details**
General Facilities	Seating areas with shade canopies	
	Provision for catering needs	
	Provision of unrestricted free city-wide internet	

Table 4.10. *(Continued) Equipment for a public space that can support unrestricted free internet, Source: Author*

Technological Facilities	Mobile phone charging stations	Installation of charging poles, placement of power outlets
	Spaces for placing tablets and laptops	Designated tables with power outlets, secure storage options
	Installation of equipment for improving security and surveillance	Cameras, motion detectors
	Enhancement of square security through installation of security equipment	Security guards, emergency call stations
	Increase in the number of communication poles and stations	Installation of new poles, upgrade existing stations
	Installation of technology-based recreational equipment	Interactive screens, smart benches
	Installation of digital displays for city information and educational/cultural programs	Set up information kiosks
	Provision of consultancy and technical support services for users of technological equipment	

Evaluation of Figure 4.54 illustrates essential facilities for a district offering free and unlimited internet access. Each color represents a type of need that citizens require from an environment with unrestricted access to the Internet in order to meet their needs. The necessary facilities for this area are detailed in Table 4.7. Figure 4.55 demonstrates the integration of these facilities in Kadıköy Square, indicating that if all these amenities are deployed here, the morphology of the area will be significantly impacted. Upgrading the facilities in this square will have noticeable effects on surrounding streets, commercial activities, and regional security, potentially influencing the identity and shape of the area. Given that Kadıköy Square is one of the historic squares in Istanbul's Asian side, there is a need to create a new layer to address the modern-day needs of citizens, posing challenges. Preserving heritage buildings, smartifying the area, and meeting the new demands of citizens present planning challenges for the municipality. Another challenge in this area could be vulnerability in digital security, which can be resolved through collaboration with digital security experts.

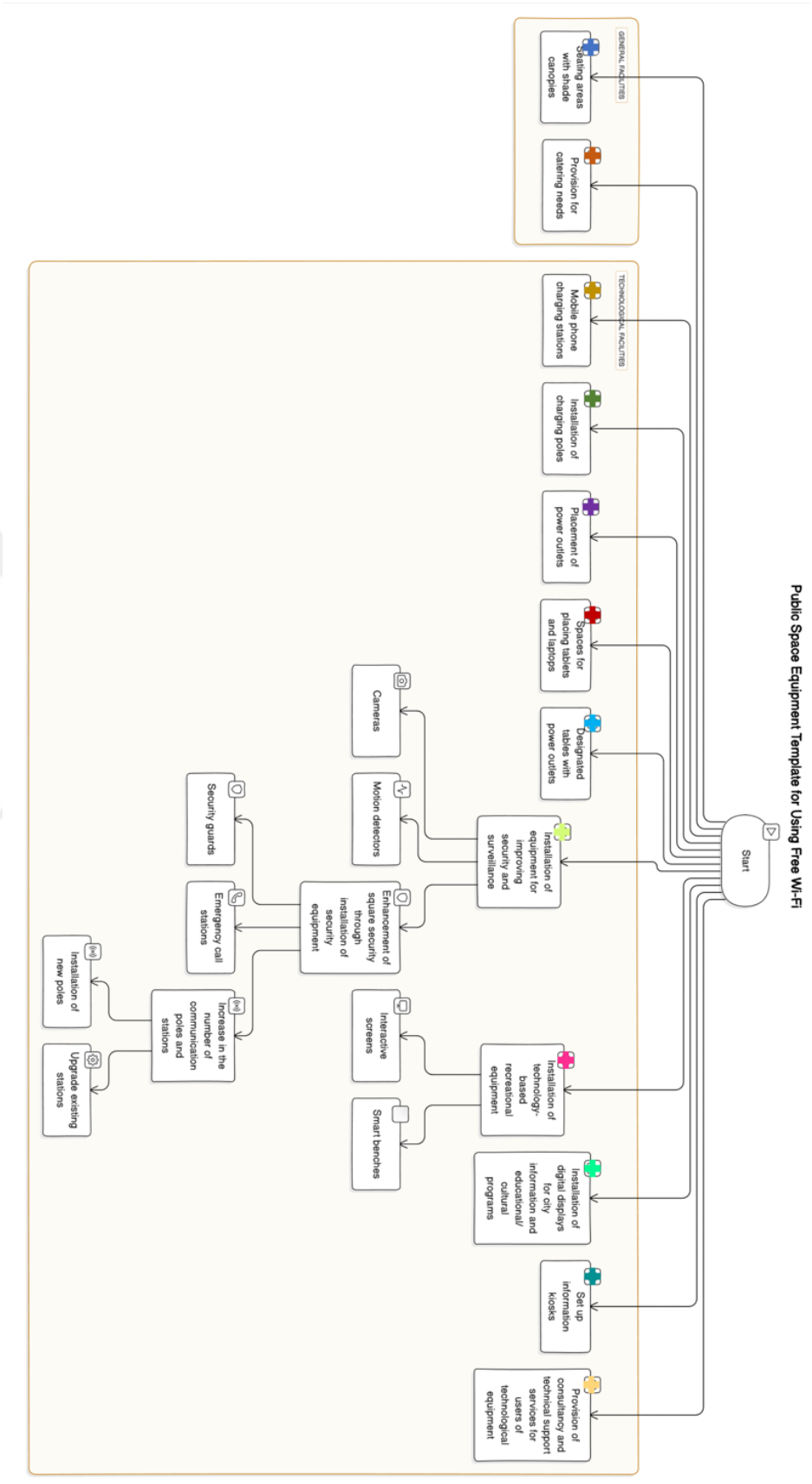


Figure 4.20. *Public space equipment template for using free Wi-Fi, Source: Author*

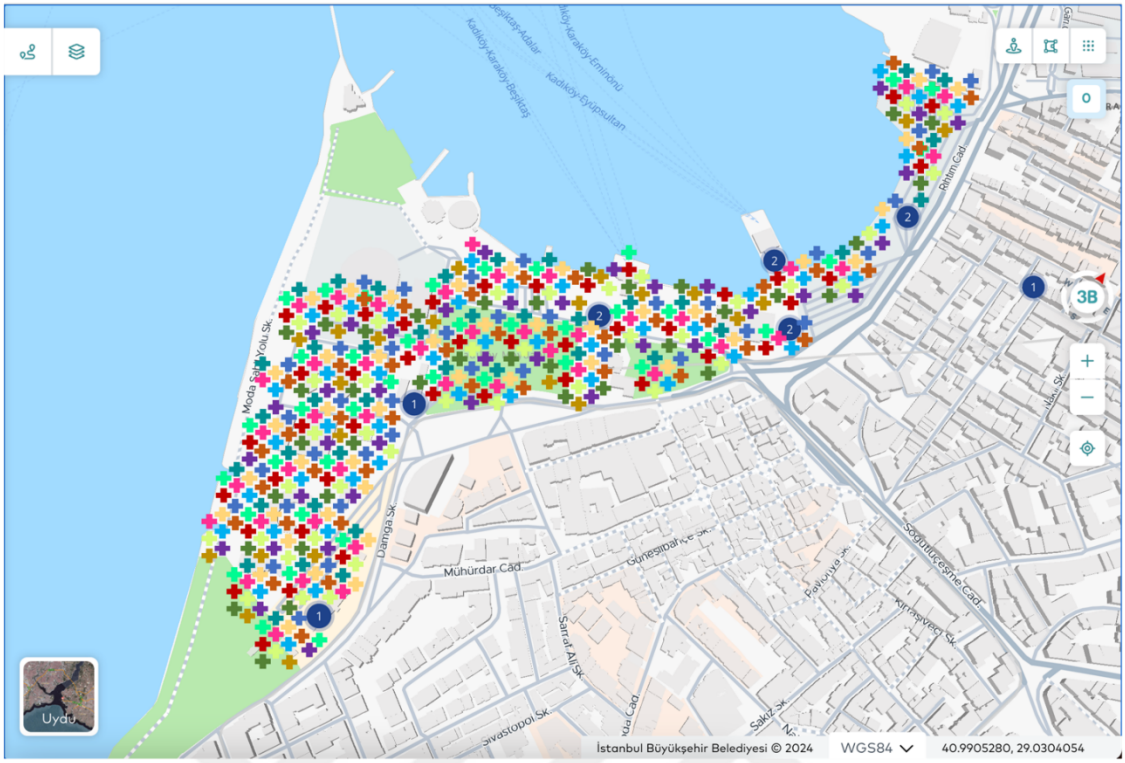


Figure 4.55. *Marking the implementation of necessary equipment for Wi-Fi in Kadikoy square (According to figure 4.54)*

4.6.5.2. Digital transformation and urban accessibility (Context of Internet integration): Redefining city dynamics

The provision of internet access is integral to the smartification of urban spaces, representing a significant initiative in urban connectivity. Access to internet services in cities extends beyond conventional notions, encompassing broader dimensions. It transcends the traditional concept of physical access through roads, pathways, and transportation networks, defining a more extensive scope. Internet access has emerged as a new dimension in recent years, becoming essential to the needs of modern city dwellers.

Historically, urban planning paradigms and city planning strategies require infrastructural adaptations to meet the demands of modern human needs. Infrastructures interconnected through networks enable enhanced accessibility for individuals within empowered environments. Although city structures, particularly historical ones, are not always conducive to immediate changes, relevant organizations strive to incorporate digital and smart layers into cities with minimal disruptions.

In the past, urban access primarily relied on physical factors such as distances between cities and mobility from one point to another. The quality of a city's infrastructure indicated its accessibility and how accessible it was to its residents.

Additionally, access to specific areas or resources within a city and society was defined by social classification or individual wealth. However, modern perspectives on access are more comprehensive, defined by additional factors. Urban transport networks, including metros, buses, roads, shared car programs, scooters, and bicycles, have expanded access to other dimensions. The use of GPS applications, mobile apps, and real-time transport information has made access to cities more accessible. Emphasizing attention to universal design (Goldsmith, 2000), ensuring that urban spaces are accessible to all members of society, including people with disabilities and elderly citizens, is a top priority in urban planning for new cities. Audible signals, smart lights, and digital tools to help people with disabilities are among the changes made in recent years in public and urban spaces. Smart city planning, with the help of some applications, helps integrate citizens as much as possible into the city and reduce reliance on cars by encouraging people to walk and bike. In addition to these, access to city information and services online is very important. Almost all city services are accessible through digital platforms and support residents for an accessible city. Services such as information on urban transport, accessibility of parking, city information, communication with city managers, and designers through platforms, etc.

In general, access in cities has moved beyond focusing on physical distances and is trying to eliminate both physical and social barriers in the modern era. The goal of this evolutionary process is for the city to be more accessible, fairer, and livable for all residents and visitors (Figure, 4.56).

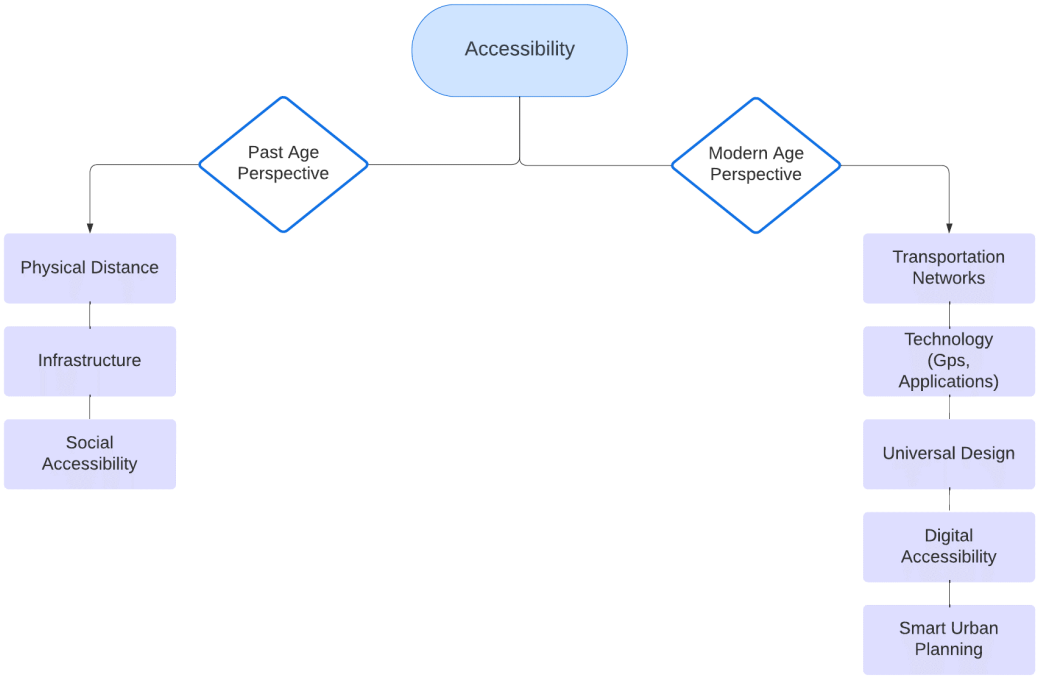


Figure 4.56. *Accessibility in past and modern age perspective, Source: Author*

CHAPTER 4: SUMMARY

Chapter 4 delves into the transformative impact of digital technologies on public spaces, providing a foundation for Chapter 5's exploration of their effects on urban identity and morphology. Through a comparative analysis of cities such as Singapore, Barcelona, Tokyo, Amsterdam, and Istanbul, it illustrates diverse approaches to smart city development. The chapter highlights how innovative digital tools—like Singapore's smart waste monitoring systems and Barcelona's bike-sharing programs—enhance urban services and improve stakeholder engagement. Each case study offers insights into the practical applications of these technologies, their effects on user experience, and the design principles underlying their implementation. This broad analysis helps in understanding the different ways cities leverage digital solutions to address urban challenges and improve the quality of public spaces.

In particular, the chapter focuses on Istanbul, examining initiatives like Vision 2050 and the significant expansion of free Wi-Fi across the city. The case study of Kadıköy Square, which experiences high usage of free internet services, is central to this analysis. It assesses whether these digital advancements are merely superficial enhancements or if

they significantly alter Istanbul's urban identity and social dynamics. By evaluating how such technologies influence urban form and resident interactions, the chapter aims to determine the extent to which digital infrastructure reconfigures the city's spatial and social landscape.

Overall, this chapter provides a comprehensive view of how digital technologies are reshaping public spaces and urban environments. By examining various global examples and focusing on specific initiatives within Istanbul, it sheds light on the broader implications of digitalization for urban identity, infrastructure, and the evolving needs of residents. The findings set the stage for a deeper understanding of the interplay between digital advancements and urban development in the subsequent chapters.

CHAPTER 5: INTRODUCTION

In Chapter 4, we examined how digital technologies are transforming public spaces, laying the groundwork for understanding their effects on urban identity and morphology in this chapter. Building on this foundation, Chapter 5 delves into the profound ways in which digitalization is reshaping urban morphology and identity. The integration of digital tools and innovations is not merely augmenting existing urban forms but is fundamentally altering them. The chapter explores how these digital transformations are reconfiguring the physical and social fabric of cities.

As cities adapt to technological advancements, they are not merely evolving but undergoing profound shifts in their structural and social fabric. This chapter explores these transformations in detail, focusing on how digitalization has reconfigured urban spaces and influenced the essence of cities.

Digital tools and innovations have introduced new paradigms (as discussed in chapter 4) in urban design, significantly altering how cities are planned and experienced. Technologies such as AI-driven urban planning systems and rapid prototyping tools like Singapore's Digital Blue Foam are reshaping conventional urban structures, facilitating more efficient and responsive city designs. This model reflects a broader trend towards integrating digital technology with urban planning to create more functional and sustainable urban environments. As cities embrace these technological innovations, the integration of digital and physical realms has led to a redefinition of urban morphology (emphasizing urban form, infrastructure transformation, and physical-digital integration). This chapter examines how digital tools are influencing the transformation of urban infrastructure, the blending of organic and planned growth, and the emergence of new urban forms. It delves into the complex interplay between historical evolution, technological progress, and urban design, highlighting how these factors contribute to the dynamic nature of contemporary cities.

Furthermore, the chapter explores the impact of digitalization on urban identity (with a focus on both material and immaterial dimensions). Urban identity encompasses both material and immaterial dimensions, including physical characteristics, cultural practices, and social interactions. The chapter investigates how digitalization of public spaces affect these aspects, reshaping the way cities are perceived and experienced. By analyzing the material and immaterial dimensions of urban identity pre- and post-digitalization, this

chapter provides a comprehensive understanding of how technological advancements are influencing the character and significance of urban spaces.

5. CHANGES IN URBAN MORPHOLOGY AND URBAN IDENTITY DUE TO THE DIGITALIZATION OF PUBLIC SPACE

The digital era has exerted significant influences on urban identity and morphology, driven by shifts in citizens' needs and technological advancements. As urban spaces evolve to enhance their functionalities, the integration of digital tools and innovations with traditional structures is fundamentally altering the essence of cities. For example, advanced AI-driven tools, such as the AI-based urban planning system developed by researchers from Tsinghua University, demonstrate this shift by surpassing traditional methods and optimizing designs based on the "15-minute city" (the 15-Minute City, developed by Carlos Moreno and supported by Paris mayor Anne Hidalgo, is an urban model where all essential services are within a 15-minute walk or bike ride and emphasizes density, proximity, diversity, and digitalization) concept. This system quickly generates plans incorporating essential urban elements, while Singapore's Digital Blue Foam has introduced Urban Insights for rapid urban prototyping, integrating data from various sources to assess urban scenarios. These digital innovations exemplify how urban design is being revolutionized by enhancing efficiency and precision (Ghisleni, 2024). As cities adapt to these changes, the transformation of physical infrastructure, influenced by historical and technological progress, reflects a dynamic urban fabric that blends organic growth with intentional planning. The redefinition of the link between physical and digital realms represents a new paradigm, driving cities towards sustainable, citizen-centric designs. Despite these advancements, cities strive to maintain their distinctive identities while creating vibrant, dynamic, and sustainable spaces for their inhabitants.

5.1. Morphological Transformation of Urban Spaces in the Digital Age

In delving into the morphological transformation of urban spaces in the digital age, it becomes evident that the intersection of urban morphology and technological advancements holds profound implications for the human-centric development of cities. As highlighted by Rossi in "The Architecture of the City," urban morphology is perceived as an artistic expression, delineating the human-designed landscapes within urban environments. To comprehensively analyze and understand these complex urban

structures, Rossi advocates for the integration of various disciplines such as urban geography, topography, and architecture (Rossi, 1982).

Moreover, the topographical and morphological elements of urban spaces, including streets and squares, emerge as pivotal components shaping the urban fabric. These elements not only contribute to the visual aesthetic of cities but also play crucial roles in facilitating movement, social interactions, and overall urban functionality (Krier, 1988).

In the context of the digital age, the fusion of urban morphology with technological innovations prompts significant inquiries into the creation of sustainable and healthy cities. Scholars such as Guan (2018) underscore the importance of addressing these questions, as the digitalization of urban design necessitates considerations for environmental sustainability, public health, and societal well-being. Thus, the morphological transformation of urban spaces in the digital age calls for holistic approaches that balance technological advancements with principles of sustainability and human-centric design.

5.1.1. Transformation of physical infrastructure

The transformation of physical infrastructure in urban areas is a dynamic process shaped by the interplay of historical evolution, intentional planning, and technological advancements. Urban planning, as an ancient practice, has witnessed the coexistence of two distinct types of cities: natural cities, which evolve organically over time, and artificial cities, intentionally designed by planners. The dichotomy between these forms—spontaneous development and systematic planning—creates a rich multi-layered urban fabric, each influencing the character of the city. Alexander's distinction between natural and artificial cities emphasizes the role of structural components, such as topography, public spaces, and interconnected buildings. These elements play crucial roles in shaping the character and vibrancy of a city. In both naturally evolving and systematically planned cities, the organization of the urban fabric, including the topography of the residential environment and the arrangement of open architectural spaces, contributes to the overall clarity of the city's layout. The geometric regularity in outlining the urban fabric facilitates the initial interpretation of the cityscape (Aga, 2010).

Urban morphology, as the study of evolving human settlements, further connects the physical structure of a location to various attributes, including economy, historical events, land use, pedestrian activity, urban design, well-being, and social hierarchies. Morphologists, observing patterns over centuries, reveal that configurations of cities

undergo similar changes or persistence across diverse cultures and historical periods (Duany & Talen, 2002; Scheer, 2017). The advent of state-of-the-art technologies, as conceptualized by Coyne's techno-romanticism, has ushered in a new era in the transformation of urban landscapes. Digital technology governs cities and their infrastructure, impacting healthcare, education, and citizen-government interactions. This integration of Information and Communication Technologies (ICTs) extends beyond virtual spaces, influencing physical infrastructure. Multimedia hubs, innovation centers, and technology hubs are reshaping cities at global, national, regional, and local levels. Terms like ubiquitous computing, augmented reality, intelligent buildings, and wireless networks are becoming integral parts of urban lexicon, fundamentally reshaping the relationship between people and their surroundings (Houghton, 2010). The trajectory of smart homes, driven by technological advances, parallels the smart transformation of public spaces, raising questions about the potential improvement and impact on their performance. Researchers and developers must investigate the consequences these spaces face after digitalization, as technology continues to advance. In viewing the city as a living organism, the layers of memory, culture, ecology, and morphology intersect over time. The debate on whether place still matters in a globalized and digitalized world underscores the ontological needs of humanity. Acknowledging the overlapping layers and the evolving role of technology, the transformation of physical infrastructure becomes a critical aspect of urban development in the contemporary era (Özbek Eren, 2020).

5.1.2. Physical-digital integration and its impact on urban morphology

The integration of digital layers within contemporary urban landscapes indicates a change in urban development paradigms that can significantly affect urban morphology, especially public spaces. Since these digital tools introduce new forms and tools from urban physical infrastructure to tangible structures in urban shaping, it becomes an important area of study for urban researchers. Physical-digital integration can impact urban form, and this synergy redefines the functional, structural, and even experiential aspects of public spaces.

5.1.3. Transformative effects on urban infrastructure

The impact of digitalization on urban infrastructures is examined from various perspectives, including urban mobility, digital connectivity, and urban form. The advent

of digital technologies has led to significant changes in urban mobility patterns, giving rise to the emergence of smart mobility solutions. Existing digital solutions, facilitated by digital tools such as city cameras, digital mapping, and data-driven online routing systems, have fundamentally transformed transportation infrastructures. These transformations have influenced mobility patterns in public spaces and introduced new paradigms to the urban landscape. Smart parking, micro-mobility solutions, and electric vehicle chargers in public spaces have become essential components of digitally-enabled urban mobility. Consequently, urban management and related organizations in urban areas are experiencing significant changes to adapt to this trend towards smart mobility. For example, future cities such as Neom (The Line) in Saudi Arabia (as of the writing of this study) are exploring strategies for implementing car-free urban mobility programs. Hence, future cities and the digitalization of public spaces can potentially create fundamental changes in urban form. Additionally, digital connectivity has fundamentally transformed the configuration of urban spaces to provide high-speed internet access, a critical prerequisite for smart cities. Considering the coexistence of physical and digital spaces, citizen-centric designs and plans capable of dynamically updating in response to citizens' evolving needs can be incorporated into short-term and long-term urban planning by municipalities and relevant organizations. Attention to this aspect prioritizes urban environments capable of updating and synchronizing with technological advancements and, consequently, meeting citizens' needs for greater well-being and sustainability.

5.1.3.1. Urban mobility

Digital mobility or smart mobility can be defined as the integration of digital technologies and data-driven solutions to enhance urban transportation and mobility systems. Digital mobility comprises a set of sensors, cameras, and Internet of Things (IoT) devices in transportation infrastructures such as roads, parking lots, traffic lights, and data collection devices related to traffic conditions. Smart parking, electrification for electronic vehicles, micro-mobility solutions, and, in general, any intelligent device utilized in urban spaces after digitalization and smartification, require a specific spatial organization. Additionally, parking spaces for micro-mobility vehicles, which require dedicated areas, are spaces that did not exist in the past several years. After technological advancements and cities' interest in becoming smarter, these spaces have been added to urban areas (Image 5.1, Image 5.2).

Image 5.1. *Micromobility parking, Source: (Brown et al., 2020)*

Image 5.2. *The need for a place to charge rechargeable cars, Source: https://www.chargepoint.com/blog/5-ways-retail-stores-can-boost-sales-ev-charging*

Although in some future cities under construction, such as Neom (The Line) in Saudi Arabia, strategies for car-free cities are being implemented. In this regard, the urban design intended for car parking spaces can gradually be repurposed into public urban spaces (as expressed by the author based on ongoing projects). It is not clear whether future cities will be surrounded by intelligent public transportation systems, sustainable personal transportation systems, or spaces designed for parking cars, bicycles, and micro-mobility in the long run. Over time, some experts advocate for 5-minute zoning to meet citizens' needs and eliminate private vehicles (The Line), while others emphasize the impracticality of this approach and recommend smart parking solutions.

5.1.3.2. Digital connectivity

High-speed internet access stands as one of the most critical prerequisites for the digitalization of public spaces. The interaction among individuals, urban navigation, and digital services in public areas all require a structured framework capable of addressing these needs. Given that the requirements of modern humans transcend those of the past, the form and spatial configuration of the city are naturally undergoing evolution or transformation to meticulously accommodate these evolving needs (Image 5.3). The act of sitting on a park bench and enjoying a desired view can no longer adequately meet the needs of modern individuals. A combination of physical and digital spaces has concurrently prompted humans to seek out a digital environment wherever they may be. While we unwind on a park bench, we can also conduct a business meeting in another city. To meet a friend, we need to find the route through internet-connected navigation apps, and digital displays become essential for assessing information about our surroundings.

Hence, with advancements in technology, the sought-after quality of public spaces is undergoing a profound transformation. Future cities aspire to build citizen-centric urban foundations capable of dynamically updating themselves in response to the changing needs of their residents. This objective aims not only to enhance quality in terms of sustainability but also to fulfill the evolving needs of citizens. Therefore, the physical design of the city, which has historically advanced across various social, economic, cultural, and functional dimensions, encounters a new digital layer upon entering the digital age. Planners, cognizant of the technological domains supporting this paradigm, aim to shape these new urban configurations and improve the physical-digital space.

Image 5.3. *The demand for digital and electronic tools, Source:https://www.zocalopublicsquare.org/2014/09/02/public-space-meet-cyberspace/ideas/up-for-discussion/*

5.1.3.3. Urban form

In recent years, as the topic of sustainable and smart cities has gained momentum, countries are making efforts to take a leading role in this discourse. Currently, numerous projects are being explored in countries such as Saudi Arabia, the United States, Japan, Canada, and the United Arab Emirates. In the figure below, various future city projects are carefully assessed with regard to urban design, utilized technologies, forthcoming challenges, societal impacts, and several other considerations (Figure 5.1).

The Project/Location	Urban Form	Features	Purpose	Technologies Used	Challenges Overcome	Lessons Learned	Impact on Community
Masdar City/Abu Dhabi Source: https://masdarcity.ae/	-Planned and grid-like -Grid pattern form	-Zero-carbon and sustainable design -Renewable energy integration -Advanced technologies for smart city -Green building standards with LEED certification -Public transportation and walkability -Water management with efficiency technologies -Waste management with a focus on sustainability -Mixed-use development (residential, commercial, recreational) -Cultural and educational facilities -Streets for automated driving, pedestrians, and personal mobility vehicles. -Underground road for goods transport. -Hydrogen fuel cell system for energy. -Living lab for testing mobility, autonomy, connectivity, and more. -Sustainable features: solar, geothermal, timber construction. -Integration of advanced tech: automated driving, robotics, ai, 5g/6g.	-Sustainable, carbon-neutral urban oasis -Human-centered community development with a tech focus. -Transition from auto manufacturer to mobility company. -Test and evolve software-hardware integration. -Future vision: diverse, happy communities. -Explore "mobility for all" concept.	-Solar power -Personal rapid transit (PRT) system -Innovative waste management -Sustainable architecture -Advanced water conservation technologies -Integrated urban planning -Research hub -Green spaces -Smart grid -Sustainable transportation -Automated driving tech. -Personal mobility vehicles. -Robotics. -Artificial intelligence. -Hydrogen fuel cell system. -5g/6g connectivity. -Advanced customer-focused software. -Automated mapping platform for precise localization.	-Carbon emissions -Energy conservation -Sustainable living -Shift to a mobility company. -Living lab for testing new tech. -Integration of software and hardware for ongoing value.	-Commitment to a sustainable future -Global model for smart city development -Tests mobility, autonomy, and connectivity innovations. -Unique street design for automated driving, pedestrians, and personal mobility. -Focus on "new equality" in urban planning. -Sustainable features: solar, geothermal, hydrogen tech, and timber construction. -Integrates advanced tech: automated driving, robotics, ai, and 5g/6g. -Aims to be a model for smart city development. -'Digital Infrastructure, 'digital twin,' optimizes utilities, delivery, and mobility.	-Commitment to a sustainable future -Global model for smart city development -Unique living lab for testing and advancing beneficial technologies. -Empowers residents as contributors to innovations. -Potential to set new standards for future cities. -Shift towards a more helpful, beneficial society through tech and mobility advancements.
Toyota Woven City/Japan Source: https://worldlandscapearchitect.com/	-Biomimicry morphology -The theoretical model of A linear city	-The theoretical model of a linear city -the 170-kilometre-long -a city without cars -Implementation of mass fiber-optic cable systems -Forward-thinking approach to future technologies -Emphasis on sustainable design practices -Integration of driverless vehicles, ride-sharing, and green spaces -Integration of Innovative streets -Innovative infrastructure integration	-Geometric shaping of urban space -Addressing urban and social problems -Political class struggle -Seeking new forms of urban development -High-speed mass transit response -Addressing population growth challenges -Support for responsible, dense population growth -Establishment of a forward-thinking community -Model for sustainable city development -Provision of access to major economic centers	-Contemporary knowledge and experiences in urban linearity -Potential technologies for communication -Potential technologies for transportation -Autonomous mobility solutions -Ultra-high-speed transit -Renewable energy -Environmental technologies -Zero net carbon emissions -Predictive technologies -Implementation of mass fiber-optic cable systems -Consideration of drone ports and self-driving cars -Establishment of a fast and secure fiber-optic network	-Systematics in linear geometry -Addressing diversified topography challenges -Potential challenges in various technical aspects -Overcoming suburban sprawl -Addressing decentralization of civic services -Discouraging overdevelopment of rural surroundings	-Systematics in linear geometry -Addressing diversified topography challenges -Potential challenges in various technical aspects -Zero net carbon emissions -Innovative transportation solutions -Layered city planning -Decentralized urban clusters -Integration of artificial Intelligence -Vision for future cities -Drawing lessons from suburban sprawl mistakes -Constructing a community based on innovative urban planning concepts	-Traffic congestion reduction -Air pollution mitigation -Enhanced accessibility -Improved safety -Promotion of social equality -Cultivation of social homogeneity -Positive influence on urban factors - Anticipated major population growth - creation of a dynamic center of activity - Providing sustainable and innovative solutions - reimagining community building for the future
Linear City, Saudi Arabia Source: www.neom.com	-Concentric zone model						
The Orbit, Innisfil, Canada Source: urbantoronto.ca	-Grid-multicenter	-Smart infrastructure -Digital accessibility -Innovation hubs -Smart city ambassadors -Education technology -Intelligent zoning -Smart housing solutions -Preventive healthcare -technologies -Next-gen economic strategies	-Sustainable city creation -Inclusive urban development -Focus on well-being -Emphasis on innovation	-AI (artificial intelligence) -Advanced monitoring and sensors -Blockchain -Smart metering -Telemedicine -Renewable energy sources -EVtols (electric vertical takeoff and landing) -Innovative water design -Experiential transportation -Zero carbon emissions	-Inclusive zoning policies - Technology for preventive healthcare -Zero carbon emission transportation -Funding public campaigns - Transparent city departments -Equal service levels -Safety measures -Integrating ecology	-Importance of inclusive zoning policies -Integration of sustainable technologies -Citizen participation -Inclusive economic development -Transparent governance	-Transformation into a sustainable, inclusive, and innovative city -Improved well-being -Increased community engagement -Vibrant cultural scene -Improved safety -Accessible urban design -Regenerative practices -Experiential tourism
Telosa, United States Source: cityoftelosa.com							

Figure 5.1. *Examination of Technologies and Characteristics in Future Smart City Projects (This figure analyzes various future smart city projects, highlighting the technologies used and their distinct characteristics). Source: Author*

Transformation of Urban Infrastructure and Form in Future City Projects: An examination of various future city projects—some currently in progress and others in the proposal stage (Figure 5.1)—reveals several common characteristics. These projects often exhibit:

- Selection of New Development Areas: Many future city initiatives focus on developing areas outside existing urban infrastructures, often in previously undeveloped regions. This approach allows for the creation of innovative urban environments unbound by existing limitations.
- Adoption of Urban Planning Models: Future city designs frequently employ grid-based or centralized plans, or a combination of both. These models offer flexible and scalable frameworks that accommodate both traditional and emerging urban needs.
- Preference for Unified Urban Networks: There is a marked trend towards integrating digital configurations and smart technologies into a cohesive urban network. This unified approach facilitates streamlined data management and enhanced connectivity.
- Utilization of Geometric Urban Forms: The use of specific geometric patterns, such as grid layouts and concentric zones, is evident in many future city designs (Figure 5.2). These forms contribute to efficient spatial organization and adaptability.

According to Batty (2018), traditional city planning has long concentrated on spatial arrangements using radial and concentric patterns. This historical focus on location over interaction has shaped many urban designs. However, as cities transition into the digital age, there is a noticeable shift towards prioritizing networks and digital integration. This new emphasis reflects the growing importance of connectivity and real-time data in urban planning.

Analysis of Public Spaces in Future City Projects: In relation to public spaces, the transformation observed in these future city projects presents several noteworthy implications:

- Integration of Digital Elements: Public spaces are increasingly incorporating digital tools and technologies. This integration aims to enhance functionality and user experience, providing smart amenities and real-time information.
- Design Adaptations: The shift towards grid-based and centralized plans allows for more adaptable and multifunctional public spaces. This adaptability is crucial for accommodating diverse activities and ensuring accessibility.
- Unified Networks and Smart Integration: The development of unified urban networks supports the creation of interconnected public spaces. This connectivity enhances the flow of information and services, making public areas more responsive to user needs.
- Geometric and Functional Efficiency: The application of geometric forms in public space design contributes to efficient use of space and facilitates the incorporation of smart technologies. These forms help in organizing public spaces to support both physical and digital interactions.

Overall, the evolving focus on networks and digital integration underscores a significant shift in how public spaces are designed and utilized. This transformation aligns with the thesis's emphasis on the impact of digitalization on public spaces, highlighting the need for thoughtful planning that integrates both physical and digital aspects to create functional and user-centric environments.

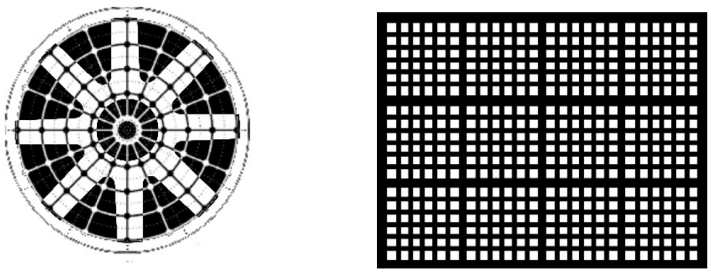


Figure 5.2. *Urban Geometric Forms in Future City Design Projects (Figure 5.1). This figure illustrates various geometric shapes used in modern urban planning, such as grid patterns and concentric area models. According to Figure 5.1, a common feature of future urban projects is the adoption of these urban form models. Source: Author*

The common elements of these projects are also outlined in the table below (Table 5.1):

Table 5.1. *Common Elements of Future Cities Projects, based on the Analysis of Projects Described in Figure 5.1, Source: Author*

Urban and Public Space Aspects	**Key Points**
Urban Form	-Grid pattern form and biomimicry morphology principles in design. -Exploration of linear city and concentric zone models. -Utilization of grid-multicenter structures.
Features	-Emphasis on zero-carbon, sustainable design. -Integration of renewable energy, advanced technologies -Promotion of public transportation, walkability, and mixed-use development. -Streets designed for automated driving and personal mobility vehicles. -Integration of cultural facilities
Purpose	-Creation of sustainable, carbon-neutral urban spaces. -Human-centered development with a tech focus. -Vision for diverse, happy communities. -Attaining of "Mobility for All" concept.
Technologies Used	-Implementation of solar power, PRT systems, and advanced waste management. -Integration of smart grids, sustainable transportation, and AI. -Utilization of automated driving, robotics, AI, and 5G/6G. -Incorporation of contemporary knowledge in urban linearity and potential technologies
Challenges Overcome	-Overcoming carbon emissions, energy conservation, and suburban sprawl challenges. -Addressing decentralized civic services and promoting inclusive zoning policies. -Overcoming obstacles in technology integration and systematics.
Lessons Learned	-Commitment to a sustainable future and global smart city development. -Drawing lessons from suburban sprawl mistakes and emphasizing inclusive zoning.
Impact on Community	-Becoming a global model for smart city development with a focus on testing and advancing technologies. -Empowering residents through innovation and anticipating positive impacts on traffic, safety, accessibility, and community well-being.

The evaluations referenced in the above table indicate a transformative shift towards cohesive urban changes. These assessments suggest a move towards a unified

urban morphology, emphasizing urban form, infrastructure transformation, and physical-digital integration, alongside the synchronization of urban networks driven by increased reliance on digital tools. This evolving trend has significant implications for the design of urban public spaces, where there is a noticeable shift towards modular and parametric urban shapes. The preference for grid-based and centralized urban forms is evident. The combination of structured and modular urban configurations, along with the integration of digital layers, reflects a strategic approach in smart city planning. This strategy aims to harness the benefits of digitalization, focusing on creating an efficient, connected, and citizen-centric urban environment.

5.2. Influence of Digitalization on Urban Identity

One of the fundamental questions posed in the exploration of urban spaces is: do we create our urban environments, or do they shape us? On a daily basis, we engage with various forms of public spaces, and the quality and functionality of these spaces have a direct impact on our behaviors and our perception of the environment. However, a crucial debate emerges regarding whether urban identity evolves in accordance with the historical trajectory and cultural context of each society. While there exists a plethora of studies on urban identity, pinpointing this concept and its determining factors remains elusive. Despite urban planners delving into realms that significantly influence urban identity, the precise definition of urban identity remains somewhat elusive.

Urban identity is commonly understood as the distinguishing features that set one city apart from another (Lynch, 1960) (Relph, 1976). The term "identity" itself, as per the Oxford English Dictionary's definition, dates back to 1690, originating in discussions on human understanding. However, the inception of scholarly exploration into the concept remains somewhat ambiguous. Among the earliest scholars to elucidate the notion of identity was Al-Farabi, whose work in the 9th and 10th centuries defined identity in Arabic as "an indication of a thing's character, peculiarity, and unilateral existence" (Al-Jabri, 1986). Identity has consistently intrigued scholars and observers across diverse fields including urbanism, philosophy, literature, anthropology, psychology, and sociology, leading to a plethora of interpretations of this concept (Lalli, 1992; Mansour, Brandão Alves, & da Costa, 2023) (Table, 5.2).

Table 5.2. *Definitions and notions of "Identity" in different fields of study. (Mansour et al., 2023)*

Author	Field	Definition
(Frege 1967) (p.20)	Philosophy	"Identity is the relation between names, understood as signs expressing senses, of denoting the same denotation."
(Hegel 1812) (pp.38-39)		"self-equal in its absolute negativity, through which otherness and relation-to-other has vanished in its own self into pure equality-with-self"
(Ibn Khaldun 1858)	Sociology	Each of the accidents, whether a subject or an action, must have a nature that is specific to it in itself, and in what is exposed to it in its circumstances.
(Clifford 1988) (p.344)		"Nexus of relations and transactions actively engaging a subject."
(Ferguson 2009) (p.15)	Psychology	"Notions of identity that emerge…are constituted as relations rather than entities. In the context of everyday life, identities describe how people and things are interconnected".
(Jenkins 1996) (p. 4)	Sociology / Psychology	Identity "refers to the ways in which individuals and collectivities are distinguished in their social relations with other individuals and collectivities."
(Relph 1976) (p.62)	Geography / Urbanism	"The identity of place is not a simple tag that can be summarized and presented in a brief factual description…. The identity of place takes many forms, but it is always the very basis of our experience of this place as opposed to any other."
(Lynch, A Theory of Good City Form 1981) (p.8)	Urbanism	"The identification of an object, which implies its distinction from other things, its recognition as a separable entity. It is not in the sense of equality with something else but with the meaning of individuality or oneness."

Considering the various definitions proposed regarding urban identity, urban environments differ based on their unique cultural and characteristic attributes. Urban identity manifests itself in different urban public spaces through their distinct structures. Therefore, both physical and non-physical features (such as architecture, urban fabric, social interactions, sense of belonging, and economic and social conditions) influence urban identity. Consequently, urban identity can be perceived as distinctive in various locations such as cities and different countries.

The material and immaterial attributes influencing urban identity are discussed in the following research article. Titled 'A Comprehensive Methodological Approach for the Assessment of Urban Identity', Mansour, Alves, and Costa (2023) offer valuable insights into the evaluation of urban identity. Through their work, they conduct a methodologically rigorous examination of this complex subject, shedding light on its intricacies and providing valuable perspectives for further research and understanding.

This study addresses the multifaceted nature of urban identity components, which are examined primarily under two fundamental dimensions: material and immaterial. While these dimensions encompass numerous elements, compiling a comprehensive list of them

is impractical. Therefore, the narratives presented by the referenced researchers (Mansour, Alves, & Costa, 2023) will be provided. Additionally, after investigating these items, supplementary components will be presented in the form of (Figure 5.4) in this thesis.

5.3. Examining the Material and Immaterial Dimensions of Urban Identity Pre- and Post-Digitalization of Public Urban Spaces

Urban identity is comprehended from both material and immaterial perspectives. Urban identity is a multidimensional concept that includes different characteristics and identities of a city. It is defined not only by immaterial elements that form the cultural, social and historical landscape of the city, but also by material elements such as the architecture of buildings, urban infrastructure and geographical features.

5.3.1. Material Dimensions of Urban Identity Pre- and Post-Digitalization of Public Urban Spaces

The material dimension encompasses visual constituents delineating urban space, which include geographical location, natural features, territorial boundaries, regional characteristics, vegetation coverage, climatic conditions, urban morphology, and historical characteristics (Table 5.3). These dimensions are structured through the formation of mental constructs held by citizens regarding cities. All material dimensions encapsulating the relationship between individuals and public spaces are regarded as integral facets of urban identity. The manner in which governments engage with public spaces within a city is indicative of its urban identity. The allocation of national budgets by governments to public spaces can be considered one of the most important factors directly influencing the material dimensions of public spaces. When embarking as tourists to another country for the first time, our initial interactions with public spaces afford us the opportunity to evaluate the urban identity, its level of development, the societal standing of its populace, as well as the nature of governmental interactions, whether democratic or dictatorial, to a considerable degree. Figure 5.4, presents some of these components, with the first part pertaining to the research Mansour, Alves, and Costa (2023), and the second part relating to this study.

Table 5.3. *The material dimension of the urban identity and its factors. Source: (Mansour et al., 2023)*

Factors	Metropolitan Scale	City Centre Scale	Neighbourhood Scale	Street/Public Space Scale
Geographical location	Regional positioning in relation to neighbouring cities and natural features	Location within the metropolitan area, proximity to key city features	Location within the city centre, proximity to local amenities	Position on the street grid, relationship to nearby public spaces and landmarks
Natural features	Large-scale landscape elements (mountains, rivers, forests)	City parks, waterfronts, and prominent natural features	Green spaces, community gardens, and smaller natural features	Street trees, planters, and micro-scale natural features
Territorial boundaries	Overall city limits and administrative borders	Boundaries of central business districts, historical centres, or key city zones	Boundaries of residential, commercial, or mixed-use areas	Edges and transitions between different types of public spaces, building frontages, and land uses
Regional characteristics	Unique aspects differentiating the city from other metropolitan areas (climate, culture, architecture)	Distinct architectural styles, cultural institutions, and urban patterns in the city centre	Local cultural, architectural, and demographic characteristics of neighbourhoods	Specific design elements, materials, or cultural references at the street or public space level
Vegetation cover	Distribution of green spaces and natural areas throughout the metropolitan region	Presence and distribution of parks, gardens, and green spaces within the city centre	Community parks, gardens, and other green spaces within neighbourhoods	Street trees, planters, and greenery integrated into the design of streets and public spaces
Climatic conditions	Prevailing weather patterns and conditions affecting the entire metropolitan area	Microclimate influences due to the density and arrangement of buildings in the city centre	Localised climatic conditions within neighbourhoods, influenced by vegetation and building patterns	Microclimate influences at the street or public space level, such as wind patterns or sun exposure
Urban morphology	Macro-scale layout and design of the metropolitan area, including major transportation networks and land uses	Spatial organisation of the city centre, including major streets, public spaces, and building arrangements	Layout and design of neighbourhoods, including street patterns, building types, and land uses	Spatial layout and design of individual streets or public spaces, including street furniture and amenities
Historical and Archaeological Characteristics	Investigates the broad historical and archaeological narratives and landmarks of the city	Assesses the city centre's specific historical narratives and archaeological sites	Examines historical narratives and archaeological remnants specific to the neighbourhood	Looks at historical narratives and archaeological features tied to specific streets or public spaces

Drawing on the case studies examined in Chapter 4, we investigate the changes that have occurred in the material and immaterial dimensions of urban identity following the utilization of digital layers and technology. The transformations induced in the cityscape post-digital layer embody an evolutionary process aligned with technological advancements. The city, akin to a living organism, is constantly evolving, adapting to the progresses, regressions, and temporal currents with distinctive velocity. The cities we currently inhabit reflect the simultaneous impacts of both material and immaterial dimensions imposed upon them. While certain urban characteristics may remain unchanged over time, cities consistently undergo transformation into places where people reside and necessitate. This process has embraced new trajectories with the progression of technology and the incorporation of citizens' opinions and suggestions. Through platforms and other technological tools, citizens can more readily influence their cities.

In the current study, an assessment of both the material and immaterial dimensions before and after the digitalization process is conducted. This evaluation draws upon insights

derived from carefully examined case studies. Ultimately, the analysis leads to the creation of the diagram represented by the Figure 5.4.

1- Geographical Location

Before Digitalization: The geographical location involved considerations such as its adjacency to other cities and places, proximity to urban centers, amenities, and local facilities, and the nature of connections with neighboring spaces. This information was traditionally available in paper format, with physical locations being identified directly by names and addresses. Finding addresses and adjacencies was a one-dimensional process, with municipal maps being the primary source.

After Digitalization: The geographical adjacency of urban spaces can now be digitally integrated with other data and systems, and geographical information and access to it are freely available to everyone. Traffic patterns, public transportation, and urban structures are now accessible in real-time, facilitating more efficient managerial and civic decision-making. New features such as live routing, precise information about adjacencies and public spaces, and access to amenities are available in applications, allowing for easier access for all.

2- Natural Features

Before Digitalization: Natural features such as mountains, forests, rivers, and springs were recognized as integral components of the material identity of urban spaces. Social gardens, parks, trees, and the like, whether on a large or small scale, have had their own impact on urban identity. Urban space management with natural elements was significantly different before digitalization. For instance, a city with more natural elements has a distinctly different urban identity compared to a city with fewer natural elements. Citizen behavior in public spaces in these two areas also differed.

After Digitalization: With advancements in technology, smart systems, and digital data, efforts can be made to preserve, conserve, and manage these natural features using monitoring systems. The use of sensors enables monitoring of plant status, air and water pollution, facilitating their preservation and management. Significant strides can be taken towards environmental management of the city.

3- Territorial Boundaries

Before Digitalization: The territorial boundaries of urban areas, including administrative, commercial, historical, residential, central, and key areas of cities, as well as the boundaries between public and private spaces within cities, are among the components that signify urban identity. The identification of private boundaries over public boundaries or vice versa in a city significantly influences the identity and image that the city projects.

After Digitalization: While some express concerns about the potential loss of public boundaries after digitalization, urban space digitalization has the capability to effectively manage and control these spaces against various threats. As witnessed during the pandemic era, the control of public and private boundaries was effectively conducted through certain cameras and smart sensors, which proved to be noteworthy.

4- Regional Characteristics

Before Digitalization: Unique features of each region such as architecture, cultural, demographic, and local elements, along with distinctive design elements, constituted one of the dimensions of regional urban identity. These elements varied from region to region within a city, reflecting the specific identity of each area.

After Digitalization: The digitalization of urban spaces has significantly impacted regional urban management. For instance, through the implementation of smart solutions in regional spaces, such as waste management, public transportation, and the promotion of cycling through smart applications, a new identity has emerged for these regions. This digitalization has even influenced the interaction between citizens and the regional area. By digitalizing regional spaces, new dimensions of interaction between citizens and the urban area have emerged, fostering positive engagement in the urban process and enhancing the quality of life for residents.

5- Vegetation Cover

Before Digitalization: The distribution of green spaces and natural areas within urban regions as breathing spaces for the city, are among the distinguishing components of urban identity that vary in every city. Green spaces, trees, and even the flower pots

considered by municipalities all contribute to the city's identity. Another reason vegetation cover influences urban identity is its impact on shading in the city.

After Digitalization: The use of smart technology in irrigation, protection, and overall management of vegetation cover, with the precise information it provides, assists us in their maintenance. Through this, precise maintenance of vegetation cover helps the city preserve its greenery and significantly prevent fires and their destruction.

6- Climatic Conditions

Before Digitalization: Just as the patterns and climatic conditions of each region influence the type of architecture and urban planning, they also have an impact on the regional urban identity. For instance, the urban planning pattern of Yazd city in Iran, based on its warm climate, has directly influenced the regional culture and urban identity, distinguishing it as one of the most indigenous cities in Iran. Climatic conditions not only affect buildings and urban architecture but also influence human behavior, shaping the behavior of citizens.

After Digitalization: In recent years, the use of technology for urban resilience against weather conditions and enhancing urban functionality during climate crises has been significant. Precise weather systems and timely climate information assist citizens in making better decisions regarding daily urban activities. Furthermore, this information aids city management in making better decisions to protect the city against climate change.

7- Urban Morphology

Before Digitalization: Urban designs, city layouts, land uses, street patterns, and spatial designs were all decided through urban planners, specialists, and city planners. Citizens had little involvement in the city shaping process and only chose their city's formation path through mayoral elections. Consequently, cities did not undergo a harmonious process with citizen decision-making in shaping their trajectory.

After Digitalization: The urban design process, decision-making for creating amenities, urban transportation routes, the presence or absence of certain urban furniture, and other

factors influencing city shaping have improved post-digitalization and citizen participation through urban platforms.

8- Historical and Archaeological Characteristics

Before Digitalization: The historical and archaeological identities of each city and region are considered integral parts of their cultural and urban identity. Reviewing historical events that occurred in urban environments is an inseparable part of the culture of public spaces in cities, which varies from city to city around the world. For instance, the historical identity of a public space in Barcelona is specific to the history of that country and represents the urban identity of that region.

After Digitalization: Preserving these historical urban spaces and recreating the narratives of ancient civilizations helps transmit them to future generations. Smart technologies are utilized to protect historical urban artifacts and preserve them for future generations. Additionally, efforts have been made to digitally capture these areas in three dimensions and make them accessible to the public on historical archaeological sites. This endeavor aims to familiarize people worldwide with the historical areas of cities in other countries.

5.3.2. Immaterial dimensions of urban identity pre- and post-digitalization of public urban spaces

The identity of a public urban space encompasses not only its material dimensions but also its immaterial aspects (Table 5.4). Activities that take place in a public space shape the lifestyle and ultimately, interactions between individuals and their environment. Public spaces are not merely constructed to provide something to individuals; they also receive something from them, creating a cycle that influences urban identity. Some public spaces serve as livelihoods, some are used for advertising campaigns for specific candidates, and others are frequented for social interactions and connections, all contributing to the identity formation and acceptance of urban spaces.

Activities that reinforce the social and cultural values of a society serve as vital indicators of urban identity. Celebrations, social gatherings, rituals, and the observance of important days all play a direct role in defining the immaterial dimensions of urban identity. The identity of individuals within a community can be assessed based on their actions and interactions in public spaces. The identity of a city or country can be gauged from the

feelings of joy, fear, interaction, friendliness, and participation observed in its public spaces. Countries with diverse governments create urban spaces with varying urban identities.

Table 5.4. *The immaterial dimension of the urban identity and its factors. Source: (Mansour et al., 2023)*

Factors	Description
Social and cultural values	Investigates the shared social norms, cultural practices, and community beliefs that shape the identity of the city. These values often significantly impact both the people and urban space.
Meaning in Urban content	Evaluates the symbolic significance and perceived meanings of spaces within the city, including how physical elements, activities, human aspirations, and experiences shape these meanings. Understanding these meanings can vary greatly based on individual and collective interpretations.
Cultural activities	Cultural activities that reflect the community's meanings and values, including social relationships, special rituals, and festivals in public urban spaces, serving as vital indicators of the city's identity.
Economic activities	Assesses the dominant industries and sectors that fuel the city's economy, including the main commercial and business activities prevalent within it. Evaluates how inhabitants earn their livelihood and the extent to which they rely on these activities.
Cultural Heritage	Examines the city's collective cultural practices, rituals, and celebrations. These practices contribute to the city's identity, serving as vital indicators of it.
Religious Beliefs and Activities	Studies the dominant religions and religious practices in the city. The religious beliefs and activities of the community contribute to shaping the external features of urban identity.

1- Social and Cultural Values

Before Digitalization: Prior to the digital era, social and cultural values were among the key components shaping urban identity. These values encompassed shared social values, rituals, social beliefs, cultures, and customs, unique to each community, shaping its regional identity. These habits and beliefs directly influenced urban planning, architectural spaces, street design, and public spaces. For instance, the beliefs and rituals of a city or region could shape it into a religious, non-religious, secular, democratic, conservative, or other forms. Therefore, the cultural norms and values adhered to by a society significantly impacted urban development.

After Digitalization: With the advancement of technology and social communications in virtual spaces, cultural exchange occurs more seamlessly, transitioning societies from insular to familiar with the cultures of other cities and countries. Technology and digital platforms also facilitate the presentation of regional cultures, beliefs, and rituals, aiding in introducing other communities to the urban experiences of different citizens. Digital tools utilized in promoting and showcasing diverse cultures contribute to cultural exchanges among societies, fostering acceptance of cultural diversity in different communities. Thus, digitalization plays a pivotal role in reshaping the dynamics of social and cultural values, fostering global cultural exchange and acceptance.

2- Meaning in Urban Content

Before Digitalization: Before the digital age, various aspects of urban life such as art and music, government policies, citizen issues and successes, social problems, social and political stratifications, urban growth trends, fashion, and all other elements contributing to urban content could define urban identity. Diversity in urban content, whether in the form of celebrations, conflicts, or demonstrations, all reflected urban identity and was specific to each particular urban area. For example, comparing protest-oriented urban content with content showcasing citizen satisfaction with the government reveals two entirely different urban identities.

After Digitalization: With the utilization of digital tools, opportunities for citizen participation in urban activities have increased significantly. Cultural experiences, urban growth trends, joining groups in favor or opposition to urban policies, following urban fashion trends, and cultural, social, and political urban programs are all facilitated through digital tools and contribute to urban content. Participatory platforms in virtual spaces, digital tools in cultural, social, and political activities through art and music, digital information on urban digital walls, and other examples symbolize a transformation in urban content, altering the identities of cities.

3- Cultural Activities

Before Digitalization: Cultural activities reflecting regional meanings and values constitute another component of urban identity. Activities occurring in public spaces, whether social, cultural, political, or religious, are significant indicators of regional identity.

After Digitalization: The use of technologies to enhance cultural experiences and create new opportunities for citizen participation has played a crucial role in changing this component. The following table 5.5 highlights some of these changes:

Table 5.5. *Transformation of public spaces activities in digital era. Source: (Badel & Lopez Baeza, 2021)*

Cultural activities	Art	Digital public art
	Information	Data wall Digital signage
Social activities	Games	Digital facades Digital floors Digital playground
	Group actions	Watching movie, match, in public spaces
Political activities	Political meetings in the digital space Political support Political protests	

These digital tools and technologies effectively engage citizens in urban activities and assist in their participation in public spaces. The digital transformations through these activities facilitate communication between the city and its citizens, allowing them to play a role in shaping their city.

4- Economic Activities:

Before Digitalization: Examining how a city sustains itself economically and the existing economic and commercial activities that energize the city or face it with an economic recession can be introduced as another component of urban identity. The means by which city residents earn income, local markets' presence, and commercial activities significantly contribute to shaping urban identity. For instance, vibrant port cities have a distinct urban identity compared to cities facing economic recessions. Port cities, due to the energy derived from traffic, have a more bustling atmosphere.

After Digitalization: The utilization of online platforms, smart technologies, virtual entrepreneurship, and intelligent support for various industries create a digital economic ecosystem that contributes positively to community economic prosperity. Familiarity with smart business and economic methods, intelligent digital transactions in urban settings, facilitating commercial exchanges for citizens in their income-generating activities, all aid in economic prosperity.

5- Cultural Heritage

Before Digitalization: Cultural heritage in every country is categorized into tangible and intangible heritage. Although some aspects have been mentioned in the above sections, this section specifically categorizes them as follows: Tangible heritage such as handicrafts, historical buildings, ancient artifacts, and museums. Intangible heritage includes customs, beliefs, traditions, cultural ceremony language, and more. Both of these categories directly influence the formation of urban identity.

After Digitalization: Through the use of virtual technologies, virtual tours of tangible cultural heritage, historical buildings, and architecture of various cities can be collected and made accessible to the public. Films, images, and documentaries obtained from tangible and intangible cultural heritage of cities can easily provide access to the history and culture of the city. Additionally, digital tools provide facilities to protect both tangible and intangible cultural heritage. Overall, strengthening the protection and monitoring of tangible and intangible cultural heritage, producing audiovisual materials and 3D films, creating virtual museums, accessing past information, and preserving artifacts are among the changes that have occurred after digitization (Siountri & Vergados, 2019).

6- Religious Beliefs and Activities

Before Digitalization: Religious ceremonies and activities significantly contribute to the characteristics of cities, directly impacting urban identity. For example, the city of Konya in Turkey is considered a religious city due to the holding of certain religious ceremonies, defining its urban identity.

After Digitalization: Establishing connections among religious enthusiasts through digital platforms to integrate them for participation in rituals directly affects the identity of cities. Religious leaders, through digital tools and online platforms, encourage citizens to participate in these ceremonies and also motivate them to allocate a portion of their donations to the poor. Religious rituals alter the identity of cities. Recent years have witnessed changes in urban identity in cities like London and Vancouver following the congregation of Muslim prayers.

5.3.3. Exploring the digital transformation of urban identity

As outlined in the study "A Comprehensive Methodological Approach for the Assessment of Urban Identity," both material and immaterial dimensions are crucial to understanding urban identity. Figure 5.3 demonstrates how the integration of digital layers into urban environments affects these dimensions. Our analysis, informed by various case studies, explores the transformations in urban identity resulting from technological advancements and digital integration.

Drawing on this comprehensive analysis, we delve into the profound transformations observed in urban spaces, both pre- and post-digitalization. The introduction of digital technologies has significantly altered urban identities, as illustrated in Figure 5.4. This shift is not universally embraced, as different experts may have varying opinions on the implications of digital technologies on urban spaces. Our exploration highlights how digital layers impact material elements—such as geography, natural features, and urban morphology—by facilitating more efficient management, enhancing data accessibility, and optimizing spatial utilization and sustainability. Technological advancements have led to the integration of real-time data and smart management systems, which improve functionality and accessibility.

In addition to material changes, digitalization has profoundly impacted the immaterial dimensions of urban identity. Social and cultural values, which previously evolved through physical interactions and traditions, now experience a globalized transformation through digital platforms. This seamless cultural exchange and virtual connectivity enable cities to present and integrate diverse cultural narratives, fostering greater acceptance and interaction among communities. Digital tools have redefined how social values and cultural practices are shared and experienced, enhancing global cultural integration.

Economic activities have also been revolutionized by digital tools. The rise of online platforms, smart technologies, and virtual entrepreneurship has transformed economic interactions and commercial activities, contributing positively to urban economic vitality. This digital shift supports new business models and enhances economic resilience, reflecting a dynamic change in the economic fabric of cities. The integration of digital technologies into economic practices has facilitated smarter, more adaptable economic environments, enhancing the overall economic health of urban areas.

Ultimately, this exploration aligns with the thesis objective of assessing how digitalization reshapes both the material and immaterial aspects of urban identity and

morphology. The integration of digital technologies transforms urban spaces by influencing their physical structure and functionality, such as through smart infrastructure and enhanced spatial management. This shift underscores the need for a nuanced approach in urban planning to harmonize digital advancements with the existing urban fabric.

At the same time, digitalization impacts the immaterial dimensions of urban identity by redefining social interactions and cultural practices. Virtual platforms and global connectivity reshape community dynamics and cultural narratives, affecting how cities present and experience their identities. Understanding these changes is crucial for guiding the development of cities in a way that aligns with their evolving character and helps integrate digital advancements effectively into both the material and immaterial aspects of urban life.

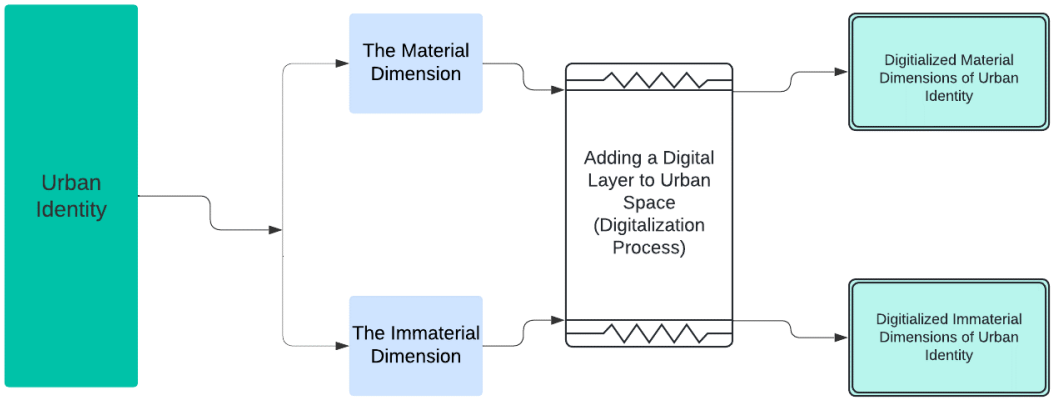


Figure 5.3. *Urban identity transformation after digitalization Source: Author*

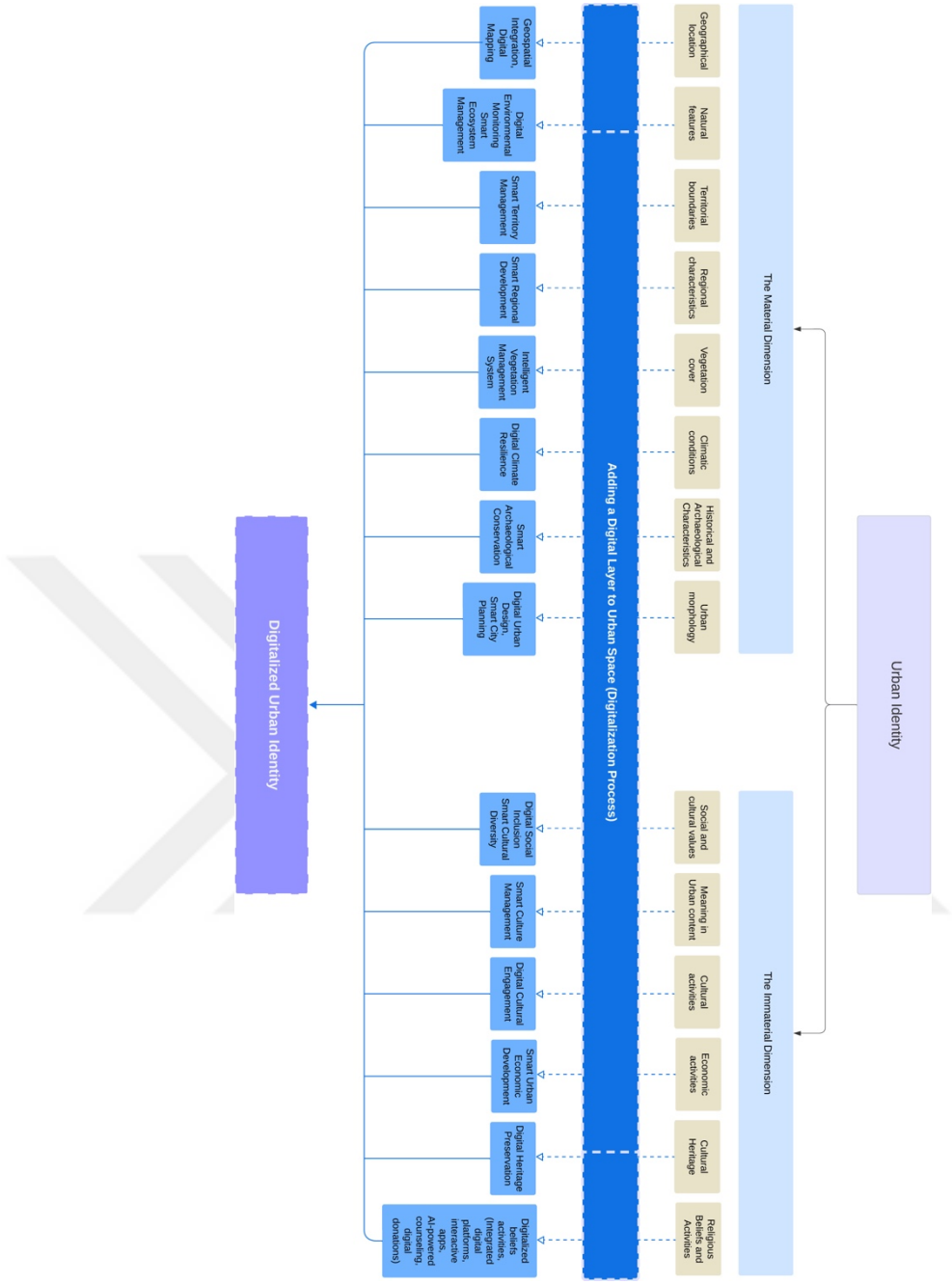


Figure 5.4. *Examining the Material and Immaterial Dimensions of Urban Identity Pre- and Post-Digitalization of Public Urban Spaces Source: Author*

5.3.4. Impact of digitalization on urban identity in public spaces

Since Tables 5.6 and 5.7 are derived from Figure 5.4, they demonstrate that digitalization profoundly impacts urban identity, affecting both the material and immaterial dimensions of public spaces. The expansion of technology in cities has led to significant transformations in these dimensions. These changes manifest through shifts in functionality, interactions, service roles, and citizen experiences within public spaces.

Consequently, the integration of digital layers brings about substantial alterations and innovations in the urban environment, particularly in public spaces.

Materially, cities are no longer defined solely by their physical attributes like geographical location, natural features, and vegetation cover (Table 5.6). Digital tools now provide real-time data and management capabilities, from live traffic patterns to environmental monitoring, enhancing how cities adapt to and manage their spaces. This evolution makes urban spaces more responsive and accessible, shaping a dynamic urban identity that integrates real-time information and digital interaction.

Table 5.6. *Material Dimensions of Urban Identity After Digitalization Source: Author*

Dimension	After Digitalization
Geographical Location	Integrated with digital systems, real-time data, and accessible applications for enhanced navigation.
Natural Features	Utilizes smart systems and sensors for precise monitoring and management of natural features.
Territorial Boundaries	Enhanced management through digital tools, improved control of boundaries especially in crises.
Regional Characteristics	Smart solutions and digital tools introduce new management and interaction dynamics for regional identity.
Vegetation Cover	Advanced smart technologies for precise irrigation, protection, and overall management of green spaces.
Climatic Conditions	Digital weather systems enhance resilience and provide better data for urban planning and citizen decisions.
Urban Morphology	Increased citizen participation through digital platforms influencing urban design and amenities.
Historical and Archaeological Characteristics	Digital tools for preservation, 3D modeling, and public accessibility of historical sites.

Immaterially, digitalization has reshaped social and cultural values, allowing for a more fluid exchange of cultural experiences and ideas. Where once local customs and rituals defined urban identity, now digital platforms enable global cultural interactions, expanding and blending regional identities. This shift fosters greater cultural exchange and understanding, altering the traditional dynamics of how public spaces reflect and shape community values. Economic and cultural activities have also evolved with digitalization. Online platforms and smart technologies facilitate economic growth and cultural participation, creating new forms of engagement in public spaces.

Table 5.7. *Immaterial Dimensions of Urban Identity After Digitalization Source: Author*

Dimension	After Digitalization
Social and Cultural Values	Enhanced cultural exchange and visibility through digital platforms, fostering global cultural understanding.
Meaning in Urban Content	Digital tools expand citizen participation, allowing diverse expressions and interactions to shape urban content.
Cultural Activities	Digital technologies create new opportunities for engagement and enhance cultural experiences.
Economic Activities	Digital platforms and smart technologies boost economic prosperity and modernize commercial activities.
Cultural Heritage	Digital tools enhance protection, access, and visibility of both tangible and intangible cultural heritage.
Religious Beliefs and Activities	Digital platforms facilitate broader religious participation and integration, altering urban identities.

The digital transformation has significantly altered the way citizens interact with and influence their urban environments. By facilitating easier digital access, it enables citizens to connect more seamlessly with urban spaces. This connectivity fosters a more integrated and multifaceted urban identity, reflecting both traditional and contemporary influences. As public spaces evolve with technological advancements, they contribute to a new urban identity that merges existing elements with modern digital innovations. This ongoing interaction between physical and digital realms plays a crucial role in shaping urban experiences in public spaces.

CHAPTER 5: SUMMARY

Chapter 5 offers an in-depth analysis of how digitalization is reshaping urban morphology (emphasizing urban form, infrastructure transformation, and physical-digital integration) and identity (with a focus on both material and immaterial dimensions). The chapter begins with a discussion of the transformative impact of digital technologies on urban planning and design. Innovations such as AI-driven planning systems and rapid prototyping tools are revolutionizing conventional urban structures, enabling the creation of more efficient and citizen-centric city designs.

The chapter explores the morphological changes in urban spaces driven by digitalization, highlighting the interplay between historical evolution and technological advancements.

It distinguishes between naturally evolving and systematically planned cities, emphasizing how digital tools contribute to the transformation of urban infrastructure and the creation of new urban forms. The integration of digital and physical layers within urban landscapes is examined, focusing on how this synergy affects public spaces and urban form. Significant attention is given to the impact of digitalization on urban mobility, digital connectivity, and overall urban infrastructure. The chapter analyzes the rise of smart mobility solutions, the transformation of transportation systems, and the role of digital connectivity in shaping urban spaces. It discusses the emergence of smart parking, micro-mobility solutions, and high-speed internet access as critical components of digitally-enabled urban environments.

The chapter also delves into the influence of digitalization on urban identity, exploring both material and immaterial dimensions. It examines how digital technologies impact physical characteristics, cultural practices, and social interactions within urban spaces. The chapter provides insights into how urban identity is evolving in response to digitalization, highlighting the ways in which technology reshapes the perception and experience of cities.

Overall, Chapter 5 provides a comprehensive overview of the profound changes occurring in urban morphology and identity as a result of digitalization. By analyzing these transformations, the chapter offers valuable insights into the future of urban development and the ongoing evolution of cities in the digital age.

6. DISCUSSION-CONCLUSION

6.1 DISCUSSION

This comprehensive exploratory thesis investigates the transformation of public spaces in the digital age, revealing a complex interplay between technological advancements and urban design. The analysis, grounded in the theoretical frameworks and practical examples discussed throughout the thesis, highlights several critical insights into how digitalization impacts public spaces and urban identity.

6.1.1. Components of digital public spaces

This section addresses the research question: "What are the components of digital public spaces?" The study identifies key elements of digital public spaces, categorizing them into three main components: Systems (e.g., smart information systems), Networks (e.g., digital communication networks), and Solutions (e.g., smart emergency alert tools). It highlights that digital components such as interactive displays, augmented reality (AR), smart infrastructure, and urban sensors are central to the digital transformation of public spaces. These technologies are not superficial additions but drive a significant shift in the functionality and experience of public spaces. Interactive digital displays and smart infrastructure enhance sensory experiences and operational efficiency, marking a new era where digital and physical realms are increasingly interconnected.

6.1.2. Transformative nature of digitalization

The research question of whether digitalization signifies a transformative shift or merely adds a digital layer to existing environments has been explored through various case studies and theoretical perspectives. The evidence suggests that digitalization is indeed transformative, altering not only the functionality of public spaces but also their social and cultural dimensions. For instance, smart city initiatives in Singapore and Barcelona demonstrate how digital tools can fundamentally reshape urban services and stakeholder interactions. These technologies are not just enhancing existing spaces but creating new forms of engagement and interaction that redefine conventional notions of public space.

Figure 6.1 provides an insightful overview of how digital tools are implemented across various cities to meet specific urban objectives. In Barcelona, tools like the Bicing Bike Sharing system and the Digital Platform for Citizen Engagement (Decidim) are

utilized to enhance accessibility, inclusivity, and diversity. These initiatives facilitate urban mobility and civic participation, contributing to a more connected and inclusive public realm.

Tokyo's Tourist Information Digital Signage Features and Amsterdam's Crowd Monitoring System Amsterdam (CMSA) reflect objectives focused on resilience and adaptability. These tools are designed to improve visitor experience and manage dynamic crowd patterns, respectively, enhancing the city's ability to respond effectively to various challenges.

Singapore's integration of Smart Lighting (Agil, LaaP) and the Garden Management System (GMS), along with Barcelona's IoT-driven waste management and smart parking solutions, underscores a commitment to safety, security, and environmental sustainability. These technologies enhance urban safety, optimize resource use, and promote sustainable practices.

The addition of digital exhibitions in Singapore and community-focused digital platforms in Tokyo and Amsterdam highlights efforts to improve utilization and community integration. These tools aim to foster public engagement and environmental quality, reflecting a broader trend towards a more interconnected and responsive urban landscape.

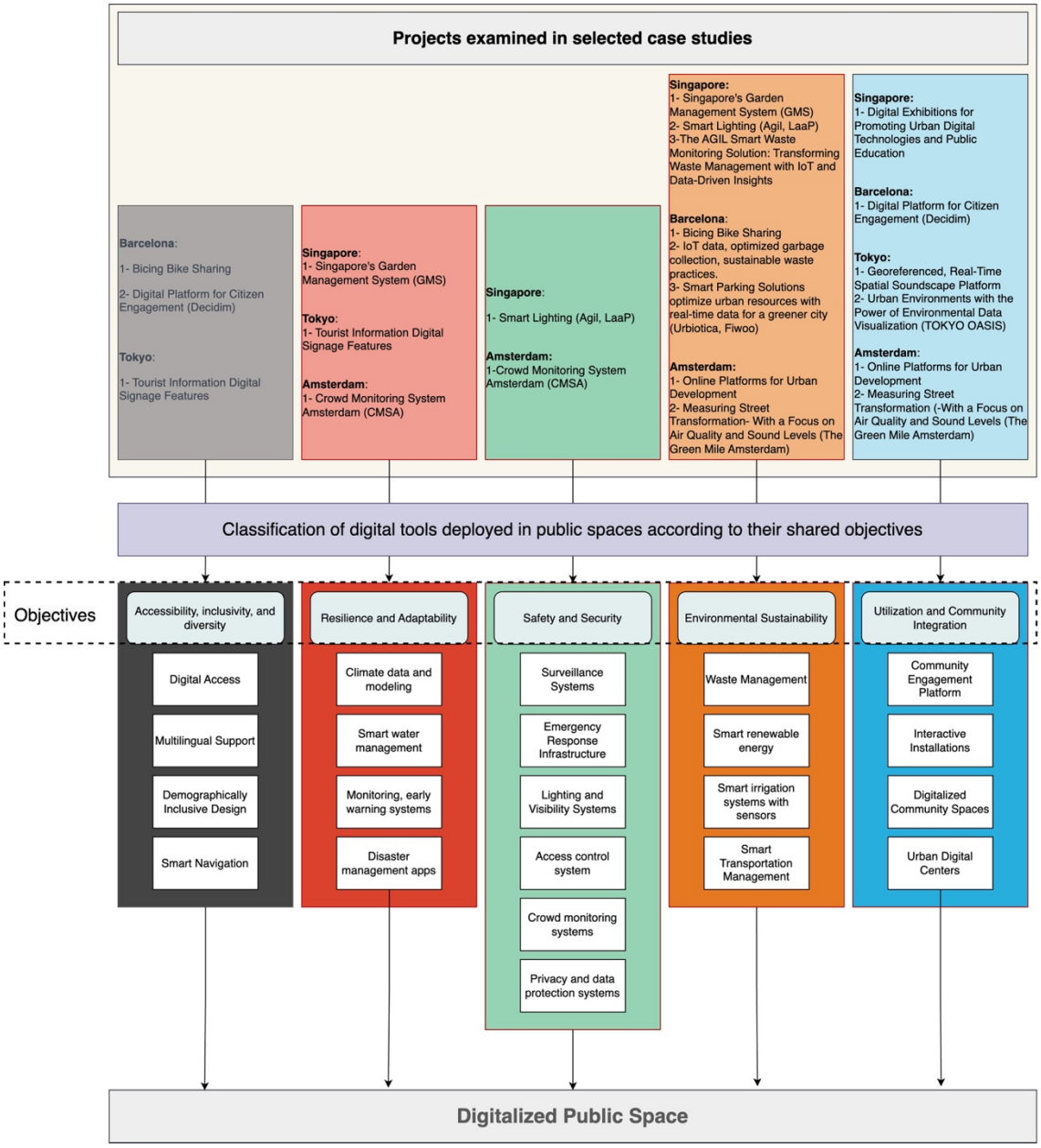


Figure 6.1. *The classification of projects examined in the case studies has been categorized based on their common objectives. This diagram illustrates the process of organizing Figure 6.2., Source: Author*

The case studies examined reveal that each digital component aligns with one of the following five objectives (Figure 6.1):

-Accessibility, Inclusivity, and Diversity (marked in black): Smart navigation, demographically inclusive design, multilingual support, and digital access.

-Utilization and Community Integration (marked in blue): Community engagement platforms, interactive installations, digitalized community spaces, and urban digital centers.

-Environmental Sustainability (marked in orange): Waste management, smart renewable energy, smart irrigation systems with sensors, and smart transportation management.
-Safety and Security (marked in green): Surveillance systems, emergency response infrastructure, lighting and visibility systems, access control systems, crowd monitoring systems, and privacy and data protection systems.
-Resilience and Adaptability (marked in red): Climate data and modeling, smart water management, monitoring and early warning systems, and disaster management apps.

To address research question number 2, which explores the objectives guiding the integration of digital layers, Figure 6.2 provides a detailed illustration of a digitalized public space. This figure evolves from Figure 6.1, showcasing how necessary digital tools are integrated to fulfill five distinct implementation objectives. It organizes these objectives and categorizes the digital tools accordingly, drawing on case studies of public space projects analyzed in this research. Additionally, the diagram (figure 6.2) includes tools used throughout the study for the digitalization of public spaces, demonstrating that specific implementation objectives systematically guide the integration of digital layers.

Figure 6.2. *From Tools to Objectives: A Comprehensive Model for Digitalized Public Spaces, Source: Author*

The integration of digital tools into urban environments represents a profound transformation that enhances accessibility, inclusivity, sustainability, and safety. This comprehensive approach underscores a broader trend towards creating more interconnected, responsive, and adaptive urban landscapes. By improving features such as smart navigation systems, multilingual support, and interactive community platforms, and by advancing sustainability through smart waste management and renewable energy systems, digital tools are not merely adding layers to existing urban spaces but are fundamentally reshaping them. This transformation reflects a significant shift towards more inclusive and sustainable urban experiences, highlighting the transformative impact of technology on public spaces (Araldi & Fusco, 2017; Rasul, 2021).

However, integrating digital elements can sometimes lead to tensions with traditional urban fabric, which includes foundational components like buildings and street segments developed through historical processes and social interactions (Rasul, 2021). While some urban areas adapt seamlessly to digital enhancements, others may reveal conflicts between new technologies and established urban patterns. This duality underscores the need for careful consideration in implementing digital tools to ensure they contribute positively to urban identity and functionality, maintaining a balance between technological advancement and the preservation of traditional urban elements.

6.1.3. Impact on urban identity and morphology

This section addresses the research question: "What is the impact of digitalization on urban identity (with a focus on both material and immaterial dimensions) and urban morphology (emphasizing urban form, infrastructure transformation, and physical-digital integration)?" The impact of digitalization on urban identity (with a focus on both material and immaterial dimensions) and morphology (emphasizing urban form, infrastructure transformation, and physical-digital integration) is profound. The case studies of cities like Tokyo and Amsterdam illustrate how digital tools influence urban form and infrastructure, leading to the emergence of new urban typologies and functions. The integration of AI-driven planning systems and smart mobility solutions highlights a shift towards more responsive and adaptive urban environments. These changes affect both the material aspects of cities—such as infrastructure and spatial organization—and the immaterial dimensions, including cultural practices and social interactions, ultimately

leading to the interpenetration of public and private spaces and a definitive alteration of their original identities (Ampanavos & Markaki, 2014).

The analysis of Istanbul's digital transformation, particularly in Kadıköy Square, demonstrates how extensive digital infrastructure reconfigures urban spaces and alters residents' needs. The expansion of free Wi-Fi and other smart technologies not only changes physical layouts but also impacts social dynamics and public engagement. This case study emphasizes that digital advancements can fundamentally reshape urban identity by modifying both the material and immaterial dimensions of city life.

6.2. Key Findings

The thesis reveals that digital technologies are profoundly reshaping public spaces and urban environments.

Components of Digital Public Spaces: The thesis identifies that digital public spaces are composed of various elements including infrastructure, services, and digital tools such as digital displays, Wi-Fi, interactive art installations, and urban games. These components contribute to advancements in sustainability and urban development (Menezes & Costa, 2017) and include technologies like ride-sharing apps and autonomous vehicles that necessitate adaptive infrastructure (Durand et al., 2021; Macharis & Geurs, 2019). The incorporation of Urban Morphological Artificial Intelligence (UMAI) signifies a shift towards data-driven, multidisciplinary urban planning (Stojanovski, 2021).

Transformation versus Digital Layer and Integration Objectives: Digitalization is not just adding a superficial layer but is fundamentally reshaping public spaces. Innovations such as the Internet of Things (IoT) and urban sensors enhance real-time data, which boosts urban efficiency, safety, and sustainability (Matei & Cocoșatu, 2024). This digital transformation impacts spatial and physical configurations, demanding a comprehensive approach to urban design and planning. The objectives guiding this integration are centered around improving functionality and responsiveness in urban management.

Impact on Urban Identity and Morphology: The impact of digitalization on urban identity is evident in case studies from cities like Singapore, Barcelona, Tokyo, Amsterdam, and Istanbul. For instance, Istanbul’s Vision 2050 and free Wi-Fi expansion have significantly transformed urban forms and social interactions, especially in Kadıköy Square. Digital tools and smart city initiatives are redefining the character and experience

of urban spaces, demonstrating that while some digital integrations may seem superficial, they drive substantial changes in urban identity and social dynamics (Oldenburg, 2007; Pittaluga, 2020). The thesis emphasizes the need for a comprehensive approach to urban design that effectively integrates digital technologies. It underscores the importance of understanding both the opportunities and challenges presented by digital advancements. As cities continue to evolve in the digital age, further research should focus on how these transformations impact public spaces and urban life, considering both practical applications and broader implications for urban morphology and identity.

Through the examination of this thesis, it becomes evident that the transformation of public spaces in the digital age is an unavoidable phenomenon. Digital components and tools are driving fundamental changes in public spaces, altering their structural and social identities. The case studies reveal that the needs of citizens and cities are in a cycle of evolution, and cities must be able to address these needs effectively. In the digital age, responding to citizen needs has led to changes in the objectives of public space components, resulting in ongoing transformations within these spaces. This transformation in public spaces goes beyond mere digital overlay, evolving into a digital paradigm that encompasses everything from urban infrastructure to place-making objectives. Ultimately, it is concluded that public spaces are undergoing significant changes in their form, structure, and identity.

6.3. Exploring Study Constraints, Avenues for Further Research, And Recommendations

This study highlights the transformative potential of digital technologies in public spaces but also acknowledges several constraints. One key limitation is the variability in the adoption and impact of digital tools across different cities and contexts. While cities like Singapore and Barcelona demonstrate significant advancements, others may face challenges due to varying levels of infrastructure, economic resources, and technological readiness (Durand et al., 2021; Macharis & Geurs, 2019). Additionally, the study's focus on selected case studies may not fully capture the diversity of experiences and outcomes across different urban settings. Future research could address this by including a broader range of cities and examining how diverse socio-economic and cultural contexts influence the integration of digital technologies.

Moreover, the rapid pace of technological advancement presents a challenge for maintaining current research relevance. As new technologies emerge, the findings of this study may quickly become outdated. To mitigate this, longitudinal studies are needed to track the long-term impacts of digitalization on urban spaces and their evolving role in shaping urban identity and morphology (Keseru & Randhahn, 2023; Matei & Cocoșatu, 2024). Investigating how emerging technologies like blockchain and advanced AI further impact urban design could provide deeper insights into future transformations of public spaces.

6.3.1. Recommendations

Insights from this study offer numerous recommendations for urban planners, designers, and policymakers:

Contextual Adaptation: Digital solutions must be customized to fit the specific characteristics of each region. For instance, in earthquake-prone areas, incorporating seismic safety protocols into digital systems can enhance resilience and risk management (Keseru & Randhahn, 2023).

- Security Enhancement: In regions with significant security concerns, digital tools should be designed to strengthen safety measures. This includes implementing robust surveillance systems, effective alert mechanisms, and responsive emergency services to address local security challenges (Matei & Cocoșatu, 2024).

- Transportation Solutions: Areas with inadequate public transportation infrastructure should leverage digital innovations to improve transit access and connectivity. This involves optimizing routes, enhancing transit information systems, and integrating smart technologies to address mobility gaps (Durand et al., 2021; Macharis & Geurs, 2019).

- Traffic Management: To combat traffic congestion, urban areas should employ digital tools to streamline traffic flow and improve real-time traffic monitoring. Implementing smart traffic management systems can reduce bottlenecks and enhance overall traffic efficiency (Jachna, 2021).

Customized Approach: There is no one-size-fits-all solution for digitalizing public spaces. Successful implementation depends on aligning digital tools with the unique needs and challenges of each community. Ensuring that digital solutions are deeply integrated into the local context will maximize their effectiveness and provide meaningful benefits to residents (Smaniotto et al., 2015).

Recommendations About Urban Priorities

Inclusivity: Strategies for developing smart cities should prioritize the accessibility and inclusivity of technologies for all societal strata. Digitalization of public spaces should not marginalize vulnerable groups but rather work to bridge social and digital divides. Ensuring that all community members benefit from technological advancements is crucial for fostering equitable urban environments.

Sustainability: The pursuit of sustainable urban development necessitates a comprehensive approach that balances technological innovation with environmental stewardship. While enhancing public spaces through digital tools is important, it is essential to uphold environmental protection and minimize ecological footprints.

Cultural Preservation: Rapid digitalization must not compromise the cultural heritage and identity of cities. Urban planners and policymakers should emphasize the preservation of local cultural heritage amidst technological advancements. Maintaining unique cultural identities within digitalized public spaces is vital to prevent homogenization and ensure that the digital transformation respects and enhances local traditions and values.

Finally, there is a need for interdisciplinary approaches combining urban design, technology studies, and social sciences. By integrating perspectives from various fields, researchers can develop more holistic models that account for the multifaceted nature of digital public spaces and their effects on urban morphology and identity.

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