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Innovative Practicies for the Spatial Sustainability and Efficiency of Smart Cities Built from Ground Up

Yeni İnşa Edilen Akıllı Şehirlerin Mekânsal Sürdürülebilirliği Verimliği için Yenilikçi Uygulamalar

Mücella Ateş[1]

Öz

Bu çalışmanın temel amacı, yeni inşa edilen akıllı şehirlerin sürdürülebilirliği bağlamında yenilikçi politika ve uygulamaları incelemektir. Bu yerleşimlerin verimliliği de bu çalışma kapsamında ele alınmaktadır. Türkiye'ye yönelik önerilere yer verilmiştir. Yeni inşa edilen akıllı şehirlerde Space Syntax yöntemi kullanılarak mekansal analiz yapılmıştır. Bu yerleşimlerin sürdürülebilirliğine yönelik önerilerde bulunulmuştur. Bulgular, akıllı şehir altyapısının mekansal konfigürasyonunun, bu şehirlerin sürdürülebilirliğini etkilediğini göstermektedir. Bulgular aynı zamanda yeni inşa edilen akıllı şehirlerin sürdürülebilirliğinde yerel faktörlerin önemli rolünü de ortaya koymaktadır. Bu çalışma, sürdürülebilirlik ve yenilikçi uygulamaları kentsel verimlilikle ilişkilendirmektedir. Akıllı şehir altyapısı ve yeni inşa edilen yerleşimlere, daha önceki çalışmalara göre farklı bir yöntem kullanılarak yaklaşılmaktadır. Dolayısıyla bu çalışma, ilgili alana katkı sağlayacaktır.

Anahtar Kelimeler: Sürdürülebirlik, Yeni Akıllı Şehirlerde Mekânsal Okuma, Yenilikçi Uygulamalar, Space Syntax

ABSTRACT

The main objective of this study is to examine innovative policies and practices in the context of the sustainability of newly constructed smart cities. The efficiency of these settlements is also addressed within the scope of this study. Suggestions for Turkey are also included. Spatial analysis was conducted using the Space Syntax method in newly constructed smart cities. Recommendations were made for the sustainability of these settlements. The findings indicate that the spatial configuration of smart city infrastructure influences the sustainability of these cities. The findings also demonstrate the significant role of local factors in the sustainability of newly constructed smart cities. This study relates sustainability and innovative practices to urban efficiency. The smart city infrastructure and newly constructed settlements are approached using a different method compared with previous studies. Therefore, this study will contribute to the relevant field.

Keywords: Sustainability, Spatial Reading in Smart Cities from Ground up, Innovative Practices, Space Syntax

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1. Introduction

Just like the general population growth in our country, our cities are experiencing rapid population expansion. Consequently, both underground and aboveground resources are being rapidly depleted, leading to an increase in environmental pollution and global warming. However, technology is progressing at a fast pace, with increased usage of computers and the Internet. This has resulted in accumulating valuable data, shedding light on how we utilize our time and the problems we face.

As a response to the evolving urban issues, the 'Smart City' approach has emerged, utilizing these technological developments to offer solutions. Although the concept was first introduced in Turkey in the early 2010s, its implementation has unfortunately been limited so far (Figure 1).

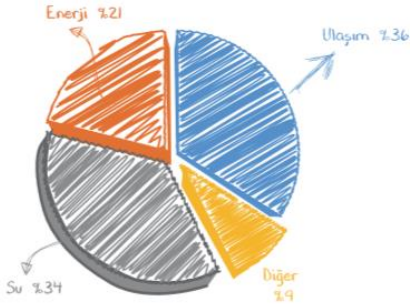

Figure 1. Smart city applications and their distributions in Turkey. Source: Turkey Informatics Foundation, 2016.

Furthermore, apart from these new technologies, the role of human capital is another vital factor in the progress of smart cities, contributing to enhanced economic, social, and environmental sustainability. This study adopts a specific definition of 'smart cities' as cities that strategically utilize Information and Communication Technologies (ICT) and attain prosperity, efficiency, and competitiveness across various socioeconomic levels. The article begins by reviewing the concept of a smart city and encompasses contents having spatial references. The first part of the article clarifies the characteristics of smart cities and distinguishes them from other types.

The second part examines the planning and implementation of new smart cities using the space syntax method, highlighting the spatial attributes of Seestadt Aspern (Vienna) from Europe and Masdar (Abu Dhabi) from Africa as selected examples. The findings section evaluates the results obtained through the employed method. In the final section, under the heading 'Conclusion and Evaluation,' the article incorporates the essential criteria for newly built smart cities to be sustainable and efficient, highlighting the innovative social practices essential for achieving these goals. The article ends with a discussion of the insights provided and suggestions for future research topics.

This paper makes a significant contribution to the smart city discourse by clarifying the misconceptions surrounding smart city efficiency and by revealing the advantages and disadvantages of these strategic choices. Additionally, it serves as a foundation for designing smart city strategies.

1.1 Literature Review

In addition to the approaches that emerged in the 1990s and were summarized earlier, the concept of the 'Smart City' emerged as a response to the challenge of integrating technological advancements and innovations into urban environments while prioritizing human well-being and the environment Smart cities are essentially based on the idea of creating urban formations that prioritize high efficiency for both humans and nature by adopting developing information technologies as the primary tool. Although cities cover less than 2% of the world's land, they consume over three-quarters of their natural resources, leading to environmental concerns. However, this challenge can be considered as

an opportunity to use innovative and strategic solutions using evolving technologies. Because the smart city concept not only entails using information and communication technologies in urban spaces but also addresses governance and policy concerns. The concept also involves diverse stakeholders, mutual interdependencies, competing values, and social and political dimensions. As a result, it becomes crucial to assess smart cities' sustainability in the context of technology (Nam and Pardo, 2011).

Another important aspect highlighted in the smart city literature is the efficient utilization of interconnected infrastructures to provide social, cultural, and urban development (Erl et al., 2016). This involves various infrastructures such as transportation, business services, housing, and a series of public and private services. In addition, it is information technologies that cover all of these networks and form the concept of the smart city. As noted by Graham (2001), smart cities serve as significant economic drivers in urban areas, encompassing computing technologies, mobile and fixed-line telephones, satellite television, computer networks, electronic commerce, and internet services. The concept generates numerous social and spatial impacts. While smart cities are commonly associated with technologically advanced cities, it's essential to acknowledge that being "wired" is not the sole defining criterion for this concept (Graham and Marvin, 2001).

In relation to the concept, the discussion includes issues concerning both social and environmental sustainability. Social sustainability refers to fostering social cohesion and a sense of belonging, while environmental sustainability is focused on addressing the ecological impacts resulting from urban growth and development. It's important to note that while sustainability is a pioneer of economic growth in cities, it can also contribute to environmental waste and resource consumption (Gleeson, Low, 2000). The Climate Group has proposed two basic models for the functioning and support system of smart city policies. According to these models, policy and public education, incentives, and coordination mechanisms are essential for ensuring the effective functioning and value generation of smart city projects (Kogan, 2014). (Table 1).

Table 1. The basic components of smart city concept

Author	Title/Publication Name/Year	Basic Concept
Beatley T.	Green Urbanism, Washington DC, Island Press/2000	- These city formations prioritize information technologies as their primary tool, leading to significant efficiency for humans and nature.
Coe, A., Paquet, G. and Roy, J.	"E-governance and smart communities: a social learning challenge", Computers and Social Sciences Review/2001	- Cities that effectively address access and education issues to harness the opportunities offered by a knowledge-based economy strategically are progressing towards becoming "smart" cities. - Active participation and effective management of these processes significantly contribute to transforming cities into smart urban centers. - Smart cities are cities that adapt to innovation and development and create innovation-friendly societies.
Graham, S. and Marvin, S.	Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition/2001	- While the term "smart city" refers to a broad range of infrastructures, such as transportation, housing, and a variety of public and private services, it is information technologies that embody all of these networks and form the basis of the concept.

Florida R.,	The Rise of the Creative Class and How It" s Transforming Work, Leisure, Community and Everyday Life/2002	- "Creativity" plays a vital role in the vision of a smart city. - Cities are at the forefront of the "creative wave," actively seeking to attract innovative individuals. - The success rate of cities greatly relies on knowledge-based, emerging globalized economies as key factors.
Komninos, N.	Intelligent cities: Innovation, knowledge systems and digital spaces/2002	- Combining emerging technologies and the notion of innovation indicates a new social structure. - In smart cities, technological advancements and innovations are essential. - It is the expression of a social structure that can use smart solutions to solve environmental and social problems.
Odendaal, N.	Information and communication technology and local governance: understanding the difference between cities in developed and emerging economies/ 2003	- Information and communication technologies are the most significant factor in expanding scientific, industrial, and commercial horizons. - Information technologies are utilized in management, commerce and communication, public communication, and multi-participation-oriented "e-governance." - It is a system that integrates smart physical spaces and infrastructures.
Glaeser, E.L., Berry, C. R.	"Why are smart places getting smarter?" Rappaport Institute Taubman Center Policy Brief/2006	- The expansion of educational opportunities is directly proportional to the cities becoming smarter and creating sustainable pathways.
Giffinger, R.	Smart Cities, Ranking of European Medium-Sized Cities/ 2007	- The concept is categorized under six main headings: smart people, smart life, smart energy, smart environment, smart governance and smart economy.
Pardo, T. A., & Burke, G. B.	Government worth having: A briefing on interoperability for government leaders. Albany, NY: Center for Technology in Government/2008	- Achieving concept innovation necessitates a sharing of an advanced level of knowledge and integration of information. - Ensuring managerial interoperability across organizations and applications holds significant importance. - ICT (Information and Communication Technology) is a vital enabler for the transformational integration of organizations.
Rios, P.	Creating "the smart city." /2008	- A smart city is one that inspires and encourages the sharing of culture, knowledge, and life. - A 'smart city' is also referred to as an 'innovative city' because its citizens have the potential to benefit from the opportunities presented by the city. - It is a 'connected city,' which argues that people are connected to each other through

		ideas produced in the dimension of art, space, and architectural thinking. - It is possible for a city to improve and develop by becoming a 'motivated city.'
Hollands, R.	Will the Real Smart City Please Stand Up? /2008	- The term "smart cities" is often used, but what it implies at the urban level remains unclear. - Singular applications that cities claim to be smart are not sufficient. - True smart cities must transcend singular, technology-focused urban models, such as digital cities or high-tech cities.
Caragliu, A., Del Bo, C., Nijkamp, P.	Smart Cities in Europa, 3rd Central European Conference in Regional Science/2009	- Urban growth encompasses creativity, the correct orientation of human capital, and the production of smart solutions within a multi-stakeholder framework. - In smart cities, significant investments prioritize human and social development while utilizing technology to support conventional transportation methods. Sustainable economic growth and high quality of life are achieved through participatory governance and intelligent management of natural resources.
Nam, T., A. Pardo, T.A,	Smart City as Urban Innovation: Focusing on Management, Policy, and Context /2011	- The concept refers to the smart application of management and policy issues in urban space. - The concept must also be examined in terms of sustainability. - The concept can be discussed under three headings: technological, managerial, and organizational innovations, as well as innovations that address institutional and non-technical urban problems and propose policies that create the conditions for a smart city.
Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J. R., Mellouli, S., Nahon, K., Pardo, T.A., Jochen,H.	Understanding Smart Cities: An Integrative Framework, 45th Hawaii International Conference on System Sciences/2012	- Smart city initiatives require a comprehensive set of components in order to formulate the most effective strategies. - The purpose of presenting such a set of components is not to contribute to the ranking of smart cities but rather to establish a framework for designing a smart city and to determine the direction urban development policies should follow.
Cohen, B.	What exactly is a Smart City? http://www.fastcoexist.com/1680538/what-exactly-is-a-smart-city/2012	- Cohen conducted research entitled "Smart City Wheel," outlining the fundamental components of smart cities. - Giffinger (2007) divided the concept into six fundamental components, explained each component with three subheadings, and placed these explanations in a circle by expanding on them.

Bullinger H.J., Röthlein B.	Morgenstadt: Wie wir morgen leben: Lösungen für das urbane Leben der Zukunft/2012	- Telecommunications and the rapidly developing internet have introduced a process that must be smartly devised. - The smart city approach must utilize existing opportunities and must promote sustainable urban development.
Ferro E., Caroleo B., Leo M., Osella M., Pautasso E.	The Role of ICT in Smart City Governance, International Conference for E-Democracy and Open Government,2103	- The foundation of successful smart city governance lies in proficient decision-making and decision processes, commonly referred to as the governance dimension.
Kaufmann, J.	Smart Cities. Beispiele und mit der Umsetzung des Konzepts verbundene Problemlagen/2013	- The concept has been the field where actors such as IBM and Siemens have come to the fore. - Upon its introduction, these companies directed their attention toward the market potential of smart solutions. - Technology-oriented approaches to urban problems have been called 'smart cities.'
Greenfield, A.	The smartest cities rely on citizen cunning and unglamorous technology/ 2014	- The concept encompasses multiple layers, but technology is considered as the primary objective. - The user is not seen at the center of the planning process. - The user is perceived as the user of technological advancements.
Kogan, N.	Exploratory research on success factors and challenges of Smart City Projects, YL Tezi, Department of Business Administration Thesis /2014	- The primary and pivotal element of the concept is the smart city infrastructure, encompassing diverse platforms, security measures, and service scenarios. - The second critical aspect involves the smart city paradigm, emphasizing the relationship between the central government and local authorities. - Another important aspect is the consulting system aimed at having a better service model than numerous organizations and business fields.
Rieder, J.	Smart Cities: Wenn Konzerne Städte bauen/2014	- Cities constructed based on the concept of the smart city are technology laboratories. - Urban life and its inhabitants serve as testbeds for new innovations, not as centers. - Newly constructed smart cities prioritize technology and new applications over people, essentially functioning as experimental test centers rather than placing individuals at their core.
Mandl, B., Zimmerman-Janschitz, S.,	Smartes Cities-ein Modell lebenswerter Städte, Real Corp. Tagungsband/ 2014	- It is essential that all actors are coordinated and organized. - Infrastructure issues such as energy, traffic, waste management, information technologies,

		and the quality of life, the environment, and social research and development fields must be approached in an interconnected manner. - When applications consistent with the concept are integrated with social fields, it will be possible to talk about a sustainable smart city.
Yanrong, K., Lei, Z., Cai, C., Li Hao, Y., Ying, C., Whyte, J., Hart, T.	Comparative Study of Smart Cities in Europe and China/ 2014	- Smart cities are cities where resource management and networks are utilized with maximum efficiency in limited time and rapid urban movement. - In this modernization process led by information technologies, cities should not be isolated; rather, they should implement the future's best practices.
Moir, E., Moonen, T., Clark, G.	What Are Future Cities? Origins, Meanings and Uses/ 2015	- The decline of "Digital City," a rising concept, is directly proportional to the prevalence of the concept of "Smart City." - The concept of the smart city is founded on digitalization and data processing technologies. Nonetheless, it aims sustainability in numerous ways.
Beinrott, V.	Bürgerorientierte smart City: Potentiale und Herausforderungen/ 2015	- Smart solutions are required for urban planning and development. - Governmental and private companies are constructing new smart cities. - However, the majority of the processes are administered by technology corporations. - Planning and other urban processes are pushed to the background.

Source: Ates, Onder, 2019

2.1 Emergence of Sustainability

The socio-economic imbalance in cities is a result of the social and economic change brought about by globalization and the transition from industrial development to knowledge development (Egger, 2006). Therefore, a strong need for sustainable cities has emerged.

Known as Brundtland Report initiated a discussion on key topics such as the environment, development, and governance. Since its publication in 1987, the report has introduced a fresh perspective on the concept of 'sustainability' concerning both the economy and individual rights. While the report's goals gained widespread acceptance, the call for sustainable development was a practical response to the contemporary challenges of that era (Sneddon et al., 2002). Therefore, the concept of sustainability has been an integral part of development studies since the late 1980s. While the call for sustainable urban development originated in the 1976 UN-Habitat (Habitat, 1976), the connections between sustainable cities and sustainable development have been discussed since the early 1990s. A precise definition of sustainable cities, which should be a fundamental principle for all cities, was formulated: " Sustainable cities should meet the developmental needs of their residents without burdening local or global natural resources and systems in an unsustainable manner" (Hardoy, Mitlin, Satterthwaite, 1992). Since 2015, the United Nations has introduced 17 interconnected Sustainable Development Goals (SDGs), and one of these goals is focused on Sustainable Cities and Communities.

Access to essential public services such as water, sanitation, electricity, and healthcare remains insufficient in developing countries. A crucial aspect of democratic legitimacy lies in creating a policy framework for the sustainable development of urban areas. These policies play a crucial role within the administrative system for decision-makers to manage change efficiently (Solesbury, 2013; Eurostat, 2016-2017).

According to the UN reports from 2013, urbanization offers new employment opportunities and openings for millions of individuals in developed and developing nations. Additionally, It also plays a significant role in poverty eradication. Nevertheless, urbanization pressures the available resources and escalates demands for various services and resources (UN, 2023).

Architects, city planners, and environmentalists have developed various concepts aimed at establishing sustainable cities, enhancing the existing urban landscape, and addressing socio-economic challenges. During the 1960s, Jane Jacobs, an American-Canadian journalist, and activist, drew attention to the detrimental impacts of urban renewal policies that led to the destruction of urban communities and the creation of isolated urban areas. In her influential book, “The Death and Life of Great American Cities,” Jacobs had a profound impact on both planning specialists and the general public by emphasizing the importance of residents’ needs and the social aspects of urban planning (Jacobs, 2020; Gehl, 2007; 2013).

Jacobs’ book and her innovative approach have established a strong basis for the emergence of new urbanism movements aimed at designing cities focusing on people’s needs. These movements include concepts like the “just city,” walkable and car-free cities. Susan Fainstein’s concept of the “just city” (2000) emphasizes the importance of urban planners incorporating a normative theory of justice. However, she argues that their attempts to address inequality often face challenges under pro-growth regimes. On the other hand, Jacobs suggests that the persistence of inequality in cities is largely due to flawed planning procedures. Therefore, he emphasizes the significance of creating democracy, diversity, and social justice, as well as actively involving marginalized social groups within urban settings (Fainstein, 2000; Healey, 2003).

Currently, the construction of new settlements from scratch is being talked about. The pie chart below presents the categories of projects and organizations found in smart cities (Figure 16).

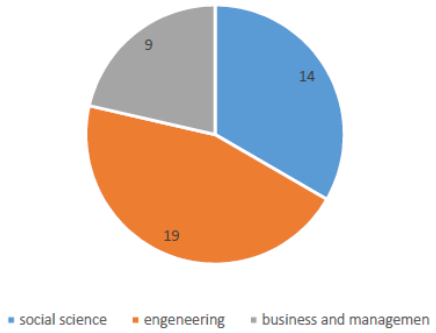

Figure 2. Project and organization categories in smart cities. Source: Fainstein, 2000

In the 21st centrury, there has been a transition toward smart city goals based on sustainability (Marsal-Llacuna, Colomer-Llinàs, and Meléndez-Frigola, 2015). The concept of smart cities emphasizes modern technologies and "smartness" compared to the concept of urban sustainability. However, in the concept of smart cities, while social and economic aspects take precedence, environmental indicators are often overlooked (Albino, Berardi, and Dangelico, 2015).

2.2 The relationship between spatial readability of sustainability, efficiency, and smart city concepts

The spatial readability of a city ensures its sustainability. Smart cities also claim to be sustainable cities, tus establishing a spatial relationship between these concepts. The higher the spatial readability, the more sustainable the city becomes. Sustainability also brings efficiency, and when all these aspects are high, it leads to smartness.

Spatial readability is related to functional roles. Additionally, the physical form and activities are important for user familiarity. Social and cultural relationships, memory, and personal meanings play a significant role in the readability of a space. However, in modern urban development, the distinctiveness created by the emotions and spirit of a place is often reduced to appearance and image, neglecting the historical, social, and cultural meanings of the past. Despite the influence of physical elements on the formation of meanings, human experience and intention, social relationships, and emotions and thoughts are crucial factors in developing the meaning of a place (Ujang, 2008).

Spatial readability plays a crucial role in sustainability (Colantonio and Dixon, 2009; Hargreaves, 2004). The more people can read a space, the more likely they are to participate in activities with a common purpose (Roˇcak et al., 2016; Woolever, 1992).

The terms 'smart cities' and 'sustainability' are often intertwined; smart city planning involves implementing environmentally friendly projects that respect the environment and enhance the quality of life. The increase in urban population and consequent, resource consumption will inevitably pose numerous challenges for cities. This reality emphasizes the importance of changing paradigms in the working style of cities in terms of sustainability. Sustainability has three dimensions: environmental, economic, and social. (Lehtonen, 2004). Sustainability develops with a high spatial readability. Different researchers have defined the concept in various ways, including reducing urban segregation, ensuring social equality, contributing to a high quality of life, meeting the diverse needs of current and future societies, promoting environmentally friendly behavior, providing equal opportunities for everyone, and encouraging community participation (Barton, 2002; Dempsey, 2006; Eizenberg, Jabareen, 2017; Lara-Hernandez, Melis, 2018; Roˇcak et al., 2016; Seaman, McLaughlin, 2014; Magis, 2010). At this point, the United Nations has introduced Sustainable Development Goals (UN, 2023).

3. Field Research

Aspern Seestadt and Masdar, featured in the field study, are among the newly constructed smart cities that have been visited. Additionally, location theory has been utilized in determining the areas. Location theory has a lengthy history and has even contributed to the emergence of a new scientific field called regional science (Barnes, 2000). In its most concise form, the theory focuses on where various activities are located. The question of "where" in location analysis is of vital importance, involving space and place. Location theory has primarily evolved within the neoclassical microeconomic tradition. Generally, economists have provided theoretical contributions to the theory, while geographers have made empirical contributions (Smith, 1981). However, the most significant theoretical contributions to the theory have come from German economists and geographers. The Anglo-Saxon tradition, on the other hand, has built institutional-level additions on the German origin and tested the theory through numerous empirical studies (Barnes, 2003).

Table 2: Austiria Smart City Initiative

AVUSTURYA				
Smart City Initiatives	**The Main Prameter**	**The Goal**	**Financing**	**Stakeholders**
Cool Rooms for Physıcal Rest	Smart energy Smart people Smart living	Creating a cool atmosphere. Keeping the temperature between 20-24 degrees. Not consuming energy in the meantime.	The public enterprises	The municipality of Vienna
Vienna Climate Team	Smart energy Smart people Smart living	Preventing climate change and global warming. Integrating citizen participation into the process.	The public enterprises	The municipality of Vienna The citizens
Wiener Supergrätzl	Smart mobility Smart environment Smart living	To increase the quality of life. Creating new open spaces in public street space by systematically reorganizing, optimizing and calming traffic, and enabling the use of these spaces for cooling, recreation and entertainment purposes.	The public enterprises	The municipality of Vienna The citizens
Repair, not Replace	Smart people Smart living	Ensuring that broken tools are repaired instead of buying new ones. To ensure sustainable resource management.	The public enterprises	The municipality of Vienna The citizens
Urban Renewal 2 With Wieneu	Smart environment Smart people Smart living Smart mobility Smart mobility	It is a 10-year urban renewal program of the City of Vienna that aims to contribute to making Vienna resilient.	The public enterprises Energy Agency	Vatandaşlar (yerel mülkiyet), enerji sağlayıcı kurumlar
Expansion of photovoltaic capasity	Smart environment Smart people Smart living	Improving Vienna's energy capacity and increasing the using of photovoltaics.	The public enterprises Energy Agency	The municipality of Vienna The citizens Enerji sağlayıcı kurumlar

Table 3: Abu Dhabi Smart City Initiative

Abu Dhabi				
Smart City Initiatives	**The Main Prameter**	**The Goal**	**Financing**	**Stakeholders**
Lift Off	Smart people Smart living	An application that powers cameras with artificial intelligence to assess a person's health by examining the face, eyes and nose.	The public enterprises	The municipality of Abu Dhabi
The KhaderR	Smart environment Smart people Smart living	It aims to help protect the environment through the use of artificial intelligence in waste recycling operations.	The public enterprises	The municipality of Abu Dhabi The citizens
The Fast Response	Smart people Smart living	It involves a remote-controlled drone equipped with special sensors connected to an application. This project aims to inform citizens in case of fire.	The public enterprises Priva sector	The municipality of Abu Dhabi Şirketler
The so Called Engıneers	Smart people Smart living	The smart helmet notifies the authorities if its user has a traffic accident. The helmet conveys the condition of the injured person, the time and place of the accident.	The public enterprises	The municipality of Abu Dhabi
Data First	Smart people Smart living	An initiative of the Abu Dhabi government that enables the collection and processing of data.	The public enterprises	The municipality of Abu Dhabi
AI Principles & Ethics	Smart people Smart living	Abu Dhabi Ethical AI Toolkit was created to provide practical assistance within a city ecosystem.	The public enterprises	The municipality of Abu Dhabi

3.1 Masdar

Masdar City, located near Abu Dhabi, is a settlement that integrates smart city infrastructure and Arabic architectural elements, primarily focusing on establishing a pedestrian-friendly atmosphere. Presently, the city is still under construction (see Figure 2). It aims to be the world's most sustainable development that embodies the ultimate vision of a carbon-neutral urban environment. (Cugurullo, 2013).

Below is the outline of the plan and functional distribution of Masdar City (Figure 3, 4):

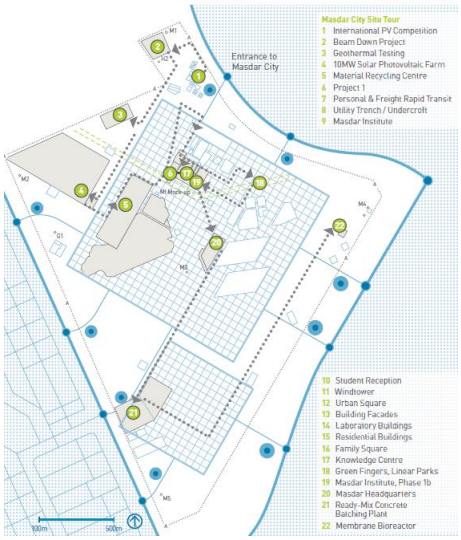

Figure 3. Masdar city plan. Source: Makdam and Ramaswamy, 2016

Figure 4. A view of Masdar City Source: Menichetti and van Vuren, 2011

Masdar City, situated in the midst of a desert, stands as a first of its kind sustainable urban project, featuring eco-friendly buildings that consume 40% less energy on average. Lutz Wilgen, the acting head of design at Masdar City, highlights that certain buildings surpass this average, achieving even greater energy savings, while others manage to operate on zero net energy consumption. This city uses entirely renewable resources to power its operations.

The International Renewable Energy Agency (IRENA) headquarters has a rooftop solar panel array, resulting in a reduction of over 60 percent in total energy demand. Additionally, the Siemens building is a LEED platinum-certified, high-performance office building that derives all its energy needs from a nearby established solar farm seen below (Figure 4, 5):

Figure 5. Masdar City solar farms. Source: Cugurullo, 2013

Figure 6. Narrow streets of Masdar City and the use of traditional Arab architecture Source: Cugurullo, 2013

Masdar City is open for visitors to come and explore its different elements. Taking a stroll through the city, one can see that it is modern yet traditional, with the presence of numerous passive design elements, including window shading, closely spaced buildings and columns, and a strategic northeast-southwest orientation that maximizes street shading. The city's streets and building walls were designed to encourage natural air flow, while the inclusion of a roof canopy, as shown in the figure below (Makdam and Ramaswamy, 2016), serves as a response to the hot weather climate (Figure 6, 7).

Figure 7. Masdar Headquarters and its roof canopy. Source: Menichetti and van Vuren, 2011

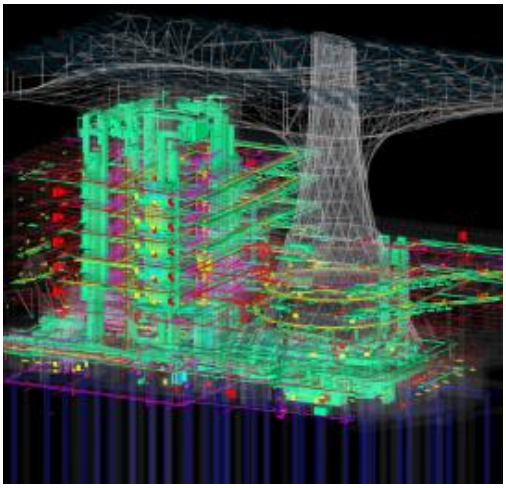

Figure 8. Masdar roof canopy drawing Source: Menichetti and van Vuren, 2011

The ingenious designs of Masdar City create outdoor spaces that are notably cooler compared to other areas in Abu Dhabi. One notable example of modern interpretation is the 45-meter-high Wind Tower, inspired by the region's iconic traditional architectural elements (Figure 8, 9).

Figure 9. Masdar city wind tower Source: Cugurullo, 2013

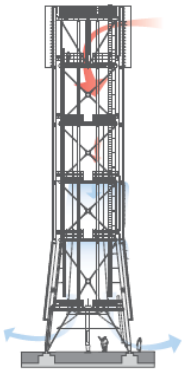

Figure 10. Masdar wind tower drawing Source: Cugurullo, 2013

Additionally, Masdar is committed to establishing an efficient transportation system, as illustrated in Figure 10.

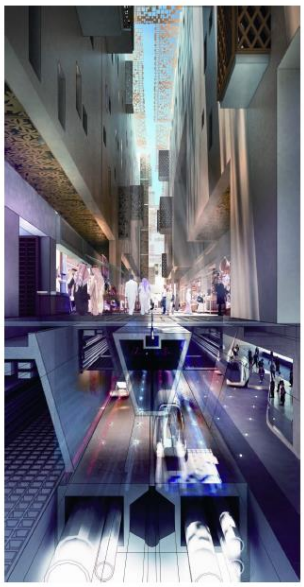

Figure 11. Masdar transportation concept Source: Menichetti and van Vuren, 2011

3.1.1 Sustainability Features of Masdar

Masdar City strives for social, environmental, and economic sustainability and creates different urban units to accommodate residents from diverse groups. Additionally, they provide energy from renewable resources to promote environmental sustainability. For economic sustainability, they work on generating new job opportunities and emphasizing economic efficiency.

To ensure the sustainability of Masdar City, a systematic reporting method is regularly employed across all fields (Mubadala Company, 2014).

With a strong commitment to renewable energy and sustainable development, Masdar remains actively participating in the sustainability agenda. In January 2014, Masdar City hosted the second Abu Dhabi Sustainability Week.

At this assembly, the following resolutions were adopted:

-The world needs to take urgent action for energy, water, and environmental challenges.

-The global adoption of renewable energy and sustainable development requires acceleration with a collective effort.

-Water issues in arid regions must be addressed.

-The global agenda should prioritize the water-energy nexus.

-Encouraging dialogue among stakeholders is essential for enhancing strategic partnerships.

-There should be an encouragement for investments in water, energy, and environmental projects.

-Young generations and entrepreneurs must be encouraged and supported. (Madakam ve Ramaswamy, 2016).

3.1.2 Environmental Sustainability

In addition to managing waste water and drinking water, Masdar has also taken steps to monitor groundwater levels. Given its desert climate location, Masdar acknowledges the significance of groundwater management to ensure the sustainable usage of water resources. This has led decision-makers to formulate policies aimed at conserving water in arid regions. In the Environmental Impact Assessment (EIA) conducted for the region, groundwater management was particularly emphasized. The report stressed the significance of contractors' consistently monitoring groundwater levels and recommended that they develop a dewatering plan for the region and use the best applications when constructing power lines (Mubadala Company, 2014).

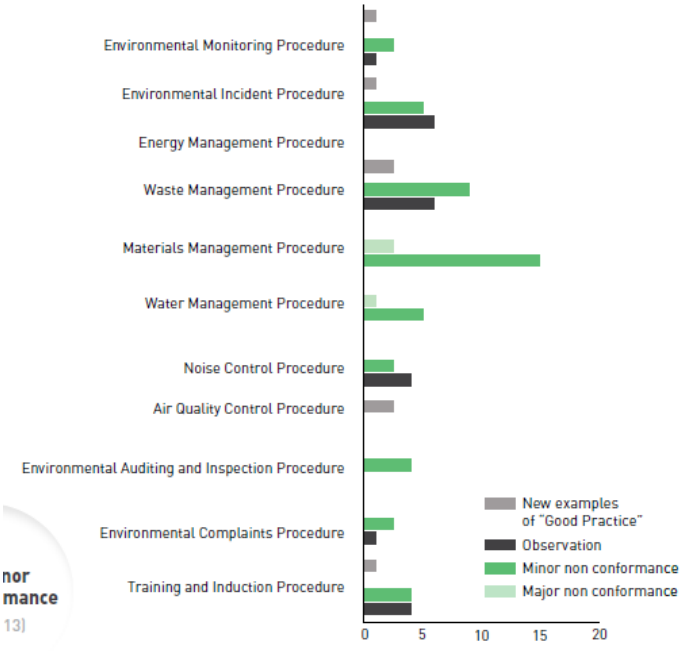

Figure 12. Carbon emission and management data for Masdar city Source: Mubadala Company, 2014

The report is based on data from an approved auditing company, presenting an assessment of various Construction Environmental Management Plan (CEMP) data conducted quarterly (Madakam and Ramaswamy, 2016).

3.2 Aspern Seestadt

The historical development of Aspern is worth recounting. In May 1808, the fields between the villages of Aspern and Essling became the battleground for a significant conflict between Napoleon's troops and the Austrian army. This battle marked Napoleon's first major tactical defeat. Later, in 1912, a new airport was established in the region. This airport played a crucial role in both World Wars and the interwar period, serving as a center for training flights and becoming one of the main bases for the Luftwaffe, particularly during the 1930s. It also continued to operate even after the conclusion of World War II. In 1954, Donaustadt was designated as the 22nd district of Vienna. At that time, the area was primarily utilized for agricultural purposes, and its connectivity to the city center through public transport networks was limited (Hauer, Krammer 2018). After purchasing this area, the City of Vienna, in collaboration with the Urban Development Commission, formulated an urban development plan for the creation of a new airport. The master plan, designed by Rüdiger Lainer, encompassed approximately half of what is now known as Aspern Seestadt (Rainer, 1961). In this new area, residential units for 10.000-12.000 people and work places for 6.000 people were planned (City of Vienna, 2020). However, the plan could not be executed due to the inadequate infrastructure connections between the Aspern district and the rest of the city. As a result, the focus shifted to constructing transportation routes in the 1990s, becoming the primary objective in preparing for urban development in Aspern (Figure 12).

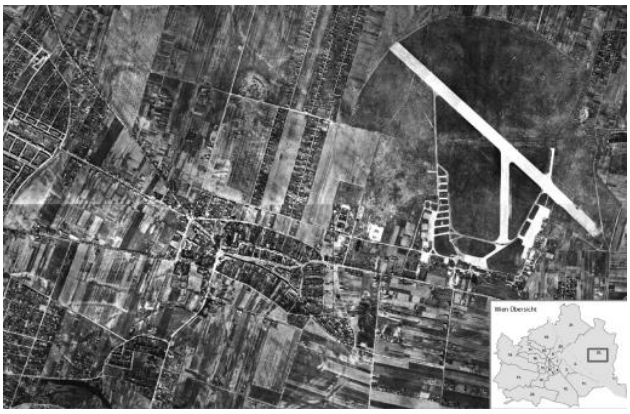

Figure 13. Location of the Aspern Seestadt project within Vienna Source: Kolontay,2021

In 1977, the airport in the Aspern district was closed down due to tough competition with the newly established airport in Schwechat, the main airport in the City of Vienna, and was transformed into a race track. The 1980s marked a turning point for the area with the opening of a new engine factory (Aspern Seestadt, 2015).

In 1992, the City Council and the Vienna Economic Fund initiated meetings involving experts and urban planners to discuss the area's development. Among the proposals presented during these meetings, Rudiger Leiner's project was chosen. In 1992, the City Council and the Vienna Economic Fund collaborated to host meetings with experts and urban planners to discuss the area's development. Among the proposals presented, Rudiger Leiner's project was selected. This plan envisioned the construction of residential units for 10.000-12.000 people and work places for 6.000, adhering to the principles of "Urban Partitur," which emphasized the development of low-density urban areas interconnected by green spaces. However, due to the large amount of capital required for transportation infrastructure, this plan could not be realized then (Vienna City Council, 2015). Finally, in May 2007, the Vienna City Council approved the Master plan for Aspern Seestadt.

The modern Aspern Seestadt in 2010 has its history. (Wien Geschichte Wiki 2019a). The infrastructure projects were undertaken in the region from 2009 to 2013. In 2010, the U2 metro line extension

reached Aspernstraße, and by 2013, it was further extended to Seestadt; thus, a public transport connection between Aspern Seestadt and central Vienna was established (Wien Geschichte Wiki 2019b; Tramwayforum 2019).

Located in Vienna's 22nd municipal district, northeast of the city center, the Aspern Seestadt project is one of Europe's most extensive urban development projects. Expected to be finished in 2028, the project will be constructed in multiple phases. Notably, this new smart city incorporates numerous exemplary initiatives, with their key characteristic being their interconnectedness to each other.

The Aspern Seestadt project reflects a novel planning philosophy that integrates place-making and management-oriented strategies to address the rising uncertainties and complexities effectively. Currently, in the new settlement plan for the eastern part of Vienna's 22nd district, six centers have been created, available in strategic planning (MA 21, 2013). The upper-scale plan for Aspern Seestadt has served as a guide.

Starting from the basic principles of the airport development program, a two-stage procedure was implemented to choose a team for creating a draft master plan. Initially, in the first phase of the tender, various tender syndicates from the European Union were invited to demonstrate their relevant experience and project performances to qualify for participation in the tender. In the second phase, 10 tender syndicates were selected and asked to prepare proposals for the urban development of the former airfield and submit a draft master plan (Aspern Airfield Master Plan, 2008). Afterward, an international evaluation commission was comprised of different stakeholders such as experts, landowners, political decision-makers, and local residents. Eventually, the contract was given to the Swedish architects firm Tovatt Architects & Planners in collaboration with the German project developer N+ Objektmanagement.

The Aspern Seestadt project has become a prestigious planning project of immense significance, deemed "too big to fail." Its development relies on collaborations among various groups of actors who contribute to formulating development policies for Aspern (Figure 13). Notably, the settlement within the district was established in close consultation with the Vienna municipality. In 2005, the urban development plans STEP 05 (MA 18, 2014) and in 2014, the Smart City Strategy (Magistrat der Stadt Wien, 2014) was prepared. One year later, in 2006, the Aspern Seestadt was introduced as an independent sub-center. In 2005, urban development plans STEP 05 (MA 18, 2014) and in 2014, Smart City Strategy 2014 (MA 21, 2013) were prepared. By 2006, Aspern Seestadt was introduced as an independent sub-center (City of Vienna 2020). It was described as a "Smart City Laboratory" that "offers excellent development prospects" in the STEP 2025 plan The Vienna Smart City Strategy Plan further characterized Aspern Seestadt as a "multifunctional and attractive district based on the latest findings in energy efficiency, building standards, and use patterns". (MA 18, 2014).

In 2012, significant progress was made as the master plan of the Aspern Seestadt project was refined (Figure 14). Detailed plans were created for the development of the northern part and for the public spaces in the Seestadt (Krisch and Suitner, 2020).

Nonetheless, it reflects the fundamental planning philosophy of the city of the future. It has also impacted Vienna's future vision (Figure 15).

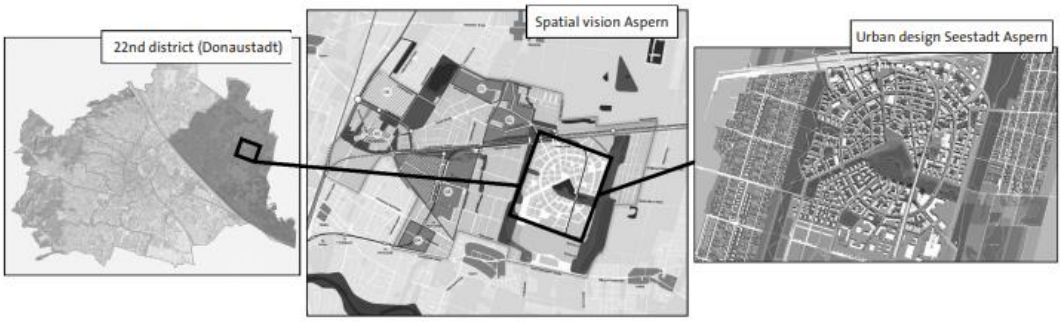

Figure 14. Location of the Aspern Seestadt project within Vienna Source: Wiengv.at, 2022

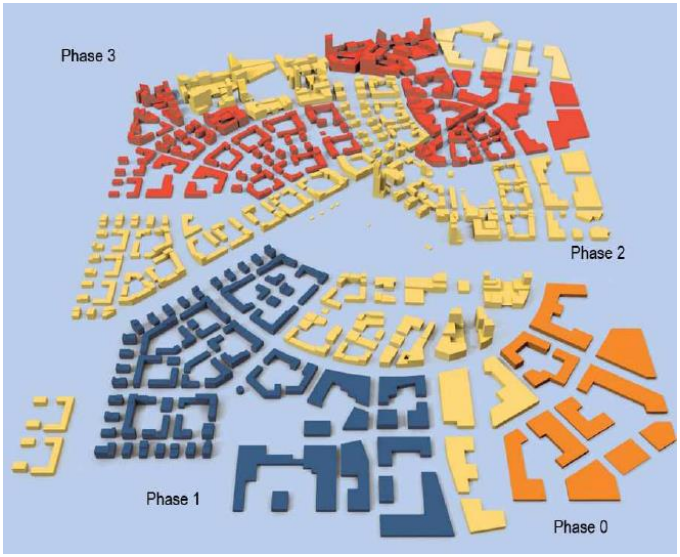

Figure 15. Aspern Seestadt Project phase list Source: Wiengv.at, 2022

Figure 16. Aspern Seestadt Project Source: Kolontay,2021

4. Method

This article utilizes the Space Syntax method to analyze two new smart cities, Aspern and Masdar. The efficient use of space plays a crucial role in ensuring the sustainability and efficiency of cities.

The Space Syntax studies initiated by Bill Hillier and his team in the fields of architecture and urban planning (Hillier et al., 1983) are noteworthy. The Space Syntax approach is distinct from other

analytical methods of the same period due to its focus on defining space based on "human spatial experiences," as emphasized by David Seamon (Seamon, 2007).

The practical application of the Space Syntax method is based on established theories and research findings. While it may not definitively determine the 'optimal' design solution or ensure the highest efficiency and sustainability of cities, it can predict the socio-economic impacts of urban planning and design proposals (Ye and van Nes, 2014). Space Syntax cannot make normative claims about the optimal design solution. Instead, its primary goal is to determine the intended goals of urban design proposals and what can realistically be achieved. After testing various spatial options, Space Syntax reveals potential impacts on movement and economic development in the relevant area, considering existing theories of space and spatial relationships (Yamu et al., 2021).

In conclusion, the Space Syntax approach allows for an in-depth examination of the spatial changes that a design proposal would bring (Yamu et al., 2021). However, determining the ultimate results regarding socio-economic impacts depends on various factors. Conducting fundamental analyses of the existing context is crucial as a starting point. The interpretations of these analyses are dependent on existing Space Syntax theories and research findings related to the issues that need to be addressed. Additionally, awareness of the limitations of Space Syntax is necessary. For example, issues related to social rationality, place identity, and various cultural contexts cannot be addressed by Space Syntax (Hillier, Hanson, 1984; Hillier et al., 1983).

Bill Hillier (2009) provides the best definition of the connection between urban sustainability, efficiency, and Space Syntax with the following statement: "Space Syntax reveals the self-organizing spatial structure of the city. It uncovers the foundational structures directly linked with sustainability that form the basis of the city" (Hillier, 2009).

As widely accepted, the distribution of urban land use is an integral part of urban sustainability. Lu and Ka (2017) emphasize its importance by highlighting its effects on energy consumption efficiency, environmental conservation, and economic and social development. Besides the city's form, the intensive use of land also determines the locations of emission sources affecting air quality, urban sustainability, and urban traffic patterns (Borrego et al., 2004). Khalil (2009) also supports the idea that land use distribution in a city has a significant impact on the city's sustainability. The distribution of land use directly influences travel distances, affecting fuel consumption and air pollution.

In this study, axial maps describing the spatial structure of street patterns were created to obtain both formal and quantitative outputs. Axial maps consist of axial lines representing the longest sightlines in an open space and intersecting axial lines. The method abstracts the spatial pattern into axial lines based on the assumption that users' wayfinding abilities are influenced by changes in the direction of sightlines and street patterns, regardless of street length. Axial lines are used as a substrate in measurements that calculate the topological features of space quantitatively. The primary goal of creating axial maps is to objectively examine the relationship between spatial organization and human movement and visibility areas, revealing the potential of "spaces" to bring people together and direct them, and its impact on sustainability. This study, based on the assumption that there is a direct relationship between spatial organization and social structure and sustainability, investigates the potential for people to come together by overlapping movement and visibility areas in urban open spaces. This study, which is based on the share of spatial organization in user movement, analyzes pedestrian movement routes as a system consisting of linear axes. Among the most commonly used measurements in this context are integration calculations. Integration is an indicator of the accessibility of an axis (street) in an axial map representing the urban pattern. In the method, the integration value is determined by identifying and calculating the axes that need to be crossed while moving from all axes (streets) to all other axes (streets) in the axial map representing the urban pattern. Axes with high integration values represent axes with low depth (accessible) and strong connections with the network structure within the spatial pattern, while axes with low integration

values represent axes separated from the spatial pattern, with high depth (difficult to access) (Hillier et al., 1993).

In the examined areas, axial maps were created initially. These maps were generated to define the spatial models of building groups in the selected areas, describe the intra-space organization of structures, and assess the impact of social structure parameters on sustainability. Streets were classified into groups using the Natural Breaks (Jenks) classification method based on the integration value of segments within the study area. In this method, automatic classification was performed based on the distribution of data without manual intervention of the classifier. Subsequently, using data suitable for network analysis and the ArcGIS for Desktop Network Analyst module, various access areas were created for groups with high integration values. Since areas with the highest integration values are preferred as more walkable areas, these areas were evaluated in the map study. Then, the estimated population residing within the access distance of each group was calculated. Graphs were obtained in Microsoft Excel, showing the total length of each group's segments. This allowed for the interpretation of the population in the access area with the length of segments

5. Findings

5.1 Masdar

Upon analyzing this new city using the Space Syntax method, it becomes evident that the primary axis running through the city's center experiences the highest volume of usage, represented by the color red. Some connected roads are colored yellow, indicating a lower usage compared to the red axis but higher than the green ones (Figure 17). The less utilized areas are shown in blue. Regarding spatial use, the green-colored axes are identified as residential areas primarily accessed and used by property owners. However, upon examining the axial map, it becomes apparent that the space is not being utilized very efficiently and there is a limited number of intersection points. Although the city incorporates Arabic architectural features, the scarcity of public intersection points stands out when viewed through the lens of the article's methodology. The central region highlighted in red holds significance, but its accessibility from the city's entrance is of secondary importance as more residential areas are accessible from there. Both the axial maps, generated based on the article's methodology, and the current data indicate that the overall legibility of this new settlement appears to be quite low. Although local Arab architectural features is present, but the lack of distinctive local characteristics leads to the reduced spatial legibility. Settlements with low legibility also tend to exhibit lower sustainability and efficiency.

Figure 17. The spatial legibility map for Masdar project

As shown in the figure, the central public space within the city is the most favored area for pedestrians. The fact that it is covered by a canopy is also an important factor for this (Figure 18).

Figure 18. The spatial legibility map of Masdar project

5.2 Aspern Seestadt

The axial map of Aspern Seestadt clearly indicates that the oval road running through the center of the settlement is the most frequently used area. The roads that cut vertically to this oval road in both the x and y directions are also evident. Notably, the green and blue areas are limited in number, highlighting the high legibility of the settlement when analyzed using the Depthmap program. The settlement plan and axial maps are presented in the following figre (Figure 19).

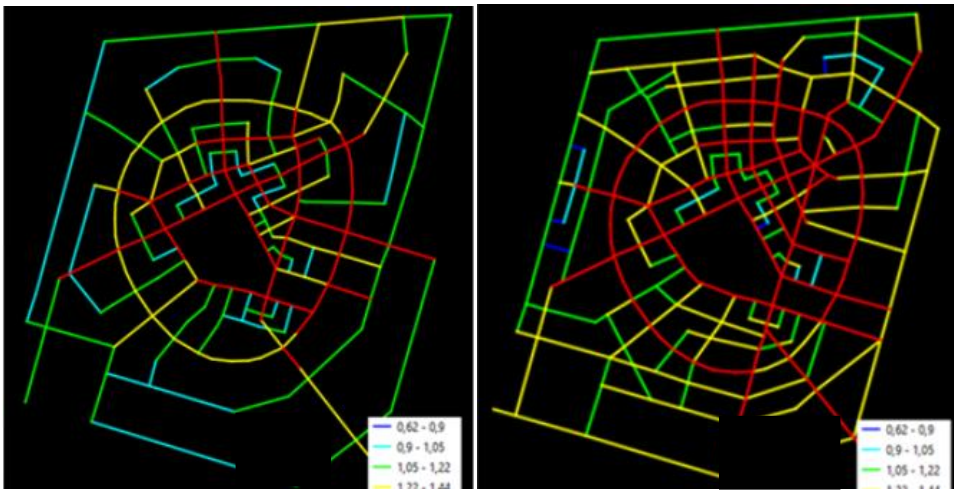

Figure 19. The spatial legibility map of Aspern Seestadt Project

The settlement's axial map also reveals the existence of three coordinate systems in Aspern Seestadt, represented by red, green, and blue lines. A notable feature is the main oval road positioned at the

center of these three coordinate systems, signifying its spatial legibility. This oval road is located on a common (diagonal) axis, equidistant from the central lake. In the Aspern Seestadt area, the dominance of the monocentric system is apparent, where the axis radii coincide with the axes of the ring coordinate system. This means that the radial streets located in the center and leading towards the lake are defined primarily. The Y axis holds particular importance due to its association with the U2 metro line and the metro station. Observing the axial map reveals a distinct spatial composition of the area. Analyzing the axial maps of Aspern Seestadt, one can easily spot numerous areas marked in red, indicating a high level of legibility in the settlement. This spatial legibility serves as a measure of sustainability and efficiency. The presence of a natural lake within the settlement and the construction extending over time contribute significantly to this high spatial legibility (Figure 20).

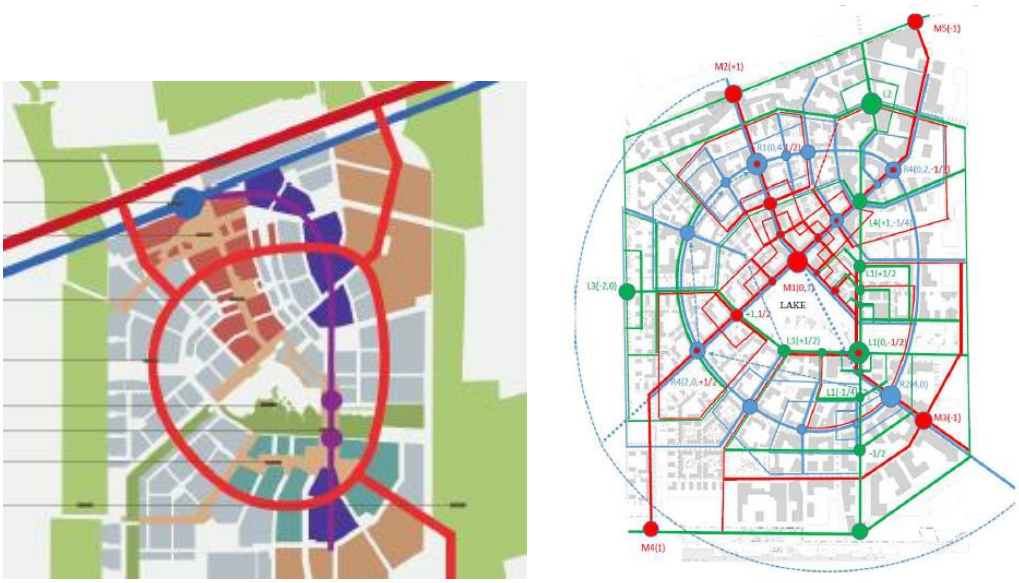

Figure 20. The spatial legibility map of Aspern Seestadt Project

6. Recommendations for Turkey

The notion of innovation is closely linked to the idea of competition. According to Porter's definition, competition involves enhancing productivity (Porter, 1990). On the other hand, innovation contains both a process and its results. When applied to cities, social innovation can be understood as the conversion of scientific and technological advancements into economic and social advantages. Essentially, social innovation entails innovating urban processes.

In a rapidly advancing and developing world, the concept of social innovation has surfaced as a means to both progress and give responses to local changes. This involves bringing together individuals from diverse sectors, each possessing varied skills with the help of evolving technologies. Through this collaborative effort, a common value is generated, leading to the creation of new business models within the scope of social innovation. As cities continue to expand and the gross national product (GNP) increases (e.g., our country's GNP reached 105 trillion dollars in 2020), certain sectors such as energy, water, transportation, health, manufacturing, construction, and natural resources require innovative solutions to keep pace. The primary aim of social innovation is to achieve a society where environmental and economic needs are balanced and fulfilled. The key stakeholders in this process are the government, non-profit organizations, and citizens (Frost and Sullivan, 2014).

For 21st-century skills, which include critical thinking, new job fields are needed. In this context, new job opportunities are emerging, and new business models are being developed. Examples include open-source software, cafes run by individuals with Down syndrome, associations established to promote renewable energy sources, and platforms where producers directly connect with consumers online to eliminate intermediaries (Ates, 2019). Social innovation is a key factor in economic growth and international competitiveness. The concept of social innovation has become significant with the transition to the knowledge economy (Maden and Kutgi, 2019). Social innovative policies worldwide have also shaped the policies to be implemented in existing cities in Turkey (Ates, 2020).

Based on the findings ofthis study, local governments should adopt a more participatory approach and involve citizens in governance. Aspern Seestadt is a good example in this regard, where citizens play an active role in decision-making mechanisms. The study reveals that Masdar City is managed by a single company. If local governments want to create a smart city, they must develop a participatory approach. Relevant ministries and local governments should set goals in terms of participatory management. New parameters measuring participatory management should be developed. However, based on the study findings, it should also be emphasized that the readability of urban spaces should be high. The higher the urban readability, the better the implementation of smart city parameters. Urban readability is also provided by the spatial design of local governments.

In the study, the importance of making new smart cities sustainable is also highlighted. In this context, we should rethink local financing systems to make cities sustainable. Accountability for budgets and implementation of accountable and transparent information systems are crucial. Local governments should build a spirit of solidarity and enhance collaboration. For a place to be considered smart, it also needs to be resilient. In Turkey, risk and crisis management should be emphasized, and capacity should be developed in this regard. Among the priorities should be the reduction of disaster risk and increasing resilience to natural disasters and climate change. In addition to land use plans, infrastructure plans and city development strategies should be developed.

Encouraging innovative, multi-stakeholder, and multi-level partnerships is one of the most important practices that Türkiye can implement. In the cities covered in the study, a multi-stakeholder process is evident inthe projects. Looking at the study findings, all innovations implemented emphasize the importance of coordination. Among the numerous innovations in Turkey, coordination should be ensured.

To support these advancements, it is imperative for relevant Ministries and local governments to establish objectives in these areas. Additionally, the development of new parameters to evaluate social innovation is essential, both on a global scale and within our own country.

The progress of cities and their ability to compete globally are directly linked to implementing innovative social policies. In this regard, our cities, like Istanbul and Konya, are adopting and implementing innovative policies like those observed in cities such as Barcelona, London, and Amsterdam.

Within the context of smart life and smart people, our initiatives are of great importance. Our country is currently implementing diverse projects for the elderly, children, and individuals with disabilities. As part of smart governance, the primary focus is to foster citizen participation and ensure the effective functioning of city councils. However, in terms of smart transportation and smart environment, our cities have not yet fully achieved their desired goals. Nevertheless, there are plans to increase the number of bicycle lanes and introduce a non-motorized transportation system. Local governments in our cities are aimed at combatting environmental pollution and transitioning to renewable energy sources. Within the scope of the smart economy, our cities are actively engaged in production-oriented endeavors. It is essential to make efforts to make our cities greener, as well as in the fields of energy, transportation, and health.

In our cities, it is imperative to address water policies as water resources become increasingly scarce. Additionally, enhancing water resources, managing wastewater effectively, and preventing water wastage are needed to be much more addressed.

Currently, our cities are making efforts toward rationality and sustainability. The current policies being implemented are singular in their approach. However, future practices have the opportunity to incorporate advancing technologies to meet the demands of a growing population.

As we observe cities constructed from scratch, numerous completed projects worldwide serve as examples. In our own country, a significant project, Canal Istanbul, is planned to be built from scratch. If this project adheres to sustainability criteria, it has the potential of becoming a noteworthy exemplar.

In greenfield settlements worldwide, active participation takes center stage. To achieve higher efficiency and spatial legibility, it is essential to conduct a spatial legibility analysis as a primary step. Simply constructing high-tech and smart buildings will be insufficient; sustainability must also be ensured to avoid turning the settlement into a deserted city. To ensure this new settlement's sustainability, socially innovative policies must be formulated. Introducing new business models would also be crucial. In order to prevent environmental pollution, implementing eco-friendly approaches to water efficiency, waste management, and transportation becomes imperative.

When constructing a new and smart settlement in Turkey, renewable energy sources should be utilized. Moreover, adopting a holistic approach and avoiding a singular focus is crucial for the project's success.

7. Conclusion and Evaluation

Spatial legibility contributes to the sustainability and efficiency of newly constructed smart cities. Additionally, social innovation policies implemented play also a crucial role in creating sustainable cities.

This research examines the innovative policies and practices, focusing on the context of newly built smart cities, and also addresses the efficiency situation in these settlements. Moreover, the study includes recommendations tailored to Turkey's context.

The efficiency of newly constructed settlements heavily relies on their high spatial legibility. To attain this legibility, it is crucial to incorporate a local asset into the design and construction of the settlement. Moreover, the social innovation policies also significantly contribute to the sustainability of the settlements.

This article compares the spatial legibility of two new smart cities located on different continents. It examines the spatial legibility of Aspern Seestadt near Vienna in Europe and Masdar near Abu Dhabi in Africa, using the Space Syntax method. The analysis involved studying digital maps of these cities through the use of Dept Map software. The study reveals that Aspern Seestadt near Vienna exhibits higher spatial legibility in comparison to Masdar. Several factors, including the presence of a natural lake and the existence of an old airport within the area, contribute to this finding. Additionally, Aspern Seestadt was constructed gradually over time, and a participatory approach was followed during its construction.

Considering these two new settlements, the study encompasses recommendations aimed at ensuring the sustainability and efficiency of a forthcoming settlement project in Turkey. The EU's emphasized sustainable development goal is the establishment of 'Sustainable cities and communities'. To achieve this objective, the key factors that contribute to the sustainability of a settlement should be identified. In this context, this study linked sustainability and innovative practices to urban productivity, aiming to make a valuable contribution to the relevant field. Furthermore, it is anticipated that the study's methodology and the proposed innovative social policies can be promptly revised and ready for implementation in a short time.

Etik Standart ile Uyumluluk

Çıkar Çatışması: *[TR] Yazar / yazarlar, kendileri ve / veya diğer üçüncü kişi ve kurumlarla çıkar çatışmasının olmadığını veya varsa bu çıkar çatışmasının nasıl oluştuğuna ve çözüleceğine ilişkin beyanlar ile yazar katkısı beyan formları makale süreç dosyalarına ıslak imzalı olarak eklenmiştir.*

Etik Kurul İzni: *Bu makalede etik kurul iznine gerek yoktur, buna ilişkin ıslak imzalı etik kurul kararı gerekmediğine ilişkin onam formu sistem üzerindeki makale süreci dosyalarına eklenmiştir*

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