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CHAPTER 1

A PROACTIVE PLANNING PARADIGM IN CLIMATE CHANGE ADAPTATION: URBAN MANAGED RETREAT

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1. INTRODUCTION

Climate change is emerging as a significant threat to urban areas. Sea level rise, flooding, and extreme weather events are negatively affecting the lives of coastal cities, with millions of people directly impacted by these risks (Hino et al., 2017; Sharaan et al., 2022).

Traditionally, urban planning has favored "resilience" and "defense-oriented" strategies. Sea walls, flood control structures, and protection of existing settlements are fundamental elements of these approaches (Carey, 2020; Siders & Ajibade, 2021). However, the rapid advancement of climate change is exposing the limits of these methods. Rising costs and technical challenges are driving urban planners to seek new solutions (Hino et al., 2017; O'Donnell, 2022).

Urban managed retreat emerges as an important adaptation strategy at this point. Hino et al. (2017) define managed retreat as the intentional relocation of people, assets, and infrastructure away from areas at risk. This strategy is not merely an evacuation but encompasses a process in which communities plan and design their future (Siders & Ajibade, 2021; Hossain et al., 2024).

At the foundation of retreat is the welfare of people and nature. The goal is to make a just and planned transition from risky areas to safe zones. This approach provides communities with the opportunity to shape their new living spaces (Siders & Ajibade, 2021; Doberstein et al., 2024).

The purpose of this study is to examine the theoretical foundations of urban managed retreat strategy, international examples, and planning process components. Thus, a new paradigm of planning for climate change adaptation is presented.

2. THEORETICAL BACKGROUND

Urban planning has undergone significant changes in recent years. A shift is occurring from growth-oriented approaches toward strategies focused on resilience and adaptive capacity (Khavarian-Garmsir et al., 2023; Giordano et al., 2012). Davoudi (2009) notes that this shift increases capacity for dealing with uncertainty and managing complex systems.

Traditional planning approaches have focused on controlling and organizing space. These approaches have been built on deterministic and hierarchical models (Davoudi, 2009; Giordano et al., 2012). However, climate change clearly demonstrates that these models are insufficient. Adaptive planning provides a new framework that accepts uncertainty, embraces flexibility, and adopts iterative processes (Langendijk et al., 2025).

Urban managed retreat requires understanding the working principles of socio-ecological systems. Hossain et al. (2024) show that human communities and ecosystems are not separate but co-evolving systems. This approach is critical for increasing resilience.

Socio-ecological resilience measures systems' resistance to shocks and adaptive capacity (Qu et al., 2025). Retreat decisions should be made considering not only physical risks but also the social, economic, and cultural strengths of communities (Asibey et al., 2025; Qu et al., 2025).

Urban managed retreat is also a topic that must be discussed within the framework of justice. Siders and Ajibade (2021) demonstrate that most of these strategies produce environmentally unjust outcomes. Particularly low-income and marginalized communities are more affected in cases of urban managed retreat (Effiong et al., 2025; Alves et al., 2018).

Environmental justice is examined in three dimensions: distributional justice (sharing benefits and burdens), procedural justice (decision-making process), and recognition justice (respect for cultural values) (Siders & Ajibade, 2021). Each dimension is necessary for success in retreat programs.

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Questions about which communities will be relocated, how compensation will be distributed, and the quality of new settlements are among the key points in these issues (Ajibade, 2022; Siders & Ajibade, 2021). Procedural justice ensures communities' participation in the decision-making process (Strange et al., 2024). Hanna et al. (2021) show that decision-making processes are often expert-focused and community needs are overlooked.

Retreat is finding an increasingly important place in global climate policy. Intergovernmental Panel on Climate Change (IPCC) reports identify managed retreat among adaptation options (IPCC, 2022). This report emphasizes that retreat is not merely a last resort but can be part of proactive risk management (Hino et al., 2017; IPCC, 2014).

The Sendai Framework for Disaster Risk Reduction (2015-2030) aims to reduce disaster risk (UNDRR, 2015; UNECE, 2015). It emphasizes the importance of proactive risk reduction strategies and indirectly supports retreat.

New Zealand is among the first countries to adopt managed retreat as an official policy option (Ocean & Climate Platform, 2025). This country adopts a community-led approach to managed retreat (British Columbia, 2024).

3. URBAN MANAGED RETREAT AS A STRATEGIC TOOL

3.1. Reactive and Proactive Retreat

Urban managed retreat is divided into two categories regarding timing: reactive retreat and proactive retreat. Reactive retreat occurs after a disaster (Hino et al., 2017). Property buyout programs are an example of this. However, this method carries the risk of victimizing communities again (Doberstein et al., 2024).

Proactive retreat, on the other hand, is planned before a disaster occurs (Doberstein et al., 2024). Communities relocate to safe areas with an understanding of climate risks. This approach provides the opportunity to act before people are harmed.

Planning time affects the quality of community decisions. Kondo et al. (2022), examining experiences in Japan, showed that more conscious decisions are made when proactive planning is conducted. With sufficient time, communities can actively shape their new living spaces.

3.2. Partial Retreat Models

Partial retreat does not require evacuation of the entire settlement. While critical infrastructure (hospitals, administrative buildings) is moved to higher elevations, other areas are gradually emptied (Nakai et al., 2025). This method encourages voluntary relocation by creating attractive factors.

Buffer zones create a protective intermediate area between areas at risk and developed areas (Guo et al., 2023). These areas have the capacity to absorb floodwaters and support ecosystems. In the Medmerry (England) example, 185 hectares of new tidal area was created and biodiversity increased (Environment Agency UK, 2013; ABPmer, 2012).

3.3. Complete Retreat and Community Relocation

Complete retreat involves the full relocation of settlements to safe areas. Hino et al. (2017) note that approximately 1.3 million people have relocated over the past thirty years. These large-scale movements bring complex social and economic problems.

New York's Oakwood Beach neighborhood provides a successful example. After Hurricane Sandy, 184 out of 185 homeowners applied for a voluntary buyout program (Georgetown Climate

Center, 2020). This success highlights the importance of community participation and fair compensation mechanisms.

Japan's mass relocation projects have preserved social fabric. In Iwanuma, care was taken to keep former neighbors together in new settlement areas (Cosson, 2020; Otsuyama et al., 2023). Basic services including schools, health centers, and parks were included.

3.4. Integrated Models with Nature-Based Solutions

Areas where retreat occurs can be used for ecosystem improvement. Nakai et al. (2025) emphasize that managed retreat and nature-based solutions complement each other. Mangrove forests, salt marshes, and seagrasses create natural defense lines (Gedan et al., 2011).

The Medmerry project is the best example of this integration. The new tidal area compensated for habitats lost due to coastal squeeze and eliminated annual maintenance costs of £300,000 (Environment Agency UK, 2013; ICE, 2025). The project provides both ecological and economic benefits.

4. INTERNATIONAL CASE STUDIES

4.1. United States: Post-Hurricane Sandy Applications

In the United States, particularly after Hurricane Sandy, buyout programs have been widely implemented. Guo et al. (2023) showed that the New York State program had positive effects on the local economy. The program consists of two main components: buyout (purchase and demolition) and acquisition (purchase and strengthen for reconstruction).

The Oakwood Beach neighborhood provides a successful community-led example. Three months after the hurricane, the Governor announced $200 million in funding (Georgetown Climate Center, 2020; Lincoln Institute, 2024). Out of 185 homeowners, 184 applied to the program and 180 were accepted.

Hashida et al. (2023) note that acquisition programs create stronger economic impacts. These programs preserve housing stock and contribute to the development of local businesses. Buyout programs, on the other hand, create natural buffer areas, providing long-term resilience.

4.2. England: Medmerry Planned Coastal Retreat

Medmerry is the largest retreat project carried out on Europe's open coasts, located on the West Sussex coastline. The collapse of the shingle bank in 2008 caused £5 million in damage (Internet Geography, 2023; Environment Agency UK, 2013). The project, completed in 2013, constructed a new 7-kilometer flood defense and created a controlled opening allowing seawater to enter the area (Image 1.) (ICE, 2025). Three main objectives were set: manage flooding and erosion, create habitat, and ensure community participation (Landscape Institute, 2020; ABPmer, 2012).

Image 1. *Aerial view of the Medmerry Coastal Realignment Scheme (Internet Geography, 2023)*

Medmerry's success is based on a multi-stakeholder participatory approach. The Environment Agency conducted a comprehensive stakeholder engagement process to address local concerns. The project eliminated annual maintenance costs of £300,000 and increased biodiversity.

4.3. Japan: Post-Tsunami Community Relocation

Japan's reconstruction following the 2011 tsunami demonstrates a comprehensive application of mass relocation strategy. Otsuyama et al. (2023) note that local governments purchased tsunami-affected areas with national budget support. Affected families were relocated in groups to safe high-elevation areas (Image 2.).

The city of Iwanuma provides a successful example. The three neighborhoods affected by the tsunami chose collective relocation (Cosson, 2020). In the reconstruction, the goal was not just physical relocation but preservation of social fabric.
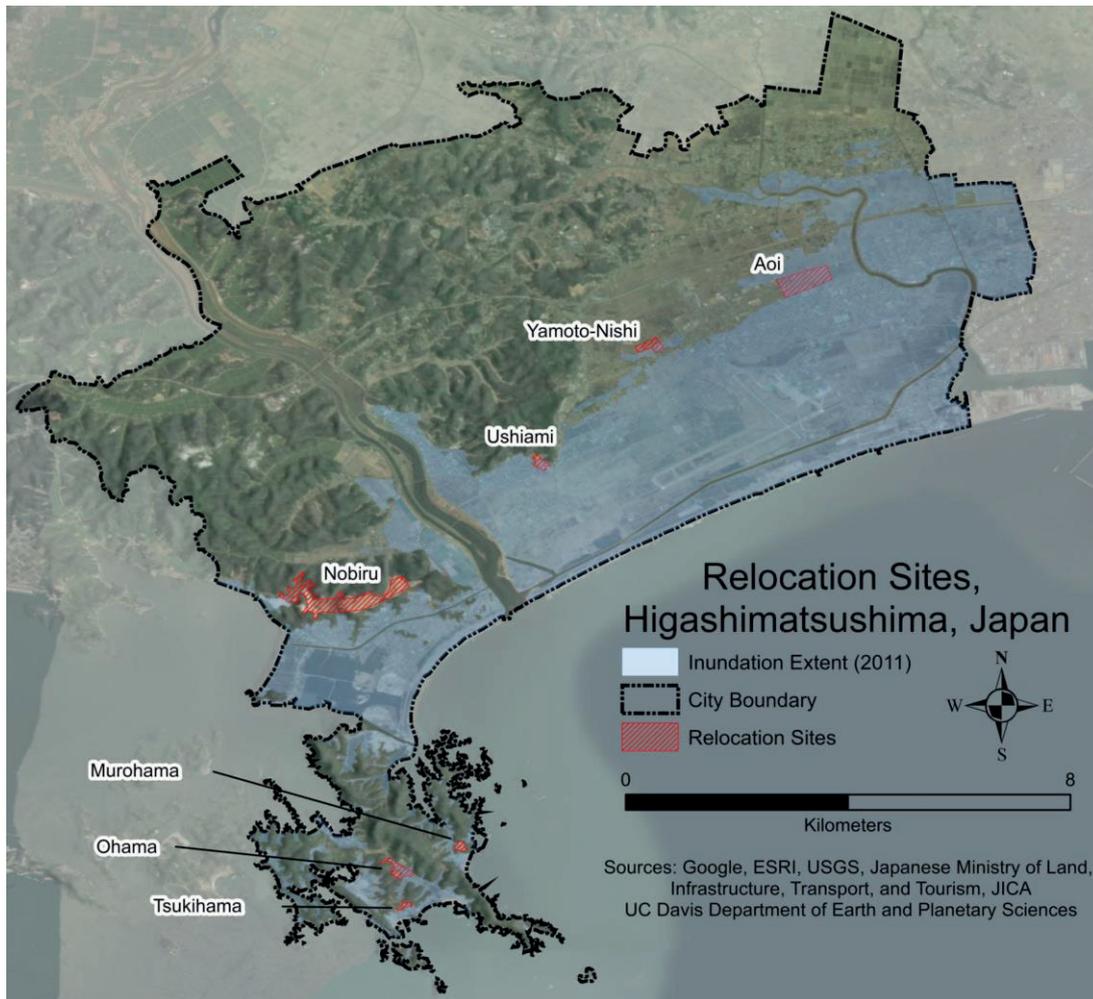
Image 2. *Relocation sites of Higashimatsushima Scheme (Managed Retreat at UC Davis, 2019)*

Designers worked with the community to create better housing than what was lost (Cosson, 2020; Tsubouchi et al., 2023). Schools, health centers, roads, and park areas were included.

Kushimoto's proactive planning experience provides important findings. Kondo et al. (2022) found that the relocation of the municipal building and disaster management center to high-elevation areas created an attractive factor for voluntary community relocation.

4.4. Potential Examples and Risk Areas from Turkey

Turkey faces increasing risks from flooding, coastal erosion, and sea level rise. The Climate Change Adaptation Strategy emphasizes the need to develop adaptation measures for urban settlements (Turkish Ministry of Environment, Urbanization and Climate Change, 2024). However, managed retreat has not yet been widely addressed in planning practice.

Istanbul's coastlines stand out in sea level rise and erosion. Istanbul's Climate Change Action Plan reveals increasing urbanization and coastal risks (IBB, 2022). Raising community awareness is essential work.

The Eastern Black Sea region carries high flood risk. In particular, steep topography increases the impact of heavy precipitation in this region. Post-disaster resettlement practices are sometimes discussed, but proactive strategies have not been developed.

In this context, Law No. 6306 provides a legal framework for transformation of risky areas (Turkish Ministry of Environment, Urbanization and Climate Change, 2023). However, this legislation is in-situ transformation oriented and provides limited space for retreat options.

5. CRITICAL COMPONENTS IN THE PLANNING PROCESS

5.1. Risk Assessment and Hazard Mapping

Risk assessment is the foundation of the retreat process. Hino et al. (2017) emphasize the critical role of risk assessment in determining which areas are prioritized. This process includes climate projections, sea level scenarios, and geomorphological changes (Ankrah et al., 2023; Sharaan et al., 2022).

Flood risk assessments combine spatial planning and risk management. Ran and van der Vlist (2016) show that these assessments inform local development plans. Thus, the decision-making process is data-driven.

Hazard mapping visualizes risk levels. Turkey's Climate Change Strategy maps severe precipitation and weather risks for urban settlements (Turkish Ministry of Environment, Urbanization and Climate Change, 2024). These maps help determine spatial priorities in planning decisions.

5.2. Legal and Financial Mechanisms

Managed retreat programs require complex financial mechanisms. Land acquisition, compensation, insurance, and resettlement costs affect program success (Hino et al., 2017; Ajibade, 2022). In the United States, the Federal Emergency Management Agency (FEMA) and Housing and Urban Development (HUD) programs are the main funding sources for buyout operations.

FEMA aims to pay 100% of fair market value before disaster to property owners (Hashida et al., 2023; Impact Wharton, 2021). However, Manda et al. (2023) note that the cost-benefit analysis requirement complicates programs. Matching fund requirements create barriers for local governments.

Local fiscal capacity determines the pace of the program. Impact Wharton (2021) recommends that accelerating fund distribution and relaxing matching requirements would improve the process.

5.3. Community Participation and Social Acceptance

Community participation is the most important factor for the success of retreat programs. Siders and Ajibade (2021) show that a co-production approach ensures procedural justice and increases acceptance. This approach integrates local knowledge into institutional decision-making mechanisms.

Psychological resistance creates a significant barrier to people accepting relocation. Cohn et al. (cited in O'Donnell, 2022) identified lack of proper communication and community consultation as the main cause of failure. Negative connotations of the term "managed retreat" increase resistance.

Cultural heritage preservation is a sensitive issue, especially for indigenous communities. In Guadeloupe and Martinique examples, active participation of residents led to acceptance of transformations (Ocean & Climate Platform, 2025). Reshaping community identity becomes possible through participatory processes.

5.4. Governance and Institutional Capacity

Multi-level governance is necessary to manage the complexity of retreat programs. Moises et al. (2024) note that effective coordination and communication are critical for resilience. The Sendai Framework supports multi-sectoral collaboration (UNDRR, 2015).

Coordination mechanisms ensure policy consistency. Experience in Nouvelle Aquitaine (France) shows that integration is necessary across all scales, from neighborhoods to state institutions (Ocean & Climate Platform, 2025). This overcomes fragmented initiatives.

Institutional capacity is often limited, especially in developing countries. Wieszczeczynska et al. (2024) note that capacity development is a fundamental necessity in the Global South. New skills in planning and management must be supported.

5.5. Just Transition and Social Equity

Protection of vulnerable groups is the foundation of a just retreat process. Ajibade (2022) shows that successful programs consider socio-economic welfare and cultural continuity. The program aims for more than physical relocation; it targets increased quality of life.

Tamasiga et al. (2024) show that social protection programs strengthen climate resilience. Climate change disproportionately affects vulnerable communities (Tamasiga et al., 2024; Alves et al., 2018). Equal burden sharing must be ensured.

Quality of life in new settlement areas should include not just infrastructure but social amenities, economic opportunities, and cultural continuity. In the Iwanuma example, care was taken to preserve community identity alongside basic services. This holistic approach turns relocation into an opportunity.

6. NEW GENERATION CITY AND REGIONAL PLANNING PRINCIPLES

6.1. Flexible and Adaptive Master Plans

Traditional static plans are insufficient against climate uncertainty. Giordano et al. (2012) show that adaptive planning can make long-lived infrastructure climate-resistant. Adaptive planning involves processes open to periodic review and capable of responding to changing conditions.

Adaptation roadmaps provide opportunities for planning gradual responses. Langendijk et al. (2025) systematically integrate adaptation, mitigation, and sustainable development. This approach enables stakeholders to contemplate profound changes.

Rey-Valette explains that population relocation should be approached with adaptation roadmaps (Ocean & Climate Platform, 2025). This roadmap provides a timeline of what must be done. Accordingly, in the first phase parking areas should be moved, then moveable assets, then residential buyouts.

6.2. Green and Blue Infrastructure Networks

Retreated areas can be integrated into ecological continuity. Ferrario et al. (2024) show that nature-based solutions are tools for urban resilience. Green and blue infrastructure provide multiple benefits such as flood risk reduction and mitigation of heat island effects.

In coastal areas, nature-based adaptation strategies are increasingly adopted. The California Coastal Commission (2021) states that these strategies provide hazard adaptation, ecosystem

improvement, and recreation opportunities. Dune restoration and wetland recreation are examples of these strategies.

Medmerry exemplifies successful ecological integration of retreated areas. The 185-hectare new tidal area provides biodiversity and tourism opportunities. These areas create economic value for local communities.

6.3. Polycentric Development Model

Economic and social vitality transfer from risky areas to safe zones can be supported by a polycentric development model. This model plans multiple development centers rather than single central growth. In the context of retreat, it enables planned reorientation from coastal areas toward inland regions.

The Kushimoto example demonstrates this approach. Kondo et al. (2022) note that the city created new development centers in high-elevation areas. The highway provides both emergency access and daily transportation.

Sustaining economic vitality is necessary for program success. Guo et al. (2023) show that acquisition programs in New York created positive effects in the service sector and local businesses.

6.4. Technology Tools and Decision Support

Early warning systems, risk monitoring, and decision support tools increase the effectiveness of retreat processes. Moises et al. (2024) show that effective coordination structures are of critical importance. Early warning systems allow timely decisions by identifying risks in advance.

Geographic Information Systems (GIS) and remote sensing are powerful tools in risk assessment. These technologies visualize sea level projections and flood simulations (Ran & van der Vlist, 2016). Turkey's Climate Strategy creates maps using these technologies.

Participatory decision support tools ensure active community participation. British Columbia (2024) recommends the use of tools such as economic evaluation and multi-criteria decision analysis. These tools provide more holistic decisions by adding non-monetary factors.

7. CONCLUSION AND RECOMMENDATIONS

Urban managed retreat should be viewed as a smart adaptation strategy, not an inevitable failure. Carey (2020) and O'Donnell (2022) note that retreat is becoming an increasingly necessary strategy. Urban planners and policymakers must move away from the approach of protecting existing areas at all costs.

Retreat is not just physical relocation but an opportunity for communities to rebuild their living spaces. The Ocean & Climate Platform (2025) emphasizes that this strategy provides an opportunity to design a more desirable future for coastal cities. Communities can create safer and more sustainable areas.

Planning requires the joint work of disciplines including planning, ecology, sociology, economics, and law to manage the complexity of retreat strategy. Wieszczeczynska et al. (2024) show that interdisciplinarity is one of the fundamental parameters of capacity development.

A co-production approach combines scientific expertise with local knowledge. Siders and Ajibade (2021) note that this approach strengthens procedural justice and increases community capacity. Neither science nor local knowledge alone is sufficient.

Every community and geographic context has unique characteristics. Ajibade (2022) shows that one-size-fits-all solutions are not appropriate. Cultural values, socio-economic structure, and physical risks require specialized strategies for each region.

Cross et al. (2025) note that fundamental principles are context-specific design and continuous community participation. Just transition aims to protect vulnerable groups and reduce social inequalities.

Planning education should include climate adaptation and managed retreat strategies. Wieszczeczynska et al. (2024) show that education is central to capacity development. New curricula should integrate climate science, risk assessment, socio-ecological systems, and environmental justice.

Applied learning is important. International case studies (Oakwood Beach, Medmerry, Iwanuma) provide students with opportunities to understand complex processes. Simulations and role-playing exercises help understand different stakeholders' perspectives.

Integrating managed retreat options into Turkey's climate adaptation strategies is an urgent necessity. Proactive planning should begin for Istanbul's coasts, the Eastern Black Sea, and other at-risk areas. Law No. 6306 should be expanded to include retreat options.

Pilot projects can contribute to building local knowledge and capacity. Small-scale, high-risk areas can be selected to test voluntary programs. Local experience can be gained in compensation mechanisms, resettlement, and ecosystem restoration.

Institutional capacity development is critical for success. Coordination structures between central and local governments must be established. Learning from international experiences and knowledge-sharing networks should be created.

In the climate crisis, the purpose of planning is not just to resist but to adapt with dignity in changing conditions. This perspective views retreat as responsible planning rather than defeat. Hino et al. (2017) note that retreat is an important adaptation option.

Dignified adaptation respects people's rights, identities, and dignity. Siders and Ajibade (2021) emphasize that a just process must combine procedural, distributional, and recognition justice. Communities must find physical safety, social welfare, and cultural continuity in new areas.

Safe adaptation aims to protect from risks and create sustainable areas for future generations. The Ocean & Climate Platform (2025) notes that managed retreat is a proactive adaptation strategy. By avoiding emergency post-disaster evacuations, communities can make conscious decisions.

In conclusion, urban managed retreat will become an inevitable part of planning practice in the 21st century. Urban planners, policymakers, and communities must develop proactive, just, and sustainable retreat strategies. This process will contribute to establishing a new balance between humans and nature and building more resilient societies.

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CHAPTER 2

SMART APPLICATIONS IN PUBLIC SPACE FOR HEALTHY CITIES

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INTRODUCTION

Globally, more people live in urban areas than in rural settings. While cities offer many opportunities for employment and access to better services (health, education, social protection) that are necessary for good health and human development, cities can also pose unique health risks.
In urban slums and smaller informal settlements, overcrowding and lack of access to safe water and sanitation contribute to the spread of infectious diseases such as tuberculosis (TB), for example. Rates of noncommunicable diseases (NCDs), violence, and mental illness are also often higher because of cities' social, built and food environments.

Meanwhile, only 12 percent of cities globally reach pollution control targets. With such trends in mind, the World Health Organization (WHO) has identified urbanization as one of the key challenges for public health in the 21st century (WHO and Metropolis, 2014).
The importance of managing and planning urbanization in a way that advances, rather than holds back, health and health equity will only grow. By 2050, 70 percent of the world's people will live in cities. We must strive to ensure that they are living in healthy and livable cities that are: "continually creating and improving those physical and social environments and expanding those community resources which enable people to mutually support each other in performing all the functions of life and developing to their maximum potential." (WHO, 1998).

The Healthy Cities Movement project was launched in 1988 by the World Health Organization to identify health indicators in cities and to find solutions to factors that negatively affect these indicators. A healthy city is one that is alive, breathing, growing, and constantly changing. It is a city that provides employment, protects the natural and historical environment, has a distinct identity that is preserved, is safe from natural and other disasters, offers affordable housing with a high quality of life, has strong services such as education and health, provides sufficient open spaces, strengthens social relations among its residents, and develops in a planned manner.

The Healthy Cities approach adopted by the Healthy Cities Project strives to increase the physical, mental, social and environmental well-being of people living and working in the city.
In the context of healthy cities, public space plays a very important role in terms of services to be provided to citizens. Because public spaces belong to everyone living in the city and all citizens have the right to use them equally (Çelikyay, 2017). Therefore, public spaces can be planned and designed in a way that will contribute positively to the health of citizens.

The main purpose of Healthy City Planning is to create socially supportive environments that facilitate walking and cycling, and to plan urban areas that can meet the expectations of all citizens regarding safety, accessibility, comfort and active living. With the goal of Healthy Transportation, access to integrated transportation systems and green and open areas for physical activity and recreation can be increased through planning and design. By increasing accessibility for everyone, including the disabled, the elderly and individuals with limited mobility, it can be easier to reach the desired location without using a car.

With the goal of creating healthy cities, regulations and practices in public spaces, which are also living spaces for urban dwellers, are of great importance. Urban public spaces are areas within a city that are separate from buildings and have the potential to provide environmental, social, and economic benefits to the community (Uzgören and Erdönmez, 2017). For city dwellers, squares, parks, boulevards, avenues, and streets are indispensable elements of urban public spaces, serving both as transitional areas and as places of interaction and communication with the city and with each other (Çelikyay, 2017). Public spaces are defined as "places or spaces open to the use and enjoyment of all citizens" (Jackson, 1974). In urban design processes regarding the design of public spaces; It is expected to create barrier-free and accessible, ergonomic public spaces and healthy living environments.

SMART AND SUSTAINABLE CITIES FOR HEALTH

Despite occupying just 1.7% of the Earth's surface, cities are home to 57% of the global population and contribute to 70-80% of anthropogenic air pollution (UN Habitat, 2024). Rapid urbanization amplifies challenges such as social inequality, traffic congestion, and environmental degradation − all of which directly affect public health and quality of life. Yet, these challenges present an opportunity for transformation. By harnessing digital technologies, governments and municipalities can reimagine cities as smarter, more sustainable spaces that put people at the center of development (ITU, 2025).

Smart Cities are urban structures that possess an advanced Urban Information System, where citizens can access all services through fixed or mobile systems, and which operate with an integrated information organization. To ensure the efficient use of urban resources, all units work together through a single automation system, and the cities are equipped with Information and Communication Technologies that will improve the quality of life.
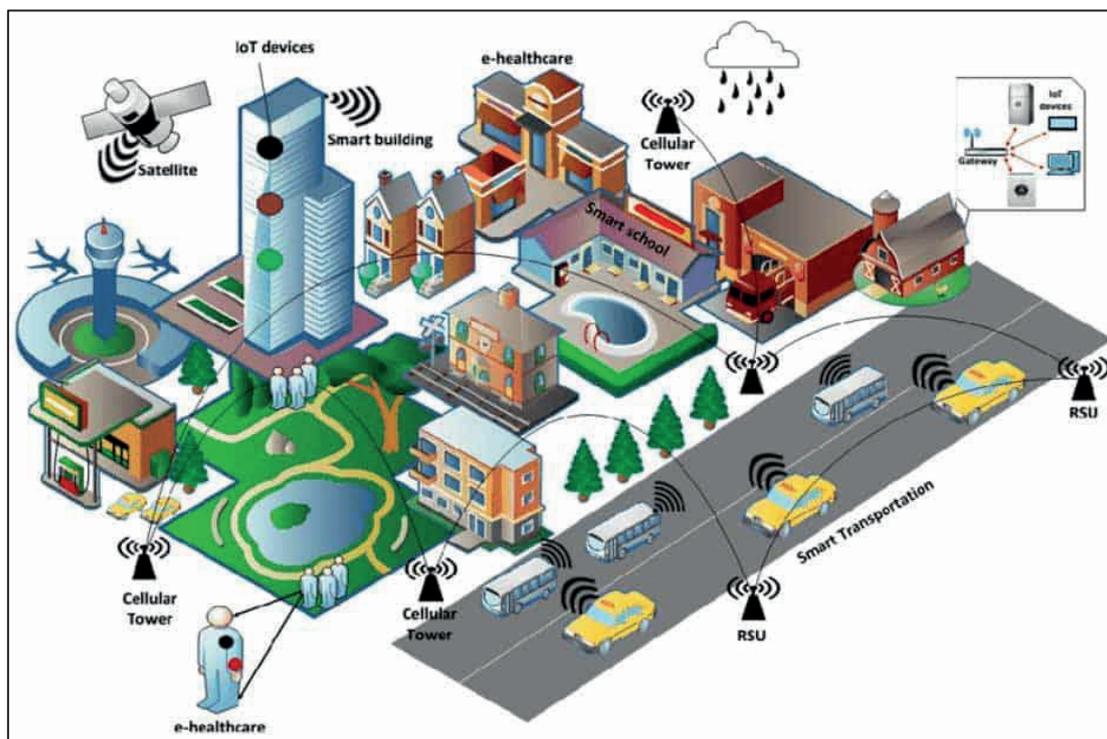

Figure 1. Characteristics of a Smart city (URL-1).

ICT can play a significant role in fostering livability in cities, enabling us to live more sustainably. Urban infrastructure and services that rely on ICT-integrated solutions can enhance sustainable lifestyles, foster a more intelligent and profitable use of resources and promote social justice (ITU, 2014).

The most common sustainable cities definition you will come across is "an urban community that is taking practical measures to minimize its environmental footprint". Think of cities with many parks and large green areas, well suited for cyclists and pedestrians, utilizing renewable energy and predominantly electric or hybrid public vehicles, self-sufficient in waste utilization, energy and water management (Figure 2) (URL-2).

Figure 2. Characteristics of a sustainable city (URL-2).

For the sustainability of cities, technology and ecology must be integrated, and ecological principles should guide all decision-making processes, from planning to design. Eco-design, an important tool for ecological sustainability, is a design method that creates a system for evaluating natural resources and using renewable energy sources and ensures energy efficiency in urban design and architecture.

A smart and sustainable city is an innovative city that uses information and communication technologies and other tools to improve quality of life, efficiency of urban service delivery, and competitiveness, while considering the economic, social, environmental, and cultural needs of present and future generations. A city becomes smart when investments in human and social capital, participatory governance, intelligent management of natural resources, sustainable economic growth, and a high quality of life are combined (Dubbeldeman and Stephen, 2015).

SMART APPLICATIONS IN PUBLIC SPACE

Urban furniture, an important and complementary part of public spaces that constitute the urban environment, facilitates communication between people and space. Changing lifestyles and the increasing importance of technology in human life have necessitated change and development in public spaces and urban furniture as well (Çelikyay and Özbek, 2019). In some cities around the world, smart applications in public spaces have begun to become widespread with the goal of creating healthier cities. These technological, ecological, smart, and engaging applications contribute positively to the mental and physical health of urban dwellers in public spaces. Innovative practices that contribute to public health are increasingly featured on the agendas of city administrations.

City Tree

Operating in Germany, Green City Solutions, which is known for its environmentally friendly projects, has created the City Tree – a bench that cleans the air (Figure 3). The City Tree boasts the capability of purifying air with the power of 275 trees, while occupying a remarkably small footprint. This system, designed to be compact and portable, has gained considerable popularity, showcasing an innovative approach to improving urban air quality. The City Tree is an air filter that occupies 99% less space than 275 trees derived from plant sources. Creating large green spaces in densely populated metropolitan areas is quite challenging. While beautiful examples like Central Park in New York exist, there are also many cities surrounded by concrete. In response to this challenge, Green City Solutions (GSC) has developed an effective solution with the City Tree, which serves as a powerful tool against air pollution. Covering an area of just 3.5 square meters, this bench filters 265 tons of

carbon dioxide each year. Additionally, it is integrated with a digital system that provides information about soil moisture and the level of air pollution.

The City Tree, created with a combination of moss and various plants, has attracted the attention of many municipalities with its innovative approach to combating air pollution. It has been installed in some cities in London and at many locations across Europe. Its protective features against vandalism and its ability to generate its own energy through solar panels are significant advantages, making it an appealing solution for urban environments looking to sustain air quality (URL-3).

Figure 3. City tree (URL-3).

Wind Tree

Wind Tree is a new solution to green energy production. The Concorde Square in Paris, the capital of France, is now being adorned with wind turbines shaped like trees, known as the Wind Tree. Traditional wind turbines have often been criticized for being ugly, large, and mostly noisy; however, the French company New World Wind is changing this perception with a brand-new project. These innovative structures not only produce clean energy but also enhance the aesthetic appeal of urban spaces. The Wind Tree, designed with micro turbine blades, stands 8 meters tall and is surrounded by 63 aeroleaves (Figure 4). With its unique technology, the Wind Tree can generate electricity even in light breezes. Each leaf functions through tiny blades that capture wind energy. Regardless of wind direction, each leaf can produce electricity even in winds of 7 km/h. Additionally, they are so quiet that they can be installed throughout the city, including in gardens, without contributing to noise pollution (URL-4).

Figure 4. Wind tree at Concorde Square in Paris (URL-4).

Rainwater Harvesting

Rainwater harvesting is the collection and storage of rainwater on-site for reuse rather than letting it run off. Rainwater can be collected from rivers or rooftops, and the collected water is directed to a deep trench, aquifer, a drained reservoir, and then collected from dew and mists with nets or other tools. Uses also include water for gardens, livestock, irrigation, domestic use with appropriate treatment, and indoor heating for homes. Harvested water can also be used for other purposes such as drinking water, long-term storage and groundwater enrichment (Figure 5). Apart from storing rainwater, there are aesthetic examples in public spaces that are also functional.
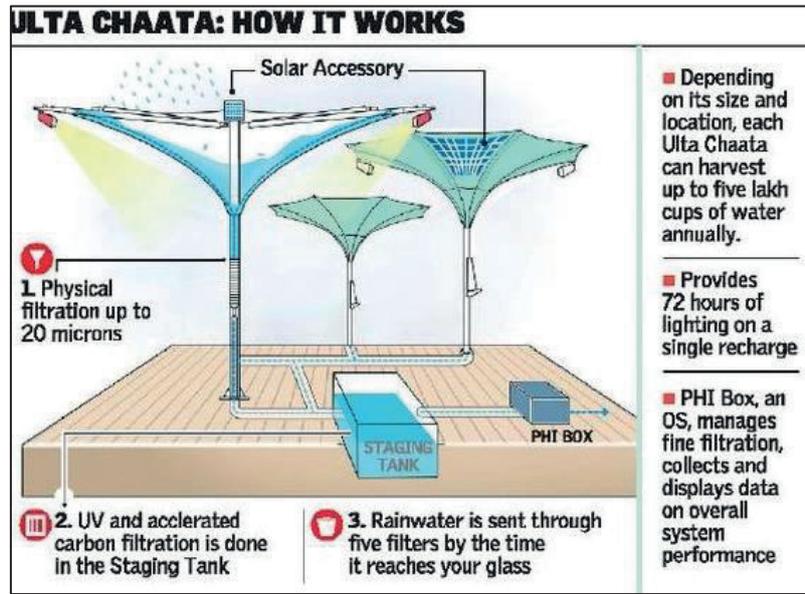

Figure 5. Inverted umbrella that purifies rainwater (URL-5).

Entrepreneurs Samit Choksi and Priya Vakil say that necessity is the mother of invention. India is in desperate need of two things — clean water and clean power. They have created a new product that addresses both needs (Figure 6). It is a stainless-steel structure that is for all intents and purposes an upside-down umbrella. It filters rainwater to make drinking water and is lined with solar panels to generate electricity (URL-6).

Figure 6. Inverted-umbrella brings clean water&clean power to India (URL-6).

Smart Bus Stop

In some cities intelligent transportation systems have been implemented in city bus shelters. A smart bus shelter project integrated with LCD displays (schedule&details of buses, routes), piezo-electricity and crystals using IoT Tech (Figure 7). The focus of the project is about utilizing digital displays of information in public spaces such as bus shelters. The information or content that we focus on in the research concerns digital advertisements or announcements from businesses, institutions and other points of interest around the city (URL-7). The user is the public transport commuter or a pedestrian who interacts with the smart bus shelter almost every day. Relevant information about the city can be of value to the user in terms of saving costs. From the user perspective, another key aspect that comes into play is the users' experience in a bus shelter while he/she is waiting for the bus.

Figure 7. Smart Bus Stop (URL-7).

Green Bus Stop

More green roofs are installed as part of a sustainable city. Especially in urban areas, green roofs can be an important factor for improving the living environment (Figure 8).
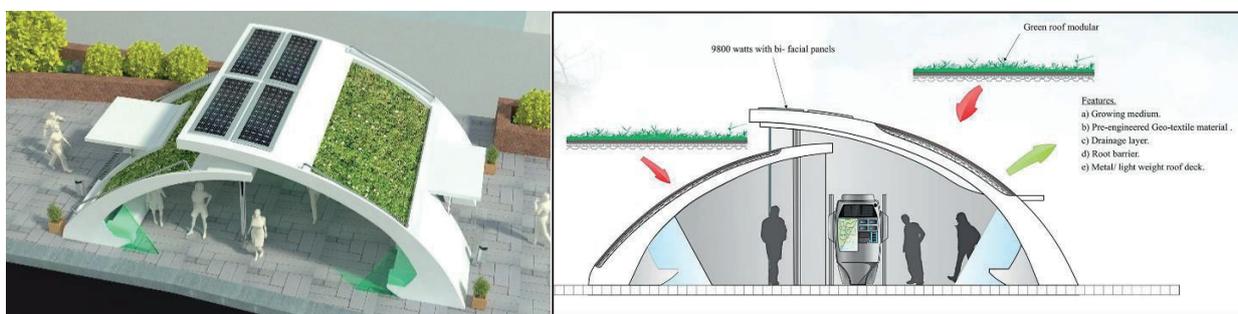

Figure 8. Green Bus Stops (URL-9).

The challenge is, however, that there is often little space for more green in the city. Bus shelters have long been unexplored areas, until now. A wonderful example is the Dutch city of Utrecht where since June more than 300 bus shelters feature a Sedum roof. The attention and positivity that the green

roofs evoke creates movement throughout the world. The bus shelters make other municipalities and residents enthusiastic about contributing to a greener world themselves (URL-8).

Solaroad

In the Netherlands, the world's first solar energy-producing bicycle path, called "Solaroad," has been opened for use (Figure 9). The SolaRoad was the world's first bike path made from solar panels, and was a prototype project testing the feasibility of various proposals for smart highways. The 72-metre (236 ft) path opened in the week of 21 October 2014, and was designed by a consortium of organizations, which built the pathway in Krommenie, Netherlands. The first phase of Solaroad cost approximately 3 million Euros. Each concrete module, measuring 2.5 by 3.5 meters, is topped with shatterproof glass, beneath which there is a solar panel. Once the project is completed, the electricity generated is planned to be used for street lighting, traffic systems, electric cars, and the energy needs of homes (URL-10).

Figure 9. Solaroad in the Netherlands (URL-10).

Examples converting movement energy into electricity

We're producing unused energy. But what if we could harness that to save money, protect the planet, and even have a little fun? We could generate electricity while walking around our cities, heat the neighboring building with the energy from trains, and our children could illuminate the park while playing in playgrounds. This innovative approach could not only lead to more sustainable urban living but also foster a sense of community and creativity in finding new ways to use everyday activities to benefit the environment.

There is significant research focused on wearable devices that can convert kinetic energy (movement energy) into electricity, but none are as effective as foot strikes. A UK-based initiative has designed innovative flooring that converts mechanical energy from footsteps into usable electrical energy. Pavegen was established in 2009 by Laurence Kemball-Cook, when he conceptualized the idea of capturing energy from densely populated urban areas.

According to the CEO of Pavegen, a UK-based company that is a pioneer in kinetic energy harvesting, the advancements in footstep energy technology have progressed much more rapidly than the early developments of solar energy (Figure 10). This highlights the potential and efficiency of harnessing energy from everyday human activities in urban environments (URL-11).

Figure 10. Changing movement energy to electiricity (URL-11).

In London, a project has been implemented on a street called "Bird Street" that transforms daily pedestrian movement in the city into electrical energy (Figure 11). A specially designed floor has been installed in a 10m² area of the street that generates electricity when walked upon. This floor is designed as a system that converts the kinetic energy generated by the pressure exerted by pedestrians into electrical energy (URL-12).

Figure 11. Human movement powering change and binding communities in Bird Street, London (URL-12).

Pedal-Powered Technology

Cycling increases the body's capacity to utilize oxygen. This activity, which involves the dynamic and rhythmic work of large muscle groups, helps protect lung health. Bicycles are a fantastic way to utilize human power for exercise, transportation, and to save on traditional energy consumption. For instance, if we can make bicycles more enjoyable for people, we could encourage more individuals to embrace human-powered transportation. An example of this is Electric Pedals, a company based in London that employs pedal-powered technology to generate electricity for events such as outdoor cinemas, educational workshops, and music venues.

In China, Shandong Fandiluo Arts & Crafts Co., Ltd. produces energy-generating products such as interactive fountain bikes and pedal-activated water jet bikes, which are used in amusement parks (URL-13).

Figure 12. Pedal-powered fountain (URL-13).

CITYLIGHT Street Lamp

The CityLight Street Lamp concept as a pedal powered lamp allows motivated passers-by to use integrated exercise machines to charge its batteries (Figure 13). The CityLight LED lamp poles feature an interactive display that shows battery life and how much power has come from humans while also displaying feedback to the person powering the machine, such as number of calories burned. The designers believe the concept could not only save energy but also enhance community awareness of green energy. The CityLight Street Lamp won the 2011 Green Dot Award.

Figure 13. CityLight Street Lamp (URL-14).

Wheel

The Wheel (pictured) was created by South Korean designer Si Hyeong Ryu for the 2014 Electrolux Design Lab competition (Figure 14). His concept collects kinetic energy generated by the treadmill, which is built into a large hamster-style wheel. It uses this energy to power washers built into the wheel, to churn water and wash clothes as well as light up a display (URL-15).
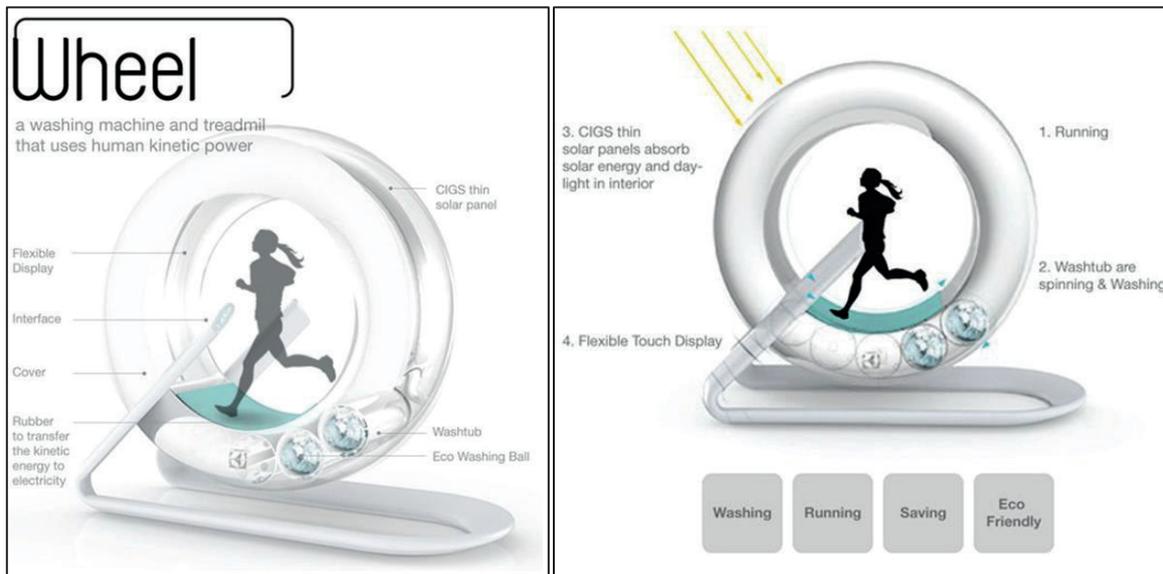

Figure 14. Wheel that uses human kinetic power (URL-15, URL-16).

Smart Trash Bin

Designs that combine renewable solar energy and Internet of Things (IoT) technologies offer options that reduce carbon emissions. BigBelly, a company based in Massachusetts, has been generating revenue while reducing carbon emissions since 2003, thanks to its advanced design. The trash bin designed by BigBelly has solar panels on top that allow the trash inside to be compacted, enabling the bin to hold more waste. When the bin is completely full, it sends a signal to waste collectors using wireless technology. This way, collectors do not have to manually check the bins every day. As a result, waste collectors do not contribute to carbon emissions by going out on the road every day.

Bigbelly Smart Max revolutionizes public waste management with advanced sensor technology and highly efficient solar panels. This smart device minimizes collections through efficient compaction and fill monitoring. BB6 Smart Max improves recycling, reduces CO_2 emissions and updates the urban environment with its modern design and user-friendly interface (Figure 15). This is a sustainable solution for a cleaner future (URL-17).

Figure 15. Smart trash bin (URL-17).

CONCLUSION

Public space is an area for all citizens to come together, meet, gather, stroll, organize events, and socialize, outside of private spaces. Because of this characteristic, public space provides a foundation for urban policymakers, local governments, planners, and designers to plan and design cities in a way that contributes to the health of their citizens.

Indeed, with the goal of creating smart and sustainable cities, designs that combine renewable energies and the Internet of Things to meet the technological needs of individuals in public spaces are increasingly contributing to public health. Smart applications presented in this chapter, such as the City Tree that cleans the air and Pavegen that converts kinetic energy generated by foot movement into electrical energy, and a pedal powered CityLight Street Lamp constitute innovative examples of creating healthy cities.

As designers and entrepreneurs increasingly utilize their potential and creativity in a human-centered way, more innovative and attractive eco-tech designs will emerge, making cities more livable.

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CHAPTER 3

EVALUATION OF THE 15-MINUTE CITY MODEL IN THE CONTEXT OF SPACE SYNTAX

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1. INTRODUCTION

The first quarter of the twenty-first century has witnessed profound paradigm shifts in the discipline of urban planning. Climate crisis, the collapse of fossil fuel-dependent transportation systems, and restrictions imposed by the COVID-19 pandemic have necessitated a re-examination of cities' spatial organization (Allam et al., 2022; Khavarian-Garmsir et al., 2023). In this context, the "15-Minute City" model, formulated by Carlos Moreno and transformed into a global phenomenon through the political support of Paris Mayor Anne Hidalgo, has emerged as one of the most effective visions aimed at enhancing urban quality of life (Moreno et al., 2021; Di Marino et al., 2023). The model essentially proposes that city residents should be able to access their essential needs (housing, work, education, healthcare, shopping, entertainment) on foot or by bicycle within a maximum of 15 minutes from their homes. This approach emerged as a reaction to the functional separation (zoning) brought about by modernist planning and has redefined the city through the lens of "chrono-urbanism," reorganizing it around time-based accessibility (Baig et al., 2025; Shoina, 2024).

However, planning urban space solely on the basis of time and distance metrics proves insufficient in explaining the space's intrinsic logic and its capacity to produce social relationships (Yamu & Garau, 2022). A city's functioning is determined not merely by the physical proximity of services to one another, but by the topological structure of the street network connecting these services (Hillier et al., 1993; Karimi, 2012). At this juncture, the "Space Syntax" theory, developed by Bill Hillier and Julienne Hanson in the 1980s, offers a powerful mathematical and theoretical framework for analyzing urban morphology (Hillier & Hanson, 1984). Space Syntax treats space not as a static background but as an active variable that shapes human movement and social interaction (Charalambous, 2006; Karimi, 2012). According to the theory, pedestrian movement is largely determined by the "configurational" properties of the street network, independent of land use decisions; this is termed "natural movement" (Hillier, 1996; Hillier et al., 1993).

The fundamental problem of this study is the extent to which the "local accessibility" ideal envisioned by the 15-minute city model aligns with the syntactic (spatial ordering) reality of space. If a planning decision places all necessary services (school, market, park) in a neighborhood, can the intended vibrancy and pedestrian mobility emerge if the street network lacks an integrative structure? (Koohsari et al., 2023; Sirjani & Szabó, 2023). Conversely, when the 15-minute city model is applied to areas with high "segregation" values in Space Syntax analyses, might this lead to ghettoization or spatial injustice? (Casarin, 2023; Rojas-Rueda, 2024).

This study defends the following fundamental argument in seeking answers to these questions: the success of the 15-minute city model depends not solely on the metric proximity of services but on the topological relationship these services establish with the urban network as a whole and on the level of "spatial integration" (Yamu & Garau, 2022; Law et al., 2018). Within this study, both theoretical approaches will be detailed, the 15-minute city model will be analyzed through Space Syntax parameters (integration, choice, depth), and finally, an evaluation will be presented in light of empirical findings in the literature.

2. THEORETICAL BACKGROUND

2.1. The 15-Minute City Concept and Its Fundamental Principles

The 15-Minute City model developed by Carlos Moreno represents an approach that reorganizes urban life around the axis of "time" (Moreno et al., 2021). The model's foundation rests on reducing "forced mobility"—viewed as modern cities' most pressing problem (Allam et al., 2022; Khavarian-Garmsir et al., 2023). Traditional modernist planning, by separating residential, industrial, and commercial areas, condemned city dwellers to long and costly journeys. According to Moreno, the solution lies in transitioning from the city's "monocentric" structure to a polycentric and network-based structure.

The model is built on four fundamental pillars (Moreno et al., 2021; Shoina, 2024):

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- **Density:** Sustainable population density is essential for local services to maintain economic viability. Without sufficient density, local businesses and services cannot achieve economic sustainability (Elldér, 2024; Carvalho, 2025).
- **Diversity:** Diversity in both land use (mixed-use) and social composition is essential (Di Marino et al., 2023). Rather than single-function residential areas, spaces where production, living, and leisure are interwoven are targeted. Mixed-use is one of the fundamental drivers of walkability (Sonta et al., 2023).
- **Proximity:** Service access distances must be traversable through active mobility modes (walking, cycling) (Baig et al., 2025; Omwamba, 2025). However, proximity should be defined not only by Euclidean distance but also by perceived accessibility (Hillier & Iida, 2005).
- **Digitalization:** Smart city technologies and remote work options support the model by reducing the need for physical mobility (Rodriguez-Escalante, 2022; Biferale et al., 2025).

While this model shows similarities to movements such as "New Urbanism" and "Transit-Oriented Development" (TOD) in urban planning literature, it distinguishes itself by shifting focus from "transportation speed" to "access time" (Carvalho, 2025). The aim is not to increase speed to travel farther but to reduce speed (slow cities) and enrich nearby opportunities (Khavarian-Garmsir et al., 2023).

2.2. Space Syntax Theory and Method

Space Syntax is a comprehensive body of theories and techniques developed to analyze spatial configuration in architecture and urban design, based on mathematical foundations (Hillier & Hanson, 1984; Şıkoğlu & Arslan, 2015). Developed by Bill Hillier and the UCL (University College London) team, this theory argues that space is not an independent physical void separate from human behavior, but rather a spatial projection of social organization.

The most fundamental proposition of Space Syntax is the "Natural Movement" theory (Hillier, 1996; Hillier et al., 1993). Hillier proposes that the primary determinant of pedestrian and vehicle movement in urban areas is not land use (attraction points) but the geometry and topology of the street network. In other words, people do not walk on a street because there are many shops there; rather, people pass through that street because it is highly integrated (accessible) in the street network, and this high traffic potential attracts shops to open there (Karimi, 2012; Özbil et al., 2011). This reverses the cause-effect relationship and holds critical importance for 15-minute city planning.

The fundamental metrics used in Space Syntax analyses are as follows (Hillier & Hanson, 1984; Charalambous, 2006; Lamprecht, 2020):

- **Integration:** Shows how few steps (depth) a space (street segment or axis) requires to reach all other spaces in the system. Streets with high integration values ("To-movement") typically form the city's main backbone and commercial centers (Hillier, 1996; Özer & Kubat, 2007).
- **Choice (Betweenness):** The probability that a space lies on the shortest paths between two other spaces in the system (Law et al., 2018; Turner, 2007). This measures the potential for "through-movement" traffic.
- **Depth:** The number of topological steps required to move from one point to another (for example, how many times direction must be changed) (Hillier & Hanson, 1984; Şıkoğlu & Arslan, 2015).
- **Connectivity:** The number of other spaces directly connected to a space (Yılmaz & Yılmaz, 2024; Long et al., 2008).

Space Syntax measures distance not in meters (metric) but in visual and topological steps (direction changes) (Hillier & Iida, 2005). Human cognitive maps perceive a straight 500-meter road

as "closer" than a 300-meter but labyrinthine path requiring four turns. This finding carries critical importance for 15-minute city planning (Koohsari et al., 2023).

2.3. Conceptual Intersection Points

The conceptual intersection points between the 15-minute city model and Space Syntax offer important insights for the future of urban planning. Both approaches target creating human-scale, walkable cities (Bhiwapurkar, 2018; Sirjani & Szabó, 2023). However, they differ in how they define walkability.

While the 15-minute city focuses on functional accessibility (how much service can be accessed?), Space Syntax focuses on configurational accessibility (how easy/natural is accessing these services?) (Yamu & Garau, 2022; Koohsari et al., 2023). Integrating these two approaches enables developing more comprehensive and successful urban planning strategies.

*Table 1*. *Comparison of the key parameters of the two approaches*

Parameter	15-Minute City	Space Syntax	Integration Potential
Accessibility Measurement	Metric distance (meters/minutes)	Topological depth (number of steps)	Hybrid measurement models
Focus	Functional distribution	Configurational structure	Synchronization of both dimensions
Analysis Scale	Neighborhood	Multi-scale (global-local)	Inter-scale integration
Success Criterion	Service proximity	Movement potential	Both proximity and accessibility
Planning Approach	Normative (what should be)	Positive (what will happen)	Evidence-based design

3. ANALYSIS OF THE 15-MINUTE CITY MODEL FROM A SPACE SYNTAX PERSPECTIVE
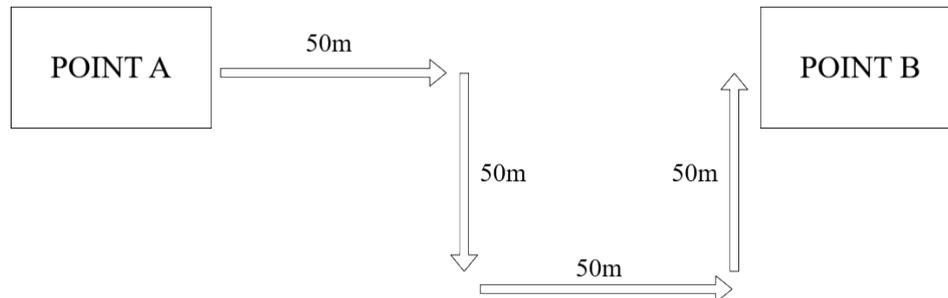
3.1. Metric Radius and Topological Depth

The 15-minute city model is typically visualized through circles drawn from a center (isochrone) or metric walking distances (Baig et al., 2025). For example, a region within a 1000-meter radius from a residence is defined as an "accessible area." However, from a Space Syntax perspective, this approach is misleading (Yamu & Garau, 2022; Hillier & Iida, 2005).

Space Syntax research has proven that people prefer not "the shortest metric distance" but "the least direction changes" (least angular change) or "the least topological depth" (Turner, 2001). Having a school 400 meters away in a straight line (as the crow flies) from a home does not mean that reaching the school is easy. If the street network requires frequent turns, is full of dead-end streets, or is disconnected (segregated), that 400 meters feels perceptually much longer and discourages walking (Koohsari et al., 2023; Hajrasouliha & Yin, 2015). The conceptual diagram shown in Figure 1 illustrates the difference between metric and topological distance:

POINT A → 200 m straight road → POINT B
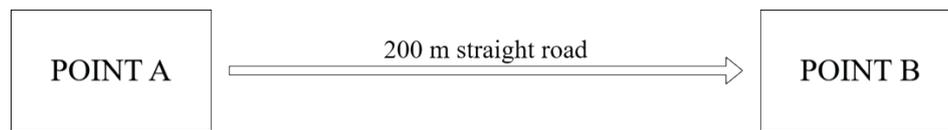
(Topological depth: **0 turns**, Perceived distance: **SHORT**)

POINT A — 50m ↓ 50m — 50m — 50m ↑ POINT B

(Topological depth: **3 turns**, Perceived distance: **LONG**)

Figure 1: Comparison of Metric and Topological Distance

Metric distances are the same (200m vs 200m), but the winding route feels perceptually much longer. For this reason, when planning a 15-minute city, it is necessary to look not only at the location of services but also at the "segment angular choice" and "local integration" values of the paths leading to those services (Law et al., 2018; Özbil et al., 2011). A local market or park placed on a street that does not have high integration values may fail to create the expected social interaction (Hillier, 1996; Karimi, 2012).

3.2. Neighborhood Concept and Risk of Spatial Isolation

The 15-minute city model tends to divide cities into self-sufficient neighborhood units (Moreno et al., 2021). This approach argues that each neighborhood should have its own center. However, Space Syntax theory emphasizes that cities function in "lattice" structures rather than "tree" structures, and vibrancy is achieved through inter-scale permeability (Hillier & Hanson, 1984; Alexander, 1965).

In Space Syntax analyses, it is observed that vibrant urban centers are not isolated islands but rather areas where "Global Integration" (city-wide scale) intersects with "Local Integration" (neighborhood scale) (Hillier, 1996; Özer & Kubat, 2007). According to Hillier's "Movement Economy" theory, a local center can only remain viable not solely through the movement of those living in that neighborhood (local movement) but also through the contribution of those passing through the area (transit/through movement) (Hillier et al., 1993; Law et al., 2018).

If the 15-minute city model organizes neighborhoods as disconnected, self-contained "cells," there is a risk of "spatial segregation" from a Space Syntax perspective (Casarin, 2023; Rojas-Rueda, 2024). This situation may result in socio-economically disadvantaged neighborhoods failing to integrate with the rest of the city and deepening ghettoization (Nieuwenhuis et al., 2020; Martín-Legendre et al., 2021). Yamu and Garau (2022) demonstrated in their Vienna study that without a fractal and multi-scalar network structure, functional distribution alone does not increase walkability.

3.3. Polycentricity and Urban Networks

Moreno's model advocates for a polycentric city (Moreno et al., 2021). Space Syntax also shows that cities are inherently polycentric, but this emergence of centers is not "planned" but "emergent" (Hillier, 1996; Fusco, 2021). In Space Syntax analyses, centers spontaneously form where street network density increases and integration peaks (Hillier & Hanson, 1984).

A common mistake in 15-minute city applications is imposing a center geometrically in the middle of a neighborhood (Yamu & Garau, 2022). However, Space Syntax analyses show that "vibrant centers" typically do not form at the geometric center of a neighborhood but rather at the edges where the neighborhood connects to the city's main axes or along main arteries (Hillier, 1996; Özer & Kubat, 2007). Studies conducted by Özer and Kubat (2007) found that in cities like Istanbul, pedestrian concentration is concentrated on axes where global and local integration overlap, rather than on functional locations. Therefore, 15-minute city centers should be designed on axes with high configurational potential (Karimi, 2012). Figure 2 shows the relationship between global and local integration in a polycentric urban structure:
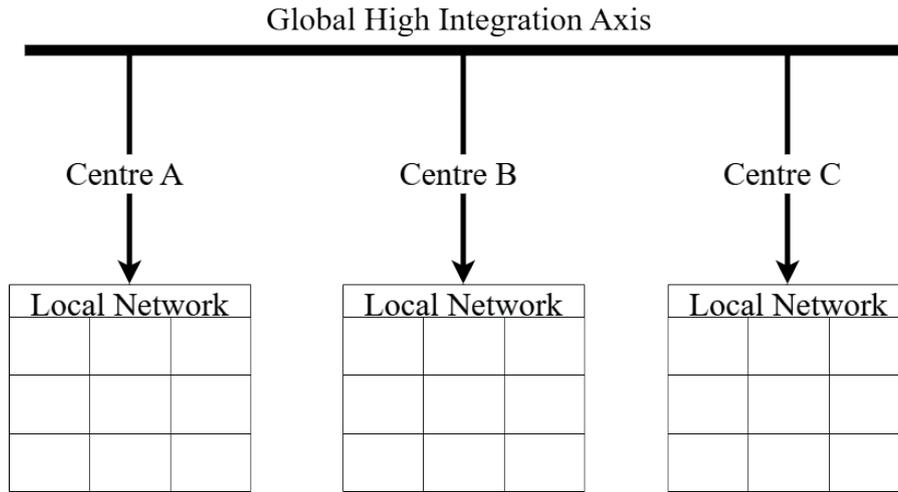

Figure 2: Integration Relationships in Polycentric Urban Structures

3.4. Accessibility Measures and Geographic Information Systems

For successful implementation of the 15-minute city model, traditional Geographic Information Systems (GIS) based accessibility measurements should be integrated with Space Syntax metrics (Kesik et al., 2015; Ertuğay et al., 2018). Traditional GIS analyses calculate accessibility using Euclidean distance or network distance, but overlook the configurational properties of the street network (Geurs & van Wee, 2004).

Hybrid approaches provide more realistic accessibility measurements by considering both metric distance and topological properties (Huang & Wei, 2002; Movoa et al., 2012). For example, LUPTAI (Land Use and Public Transport Accessibility Index) creates a comprehensive accessibility index by combining walking distances, public transport frequency, and public transport travel time (Huang & Wei, 2002).

Table 2. *Comparison of different accessibility measurement methods (Adapted from Kesik et al. (2015) and Huang & Wei (2002).)*

Method	Measurement Unit	Factors Considered	Advantages	Disadvantages
Euclidean Distance	Meters (as the crow flies)	Linear distance only	Ease of calculation	Ignores street network
Network Distance	Meters (along roads)	Road length	Actual travel distance	Overlooks perceptual factors
Isochrone Analysis	Minutes	Time-based access	Time emphasis	Does not account for turns
Space Syntax	Topological steps	Configuration, depth	Behavioral reality	Requires technical expertise
Hybrid (LUPTAI)	Composite index	Distance + Time + Configuration	Comprehensive evaluation	Complex calculation

4. FINDINGS AND DISCUSSION

4.1. Functional Mix and Spatial Depth Relationship

One of the fundamental assumptions of the 15-minute city model is that local economic vibrancy is created through mixed land use (Moreno et al., 2021; Di Marino et al., 2023). However, Space Syntax analyses have proven that functional diversity alone does not generate pedestrian traffic; for this to occur, the street's "spatial depth" must be low (Hillier, 1996; Hillier et al., 1993).

A study on the Düz and Şarkiye neighborhoods in Ordu city center revealed that pedestrian mobility showed a 72% positive correlation with "global integration" (Rn) values, but only a 28% relationship with connectivity (Yılmaz & Yılmaz, 2024; Yeşil, 2024). This finding confirms that placing a market, café, or pharmacy on a street (functional intervention), if that street is more than 4-5 topological steps away from the main network (high depth), does not create the expected "15-minute vibrancy" (Boz Günay & Kubat, 2021).

In Turkey's applications, this situation is called the "dead shops" paradox (Said et al., 2020). For example, in new urban regeneration projects in Istanbul and Ankara, while ground-floor commercial spaces are mandated in residential blocks, most of these shops remain empty. From a Space Syntax perspective, these blocks are typically positioned in the "background network," meaning their local integration (R3) values are low (Hillier, 1996; Karimi, 2012).

According to Hillier's "Movement Economy" theory, commercial units should be located on "foreground streets" where natural movement concentrates; otherwise, economic unsustainability is inevitable (Hillier et al., 1993; Özer & Kubat, 2007). A Tehran case study of Valiasr Neighborhood also yielded similar results, showing that grid patterns attracted 40% more pedestrians than organic patterns (Soltani et al., 2024).

In international literature, the effects of mixed-use on walkability have been extensively studied. Hajrasouliha and Yin (2015) found in their Buffalo (USA) study that both physical and visual street network connectivity had significant positive effects on pedestrian volumes. Sonta and colleagues (2023) emphasized that different aspects of walkable urban design can have contradictory effects on social cohesion, highlighting the importance of demographic controls.

4.2. Spatial Justice and Periphery Problem

One of the most serious criticisms of the 15-minute city model is its potential to deepen socio-spatial inequalities (Casarin, 2023; Rojas-Rueda, 2024). The model can be easily implemented in already integrated and well-serviced central neighborhoods while failing in peripheral and squatter settlement redevelopment areas (Elldér, 2024). Space Syntax analyses show that these areas typically have high "segregation" values (disconnected from the city's main network) (Hillier & Hanson, 1984; Nieuwenhuis et al., 2020).

Research on gated communities in Ankara found that while their internal integration was high, their global integration was 60% lower, creating "spatial exclusion" (Çelik & Şahin Çağlı, 2023; Boz Günay & Kubat, 2021). In the Turkish context, TOKİ projects (Housing Development Administration) are typical examples: Although promising "15-minute self-sufficiency" with internal markets, kindergartens, and parks, insufficient road connections between sites and disconnection from main arteries drive residents to car dependency (Yılmaz & Yılmaz, 2024).

A comparison of traditional housing fabric with TOKİ in Antakya revealed that traditional fabric with its "deformed grid" structure provided both privacy and permeability, while modern blocks with their "tree-like" hierarchical structure remained isolated (Yılmaz & Yılmaz, 2024). These findings show that 15-minute cities increase the risk of gentrification: the wealthy remain in integrated neighborhoods while the poor are pushed to segregated peripheries (Khavarian-Garmsir et al., 2023; van der Berg, 2023).

International examples also reflect similar concerns. Elldér (2024) investigated the relationship between the 15-minute city vision and gentrification in Gothenburg (Sweden), finding that increased local accessibility leads wealthier households to prefer these neighborhoods. Casarin (2023) argues that the 15-minute city's idea of social mixing may be misleading, and that treating symptoms without addressing the root causes of real spatial and social injustice is insufficient.

Table 3. The relationship between spatial segregation and the 15-minute city (Adapted from Çelik & Şahin Çağlı (2023) and Yamu & Garau (2022).)

Neighborhood Type	Global Integration	Local Amenity Density	15-MC Applicability	Risk Factors
Central Neighborhoods	High (Rn > 1.2)	High	Easy	Gentrification, price increases
Transitional Zones	Medium (Rn: 0.8-1.2)	Medium	Medium	Depends on planning
Peripheral Neighborhoods	Low (Rn < 0.8)	Low	Difficult	Segregation, car dependency
Gated Communities	Low (global) / High (local)	High (within site)	Isolated	Spatial exclusion, ghettoization

4.3. Walking Behavior and Cognitive Maps

Space Syntax's "psychological effects" dimension questions the 15-minute model's time-focused assumptions (Hillier & Iida, 2005). People prefer "perceived ease" rather than 15-minute metric distance. Koohsari and colleagues' meta-analysis confirmed that integration values explained 55% of walking behavior, while population density explained only 15% (Koohsari et al., 2023; Hillier & Iida, 2005).

Özer and Kubat's (2007) Istanbul pedestrian mobility study in Turkey showed that movement was predominantly "through-movement" rather than destination-based. This finding makes it necessary to use "integration maps" instead of "isochrone" maps in 15-minute planning (Yamu & Garau, 2022). For example, in topographically challenging cities like Yozgat, topography distorts metric distance; however, Space Syntax can determine the shortest topological routes and calculate true walkability indices (Hillier & Iida, 2005).

Research on cognitive maps and wayfinding shows that people attempt to minimize angular change (Turner, 2001; Turner & Penn, 2002). 90-degree turns are processed more easily by human memory and facilitate route recall. Therefore, when designing 15-minute city neighborhoods, simple and understandable street geometries should be preferred (Hillier & Iida, 2005; Hajrasouliha & Yin, 2015).

International studies have shown that visibility graph analysis (VGA) and other advanced Space Syntax techniques achieve high success rates in predicting pedestrian movement (Turner et al., 2001; Varoudis, 2014). A study on Budapest evaluated the renewal projects of Egyetem Square and Corvin Promenade using VGA, confirming the effects of spatial configuration changes on pedestrian behavior (Sirjani & Szabó, 2023).

4.4. Polycentricism and Inter-Scale Synergy

Moreno's polycentric city vision aligns with Space Syntax's "pervasive centrality" concept (Hillier, 1996; Fusco, 2021). Yamu and Garau's (2022) Vienna analysis demonstrated that successful 15-minute zones exhibit global-local integration synergy. Turkey's Ankara morphological change study notes that declining street connections since the 1950s have disrupted this synergy (Boz Günay & Kubat, 2021).

The success of a polycentric urban structure depends on each local center being accessible both for its own neighborhood and for the city as a whole (Hillier, 1996; Karimi, 2012). This emphasizes the importance of designing neighborhoods in 15-minute planning not as completely isolated units but as parts of an interconnected network (Yamu & Garau, 2022). Figure 3 compares successful and unsuccessful or failed polycentric structures: successful models feature multiple connection paths, backup options, and flexibility, while unsuccessful models have single-directional hierarchy, isolation risk, and fragility.
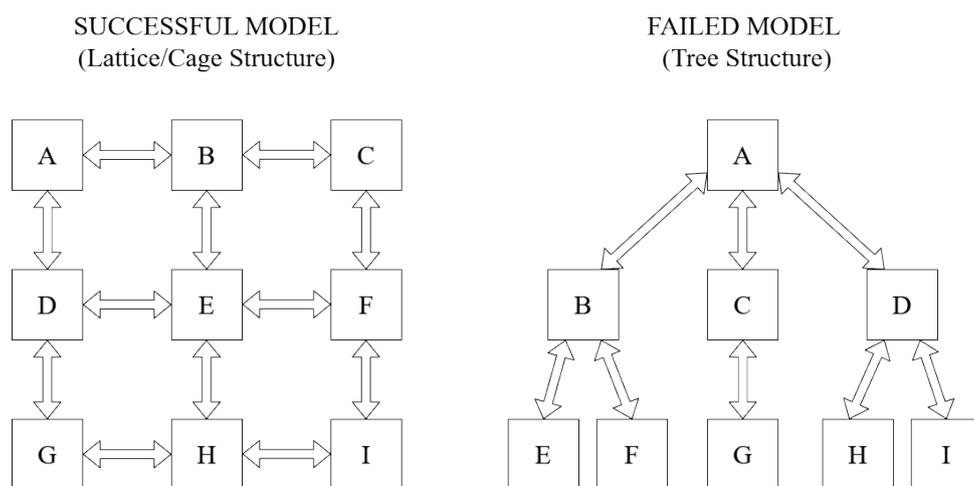

Figure 3: Successful and Unsuccessful Polycentric Structures

4.5. Transit-Oriented Development and Mixed-Use Synergy

The 15-minute city model has strong synergy potential with Transit-Oriented Development (TOD) principles (Rodriguez-Escalante, 2022). TOD encourages the development of high-density, mixed-use neighborhoods around public transportation stations (GDRC, 2024). This approach supports both 15-minute access and regional connectivity.

In developing country cities, TOD is particularly important (World Bank Blogs, 2025). Cities like Bogota, Dar es Salaam, and Quezon City have improved both local accessibility and regional mobility by developing 15-minute neighborhoods around BRT (Bus Rapid Transit) systems. These examples demonstrate how Space Syntax's multi-scalar approach can be practically applied (Hillier, 1996).

Mixed-use developments are among the most effective tools for increasing walkability (NLC, 2023; Pollution Sustainability, 2025). Bringing housing, retail, offices, and recreation areas together at close distances enables both short-distance trips for diverse activities and increases street vibrancy (Local Housing Solutions, 2025). However, mixed-use success requires an underlying street network structure that is suitable (Hillier et al., 1993; Karimi, 2012). Table 4 summarizes critical factors for TOD and 15-minute city integration.

Table 4. TOD and 15-Minute City Integration Factors (Adapted from World Bank Blogs (2025) and Rodriguez-Escalante (2022).)

Factor	TOD Focus	15-MC Focus	Integration Strategy
Density	High density around stations	Neighborhood-wide sustainable density	Density graduation (center→periphery)
Distance	400-800m walking radius	15 minutes (≈1200m)	Station spacing optimization
Mixed-Use	Vertical mixed-use	Horizontal neighborhood mixed-use	Combination of both dimensions
Connectivity	Hub-and-spoke	Mesh network	Hybrid: Main lines + local network
Scale	Regional/metropolitan	Neighborhood/local	Multi-scalar hierarchy

5. CONCLUSION AND RECOMMENDATIONS

The comprehensive analysis conducted by this study reveals both the theoretical appeal and practical limitations of the 15-minute city model, along with opportunities for spatial integration. The study's fundamental finding is that a significant misalignment exists between the chrono-urbanism understanding's metric and time-focused approach and the syntactic reality of space. Empirical research evidence clearly demonstrates that sustainable and vibrant neighborhoods are possible not only through concentrating functional services but through systematically improving the topological and configurational properties of the street network.

The fundamental conclusions emerging from all sections of the research offer important implications for planning practice. The success of functional interventions depends heavily on the underlying spatial integration structure. The "dead shops" paradox observed worldwide, including Turkish examples, strikingly shows that commercial success rates on streets without high integration values are significantly lower. This underscores that planners must conduct configurational analysis while ensuring functional diversity. Services and commercial units placed on streets with low

integration values cannot create the expected economic vibrancy and may eventually become abandoned spaces.

Regarding social and spatial justice, there are more serious risks. In model implementation, central neighborhoods already possessing high integration values and developed service systems easily benefit, while peripheral areas experiencing severe segregation and network disconnection may fall behind. From gated housing communities to gecekondu (squatter settlement) redevelopment areas, residents of spatially isolated regions, even if promised 15-minute internal accessibility, may become further disconnected from the broader urban system. This situation may unintentionally accelerate gentrification, pushing socio-economically weaker groups to increasingly isolated and marginal areas, deepening spatial injustice.

Understanding human behavior and cognitive processes is critical for improving the 15-minute city approach. Distance perception is far more complex than metric distance and is influenced by topological depth, visual clarity, safety perception, and aesthetic quality. People evaluate paths not only through time-based accessibility but through perceived ease, required direction changes, and cognitive map formation capacity. Therefore, planning maps should be supplemented with spatial integration maps rather than metric distance isochrones.

A multi-scalar urban hierarchy and inter-scale alignment are common characteristics of successful 15-minute applications. Rather than isolated neighborhoods and disconnected sites, neighborhoods must be connected through a lattice-like network structure. Each neighborhood should provide 15-minute accessibility within itself while simultaneously connecting to global integration axes. This multi-scalar integration supports both local economic vibrancy and social cohesion.

A 15-minute approach integrated with transit-oriented development strategies can effectively combine spatial planning and transportation planning. High-density mixed-use neighborhoods around transit stations can provide both local accessibility and regional connectivity, delivering dual benefits. However, this integration's success again depends on appropriately designed spatial configuration.

Recommendations for planners and designers in implementing the 15-minute city model are as follows. Before project implementation, comprehensive Space Syntax analysis of the existing street network should be conducted. This analysis enables identifying high-integration axes and positioning functions on these axes. Functional interventions should be anchored to these main axes, while not overloading secondary networks.

Developing and modernizing accessibility measures is also important. Rather than simple isochrone maps based on metric distance, composite accessibility indices combining topological depth, angular choice, and local integration values should be created. Geographic Information Systems, Space Syntax software, and artificial intelligence-supported modeling techniques can be used to calculate these hybrid indices.

Physical interventions addressing structural problems that increase network disconnection and isolation should be implemented. Adding new connections in discontinuous and closed street systems, increasing permeability, and transitioning toward lattice structures reduce segregation risk. Community participation and understanding of residents' needs are essential for successful design of these interventions.

During neighborhood design, individual neighborhoods should be conceptualized not as isolated units but as functional parts of the larger urban network. Both each neighborhood's internal integration (local accessibility) and its connection to global integration (regional accessibility) are important. Neighborhood edges should be designed to provide healthy connections with main arteries, while internal street patterns maintain defined neighborhood character without being closed to the outside.

A justice-centered implementation strategy is necessary. 15-minute city applications should be supported by social housing policies, rent control mechanisms, and laws preventing resident

displacement. Otherwise, the model, unintentionally, may become a tool for accelerating gentrification and deepening spatial inequality.

Research areas that could guide future studies exist. Comparative Space Syntax studies should be conducted in cities across Turkey's different geographies (plains, mountains, coasts), and integration values should be systematically monitored before and after model implementation. The relationship between socio-economic indicators and spatial integration should be examined, and behavioral economics perspectives should be integrated into spatial analysis. Artificial intelligence and machine learning methods can make accessibility modeling more dynamic and predictive.

In conclusion, if the 15-minute city model is implemented only from a functional services perspective, it may yield limited and contradictory results. However, if supported by Space Syntax and other spatial analysis tools, it can become a powerful instrument for creating genuinely sustainable, accessible, vibrant, and equitable urban environments. This integrated approach can become an essential strategy for developing more humane and place-based cities under the challenges of the 21st century—climate crisis, social division, and resource scarcity. Importantly, this study has demonstrated that spatial planning becomes more successful when grounded in concrete factors such as city residents' daily experiences, human cognition, topological realities, and social justice, rather than abstract theories.

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