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THE IMPORTANCE OF GREEN INFRASTRUCTURE PRACTICES IN BUILDING RESILIENT CITIES: COMPARISON OF BARCELONA AND IZMİR CASES*

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ABSTRACT

In recent years, climate change and global environmental crises have reached more serious dimensions. Along with these negativities, deterioration in the social, economic and spatial structures of cities occurs. At the point of solving these problems experienced in cities, the concept of resilience comes to the fore. The importance of the studies carried out and to be carried out at the point of creating resilient cities is increasing. Various factors come to the fore in creating a resilient city. One of them is the green infrastructure application. In this study, the models of Barcelona and Izmir, where green infrastructure is successfully implemented in the world and in Turkey, are analyzed. The main question of the research is what the similarities and differences between the two models when the green infrastructure models are applied in Barcelona and Izmir are examined. A comparative analysis method was used in the research. As a result of the research, it has been observed that both cities have developed and continue to develop green infrastructure strategies in terms of adaptation to climate change, healthy living, water management, prevention of global warming and protection of biodiversity. However, while Barcelona's larger budget and advanced technological facilities in green infrastructure projects strengthened the possibility of implementation, it was determined that Izmir, although it is sufficient on the basis of projects, has some infrastructure and legislative problems at the point of implementation.

Keywords: *Resilient city, green infrastructure, Izmir, Barcelona*

JEL Classification: *Q54, Q57*

DİRENÇLİ KENTLER OLUŞTURMADA YEŞİL ALTYAPI UYGULAMALARININ ÖNEMİ: BARSELONA VE İZMİR ÖRNEKLERİNİN KARŞILAŞTIRILMASI

ÖZET

Son yıllarda iklim değişikliği ve küresel çevre krizleri daha ciddi boyutlara ulaşmıştır. Bu olumsuzluklarla birlikte kentlerin sosyal, ekonomik ve mekânsal yapılarında bozulmalar meydana gelmektedir. Kentlerde yaşanan bu sorunların çözümü noktasında ise dirençlilik kavramı ön plana çıkmaktadır. Dirençli kentler yaratma noktasında yapılan ve yapılacak olan çalışmaların önemi artmaktadır. Dirençli bir kentin oluşturulmasında çeşitli faktörler ön plana çıkmaktadır. Bunlardan biri de yeşil altyapı uygulamasıdır. Bu çalışmada dünyada ve Türkiye'de yeşil altyapının başarıyla uygulandığı

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Barselona ve İzmir modelleri analiz edilmiştir. Araştırmanın temel sorusu, Barselona ve İzmir'de uygulanan yeşil altyapı modelleri incelendiğinde iki model arasındaki benzerlik ve farklılıkların neler olduğudur. Araştırmada karşılaştırmalı analiz yöntemi kullanılmıştır. Araştırma sonucunda her iki kentin de iklim değişikliğine uyum, sağlıklı yaşam, su yönetimi, küresel ısınmanın önlenmesi ve biyoçeşitliliğin korunması açısından yeşil altyapı stratejileri geliştirdikleri ve geliştirmeye devam ettikleri görülmüştür. Ancak Barselona'nın yeşil altyapı projelerinde daha büyük bütçe ve ileri teknolojik imkanlara sahip olması uygulama imkanını güçlendirirken, İzmir'in proje bazında yeterli olmasına rağmen uygulama noktasında bazı altyapı ve mevzuat sorunları olduğu tespit edilmiştir.

Anahtar Kelimeler: *Dirençli kent, yeşil altyapı, İzmir, Barselona*

JEL Sınıflandırması: *Q54, Q57*

1. Introduction

Today, climate change, resource depletion, global crises, pandemics, epidemics, and disasters that occur with the ever-increasing population growth and the subsequent high rate of urbanization negatively affect the social-ecological and urban infrastructures of cities. The quality of urban life is declining and more livable cities are at risk. With the current urban management systems, only increasing the jurisdiction of municipalities will be insufficient in solving these problems. Changes in urban demographics and lifestyles, sustainability, and flexibility are becoming important elements in urban management.

Solutions have been sought to prevent problems such as population growth, climate change, resource depletion, and pollution and to minimize the negative impact. The concept of resilient cities is one of the most important solutions proposed in recent years. Resilient cities generally refer to the ability of a city or urban system to withstand sudden shocks, stresses, and crises. As the rate of urbanization increases, so does the rate of concretization. Therefore, after climate change and the increase in sudden and excessive rainfall, the excess of impervious surfaces caused by concrete leads to floods and disasters. In the face of this problem, cities need to have a good green infrastructure to show urban resilience in this regard.

Green infrastructure practices aim to protect ecosystems by connecting ecologically important centers through natural corridors, creating integrated natural systems across the landscape and offsetting functional losses due to habitat fragmentation (Weber et al. 2006). Green infrastructure strengthens strategic and coordinated initiatives that focus on sustaining, restoring, enhancing and connecting existing ecological systems (Naumann et al. 2011). Green infrastructure practices contribute to human health and quality of life by protecting ecosystem services (Slatmo et al. 2019). Green infrastructure practices strengthen the life support system, support the development of sustainability policies, and enable us to think about how human and environmental interactions can be managed (Benedict & McMahon 2006).

Green infrastructure is an ecological system in which many types of green spaces in urban planning, parks, gardens, urban forests, and agricultural areas are united in a common denominator. With the implementation of this system, the protection of the ecological balance of the city, the sustainability of the city, the protection of natural resources, and the goal of a more livable city can be achieved (Parlak et al., 2022: 7). Green infrastructure applications to be implemented in cities are both cost-effective and highly successful in terms of functionality.

The main benefits include protecting the health of citizens, creating a more livable environment and urban area, reducing pollution, reducing energy costs, and protecting biodiversity (Arslantaş et al., 2020: 3). From this perspective, green infrastructure transforms the ecological impact of urban areas into social benefits and makes the functions of the ecosystem directly or indirectly beneficial to society. This benefit provides both regulatory and supportive services such as goods and product services, resources, and cultural services (Tülek & Ersoy Milici, 2019: 2).

Of resilient cities, green infrastructure practices are essential to make cities more resilient to climate change, economic risks, and natural disasters. These infrastructures offer solutions to protect and distribute the ecosystem over large areas. In this study, the models of Barcelona and Izmir, where green infrastructure has been successfully implemented in the world and Turkey, are analyses. The main question of the research is to what extent the green infrastructure Models Implemented in Barcelona and Izmir are driven by the green infrastructure Logic and what are the Similarities and differences between the two models. The study aims to compare the green infrastructure Models Implemented in Barcelona and Izmir and to create a framework that will guide other cities in planning green infrastructure Models based on similarities and differences.

2. Literature Review

2.1. Resilient Cities

Cities are areas where people have been living for thousands of years and which contain economic, social, and cultural relations. Urban areas and urban populations are increasing day by day. As long as this increase continues, the stresses and risks on cities will also increase. Cities should not remain vulnerable in the face of stresses such as global crises, disasters, and economic problems. The concept of "resilience" gains importance at this point. Resilience comes from the root "Resi-lire" and is a Latin term meaning to bounce back. In the physics literature, it is defined as the property that allows materials to return to their original state after a shock. Holling is the ecologist who adapted and used the concept in the social sciences. In his studies on the ecosystem, he refers to resilience as follows. Resilience is a measure of permanence. There are the same relationships between the ability of ecological systems to absorb change and degradation, the ability to maintain the status quo, and population or state variables (Holling, 1973: 14). Following this definition, it has been suggested that the resilience principles of ecological systems can also be used to understand the functioning of societies, that is, the structure of cities (Figueiredo, et al., 2018: 10). Because according to cultural ecology, social systems are similar to ecological ones: Therefore, social and ecological systems should be integrated and interdependent (Berkes & Ross 2013: 14; Alexander, 2013: 2713). This new system created to ensure ecological and urban sustainability is called "urban resilience". Cities, where this system is implemented, are called "resilient cities".

Urban resilience is the ability of the socio-ecological and socio-technical networks within the urban system and the urban system itself to maintain its standard functions in the face of a threat or to quickly transform systems that make it difficult to bounce back and adapt to the new situation (Meerow et al., 2016). According to another definition, urban resilience is the ability of cities to maintain their social, economic, and environmental functions in the face of crises and shocks, and to have the capacity to adapt and transform to new crises that may arise later (Dubbeling, Campbell, Hoekstra, & Veenhuizen, 2009: 4).

In a resilient city, there is no expectation of returning to the old situation or equilibrium point in the event of a shock or crisis. Because the old situation or equilibrium point may have disappeared due to the adversities experienced. In this case, other alternatives will emerge. Therefore, there is a possibility that the system can find a new way in the face of the situation. According to **Çiriş** (2017: 148), a resilient city is "ensuring that the many dynamics and actors that make up the city fight against all kinds of dangers, threats, and negative situations (natural disasters, high inflation, etc.) that cities "may face in the physical, environmental, social and economic framework in a coordinated and comprehensive manner." According to both definitions, the most basic priority of resilient cities is not to be able to return to the old situation or equilibrium point in the face of threats and shocks. The ability to cope with threats and shocks is at the forefront. In addition, a resilient city should be able to keep the negativity at a certain level in the face of disasters, environmental problems, or global crises both today and in the future. It should have the capacity to adapt to new conditions immediately.

A resilient city can preserve its core functions, physical and social infrastructure, and identity, as well as the ability to adapt to changing environmental, social, and economic conditions and to continue its development in the process. Such a city should be resilient to unexpected shocks and prolonged stressors and be able to recover quickly. Building resilience at the city level requires first identifying and analyzing hazards and risks, reducing vulnerability and exposure levels, and finally strengthening resilience capacity, adaptive skills, and disaster preparedness mechanisms (ICLEI, 2019: 5).

At its core, the resilience of cities is directly linked to improving the living conditions of the most disadvantaged and vulnerable communities. Accordingly, the vision of building resilient cities involves not only an effort to identify urban risks but also a direct response to the structural inequalities that exacerbate these risks. Equality is not only one of the fundamental principles of this process, but also the main driving force of all decisions taken and policies developed. This approach goes beyond the traditional framework of risk analysis and aims to rebuild cities from a perspective of social justice and inclusion (R-Cities, 2024: 27).

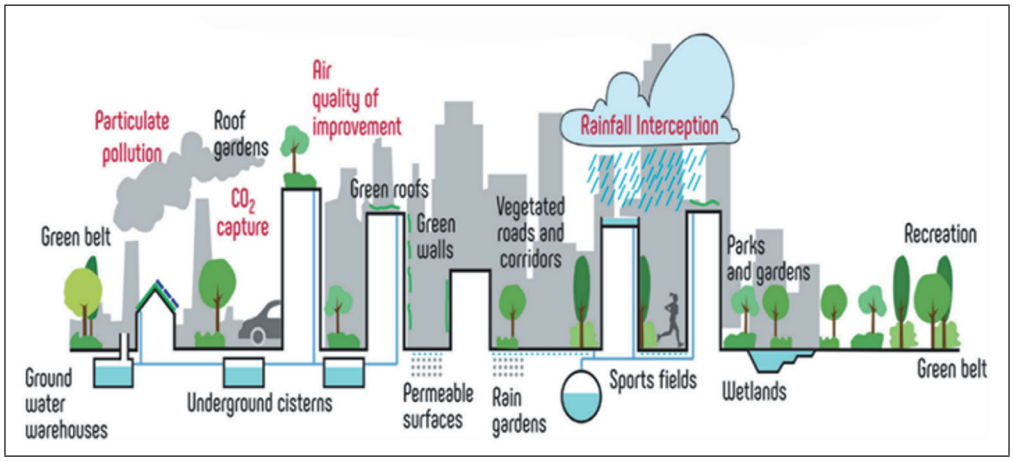
Resilient cities need to develop social, ideological, economic, and political resilience in addition to their physical characteristics. Resilient cities should include more than just the position and response to deterioration. Therefore, social, political, cultural, economic, and class structures and resilience should be considered together in a city (Tuğaç, 2019: 991-992).

2.2. Green Infrastructure

People migrate to cities for a better quality of life and better conditions. Resilient cities are needed to ensure this quality of life. Green infrastructure is one of the most important and effective ways to create resilient cities. Green infrastructure is an application that deals with the city holistically. This practice is defined as an urban modelled network designed and managed to protect biodiversity in rural areas as well as urban areas where ecosystem services are provided over a wide area. In this model, there are environmental features that can be managed and there is a strategic plan for high-quality natural and semi-natural areas. In a narrower sense, green infrastructure, which is a spatial system that benefits people from nature, aims to improve nature's ability to provide many ecosystem products (European Commission, 2013: 7). Green infrastructure is one of the key elements of resilient cities that aim to combat the effects of

global warming and climate change more strongly. In other words, it is important to make cities more resilient to reduce the risk and impact of threats posed by climate change and increase the safety and well-being of urban residents (Jabareen, 2013). The figure below shows the elements of green infrastructure.

Figure 1: Green Infrastructure Elements



Source: Hakan Alphan & Çiğdem Coşkun Hepcan, A framework for Resilient Cities to Climate Change: Green Revision Guidebook, PARDUS, İzmir, 2019, 14.

Green infrastructure aims to improve nature's Ability to provide valuable ecosystem goods and services, such as cleaning air or water. With these aims, it wants to achieve some objectives. These objectives are summarized below (European Commission, 2013: 7):

- Improving the quality of life of individuals and providing a prosperous environment. For example, providing individuals with the opportunity to live and work in high quality environment.
- Enhancing biodiversity. For example, reconnecting fragmented areas of nature and re- mobilizing wildlife.
- Taking necessary measures to combat climate change and other disasters. For example, by Mitigating floods, storing carbon, or insuring soil erosion.
- Promoting a smarter, more integrated approach to development makes the most efficient and consistent use of Europe's limited space.

Considering the benefits and Green objectives of infrastructure, it is a system capable to fulfill more than its that function by creating a healthy ecosystem. This is because green infrastructure has a multifunctional structure rather than a single target.

Green infrastructure is both a process and a product. The planning framework for green infrastructure is a collaborative process that promotes a strategic approach to land conservation. In This process, municipalities, provincial central agencies government, civil society organizations, and the private sector can act as coordinators.

3. Methodology

The method of the research is comparative analysis. Comparative analysis means comparing two or more works, items, or documents with other objects. This system, also known as "Comparative Analysis", allows us to see how two or more items compared are different or have common points. Thus, similarities and differences are better understood. Comparative analysis is important when there is a problem, to better understand the problem and to be able to give correct answers to important questions. Comparative analysis is important if you want to better understand a problem or find answers to important questions.

This study compares the extent to which green infrastructure models in Izmir and Barcelona meet the characteristics of a resilient city in terms of global warming and climate change. The data to be used for the comparative analysis were obtained from the green infrastructure project plans and implementation reports of both cities.

4. Findings

4.1. Findings on Green Infrastructure of the City of Barcelona

The Barcelona Green Infrastructure and Biodiversity Plan 2020 is a strategic tool that sets out the long-term actions needed to achieve a green infrastructure that can serve a range of environmental and social functions, bringing nature, with all its life forms, into the city. This can connect the city with the wider region, making it more efficient and resilient to face the pressures and challenges that this connection will bring.

Figure 2: Barcelona's Network of Green Infrastructure

Source: BCN, Barcelona Green Infrastructure and Biodiversity Plan 2020, Medi Ambience and Service Urbans Hàbitat Urbà, Barcelona, 2013: 31.

The main objective of the plan is to provide an urban model where nature and urbanity interact and reinforce each other, enabling citizens to benefit from natural heritage and to take an active role in the protection and enhancement of all areas. The plan also aims to promote urban green infrastructure, a government measure that aims to improve the quality of life of citizens by increasing green space in the city.

Some strategies have been identified for the objectives to be achieved. Some of these strategies include reducing the demand for water in the city, raising awareness on environmental problems caused by climate change due to global warming, developing educational strategies to increase biodiversity and protecting green areas (Ajuntament de Barcelona, 2013). However, there have also been problems arising from the structure of the city at the point of implementation of green infrastructure projects. Due to the structure of green areas in the city, problems arise in the management of these green areas. The dense population of the city also poses a problem in terms of green space utilisation. In addition, the vulnerability of tree species in the green areas of the city to climate change is also a problem (Parés, et al., 2016).

The Plan also brought about positive developments in geographical information systems. Both the benefits of GIS and the importance of biodiversity have been recognized and appreciated by the public. Annual gardening workshops for families have been established. Important information on sustainability was provided to the public through the "come to the parks" program (Ajuntament de Barcelona, 2013).

The Green Infrastructure and Biodiversity Plan is based on green infrastructure practices. The ecosystem is also an important part of the plan. Significant efforts have been made to improve and increase the provision of ecosystem services. Cultural diversity is also an important theme of the plan. Barcelona is a city with a high cultural diversity (Corbella, et al., 2015).

The Program for the Development of Urban Green Infrastructure developed in Barcelona in 2017 reinforced the city's strategy for green infrastructure (including urban gardens) through actions at various levels. Key to the successful implementation of this ambitious plan was the effective communication strategy to popularize the population's acceptance of the new management criteria for green spaces.

The city council worked with citizens, social and environmental initiatives, and researchers to understand and take into account the different perspectives of citizens. The resulting diagnosis of Barcelona's urban green infrastructure, which is at the heart of the plan, was carried out with the great involvement of different stakeholders.

Of the Barcelona Urban Mobility Plan 2013-2018, the government transformed 120 intersections and prepared the Superblock (Superilla) project. The aim was to reduce vehicle pollution and move towards sustainable mobility Starting in 2022 and moving from east to west, urban designers want to remodel 21 streets by 2030. The 2024 Urban Mobility Plan sets the city's goal of creating 503 superblocks across the city in the future (Postari, 2021).

Barcelona declared the Climate Emergency Declaration in 2020. The most important part of this declaration is the protection and enhancement of urban green infrastructures. (Ajuntament de Barcelona, 2021: 57). In the city model, aimed by this declaration, a nature- centered approach is adopted. In this way, nature will become the most important element and the nature-related problems of the regions that are disadvantaged in terms of nature will gain importance. It is emphasized that the nature of the city will be managed in coordination with the people living

in the city. The Barcelona Nature Plan 2021-2030, prepared with this vision, has determined a road map suitable for the nature of the metropolis (Ajuntament de Barcelona, 2021: 3). This urgent action plan, which includes many projects, includes a 10-year strategy. This plan aims for a global change and a healthy urban life (Ajuntament de Barcelona, 2021: 62).

Figure 3: Urban Green Areas

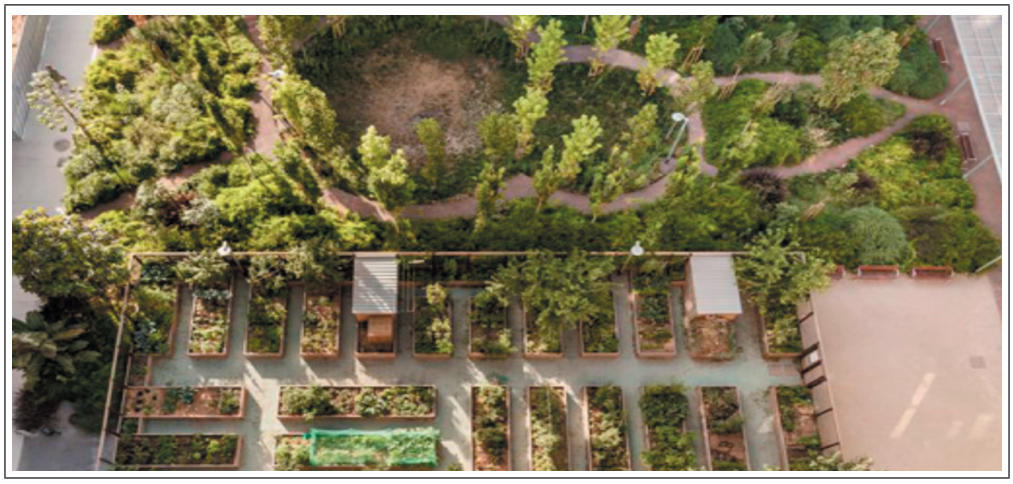
Source: Laura Bayo and Antoni París, Trees for Life Master Plan for Barcelona's Trees 2017 – 2037, Area d'Ecologia Urbana. Ajuntament de Barcelona, 2017: 38.

Figure 4: Barcelona's Superblocks

Source: Ronika PostariaLaura , Superblock (Superilla) Barcelona—a city redefined . , https://www.citiesforum.org/news/superblock-superilla-barcelona-a-city-redefined . Accessed 17.12.2024.

In 2021, Barcelona updated its strategy with the Nature Plan 2030, bringing the numerical targets of the GIBP up to date. One of these targets is to achieve around 160 hectares of green space by 2030, adding 1 m^2 of additional greenery per capita.

Figure 5: Barcelona Nature Plan 2021-2030



Source: BCNROC, Barcelona Nature Plan 2021-2030, https://ajuntament.barcelona.cat/espaisverds/en/plans-vigents. Accessed 18.12.2024.

The plan plans to increase the urban share of Barcelona's green spaces from 2,077 hectares to 2,237 hectares by 2030. Urban green areas are increased by 40 hectares in 2020 compared to 2016. Thanks to this increase, 25% of the 2030 green space target was achieved.

The Barcelona Nature Plan also envisages implementing 40 projects together involving people living in the city as part of the "All Hands to Greenery" ("Mans al verd") program.- The Barcelona Nature Plan also foresees the implementation of 40 projects with residents as part of the "All Hands to greenery" ("Mans al verd") program. In general, the implementation of the urban greening model follows the criteria of justice, gender perspective, accessibility, size and quantity, and connectivity at the city and metropolitan level. Green spaces are designed to meet diverse social demands from different social groups.

4.2. Findings on Green Infrastructure of the City of Izmir

Izmir is a city trying to take important steps towards sustainability and combating climate change through green infrastructure projects. These projects aim to increase the livability of the city by integrating nature-based solutions. Some of the important projects carried out and targeted to be carried out in Izmir are as follows:

1. URBAN GreenUP Project

URBAN GreenUP, part of the European Union's Horizon 2020 program, aims to reduce carbon emissions, minimize hazardous heat zones, and create green corridors, naturally ecological features with nature-based solutions in Izmir. Within the scope of the project, natural ditches for stormwater management, walking and cycling paths, and afforestation works were realized. Thanks to these works, it is aimed to reduce 46 tons of carbon emissions annually and reduce temperatures by 3-5 degrees in summer. In addition, awareness-raising activities are carried out by encouraging projects by city residents.

With the the project aims create green corridors, to reduce the heat effect in the city, to Combat violence such as flood risk, air pollution caused by heavy traffic and natural emissions. The Creation of Green roads, afforestation practices, recreational areas and carbon sink areas at the point of re- naturalization of urbanization are among the important targets of the plan. As a result of these aims and objectives; approximately 700,000 people will use the area from the stream restoration to the Natural Life Park with the walking and cycling road applications within the scope of the green corridor, more than 500,000 people will benefit from the BI-SIM rental bicycle system. With afforestation practices, carbon emissions will be reduced, and summer temperatures will decrease by 3-5 degrees. Regional biodiversity will not deteriorate (www.urbangreenup.eu).

Figure 6: Green Infrastructure of the City of Izmir

Source: URBAN Green UP https://www.urbangreenup.eu/cities/front-runners/izmir.kl. Accessed 22.12.2024..

2. Sponge City Practices

Sponge city, Green Infrastructure techniques, Water Sensitive Urban Design approaches are Approaches based on ecologically based rainwater management developed as an alternative and supportive to classical piped urban drainage systems. Basically, it aims to manage rainwater falling on urban areas by using green infrastructure techniques. The main idea is based on collecting, storing and infiltrating rain in the area where it falls as much as possible. In this way, surface runoff on streets and roads is reduced, existing infrastructure systems are relieved, and floods are prevented. In addition, thanks to the green infrastructure Techniques applied, the ecological environment improves, biodiversity increases, and urban heat island effects are reduced. With The changing climatic conditions, higher amounts of precipitation fall on our city in short periods of time, which strains the existing Stormwater infrastructure of the city. The "Sponge Izmir" project aims to eliminate These stresses on the infrastructure through the various uses green infrastructure Techniques such as rain gardens, biological ditches, permeable roads, above ground reservoirs and infiltration ponds (www.sungerkent.izmir.bel.tr).

In several areas of Izmir, sponge city infrastructures have been created to prevent flooding, especially from heavy rainfall, and to effectively distribute rainwater. These systems in-

clude biological ponds and permeable surfaces that facilitate the absorption of water by the soil. For example, the Fırat Living Park in Buca stands out as an example of this kind. The park includes a biological pond, walking paths, an orchard and a habitat with plants compatible with the ecosystem.

Figure 7: Fırat Park Project

Source: Izmir Metropolitan Municipality, https://www.izmir.bel.tr/tr/Haberler/bucadaki-firat-yasayan-parki-20-mayis-ta-halkla-bulusuyor/48510/156. Accessed 23.12.2024.

Another sponge city project is the Buca Bahçekapı Park project. It has gained the distinction of being Turkey's first sponge park. Within the scope of the study, Bahçekapı Park in Buca district has been transformed into a "sponge park" that can effectively manage rainwater runoff, prevent flooding and feed underground water resources.

Figure 8: Bahcekapi Park Project

Source: Izmir Metropolitan Municipality**,** https://sungerkent.izmir.bel.tr/tr/Home/Detail/b7cc96b1-0886-11ef-b659-00505601c158. Accessed 25.12.2024.

3. Green Corridors and Connections

Ecological corridors and connections are "integrative elements of urban and rural green tissue". By considering the green texture, a vital integrity that complements each other and provides transitions from urban to rural and from rural to urban for all living creatures will be realized. In other words, the unity of surface green, linear green and point green will be ensured. Today, ecological corridors and ecological connection zones have become prominent. This has led them to be recognized as critical urban infrastructures and their importance and the tasks they undertake in the city have increased. While creating connection zones, phenomena such as bird migration routes will be addressed, green roads and corridors and biodiversity will be emphasized, public transport and cycling will be encouraged, and thus the goal of achieving healthy, livable cities will be one step closer. Naturally, understanding such large-scale changes in infrastructure can only become efficient if the central authority and local governments work in harmony. Every decision taken by the central government directly affects the local government, especially planning decreases or increases environmental problems. Therefore, there is a need for a structural unit that can directly intervene in many things at the local level. In this way, timely forecasts can be made, ideas can be given to the central administration, and solutions can be sought immediately for events that will develop locally (www.izmirdoga.izmir.bel.tr).

Izmir Metropolitan Municipality aims to increase biodiversity and support the movement of urban dwellers through the distribution of corridors connecting green spaces across the city. In this context, connections between green spaces in compounds such as Karsiyaka and Bornova have been strengthened and integrated with cycle paths. The projects also aim to reduce urban heat by providing shade in fringe areas.

Figure 9: Green Corridor

Source : Izmir Metropolitan Municipality **,** http://izmirdoga.izmir.bel.tr/tr/koridorVeBaglantilar/5/15. Accessed 25.12.2024.

4.Efforts to Reduce Carbon Dioxide Emissions

Izmir Metropolitan Municipality became a party to the "European Union Covenant of Mayors", which commits to reduce carbon emissions by 20% by 2020. This capability has led to the implementation of green roof applications and appropriate projects that increase energy savings.

These projects contribute greatly to Izmir's preparation as a city in harmony with nature. They also aim to create a wider impact through the active distribution of people. With such projects, Izmir is an exemplary example of Turkey's green city category.

Funded by the EU and supported by the EBRD, SECAP was prepared as part of the obligation to participate in the Compact of Mayors (CoM). SECAP enhances the resilience of cities by ensuring that climate change mitigation and adaptation data is systematically collected and analyzed to develop actions to achieve the 40% emission reduction target by 2030 compared to the 2018 baseline year (AECOM, 2020: 36).

4.3. Findings on the Comparison of Green Infrastructure Practices of Barcelona and Izmir Cities

In this study, the green infrastructure practices of Barcelona and Izmir are comparatively analyzed in line with the goals of becoming a resilient city. The findings show that while both cities have similar environmental concerns, they differ in terms of strategic planning, implementation tools, governance mechanisms and technological infrastructure.

1. Strategic Planning Approaches

Barcelona is a city that guides its green infrastructure practices with long-term strategies. With comprehensive policy documents such as the "Green and Biodiversity Plan 2020" and the "Nature Plan 2021-2030", green infrastructure has become a core component of urban planning (Ajuntament de Barcelona, 2021). In Izmir, URBAN GreenUP and Sponge City projects offer project-based approaches focusing on specific areas; however, they have not yet been integrated into an institutional master plan (AECOM, 2020).

2. Scale of Implementation and Depth of Area

Barcelona is creating traffic-free green spaces at street scale with its Superblock (Superilla) projects and expanding these spaces across the city (Postaria, 2021). In Izmir, Sponge City and park projects are limited to thematic objectives such as stormwater management and green space rehabilitation at the local scale (Izmir BB, 2023).

3. Technological and Financial Capability

By integrating smart city applications into green infrastructure projects, Barcelona is able to digitize systems such as air quality monitoring, water management and carbon footprint calculations (BCN, 2020). In Izmir, such systematic data-driven approaches are still in their infancy, with financial resources relying heavily on EU-supported funding (Urban GreenUP, 2024).

4. Community Engagement and Outreach

Barcelona integrates citizens through participatory models such as the "Mans al Verd" (Together for Greenery) program (Ajuntament de Barcelona, 2021). In Izmir, public participation is mostly limited to post-project information and awareness campaigns, and participation mechanisms that are directly reflected in decision-making processes have not yet been institutionalized (AECOM, 2020).

5. Ecosystem Services and Sustainability

Both cities have similar motivations to develop nature-based solutions to climate change. In Barcelona, these solutions are regularly monitored and reported based on indicators. In Izmir, such monitoring and evaluation systems have not yet been systematically established (Tülek & Ersoy Mirici, 2019).

Comparison of Green Infrastructure Practices of Barcelona and Izmir Cities is given in the form of a table below.

Table 1: Comparison of the two cities

Criteria	Barcelona	Izmir
General Strategy	2030 Sustainability Plan " Green " and "Biodiversity Plan"	Supporting rural development projects and local agriculture
Targets	Increasing biodiversity, strengthening the green connectivity spaces, greening urban areas in the city	Protection of natural assets, strengthening rural green infrastructure
Urban Projects	Creating pedestrian and green areas in urban areas with Superblock projects	Flood and flood management with biological solutions
Green Space Approach	Roof gardens, urban agriculture, green corridors	Reforestation projects and creating carbon sinks
Climate Resilience	Resilience to temperature increases and water scarcity due to the Mediterranean climate	Strengthening ecosystem services, developing biological solutions against natural disasters
Water Management	Rainwater management with smart city applications, use of water-saving plant species	Biological solutions against flood and flood risk
Smart City Technologies	Integrated systems such as air quality monitoring, energy efficiency, rainwater management	Less intensive, rural-oriented technology integration
Similarities	Increasing biodiversity, green corridors, green areas	Increasing biodiversity, green corridors, green areas
Differences	Further advances in smart city technologies and compact city management	Focus on rural development and protection of nature assets

Source: Created by the author.

The table shows that Barcelona is driven by two main documents based on green infrastructure: Green Infrastructure and Biodiversity Plan (GIBP) 2020 and Nature Plan 2030. These documents establish that green infrastructure is an environmental policy and a key axis of urban sustainability. Izmir, on the other hand, relies more on externally funded projects such as the EU-funded URBAN GreenUP and SECAP (Sustainable Energy and Climate Action Plan), indicating a project-based approach rather than institutional coherence. Izmir does not yet have a city-wide "Green Infrastructure Master Plan". Barcelona is based on the urban scale; with its Superblock (Superilla) projects, it expands green spaces by limiting vehicle traffic at the neighborhood and street level and integrates these areas into the entire urban network. Izmir works on a more limited scale. Projects are often implemented in specific areas such as parks, recreation areas, valley corridors, etc., creating a lack of spatial continuity. Barcelona has integrated smart city practices into its green infrastructure. A data-driven planning and monitoring model is being implemented with digital tools such as sensor systems, air quality measurement devices, and water cycle monitoring technologies. Izmir is still in the development phase. Digital infrastructure is limited and applications are mostly project-based. There are some innovative examples, such as Sponge City, but these have not yet been systematized. Barcelona has strong local budget support and uses EU funds per its strategic objectives. This strengthens the financial basis for sustainability. Izmir is heavily dependent on EU projects. Central support and private-sector partnerships are limited. This dependency puts the sustainability of projects at risk and, when not supported by local funding, reduces the durability of project outputs. Barcelona involves the public in decision-making and implementation processes through participatory design programs such as "Mans al Verd". Participation is internalized at both institutional and cultural levels. Izmir mostly engages the public through information meetings or end-of-project presentations, suggesting a one-way rather than interactive model of participation. Barcelona regularly monitors and evaluates its green infrastructure performance through indicator-based reports. In this way, policy-making is fed through a feedback mechanism. In Izmir, monitoring is generally project-oriented and there is no performance systematization at the institutional level. The success of the implementation cannot be measured, which creates problems in terms of transparency and accountability. Barcelona uses green infrastructure as a tool to reduce social inequalities and develops neighborhood-based "green justice" principles. Access to green spaces is especially emphasized in low-income neighborhoods. While Izmir is moving towards this approach, it does not yet have a strategic inclusion policy. Green infrastructure is often concentrated in central areas and vulnerable groups are not adequately covered. Barcelona is at an advanced stage in its goal of becoming a resilient city by addressing green infrastructure practices at a holistic, technological, social, and strategic level. Izmir, on the other hand, develops innovative project-based solutions but needs institutionalization in terms of strategic, legal, technological, and social integrity.

While it is important to compare the existing green infrastructure practices of the two cities, it is also critical to assess the green infrastructure potential of both cities in order to understand their future sustainability and resilience goals. In the table below, the green infrastructure potentials of Barcelona and Izmir are presented comparatively, shedding light on the future development paths of these potentials.

Table 2: Comparison of Green Infrastructure Potential of Barcelona and Izmir

Criteria	Barcelona	Izmir	Common Ground / Explanation
Natural Capital	Mediterranean climate, coastal city, green spaces	Mediterranean climate, coastal city, agriculture and wetlands	Similar ecological basis (climate, coastal structure)
Green Infrastructure Experience	30+ years of systematic green infrastructure planning	Emerging but growing green infrastructure projects	Izmir at an early stage, high potential for learning and development
Smart City Technologies	Pioneer (sensor systems, data analytics)	At an initial stage (some smart city applications)	Capacity for technology adaptation
Financial Resources	EU funds, private sector collaborations	Municipal own resources, increasing interest in EU projects	Access to international funding possible
Public Participation	Strong participatory planning traditions	Growing civil society activity, increasing public participation	Culture of participation can be developed
Legal and Administrative Infrastructure	Special planning legislation for green infrastructure	Gaps in legislation, need for updates	Can be overcome through legal reforms

Source: Created by the author.

According to the table, there are notable commonalities and development opportunities between Barcelona and Izmir in terms of their green infrastructure potential. First of all, both cities are located in the Mediterranean climate zone and have similar ecological foundations as coastal cities. These common natural conditions create similar green infrastructure needs and opportunities to combat climate change and strengthen ecosystem services.

Barcelona has a mature model in terms of green infrastructure experience, with more than 30 years of systematic planning. This experience is embodied in the city's widespread use of green corridors, rooftop gardens, and integrated urban agriculture. In contrast, Izmir has a nascent but rapidly growing dynamism in green infrastructure. The fact that Izmir is still in its infancy shows that it has a high potential for learning and adaptation with the right strategic steps. While Barcelona's advanced applications of smart city technologies (e.g. air quality monitoring, rainwater harvesting systems) support green infrastructure efforts, this integration is still limited in Izmir. However, Izmir's current digitalization initiatives provide a foundation from which it can increase its technology-enabled green infrastructure solutions in the future. In terms of financial resources, Barcelona's access to strong EU funding and private-sector partnerships supports the sustainability of projects. Izmir, on the other hand, has the potential to develop its capacity to use external financing by increasingly turning to EU projects and international sources. This presents a significant opportunity for Izmir to scale up investments in green infrastructure. At the level of community engagement, Barcelona's long-established culture of participatory planning has ensured public ownership of green infrastructure projects. In Izmir, this culture is only just gaining strength, and increased public support could be an important dynamic to increase the success of green projects. In terms of legal and administra-

tive infrastructure, the existence of specific regulations for green infrastructure in Barcelona provides legal guarantees for projects. Although Izmir's existing legal infrastructure has shortcomings, these can be overcome through legislative reforms and a more solid foundation for green infrastructure projects can be created. While Barcelona has a mature green infrastructure system, Izmir has a strong potential for growth in green infrastructure thanks to its natural potential, increased social awareness, and growing international cooperation opportunities. The differences between the two cities are not an obstacle for Izmir, but rather a valuable guide on how to move forward.

5. Discussion and Conclusion

This study focuses on the importance of green infrastructure practices as one of the main tools for building resilient cities in today's world where climate change and environmental vulnerabilities are becoming an increasingly pressing issue. In this context, Barcelona, one of Europe's leading cities, and Izmir, a Turkish city, are analyzed comparatively. Although both cities have similar ecological foundations, they show significant differences in terms of green infrastructure planning, scale of implementation, governance capacity, access to financial resources and social participation.

Barcelona has placed green infrastructure at the center of urban planning with its 30 years of systematic planning experience, strong legal infrastructure, local budget opportunities and participatory governance model. Its Green Infrastructure and Biodiversity Plan (2020) and Nature Plan (2021-2030) address urban resilience together with social justice, ecological sustainability and technological transformation. It is also transforming urban mobility and expanding public green spaces through projects such as "Superblock" (Superilla).

On the other hand, Izmir has taken innovative steps in green infrastructure, especially with URBAN GreenUP and Sponge City projects, and has made tangible gains in increasing ecosystem services, reducing carbon emissions and protecting biodiversity. However, most of these projects are based on external funding and do not yet have an integrated city-wide "Green Infrastructure Master Plan". Deficiencies in legal and institutional arrangements limit implementation capacity, while the lack of data-based monitoring and evaluation systems is a weakness for long-term sustainability. A common observation in both cities is that green infrastructure is considered as a multifunctional tool that touches not only ecological but also social, economic and cultural dimensions. It is clear that these infrastructures need to be integrated into strategic plans in the process of building resilient cities. In this framework, the following policy and implementation recommendations have been developed, with a particular focus on Izmir:

- For the sustainability of green infrastructure practices, the legal framework at central and local level needs to be restructured. Specific legislative arrangements should be made defining green infrastructure as an urban service and setting implementation standards.
- A holistic and spatially sustainable "Green Infrastructure Master Plan" should be prepared for Izmir, structured around the axes of climate change adaptation, disaster resilience, social inclusion and economic sustainability.

- Green infrastructure should be allocated a share in the local budget, private sector collaborations should be encouraged, and green financing instruments (green bonds, carbon certificates, etc.) should be put in place, without relying solely on external funds.
- Following the Barcelona example, green infrastructure practices should be supported by digital technologies. Sensor systems for air quality, water management and biodiversity indicators should be established and integrated into decision-making processes.
- Direct participation of city residents in the planning, implementation and monitoring of green infrastructure projects should be ensured. A participatory governance structure can be developed through neighborhood assemblies, thematic working groups and digital participation platforms.
- Monitoring systems based on indicators should be established to measure the success of projects and annual performance reports should be shared with the public, thus ensuring transparency and accountability.

In conclusion, green infrastructure is one of the building blocks of resilient cities, not only in terms of environmental sustainability, but also social equity, economic vitality and quality of governance. While Barcelona's example shows how this potential can be activated through strategic vision and strong governance, Izmir's example provides important clues on the dynamics by which developing cities can be involved in this process. In the Turkish context, Izmir's institutionalization and expansion of this process can be a success story that can serve as a model for other cities

Conflicts of Interest

The authors declare no conflicts of interest.

Ethics Approval

No specific ethical approval was necessary for the study.

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