A NEIGHBOURHOOD SCALE SPATIAL AND ENVIRONMENTAL RESILIENCE INDEX DEVELOPMENT

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ABSTRACT

A NEIGHBOURHOOD SCALE SPATIAL AND ENVIRONMENTAL RESILIENCE INDEX DEVELOPMENT

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The process of urban densification has resulted in a disruption to the equilibrium between human-made and natural systems, with a range of adverse effects on various aspects of urban life. The term 'urban resilience' is used to describe a city's capacity to adapt, recover and make informed decisions in the event of unforeseen disasters and threats. Several indices are available in the literature for measuring urban resilience and developing strategies at the city and regional scales. However, their application to smaller scales as neighborhoods has been limited. It is therefore necessary to extend the application of these strategies to lower scales to improve risk management in urban areas.

The objective of this study is to define urban resilience at the neighborhood level and to develop a resilience measurement index to address environmental and spatial risks. Furthermore, the study emphasizes the necessity of measuring resilience indicators at the neighborhood level, with the input of expert opinion. The SPSS program is employed to evaluate expert opinions and construct a resilience index at the neighborhood scale. Subsequently, the index is analyzed using the ArcGIS program, with fieldwork conducted in two neighborhoods in Ankara that exhibited disparate construction patterns. The resilience of these neighborhoods is evaluated using the Quantitative Metric Measurement Method, thereby facilitating a comparative analysis. In essence, this study aims to establish a framework for measuring and enhancing the resilience of urban neighborhoods in the face of risks.

Keywords: Urban Resilience, Neighborhood, Resilience Measurement Index, Urban Risk, Robustness

ÖZ

MAHALLE ÖLÇEĞİNDE MEKANSAL VE ÇEVRESEL DİRENÇLİLİK ENDEKSİ GELİŞTİRİLMESİ

Büyüksoy, Elif Özge
Yüksek Lisans, Şehir Planlama, Şehir ve Bölge Planlama
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Kentsel yapıların yoğunlaşması süreci sonucunda insan yapımı ve doğal sistemler arasındaki denge bozulmuş ve kentsel yaşamın çeşitli yönleri üzerinde bir dizi olumsuz etki ortaya çıkmıştır. 'Kentsel dirençlilik' terimi, bir kentin öngörülemeyen afetler ve tehditler karşısında uyum sağlama, iyileşme ve bilinçli kararlar alma kapasitesini tanımlamak için kullanılmaktadır. Literatürde kentsel dirençliliği ölçmek ve şehir ve bölge ölçeğinde stratejiler geliştirmek için çeşitli endeksler mevcuttur. Ancak bunların mahalle gibi daha küçük ölçeklere uygulanması sınırlı kalmıştır. Bu nedenle, kentsel alanlarda risk yönetimini iyileştirmek için bu stratejilerin uygulanmasını daha düşük ölçeklere yaymak gerekmektedir.

Bu çalışmanın amacı, mahalle düzeyinde kentsel dirençliliği tanımlamak ve çevresel ve mekânsal riskleri ele almak için bir dirençlilik ölçüm endeksi geliştirmektir. Çalışma ayrıca, dirençlilik göstergelerinin mahalle düzeyinde ve uzman görüşü alınarak ölçülmesinin gerekliliğini vurgulamaktadır. Uzman görüşlerini değerlendirmek ve mahalle ölçeğinde bir dirençlilik endeksi oluşturmak için SPSS programı kullanılmıştır. Daha sonra bu endeks ArcGIS programı kullanılarak analiz edilmiş ve saha çalışması Ankara'da farklı yapılaşma modelleri sergileyen iki mahallede gerçekleştirilmiştir. Bu mahallelerin dirençliliği Kantitatif Metrik Ölçüm Yöntemi kullanılarak değerlendirilmiş ve böylece karşılaştırmalı bir analize olanak sağlanmıştır. Sonuç olarak bu çalışma, riskler karşısında kentsel mahallelerin dirençliliğini ölçmek ve geliştirmek için bir çerçeve oluşturmayı amaçlamaktadır.

Anahtar Kelimeler: Kentsel Dirençlilik, Mahalle, Dirençlilik Ölçüm Endeksi, Kentsel Risk, Sağlamlık

To my family

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LIST OF ABBREVIATIONS

CDRI	Climate Disaster Resilience Index
CRI	City Resilience Index
FMC	Fifteen Minute City
GDP	Gross Domestic Product
HDC	High Density Cities
IPCC	Intergovernmental Panel on Climate Change
METU	Middle East Technical University
NPRI	Neighborhood Pandemic Resilience Index
OECD	Organization for Economic Cooperation and Development
RCI	Resilient Cities Index
REDI	Resilience to Emergencies and Disaster Index
SES	Socio-ecological systems
SPSS	Statistical Package for the Social Sciences
TÜİK	Turkish Statistical Institute
UN	United Nations
UNFCC	United Nations Framework Convention on Climate Change
WoS	Web of Science

CHAPTER 1

INTRODUCTION

In recent years, there has been a notable shift in attention towards the inherent risks faced by urban centers, including but not limited to global warming, climate change, seismic activity, extreme weather events and flooding. As the urban population continues to grow, an increasing number of individuals are becoming exposed to these risks. The increasing density of urban areas has resulted in a deterioration of the equilibrium between man-made and natural systems. A disruption to this balance can have a detrimental impact on several aspects of urban life, including spatial, environmental, social and economic factors. The term 'urban resilience' is open to a variety of interpretations, given its capacity to encompass a range of meanings. Some view urban resilience as the capacity of a city to adapt and recover from unforeseen disasters, whereas others perceive it as an ongoing process of formulating crisis management strategies and making informed decisions to address potential threats.

The concept of urban resilience is supported by several interrelated dimensions that affect individual and community behavior, government assets, and spatial and environmental assets. While urban assets are typically situated within the city limits, they are part of a larger network that extends beyond the urban core. This interconnected network is subject to feedback loops, whereby damage to urban assets, whether within or beyond the city limits, can have significant results for the overall resilience of the urban area, even in the absence of a disaster. It is crucial to comprehend the interconnections between the urban center and its hinterland, as well as the relationships between diverse urban assets, to attain urban resilience. It is insufficient to evaluate urban assets in isolation. In order to enhance urban resilience, it is essential to consider the overall system and the linkages between assets.

The concept of urban resilience is developed in relation to vulnerability with the aim of understanding the differing experiences of resilience among different social groups. Urban systems are susceptible to a multitude of stressors, including natural disasters, economic challenges, technological issues, physical exposure, and social pressures. It is crucial to define urban resilience to facilitate the creation of safe settlements and to protect cities from potential risks. To define urban resilience, it is first necessary to gain a deeper comprehension of the risks that cities are exposed to at all levels, as well as the extent of the impact these risks have. Such an understanding will then allow effective risk management strategies to be formulated.

Purpose

This study aims to define urban resilience at the neighborhood scale on the basis of urban risks and to develop a measurement index for the creation of safe and resilient neighborhoods against environmental and spatial risks.

The study is important in terms of measuring the existence of resilience requirements at the neighborhood scale by integrating neighborhood-scale planning with urban resilience characteristics and urban resilience assessment strategies developed for higher scales and implementing resilience into the city structure starting from the lower scale with the development of applications in this context.

Research questions

The main research question to be answered within the scope of the study is as follows: "What is the importance and applicability of existing environmental and spatial resilience measurement indicators when measuring resilience at the neighborhood scale?" In addition to this basic question, the study aims to answer the questions: "How can resilience measurement methods and strategies at the city and regional scale be integrated into the resilience measurement method at the neighborhood scale?" and "According to which indicators can the phenomenon of resilience in the environmental and spatial dimensions of cities be tested at the neighborhood scale?".

Apart from the main question of the study, the questions that are thought to support the study are given below:

- What is the role of the urban risk factor in defining urban resilience?
- What is the importance of spatial and environmental urban dimensions in terms of urban resilience?

In this context, the sub-objectives of the study are;

- Defining the concepts of urban risk, resilience, neighborhood resilience, environmental and spatial resilience, identifying their scopes and determining the indicators to be used in measuring resilience in the neighborhood through literature review,
- Determining the importance of these indicators with expert opinions,
- Developing an index to define spatial and environmental resilience at the neighborhood scale.

Scope

The study is comprised of five principal chapters. The initial chapter, which serves as an introduction, outlines the purpose, scope and significance of the thesis. The second chapter defines the various definitions of urban resilience, tracing their evolution from past to present, and outlines the distinctive characteristics and potential risk situations faced by cities. Furthermore, the theoretical framework section analyses the position of the urban resilience definition within the literature at the neighborhood scale and the existing urban resilience measurement indices at different scales. The third section comprises the research methodology which describes the indicator selection process from literature review, preparation and implementation of expert survey and designing the field study observed according to the indicators selected by the experts in the survey. After the field study conducted, the findings presented and discussed in the fourth section. The final chapter, the fifth in the sequence, presents the conclusions and recommendations in the context of the theoretical framework.

The field study is carried out in Ankara and to compare the resilience İşçi Blokları and Demetevler neighborhoods are selected. The two neighborhoods selected for the study are both historic districts of Ankara. It is hypothesized that a comparative analysis of these two neighborhoods, which exhibit disparate construction and topographical characteristics yet occupy a significant position in Ankara's urban development history, would yield insights into their resilience. This can be achieved by examining their spatial and environmental resilience characteristics.

Since the 1920s, Ankara has undergone urban planning processes to accommodate its growing population. The city has adopted a flexible approach to address these challenges, leading to the emergence of multi-story houses in the suburbs and the development of various types of public housing. The Demetevler neighborhood in Ankara's Yenimahalle district is distinguished by a distinctive architectural style, characterized by houses that are directly aligned with the street, without any intervening gardens. The lack of zoning regulations in Demetevler has resulted in the emergence of illegal squatter settlements, giving rise to a neighborhood characterized by narrow streets, high-rise apartment buildings, and buildings constructed in contravention of planning regulations.

By contrast, the İşçi Blokları neighborhood in Ankara's Çankaya district was constructed in 1965 with the objective of providing affordable housing for low-income labor families. The residential complex has undergone a process of expansion over time, and it now offers a range of social facilities. The area was historically inhabited by low-income working families and students from the Middle East Technical University (METU) but gained increased interest after the construction of a connecting road, leading to a rise in rental prices.

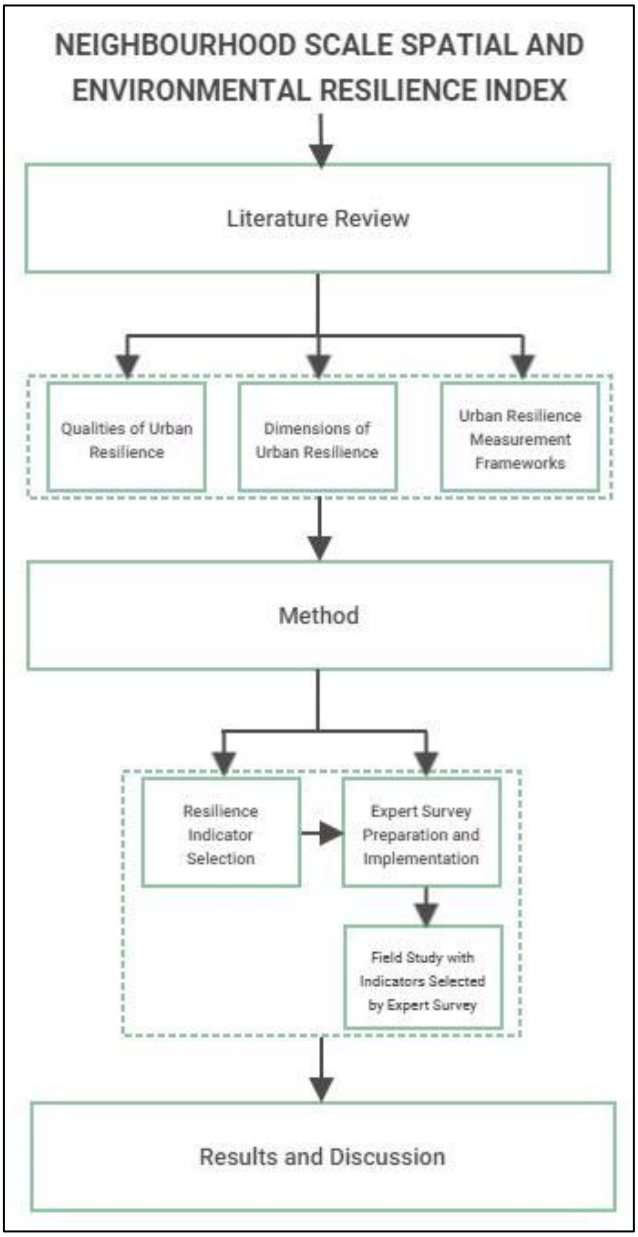

Figure 1.1. Flowchart of Method of the Study

The urban resilience approach represents a significant contribution to the field of urban planning, offering a valuable framework for enhancing welfare and safeguarding natural and urban environments. This approach holds particular relevance for developing countries like Turkey, which face the dual challenges of rapid population growth and heightened vulnerability to disasters. It is of great importance to develop an urban resilience measurement method at the neighborhood scale to implement urban resilience measurement and strategy implementation mechanisms that have already been developed at larger scales, such as country, region and city. This should be done starting from lower scales, such as neighborhood, to physically see the spatial equivalent of the strategies and to measure them at all scales.

CHAPTER 2

LITERATURE REVIEW

In the preliminary stage of the thesis study, a comprehensive literature review is conducted to examine the components of urban resilience. This entailed an in-depth analysis of the concept of resilience, the dimensions of urban resilience, and the characteristics of urban resilience. The analysis is conducted using keywords related to urban spaces such as resilience, urban resilience, neighborhood resilience, spatial and environmental resilience. In this context, an in-depth examination has been conducted of the disciplines in which keywords are employed, the concepts with which they are associated, and the distribution of published works from past to present, classified according to year of publication.

The study commenced with a comprehensive review of international databases, including Scopus and Web of Science (WoS), and a thorough examination of the national literature. A literature search is conducted using the keywords "resilience", "urban resilience", "spatial resilience", "environmental resilience", "neighborhood resilience", "measuring urban resilience" and "urban planning" in the Scopus and WoS databases. The results published between 1970 and 2024 are obtained. The data are collected from the Scopus database by filtering the document type as article, conference paper and book chapter, language as English and stage of publication.

The following sections of the literature review examine the definitions, characteristics and dimensions of urban resilience over time, resilience at the neighborhood scale and urban resilience assessment frameworks developed at various scales and concepts in the existing literature.

2.1 Urban Resilience

Cities have evolved high densely populated places, and the high density causes the balance in the artificial and natural system to be created in the city to deteriorate. At the point where the balance between artificial and natural systems is disrupted, spatial, environmental, social and economic actors in cities can affect each other negatively. According to planning discipline, cities must be constructed, designed and planned in a way that includes the resilience elements.

'Resilience' is a concept that has connoted subjects in many disciplines with different dimensions such as engineering, individual, social, community, physical, ecological and so on over the years. The word ‘resilience’ is introduced initially by Holling in 1973 within the ecological concept as the ability of a system to absorb changes and to determine the maintenance of basic functional characteristics of the system in the face of any perturbations (Riberio & Gonçalves, 2019; Folke, et al., 2010; Jabareen, 2013). Innis (1975) defined resilience based on the classical ecological paradigm as a system reverting to its equilibrium state after a time period of an instability state (Masnavi, Ghairi, & Hajibandeh, 2019). Within the several definitions of ‘resilience’ term, the necessity of the existence of the equilibrium in the system is mentioned as bouncing back in engineering and as bouncing forth in ecological concept (Spaans & Waterhout, 2017).

Resilience concept is involved in the context related to cities and planning in 1990s as a solution to the environmental risks evolved in social and institutional dimensions of the city (Spaans & Waterhout, 2017). Resilience is defined by Adger (2000), in the social resilience approach as the endurance state of human communities against the shocks damaging the social infrastructure (Folke, 2006).

In the early 2000s, resilience term is mentioned in urban social-ecological systems (SES) by Folke and others (2002) as a product that maintains the system to endure itself against threats without losing its main functions, to be able to organize itself and to have the capacity of adaptation and learning. Benedict and McMahon (2002) attracted attention to the significance of green spaces by defining resilience as the system with interconnected green spaces that provide ecosystem conservation and benefits to human (Meerow & Newell, 2019). In several research area, resilience is mentioned with the keywords of bouncing back to stability and equilibrium. However, Gunderson and Holling (2002) stated that the resilience intended to be in the ecological and planning approaches is mainly refer to a system rises itself to different stability state than it had before (Masnavi, Ghairi, & Hajibandeh, 2019).

In urban social-ecological system concept, resilience is not only a necessity for conservation of nature or resistance to any possible disruption but also related to evolving, adapting to renewal of an urban system with the possible opportunities emerged from the disruption. Walker and others (2004) highlighted several definitions from other specialist with only focusing resilience as absorption and reorganization capacity of the urban system by retaining the characteristics and functions of the system. In contrast to these definitions, an urban system needs resilience against threats in case the existing dimensions (ecological, social, economic or political) of the system do not have the capacity to resist. Therefore, resilience is having the capacity of transforming and adapting to potential newly generated system or dimension. According to Berkes and others (2003), resilience comprises the adaptability in its concept and adaptability needs to be a rational response to changes in ecosystem dynamics as well as social dynamics (Folke, 2006).

Resilience is identified in several research areas with connotating similarities. It is impossible to place a single and common definition to various research areas. Resilience definitions are combined with keywords through the years by particular specialists such as speed (Pimm, 1984), maintenance (Allenby & Fink, 2005; Holling, 1973), recovery (Bocchini, Frangopol, Ummenhofer & Zinke, 2014; Carver, 1998), reconfiguration (Martin, 2012), resistance (Haimes, Crowther & Horowitz, 2008; Zhou, Wang, Wan & Jia, 2010), adjustment (Gao, Barzel & Barabási, 2016) and so on (Riberio & Gonçalves, 2019).

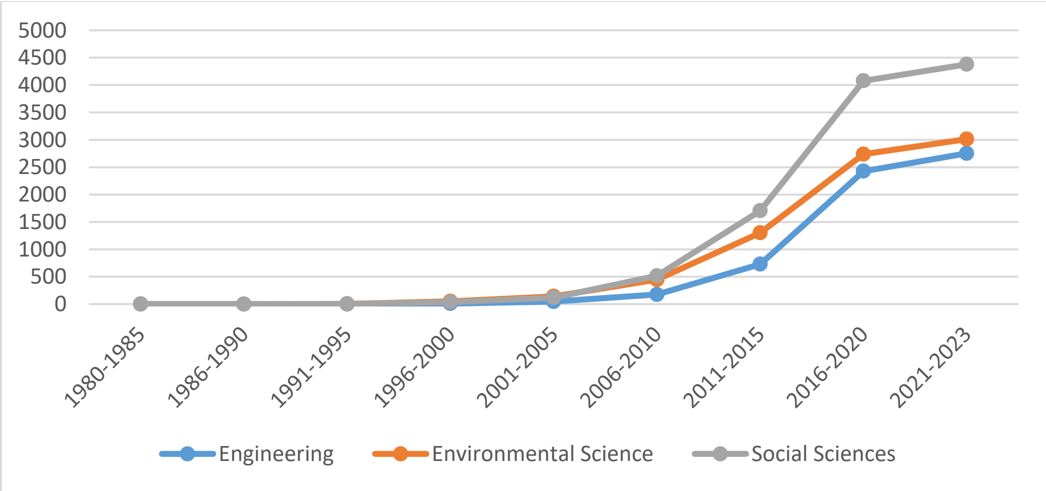

Figure 2.1. Changes in the Number of Articles Mentioning the Keyword "Resilience" in Engineering, Environmental Science and Social Science Research Areas

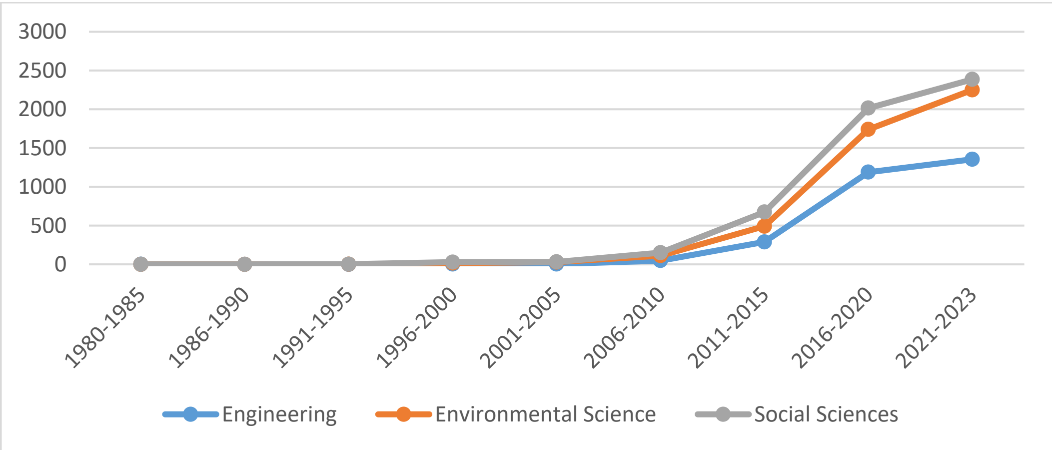

Figure 2.2. Changes in the Number of Articles Mentioning the Keyword "Urban Resilience" in Engineering, Environmental Science and Social Science Research Areas

Resilience and urban resilience keywords are content to several and numerous research areas through years. Most mentioned research areas are engineering, social sciences and environmental sciences in both keywords. Figure 2.1 and Figure 2.2 show the number of articles in research areas -engineering, environmental science and social sciences- by using the keywords, resilience and urban resilience between

1980’s and 2020’s. Data are collected from the database of Scopus by filtering document type as article, conference paper and book chapter, language as English and publication stage as final. It is obviously seen that after 2010, the articles with the content of urban resilience are rapidly increased. Even though, resilience is a general topic to be mentioned in various research areas, urban resilience also has become a more significant topic in engineering, social sciences and particularly environmental science.

The term 'resilience' began to be employed with greater frequency in academic research after 1996. Although the term 'resilience' was employed in the fields of engineering, environmental science and social sciences from 1980 to 2023, the data indicates that its usage increased markedly in social sciences between 2011 and 2020 in comparison to other research areas. In contrast, the concept of "urban resilience" has been employed predominantly in engineering, environmental science, and social sciences from 1980 to the present. Following a decline in its usage in engineering after 2020, the concept became a pervasive and enduring one in environmental science after 2011.

Urban resilience does not refer to the ability of a city turning back to its previous equilibrium state before the disruption. Threats and shocks might change the system operation and previous equilibrium point, so the city needs to be prepared for several scenarios. Adger (2003) added that the definitions in ecological approach, resilience is emphasized as the degree of the system can tolerate in the face of disruption, however according to him, the focus is how the system could maintain its sustainability and resilience and the rapidity of reaching to a stable state (Masnavi, Ghairi, & Hajibandeh, 2019).

Cities are complex systems with ever-shifting frameworks that include several options of development with non-linear dynamics, resolutions and thresholds, and according to Folke and others (2010), resilience is opted for such multifaceted systems with the way their dynamics are integrated across various urban scales. Concordantly, a necessity of developing a foresight framework has been rising through rapid urbanization in these complex systems with unpredictable dynamics. Leichenko highlighted that urban resilience is mentioned in various studies with similar and overlapped aspects, however, different sides and components of urban resilience are referred in the several studies in literature (Jabareen, 2013).

Social-ecological definitions of urban resilience take a significant role in resilience literature. According to Cumming (2011), the modern definitions of urban resilience are revealed by Carpenter, Walker, Anderies, and Abel in 2001, defining as first, 'a level of disruption that a system can absorb and meanwhile stay in the same state', as second, 'the degree of self-organization capacity of the system against absences of organization caused by internal or external factors', as third, 'the rate of a system at which to build and maintain its capacity to learn and adapt to changes against disturbance'. In this respect, the three degrees in the definitions are mainly reflect the systemic coherence, self-development and coordination while maintaining the binding of local conditions and system dynamics (Desouza & Flanery, 2013).

As well as the social-ecological side of the city, resilience needs to be defined and sustained in spatial context. Cumming (2011) identifies the spatial resilience as the interconnection of spatial aspects of the city (connectivity, structure and spatial variations) and the different system components (elements, adaptation, capacity, history and interactions) included in the resilience definitions (Desouza & Flanery, 2013). Cities are complex systems containing provisional challenges such as unknowability. These systems include variable dynamics and interactions need to be connectively working, thus it is impossible to decide an optimal predictable future state for the cities (Marshall, 2012 as cited in Desouza & Flanery, 2013). Climate change is the unknowable factor which requires an emergent approach in the city of today. Therefore, flexible and adaptive approaches should be generated within the resilient systems (Lu & Stead, 2013; Tasan-Kok et al., 2013 as cited in Spaans & Waterhout 2017).

Resilience is described as compatibility or adaptation capacity which the system would be able to tolerate and change to another condition by Folke (2006). As another approach, Folke et al. (2010) point out the relationship between resilience and transformation as the resilient systems can respond to changes in an adaptative way by shifting towards the sustainable development positively or return the former state simply. Transformation (such as urban renewal, urban rehabilitation, and so on) will create potential opportunities to system to earn innovative and robust experiences through development (Masnavi, Ghairi, & Hajibandeh, 2019).

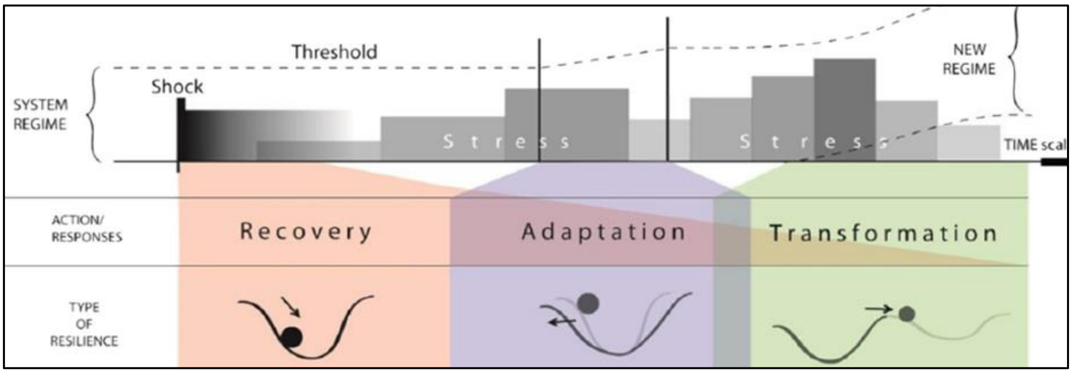

Figure 2.3. Conceptual Approaches of Resilience Thinking by Carpenter et al (2009), Folke (2006) and Folke et al. (2010) (Masnavi, Ghairi, & Hajibandeh, 2019)

Figure 2.3 visualizes the three approaches of the resilient systems as recovery, adaptation capacity and transformation. First two approaches (process of recovery and adaptation capacity), aim to prove the level of resilience of the system under the pressure. However, the transformation approach measures the capacity of system to adapt and change itself as compatible with current conditions while reaching a more developed state to maintain resilience against the disruption (Masnavi, Ghairi, & Hajibandeh, 2019).

Urban resilience implies the ability of an urban system, with its all socio-ecological, socio-economical or spatial dynamics, to continue or swiftly return to its intended capabilities against crises and disturbance, adapt to rapid changes, and transform systems to its original state or more adaptative future version of the current state (Meerow & Newell, 2019). In city resilience concept, according to all definitions, it is significant to set the primary purpose to form resilience whether in case of short-term disturbances (such as earthquake) or long-term crises (such as climate change).

According to Chelleri and Olazabal (2012), if there are short-term disturbances, resilience should focus on maintaining the system equilibrium and persistence, however if the challenge is a long-term crisis, a resilient transition and transformation will be needed in urban systems. Chelleri and Olazabal (2012), also raised another question on maintaining resilience as its' strategies and focus should be whether on foreseeing future challenges or adapting to past threats (Meerow & Newell, 2019).

The Rockefeller Foundation (2014) defines the resilience in city as that against any type of stressor which the city face of the continuation capacity of the system under the extreme pressure, thus the citizens including all vulnerable people will be able to survive against the challenges and grow continually. In addition, all the recent definitions refer to ability of resilience systems including its all networks and scales to sustain or return the balanced state and adapt positively to challenges, changes and crises that the city might face (Masnavi, Ghairi, & Hajibandeh, 2019).

Urban resilience is a planning approach that enables the dynamics of the city to tackle in a coordinated and comprehensive manner within the framework of sustainable technological innovations in case of all kinds of dangers, risks and threats in the physical, environmental, social and economic fields that cities may encounter (OECD, 2022). The concept of urban resilience in the scope of urban planning was first used by urban planner Jacobs in 1984. Jacobs examined the change in the ecological balance upon the increase in resource consumption and determined that there were malfunctions in the urban planning system. At this point, Jacobs has formed the center of resilience in order to develop solutions to urban problems. The United Nations (UN) defines the resilience concept as the ability of all settlements, societies and systems to protect themselves, ensure the sustainability of the system, restructure in a short time, use the resources effectively and have the necessary resources to be able to adapt to changes (Karahan, 2018).

Table 2.1 Definitions of Resilience and Urban Resilience

Research Approach	*Definitions of Resilience and Urban Resilience*	*References*
Ecological resilience	the ability of a system to absorb changes and to determine the maintenance of basic functional characteristics of the system in the face of any perturbations	Holling (1973)
Engineering	maintenance	Allenby and Fink (2005); Holling (1973)
Ecological resilience	a system reverting to its equilibrium state after a time period of an instability state	Innis (1975)
Engineering	speed	Pimm (1984)
Engineering	recovery	Bocchini, Frangopol, Ummenhofer and Zinke, (2014); Carver (1998)
Social resilience	the endurance state of human communities against the shocks damaging the social infrastructure	Adger (2000)
Urban social-ecological systems (SES)	a level of disruption that a system can absorb and meanwhile stay in the same state, the degree of self-organization capacity of the system against absences of organization caused by internal or external factors, the rate of a system at which to build and maintain its capacity to learn and adapt to changes against disturbance	Carpenter, Walker, Anderies, and Abel (2001)
Urban social-ecological systems (SES)	a product that maintains the system to endure itself against threats without losing its main functions, to be able to organize itself and to have the capacity of adaptation and learning	Folke and others (2002)
Ecological resilience	the system rises itself to different stability state than it had before	Gunderson and Holling (2002)
Ecological resilience	how the system could maintain its sustainability and resilience and the rapidity of reaching to a stable state	Adger (2003)

Table 2.1 (continued)

Research Approach	*Definitions of Resilience and Urban Resilience*	*References*
Spatial resilience	absorption and reorganization capacity of the urban system by retaining the characteristics and functions of the system	Walker and others (2004)
Engineering	resistance	Haimes, Crowther and Horowitz (2008); Zhou, Wang, Wan and Jia (2010)
Engineering	a process of recovery which the system is able to return its past state in the face of stressors or changes	Carpenter et al. (2009)
Social-ecological resilience	systems that respond to changes in an adaptative way by shifting towards the sustainable development positively or return the former state simply	Folke et al. (2010)
Spatial resilience	interconnection of spatial aspects of the city (connectivity, structure and spatial variations) and the different system components (elements, adaptation, capacity, history and interactions)	Cumming (2011)
Social-ecological and spatial resilience	against any type of stressor which the city face of the continuation capacity of the system under the extreme pressure	The Rockefeller Foundation (2014)
Social-ecological and spatial resilience	the ability of an urban system to continue or swiftly return to its intended capabilities against crises and disturbance, adapt to rapid changes, and transform systems to its original state or more adaptative future version of the current state	Meerow and Newell (2019)
Social-ecological, economical, and spatial resilience	approach that enables the dynamics of the city to tackle in a coordinated and comprehensive manner within the framework of sustainable technological innovations in case of all kinds of dangers, risks and threats in the physical, environmental, social and economic fields that cities may encounter	OECD (2022)
Social-ecological, economical, and spatial resilience	the ability of all settlements, societies and systems to protect themselves, ensure the sustainability of the system, restructure in a short time, use the resources effectively and have the necessary resources to be able to adapt to changes	The United Nations (UN)

2.1.1 Qualities of Urban Resilience

Urban resilience is a broadly defined word, thus characterizing the concept caused a wide range of qualities. While some believe that urban resilience mostly reflects the city's ability to adapt and repair itself in the face of unforeseen disasters, some see the resilience as a process that crisis management strategies are produced and the ability to continuously learn and make decisions to cope with possible threats (Zhang, et al., 2019).

ARUP and Rockefeller Foundation (2014) indicated eight main functions to define the qualities of a resilient city. Firstly, a city needs to deliver basic needs of large populations living concentratedly in the city. These basic needs are comprised of mostly providing sufficient food, water, energy, medicine and housing. A resilient city has to continuously supply these needs basic needs in case of any possible stress and shocks by relying on numerous sustainable sources. Secondly, a city needs to keep ready the strategies to maintain safety of citizens against threats such as natural and anthropogenic disasters that create vulnerability to urban communities. In a scenario that the city faces a stress or shock, resilient city must have enough evacuation plans and centers, sufficient number of health facilities and workers and so on to minimize the negative impacts and exposures (ARUP & Rockefeller Foundation, 2014).

Thirdly, protecting and enhancing physical assets such as bridges, transport networks, energy plants and natural assets such as rivers, soil, ground in the city will help to make the city and community resilient to any hazard. Thus, the city needs to protect the assets and their functionality to avoid harsh impacts might be happened. As the fourth function, a resilient city must be supported with a strong social cohesion including different races, religions, cultural background and so on. This integrity will prevent the social breakdown in case of threats and create a union in the community. Fifth function is city’s ability to absorb and understand the threats and raise awareness to maintain quick recovery. Resilient cities recognize the strength of knowledge and can use it to better understand shock or stress events and learn from past experiences (ARUP & Rockefeller Foundation, 2014).

According to sixth function, being resilient includes advocating for the rule of law, justice and equity to promote an effectiveness and fairness in the system that fosters accountability and peace. Strength of economic activities in the city is indicated as seventh function of a resilient city. A city's inability to provide and support livelihoods can create stress that builds up with rising unemployment in that city. Accessibility of income-generating activities, supporting businesses and promoting entrepreneurship, providing affordable housing, energy and transportation systems by increasing access to job opportunities are significant duties off a resilient city. Lastly, to maintain economic welfare, a robust form of infrastructure containing stock markets, monetary organizations and financial institutions need to be built in a resilient city to avoid loss of competitiveness and economic crises (ARUP & Rockefeller Foundation, 2014).

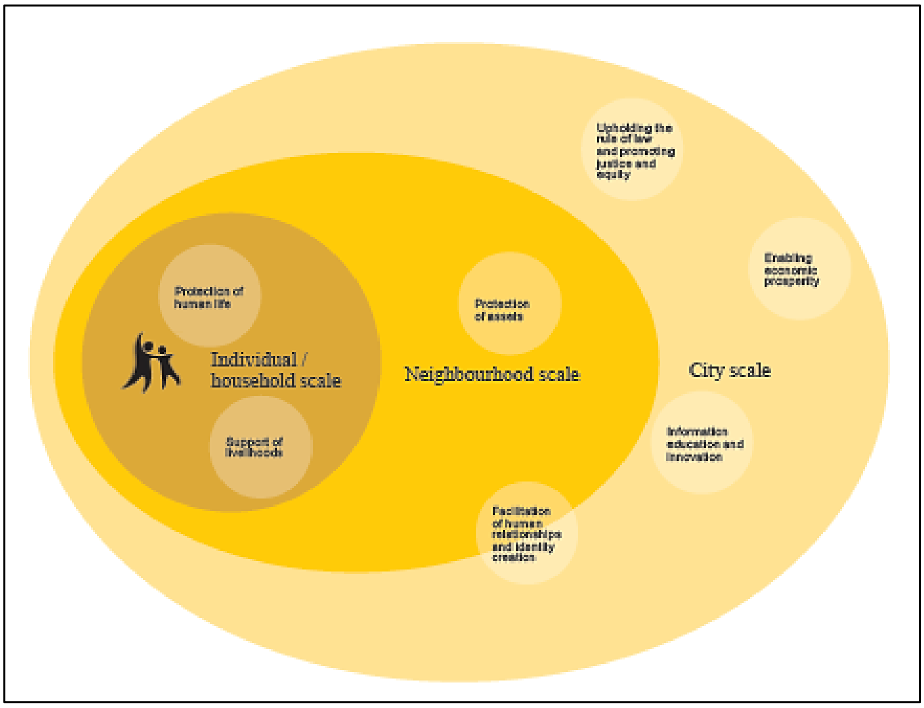

Figure 2.4. City Functions at Individual, Neighborhood and City Scale (ARUP & Rockefeller Foundation, 2014)

Resilience occurs when there is a change in the routine state of the system. The urban system tries to be flexible in this situation and thinks that the changes brought about by the crisis and shock will not harm the system, but if it experiences any disturbance in its old function and continuity, it realizes that it needs to take action. At this point, while the system tries to maintain its continuity by preserving its old structure and function, it monitors how the actors who manage the system will proceed. The monitoring feature refers to both the identification of the fluctuations that the system has undergone in the historical process and the ability to follow future developments. Once the system understands how to respond to changes, it starts to adapt (Khodkar, 2015).

The reviewed literature shows that there are eight main qualities that a resilient city should have and that these qualities support the city with different complementary features according to the systems (ARUP & Rockefeller Foundation, 2014).

Quality 1: Accepting of uncertainty and change

Rapid changes with high potential to threaten the system of city are likely to be seen today. The city might not be prepared to these changes or even predict the hazards of them. Beck (1992), Béné et al. (2012) and Berkes & Seixas (2005) indicate that accepting the increasing ambiguity and change inherent in today's world requires a change in the mindset of the urban system (ARUP & Rockefeller Foundation, 2014). Meerow et al. (2016) state the resilience as being resistant to change to radical transition (Sharma, Sharma, Kumar, & Kumar, 2023). In addition, resilient system will have a feature to rapid recovery from the shock encountered to avoid future breakdowns, while accepting the uncertainty (Al-Humaigani & Al-Ghamdi, 2024).

Quality 2: Reflective

Considering and predicting the future uncertainty will be possible by understanding how past system dynamics have shaped the current system and by learning from these past experiences to avoid any possible mistakes in resilient cities (ARUP & Rockefeller Foundation, 2014). A reflective system can improve continuously and have mechanisms that enable them to handle such ambiguities. Thus, resilient cities require standards, norms or regulations to be adjusted to consider information and data gathered from the past, rather than continually relying on the status quo (Al-Humaigani & Al-Ghamdi, 2024).

<u>Quality 3: Adaptive</u>

Resilient systems need to embrace the ability to adapt to become more stronger in the face of future changes. Adapting to changes should become not only using the new technology, but also traditional and past knowledge (Walker & Salt, 2006; Moench et al., 2011). Jabareen (2013) and Ziervogel et al. (2016) state the fact of growing complexity in world dynamics which emphasizes the unbalanced, unpredictable and complex systems such as cities and metropolitan areas. Therefore, adaptive capacities can be counterproductive and can worsen existing vulnerabilities in these complex systems. Resilient cities need an approach of enabling flexible responses to disturbances rather than only adapting to current situation (Asadzadeh, et al., 2022).

<u>Quality 4: Robust</u>

Robustness is the strength of system that enables it to continue its functionality even under the hazardous conditions. According to O'Rourke (2007), the robust systems have the internal strength or resistance to external stresses avoiding deterioration or loss of functionality. In case of emergency, a robust community in a resilient city will be able to respond to threat skillfully and be prepared (ARUP & Rockefeller Foundation, 2014). Robustness ensures the continuity of the system by tolerating external disturbances and remaining stable even in uncertainty. Any feature in the city that might degrade the robustness of a system ultimately reduce the resilience of an urban system in its every dimension (Al-Humaigani & Al-Ghamdi, 2024).

<u>Quality 5: Resourceful</u>

At all levels of urban scales, the management of all resources efficiently is the main necessity. Brown and Kernaghan (2011) highlight that resilient systems need to be redundant to assure that backup options are available when systems fail (ARUP & Rockefeller Foundation, 2014). Having a spare capacity and efficient use in both human and natural resources will create a strong system that able to fail safely and keep its system dimensions alive and stable even under harsh conditions (Moench et al., 2011; da Silva et al., 2012). Liao (2012) and Anderies (2014) explains the resourceful system as the degree of redundancy of internal variables within each function that provides the system with the buffer capacity to use alternative resources or pathways when the original resources are lost (Feliciotti, Romice, & Porta, 2016).

Quality 6: Integrated

Resilient cities need a consistent decision-making system supported across several areas, scales and strategies (Al-Humaigani & Al-Ghamdi, 2024). Alignment between these supporters, it is important to engage the city dimensions with a multidisciplinary concept and this integration will lead the system to require needed information and change its function with a suitable function under the pressure and risks. Being integrated creates a robust medium using the multiple mechanism to build resilience at any urban scale (ARUP & Rockefeller Foundation, 2014).

Quality 7: Diverse

Diversity answers the questions related to number of different elements with distinct functions, balance between response and effects of these elements across any disturbance and their disparity (Suarez, et al., 2024). In resilience concept, diversity might be defined as multiple coping strategies integrated in the system to keep the system remained in stability. Moench et al. (2011) defines the diversity in terms of space which the assets are distributed across the city to ensure not all assets are affected by a possible disaster (ARUP & Rockefeller Foundation, 2014). Also, Montgomery (1998) suggest that diverse form of urban spaces will have the potential to survive changes in urban systems such as economic status, technology and culture (Feliciotti, Romice, & Porta, 2016).

Quality 8: Inclusive

Stressors and threats affect mostly the vulnerable parts of the city and community due to their limited possession of opportunities, less income or limited access to urban infrastructure. Inclusivity aims to integrate not only vulnerable groups, but also a broad variety of governance structures and stakeholders to the decision-making and strategy development process in the resilient city (ARUP & Rockefeller Foundation, 2014).

Beyond all these eight qualities, urban resilience is also a system that able to properly schedule and sequence objectives in city, sensitive to changes and transparent and equal in data performance sharing to citizens, able to coordinate and sensitive to environmental conservation (Dinçer, 2022). Lastly, connectivity between all mentioned qualities carries high importance to maintain the ease of flow within the system. Salat and Bourdic (2014) highlights the fact that increased connectivity enhances the points of contact and exchange between elements of the urban texture in case of disturbance (Feliciotti, Romice, & Porta, 2016).

2.1.2 Urban Resilience Dimensions

Maintaining urban resilience is possible by focusing and developing strategies on a city's assets. Assets can affect the availability of resources to reduce losses caused by disasters. A city needs to maintain and improve all assets to thrive (Suarez, et al., 2024). In the face of a shock and pressure, city assets might change in four different ways. Firstly, the system recovers its characteristics better than before and the crisis, shock or pressure becomes a source of strength for the system. Secondly, the system will be relieved of this repression and will return to its former state. Thirdly, the system continues to exist in some way as a result of the crisis, but it cannot be as productive as before. Lastly, the system is affected by the difficulty of the pressure and cannot resist, and as a result it collapses (Khodkar, 2015).

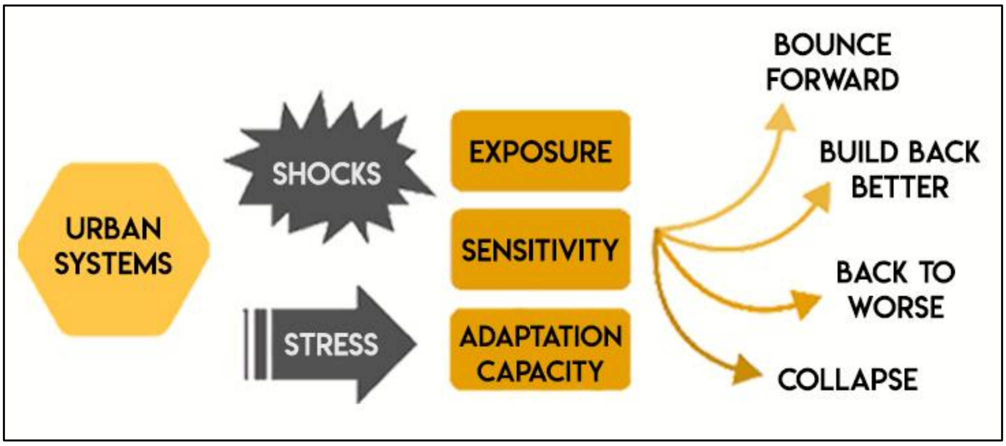

Figure 2.5. Resilience Inputs and Outputs (Translated from Khodkar, 2015)

Urban resilience is discussed with several approaches and most of the experts reviewed the urban resilience dimensions variously. Zhang et al. (2019) evaluate the urban resilience from four aspects as urban society, ecology, urban infrastructure and economy. In another perspective, urban resilience can be defined as the system composed of metabolic flows, built environment, governance networks and social dynamics. Kennedy et al. (2017) state that every material produced and consumed by or in the urban system such as energy, food, waste refer to metabolic flows in urban system. Urban infrastructure such as transportation, utilities, buildings and additionally ecological greenspace create the built environment. Governance networks in an urban system include states, labor, industry, consumers and NGO's. Social dynamics do not only include social features as demography and education, also economical features as capital are included within the social dynamics (Meerow, Newell, & Stults, 2016).

The many dimensions of urban resilience identified by experts and the features that need to be examined and developed in a resilient urban system can be analyzed under five main headings.

1) **<u>Spatial Resilience:</u>** There are various of definitions in the literature aim to state what a resilient urban system should include as physically in the built environment. Meerow et al. (2016) highlights that the spatial aspect of the

city refers to human-made infrastructure such as buildings, energy and basic need networks needed to be built in the system (Suarez, et al., 2024). Urban infrastructure risk arises mainly in large-scale population growth, which puts enormous pressure on basic need as electricity, transportation and results in significant vulnerability to disasters (Zhang, et al., 2019).

Spatial infrastructure is the vital function that need to have the potential to secure society, ensure urban health and quickly respond to and recover from disasters (Zhang, Yang, Li, & Pieter van Dijk, 2020). Spatial assets tend to function within networks that may be available in specific communities or regions or extend across the whole city (ARUP & Rockefeller Foundation, 2014).

Cirit (2017) highlights that spatial resilience can be created by ensuring that citizens have access to adequate housing, meeting their housing needs, meeting their energy needs through renewable energy systems, access to clean drinking water, and adequate transportation and infrastructure systems. In resilient cities, transportation to workplaces and other services is provided on foot or by cars powered by electric power. Intercity journeys are organized by electric railways. In a city called resilient; it is aimed to develop a railway network connected to the whole city, to create centers at walkable distances, to design green buildings and infrastructure in the best way. In this direction, Newman and Jennings (2008) state some of the spatial benefits of resilient cities as ease of movement in overcrowded areas, walkable areas and easily accessible transportation options for communities, locally produced and therefore fresher food, efficient energy sources, healthier indoor spaces at more affordable prices, ease of access to the natural environment (Özkur Karahan, 2018).

Strategies to develop resilient cities should include an infrastructure development plan. To increase spatial resilience in the city, it is necessary to develop a robust infrastructure system and strongly promote adaptive and responsive capacity to increase resilience to potential urban disasters (Zhang, et al., 2019).

2) **<u>Environmental Resilience:</u>** With the development and growth of cities, destruction of natural areas has increased. Climate change, the negative effects of which are clearly visible today, has occurred due to the failure to ensure spatial and natural balance in planning and the failure to develop ecological policies in cities. Climate change is one of the supreme risks that create vulnerability on the city. The natural assets are vulnerable due to urbanization. The fragile natural assets might be exemplified as air quality, heat waves and overheating in urban spaces, biodiversity, natural area conservation and green spaces. Environmental dimension of the city is significant to determine whether the city can respond to and recover from the disaster (Zhang, Yang, Li, & Pieter van Dijk, 2020).

   Environmental resilience refers to not only green infrastructure as trees, parks, green roof but also city metabolism including water, energy flows and ecosystem features of the urban area (Suarez, et al., 2024). Junca (2016) indicates that environmental resilience requires preserving the ecological balance, ensuring biodiversity, preventing environmental pollution and increasing green areas for the city. Ecology in the city will provide important regulations such as air filtration, micro-scale climate regulation, rainwater drainage and treatment. Biodiversity will also have psychological and social effects on the urban dweller. At the same time, green infrastructure also meets the need for aesthetics in urban space (Yılmaz, Yalçın, & Şahin, 2017).

   Çiğdem and Akyol (2016) suggest the strategies of establishment of eco-villages between densely developed transportation hubs and corridors, functions that facilitate the ecological management of the city such as renewable energy production, water, waste recycling; green infrastructure, sanitation to control system and local government. While increasing agricultural production, eco villages established in cities contribute to the management of urban biodiversity and self-sufficiency in terms of some urban functions (Özkur Karahan, 2018).

3) **<u>Economical Resilience:</u>** A resilient city has to obtain an economic stability when a possibility of facing with the uncertain economic conditions. Economic resilience might be influenced by features in the society and urban system as the fiscal deficit rate, diversity and percentage of private and individual employment rate, proportion of GDP, percentage of financial expenditure on science and technology, and so on. It is also important for an urban economy to concentrate on diversity in domestic production and investment rather than relying on foreign investments (Zhang, et al., 2019). Economical resilience must be developed as being able to recover losses, regenerate the damaged resources and minimize total consumption damages to be more effective against any kind of hazard (Khodkar, 2015).

   Economic development, which is one of the objectives of a resilient city model, improves the quality of life in the city and increases the level of welfare and livability by building better facilities. In cases where urbanization is not managed properly, economic risks are inevitable. Settlements that are vulnerable to risk in terms of economic vulnerability are areas where the population living below the poverty level is concentrated and areas with relatively low quality of life and inadequate infrastructure. This situation can be explained as follows; resilience decreases as the national income per capita decreases, resilience decreases as the population living below the poverty level increases, and resilience decreases as the number of small businesses increases (Balta, 2013).

   In order to prevent economic risks within the city, resilient investments should be integrated into the city and the risks that may occur should be minimized. Resilient urban models where resources are used efficiently come into play in planning in this context. Innovative models should be integrated by ensuring sector diversity in the city. This diversity will increase employment opportunities and make the city socially resilient. At the same time, the creation of units to provide skills and training for these sectors will increase the resilience of the sectors. Ahmed (2013) suggests another approach to economic resilience called as the green economy model. This is a model that protects the ecosystem by reducing pollution through low carbon emissions and efficient use of energy resources (Yılmaz, 2019).

Yıldırım and Göktürk (2004) believes that the new systems should be developed as economically resilient and environmentally sustainable. Thus, these systems need to protect themselves against risks, when necessary, through ecological policies. In the increasing production-consumption chain, the focus should be on producing more resilient rather than producing more (Erdinç, 2016).

4) **Social Resilience:** In the 21st century, most of the world's population lives in cities. Population in developing cities and rural-urban migration are increasing over time. It is possible to say that in this century, where consumption and service chain develops with technology, cities are expanding and merging with villages and rural areas are decreasing. This situation causes imbalance and inequality in the socio-economic structure, social segregation, and difficulties in accessing urban services in various areas (Resiliance Alliance, 2007).

With increasing population also comes crisis situations such as overuse and depletion of resources, slowing down the pace of development. Migration occurs due to limited job opportunities and access to infrastructure in rural areas, but the inadequacy of urban facilities in the face of migration shows that the current planning system in the city is not resilient. Social resilience means the ability of urban dwellers to adapt to changes in the city and cope with adversities. In a socially resilient city, people tend to react positively to crisis situations, adapt to adversity, become informed about it and find solutions (World Bank, 2013).

At the same time, the participation of urban residents who gain a sense of belonging in the city will also increase. For this reason, implementing socially encouraging, integrative and participation-oriented programs in the city will increase social resilience. The degree of social resilience in the city is determined by the Organization for Economic Cooperation and Development (OECD) through various criteria. The first criterion is income and inequality, which includes indicators such as the GINI index, household income and poverty rate. Another criterion is social capital and integration, which includes indicators such as the number of civil society organizations, the number of associations, and the presence of neighborhood relations. In addition, there are indicators such as quality of life, life satisfaction, demographic information that led to health, well-being and communication criteria. In fact, another criterion that can be considered the most important for urban dwellers in a city is the adequacy of health, social, technical infrastructure and emergency services (OECD, 2018).

The most important international step towards ensuring social resilience is the European Urban Charter. According to this declaration, every urban dweller in European settlements has the right to live in a safe, clean and healthy city, the right to adequate housing and the right to employment. At the same time, the declaration obliges governments to work towards providing urban access, sports and cultural spaces. Citizens should live in a harmonious city where natural resources and historical heritage are protected, and a quality environment and architecture are provided. For this reason, the development of economic and sustainable development by ensuring local interdepartmental cooperation and the participation of citizens is also among the items. At the same time, it is one of the most important items in terms of social resilience for every individual in the city to live together equally without discrimination of race, religion, language, culture and ability and to feel belonging to the city (Erdinç, 2016).

A resilient system can be established with an active implementation and assessment mechanism. Social resilience is significant to integration of social public policy to existing chains in the urban system. Besides, these policies increase the utilization of social resources to contribute the continuity of the process of urban development (Zhang, et al., 2019).

5) **Governmental Resilience:** Urban system needs robust governance networks containing institutions and organizations that govern the system. These networks link the organizations at different levels as regional, national and international (Karacan & Gökçe, 2020). In a sustainable urban management, it is necessary to increase the participation of the public and local units by developing democratic mechanisms in decision-making mechanisms. Ensuring cooperation between various small local units in cities and the city administration will ensure institutional resilience in the city. The establishment of local civil society organizations and their participation in governance should be encouraged. The active participation of citizens increases the trust of individuals who are directly affected by the decisions taken by the city administration (Yılmaz, 2019).

   Various criteria have been set by the Organization for Economic Cooperation and Development (OECD) for assessing institutional resilience within the city. The most important criterion is the ability of risk-based planning and emergency management to produce quick solutions in case of any risk through various strategies and land use plans. The next criteria are that the public is aware and trained for emergencies, warning systems are comprehensive and adequate, and there is trust in the administration. At the same time, the city government should be transparent in its work, encourage participation and cooperate with other small local units. Local government should also have access to finance in the event of a crisis (OECD, 2018).

   In order to ensure institutional resilience, local governments should put forward holistic and sustainable strategies for current and future crises such as climate and disaster risk. For this reason, the urban form, the distribution of buildings, social and technical infrastructure for a more resilient city should be carefully evaluated in the plans created. At the same time, local governments should also evaluate their strategies according to international resilience criteria established by various organizations such as OECD (Tuğaç, 2019).

Urban dimensions support resilience by affecting the behavioral pattern of an individual and community as social assets, ability of governmental assets to provide urban services and protection and improvement of spatial and environmental assets. Urban assets are generally located within the spatial or administrative boundaries of the city but are interconnected within broader systems created to extend to factors outside the city center. This network system is affected by the feedback loops of urban assets inside or outside the city that have been damaged by crisis situations, and this transferred damage can also cause an urban area where the disaster did not occur to be in a vulnerable condition. Urban resilience will not be achieved by examining urban assets separately, but by examining the relationship between the city and its hinterland and the link between urban assets (ARUP & Rockefeller Foundation, 2014).

2.1.3 Challenges to Urban Resilience

Urban resilience concept is developed both to be antonym to vulnerability concept and to be associated with it. Daniel and McManus (2004) define the vulnerability concept as the human ability to endure, prepare for and survive the same event, as well as the impact of being physically exposed to a disaster resulting in a degree of loss as a human product. Lucini (2013) highlights that the main aim of vulnerability is to understand how and which different society groups are affected from the risk and are experienced resilience in a different way (ARUP & Rockefeller Foundation, 2014).

Vulnerability conditions cause the potential risk in the socio-ecological urban systems that can be easily exposed and might create losses. In resilient systems, risk governance needs to be involved in the system to recognize the risk, to collect the necessary information, analyze the level of risk and manage the risk reduction and mitigation decisions to cope with it (Khazai, et al., 2015).

Resilience concept is not easily interpreted into practice and measure, according to Wilkinson (2012). The difficulty of implementing resilience is explained explicitly by Martin-Breen and Andries (2011) that resilience is not apparent, it is theoretical and in order to emphasize the concept, it needs to be related with the features can be detected through observation. Another challenge of resilience mentioned by Ali and Jones (2013) is the understanding of resilience as the direct antonym of vulnerability and failing to recognize that the interdependence between systems means that interventions to build resilience in one place may have feedback effects elsewhere. An example implementation of these feedback effects is given by Brown and Kernaghan (2011). In Quy Non, Vietnam, elevated roads were constructed to avoid flood and protect living areas caused flood cases increase in the other areas of the city (ARUP & Rockefeller Foundation, 2014).

Table 2.2 Urban Risks Chart (Aydın, 2019 as cited in Dinçer, 2022)

Urban Stressors	*Samples of Urban Risks*
Natural Stressors	Climate change Coastal or tidal flooding, rain flooding Drought Environmental degradation Extreme weather Food insecurity Hurricane/typhoon/tornado Invasive species Lack of green space Biodiversity loss Poor air quality Ecological risks Severe storm Tsunami Volcanic activity Water insecurity
Physical Stressors	Earthquake Power shortages Fire Dangerous substance accidents Inadequate infrastructure, public transportation, sanitation Illegal settlement Collapse Traffic congestion Traffic accidents Uncontrolled urban development Landslide
Social Stressors	Elderly population Crime and violence Cyber attack Epidemic diseases Migration Inequality Homelessness Inadequate health and education services Lack of social cohesion Terror attacks

Table 2.2 (continued)

Urban Stressors	*Samples of Urban Risks*
Economic Stressors	Financial crisis Lack of affordable housing Lack of investment Changing macroeconomic trends Unemployment Poverty Economic inequality

Urban systems are inevitably open to exposure of natural, economic, technological, physical and social stressors. Natural stressors are generally the natural disasters as flood, drought, environmental degradation, hurricane, biodiversity loss, severe thunderstorm and so on that might cause critical disruption (Dinçer, 2022). Natural stressors can be considered as random disasters however some argued that impacts of these stressors can be reduced by focusing on maintaining sustainability (Desouza & Flanery, 2013).

United Nations (2018) indicated that 55 percentages of world's population live in urban areas and it is estimated that this percentage will increase to 68 percentages by 2050. The increase in population inevitably affects ecological systems. Climate change can be characterized as the greatest natural stress that causes serious threats and risks such as severe floods, drought, and heatwaves. Climate change affects the urban system in environmental dimension as rise in sea level causing floods, in economic dimension as decline in crop yields, and in social dimension as migration (Asadzadeh, et al., 2022).

In the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) on "Climate Change 2022: Impacts, Adaptation and Vulnerability", it is emphasized that human destruction of ecosystems increases social and ecological vulnerability and that land cover change, biodiversity loss, unsustainable use of natural resources, deforestation, pollution have negative impact on the capacity of ecosystems, communities and individuals (IPCC, 2022).

Climate change and extreme weather events have severe impacts on society and natural systems. These impacts include the loss of ecosystems, destruction of coral reefs, harm to livelihoods, reduced food security, migration and displacement, risks to health and safety, and social inequality. Climate change affects multiple areas simultaneously and interacts with other societal changes, such as rapid technological advancements, persistent poverty, environmental degradation, biodiversity loss, food insecurity, and epidemics. As the global population grows and urbanizes, social inequality and social justice demands become more important. These demands are driven by the need to address the impacts of climate change and other societal challenges. It is crucial to take action to mitigate climate change and promote social justice to create a sustainable and equitable future (IPCC, 2022).

IPCC report (2022) indicates the near-term risks projected to be between 2021 and 2040 which are caused by climate change. According to report, global warming level is classified as five ranks from high confidence to low confidence against effects of global warming. The unique and vulnerable system risks in the condition of 1.5 °C is stated under high confidence and risks correlated with extreme weather events in the condition of 2.0 °C is stated under medium confidence. Global warming levels between 1.5 and 2.0 °C in a non-resilient city which is highly vulnerable and unable to adapt will face with pervasive and irreversible impacts. It is estimated that climate change related losses in human systems and ecosystem will be reduced, but not eliminated, in the conditions that global warming is kept close to 1.5 °C (IPCC, 2022).

Global warming has occurred because of increase in greenhouse gas emission which is caused by rising energy demand and excessive and unlimited use of resources. Demir (2009) highlights the studies showing the prediction as 1/3 of forest areas will change their composition as a result of climate change and new ecosystems will be formed by 2050. Living species will migrate or become extinct due to their inability to adapt to changes in forest areas and temperature. Drought in water resources due to global warming brings many problems such as destruction of fauna and flora structure and decrease in agricultural production. As a result of the decrease in productivity in agricultural areas, economic and spatial changes emerge (Görgülü & Görgülü, 2021).

Aydın (2019) exemplifies physical stressors as earthquake, energy shortage, wildfires, insufficient infrastructure and urban facilities, traffic congestion, unrestricted urban development and so on (Dinçer, 2022). Gökçe and others (2018) states that there are several factors contributing increase in vulnerability. These include dense and high-density construction, a rise in impervious surfaces, a decrease in green and blue areas, construction patterns that disrupt wind flow, narrow streets and alleys, poor building material quality, inadequate infrastructure, construction in hazardous areas, and the presence of informal settlements.

In addition, urban sprawl poses a threat to natural ecosystems such as forests, agricultural lands, and water resources, as well as increasing the distance between residences and workplaces. High-density construction exacerbates the urban heat island effect and reduces open-green spaces. Settlements in risky areas, such as stream beds, and poorly designed buildings that do not take climate conditions into account further weaken the sustainability and resilience of urban areas against climate change impacts. Overall, these factors underscore the need for sustainable and resilient urban planning to mitigate urban threats (Şahin , 2022).

Balta (2013) highlights that urban spaces are complex and difficult to define, making it challenging to address disaster risks. Factors such as urban poverty, unplanned urbanization, and the decline in residential areas contribute to the emergence of low-quality housing areas. Compounding this issue is the inability of administrations and institutional structures to adequately provide essential services like infrastructure and healthcare. These multiple urban disaster risks are the result of conscious or unconscious policies adopted by urban dwellers. In the event of a disaster, densely populated areas with high energy usage can easily experience fires caused by industrial explosions and leaks. These threats to urban dwellers highlight the importance of addressing and mitigating urban disaster risks (Hatipoğlu, 2019).

Urban systems are also affected from social stressors as intentional acts that human involved to damage cities, such as terrorism, war, crime, epidemic diseases, inequality and any kind of insecurity and violence (Desouza & Flanery, 2013). Additionally, unemployment, poverty, lack of investment, lack of affordable housing and changing macroeconomic trends are samples of economic stressors on urban systems (Dinçer, 2022). Füssel and others (2012) state that growing urban population, the economic assets of urban areas such as energy, water, food and waste, the complexity of urban systems existing with the aim of manage and provide other urban services create a more fragile urban area (Şahin , 2022).

Urban planners and experts from related disciplines must develop strategies to deal with uncertainties in the face of rapid urbanization and other possible new risks. These uncertainties as climate change, rapid urbanization, the emergence of new risks challenge urban risk management and urban resilience (Heinzlefa et al. 2020). Instead of focusing on engineering approaches only to eliminate risky factors, the focus should be on preventing exposure and increasing resilience through appropriate land use decisions. Sharifi and Yamagata (2018) suggest that this situation requires a shift from traditional linear and static planning to adaptive planning, which includes regular monitoring, evaluation, and scenario building. Additionally, ecosystem protection needs to be strengthened to integrate the concept of resilience into urban planning and urban disaster risk management (Dinçer, 2022).

2.2 Urban Resilience in Neighborhood Scale

The definition of neighborhood varies in terms of identifying the concept, land use and the boundaries of the urban area. Neighborhood is defined by some experts as a residential area with a number of households physically. In social perspective, it is stated as the social interaction of a number of households living in the same urban area which is in between the household level and the city level. Besides these broad definitions, Barton et al. (2003) defines the neighborhood as a home patch containing a set of dwellings and streets to make dwellings available but an area that is smaller than an urban area that meets all local needs (Uda, 2016).

In order to delineate the boundaries of the neighborhood, several perspectives are mentioned in the literature. Barton er al. (2003) and Jenks and Dempsey (2007) suggest that neighborhood boundaries need to be decided according to physical barriers as major roads, water features, urban forests and so on. In another suggestion made by Barton et al. (2003), significant function locations as school, religious space or a park might determine the boundaries. Hallman (1984) highlighted the social identity, race, ethnicity or culture as features to indicate the boundaries of a neighborhood in a social perspective. In addition, Barton et al. (2003) also adds another perspective that character or age of the residence is a feature might be considered in deciding the boundaries (Uda, 2016).

In the field of urban planning, cities can be understood and analyzed at different scales: macro, meso, and micro. The macro scale is the overall structure of the city and its position within the region. The meso scale focuses on the layout and structure of neighborhoods, including elements like neighborhood shape, density, land use mix, street design, and open spaces. Finally, the micro scale examines the design and location of individual buildings in relation to surrounding structures, roads, and open spaces (Sharifi, 2019).

Neighborhood scale is an essential representation of social and perceptual unit that cannot be defined unambiguously. A neighborhood can vary from a space with few blocks to a larger urban area covering many blocks. Neighborhood level is an often-ignored scale in urban studies, however in terms of co-creation of community engagement and climate change interventions, the neighborhood level is potentially promising for creating resilient urban places (Barron, et al., 2019).

Urban resilience needs to be analyzed from city scale to neighborhood scale by also integrating other scales such as plots, large blocks and street network inside them. The presence of diverse and adaptable plots plays a vital role in building resilience. Plots that can accommodate various functions both vertically and horizontally contribute to a complex and efficient scale-free structure. A balanced mix of small plots and a smaller number of larger plots indicates a resilient and versatile environment. Small plots are more flexible and resistant to changing uses and adaptation. On the other hand, larger plots are suitable for specialized functions. Jacob (1961) states that this combination leads to a higher level of diversity in building ages, values, layouts, and sizes. Additionally, the accessibility of land is essential for connectivity, as it determines the ease and efficiency of reaching a destination (Feliciotti, Romice, & Porta, 2016).

Urban blocks consisting of one or very few super plots have limited potential for diversity and redundancy. On the other hand, small-scale blocks allow for more diversity, redundancy and interconnectivity, which leads to a more complex and efficient structure. Salat and Bourdic (2012) argue for a mix of small, intermediate, and large blocks to create the necessary conditions for accommodating special functions or additional uses. Large blocks, formed by combining street edges, have greater complexity in their cores. The connectivity of streets within the overall street network determines their centrality and capacity to support urban life. Lhomme et al. (2013) suggest that balancing block sizes promotes resilience and a range of urban activities. The role of street layout configuration is mainly about providing easy access within a city. Increased path redundancy gives people more choices in selecting their preferred routes (Feliciotti, Romice, & Porta, 2016).

In neighborhoods, to analyze the resilience in neighborhood scale, defining potential risks and essential needs of the neighborhood residents is essential. For a neighborhood to keep functioning, the essential needs of a community must be met. The resilience of neighborhood can appear in case of whether the essential needs are continued to meet in the conditions under risks, shocks and stresses or not. Not only satisfying basic needs is enough to maintain a resilient neighborhood, but also ensuring the persistence of these essential needs are also satisfied under the potential pressures (Uda, 2016).

Table 2.3 Essential Needs of a Community (Uda, 2016)

Essential Need	*What is required to meet this need?*
Clean air	no air pollution, ventilation, energy source
Clean water	potable (CIDA, 1997) or clean water, energy source to heat water
Food	energy source, water source
Sanitation	sewage collection and treatment (CIDA, 1997), waste management, water
Shelter	energy source, system to arrange humidity, heating and cooling system, drainage system and other necessary systems
Security	police services, firefighting services, healthy society
Health	healthcare, medication, clean environment
Privacy	shelter
Space	safe outdoor space with adequate size
Communication	communication tools, energy source
Transportation	transportation tools, energy source

While analyzing and measuring the resilience, evaluating the global risks in more local scale as neighborhood is challenging. The uncertainty in global area can show its visible effects on the community and the small urban scales. Thus, not having a qualitative list of possible risks affecting the local scales and a measurement method for urban resilience in these scales create difficulties on examining the urban area and developing affirmative strategies. Downscaled data for uncertainties to local level will establish a potential to deal with risks and shocks by combining local knowledge and experience of local officials, residents and so on (Uda, 2016).

According to Feliciotti et al. (2017), to build urban resilience, it is important to establish a hierarchy of scale and integrate neighborhoods into the larger urban system. This integration can be achieved by designing resilient neighborhoods as independent modules with strong connections between their constituent elements.

This hierarchical network of modules serves several purposes. Firstly, it increases the self-sufficiency of neighborhoods, such as through the use of neighborhood-based energy systems. Secondly, it enhances the ability to maintain functionality in the event of disruptions in other parts of the city. Thirdly, it reduces the risk of spreading through cascading effects. Fourthly, it enables controllable exchanges between modules. Lastly, it provides opportunities for receiving support from other modules in the system during disasters. Overall, creating this hierarchical network of resilient modules can contribute to the overall urban resilience (Sharifi, 2019).

In the scope of urban resilience and sustainability, several neighborhood model propositions are presented through years. In 1930, Clarance Perry proposed a neighborhood unit plan focusing on aspects of sustainability. Perry identified six key factors, including easy access to amenities, walkability, safe routes for children to school, the inclusion of parks and green spaces, and the placement of public buildings and spaces in the neighborhood center. He also emphasized the need for local commercial units at the outer corners of the neighborhood and equal access to facilities for all residents. However, by 1980, rapid urbanization had significantly altered the traditional neighborhood fabric. In 2008, Doug Farr developed a more modern and resilient version of Perry's model. This updated model introduced a green ecological belt around the neighborhood to enhance energy efficiency and biodiversity. It also included factors like a 10-minute walking distance to facilities and a 3-minute access to parking areas from residences (EVstudio AEP, 2019).

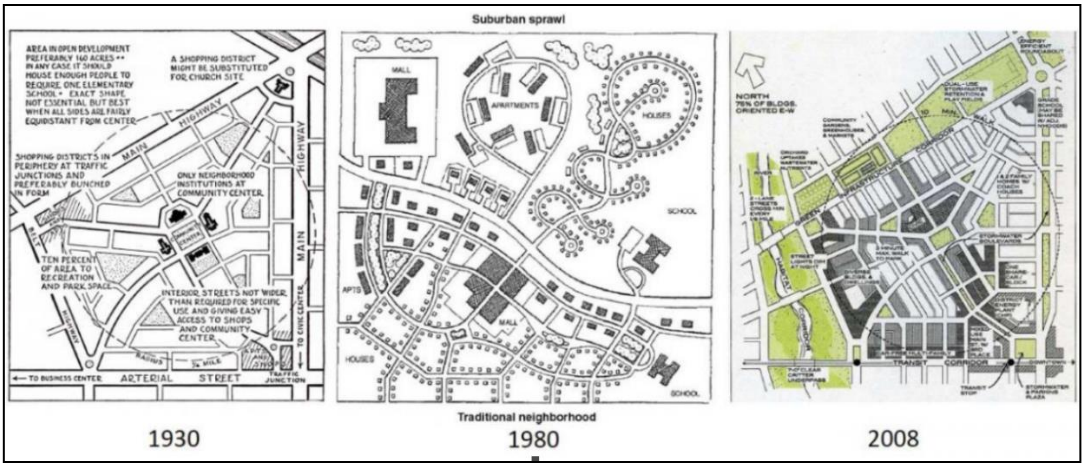

Figure 2.6. Perry (1930) and Farr's (2008) Neighborhood Model Designs (EVstudio AEP, 2019)

The Emergent Neighborhood Model, proposed by Mehaffy, Porta, Rofe and Salingaros, highlights the significance of the relationship between urban blocks and main streets in shaping urban spaces. According to Mehaffy et al. (2010), in this model, neighborhoods are adaptive socio-spatial entities that serve as shelters or are located in the middle of multiple shelters. Resembling the Clarence Perry's 'Neighborhood Unit' concept, commercial activities are concentrated at intersections of major roads, creating urban cores that often coincide with major transportation systems. This arrangement enables residents to easily access their daily needs within walking distance. The boundaries of pedestrian activity around these urban cores may not align precisely with neighborhood boundaries. Research conducted by Mehaffy and colleagues (2010) reveals that intersections are typically spaced about 400 meters apart. For improved walkability in neighborhoods and sanctuaries, it is vital to maintain appropriate levels of density, mixed-use development, and street connectivity within their boundaries (Sharifi, 2019).

The Emergent Neighborhood Model is beneficial for reducing car dependency, as well as providing equitable access to services and improving emergency response capabilities during disasters. To achieve these goals, the built environment should be designed with appropriate levels of density, connectivity, accessibility to transit and other services, diversity in terms of land use and demographics, and proximity between jobs and housing. In the Figure 2.7., the arrows represent the streets; large circles are dense urban blocks; small circles indicate dense areas with amenities around the street intersections; lastly, the shadows represent the pedestrian sheds (Sharifi, 2019).

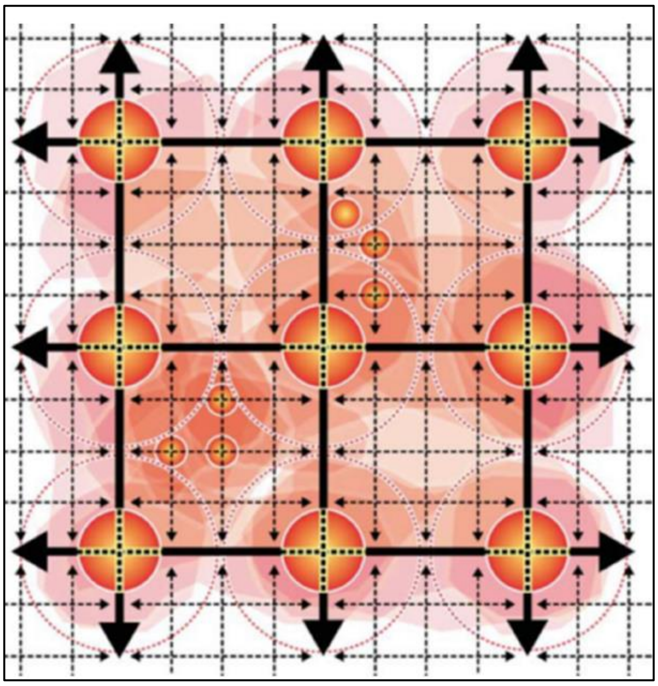

Figure 2.7. The Emergent Neighborhood Model (Mehaffy et al., 2010 as cited in Sharifi, 2019)

As another type of urban planning models, the concept of compact development has the potential to enhance urban resilience in a variety of ways. Firstly, it can improve the efficiency of the urban system by integrating infrastructure systems, such as district systems for energy generation. This can result in a reduction in the overall cost of urban infrastructure development and maintenance, which is a crucial factor in ensuring economic resilience. Furthermore, compact development fosters social resilience by fostering social encounters and the formation of social networks, thereby contributing to the development of social capital and mental well-being. However, excessive density in compact developments has the potential to negatively impact well-being and livability, creating an environment that is perceived as stressful. Nevertheless, the evidence suggests that such potentially adverse effects are minimal. The advantages of compact development outweigh the disadvantages, particularly in terms of efficiency, economic resilience, and social resilience (Sharifi, 2019).

Another urban resilience model in the neighborhood context is the Fifteen Minute City (FMC) model, which advocates for active transportation in cities. The objective is to facilitate access to daily services and amenities within a 15-minute walking or cycling distance. Although the concept was first proposed in 2016, it has gained particular significance in the context of the global pandemic. In order to achieve the model, it is essential to enhance walkability. This entails optimizing the usefulness, safety, comfort and attractiveness of walking. This can be achieved through the implementation of a range of measures, including the improvement of road safety, the enhancement of network connectivity, the promotion of a diverse range of land uses, the preservation of urban character, and the development of the necessary infrastructure. The objective is to establish an integrated network of services and amenities that are readily accessible on foot, with walking journeys being direct and comfortable (Abuwaer, Ullah, & Al-Ghamdi, 2024).

In order to create more resilient neighborhoods, it is crucial to establish clear standards and design principles that prioritize resilience at both a legislative and local level. One way to enhance pedestrian safety is developing a continuous transportation network with dedicated bicycle and pedestrian routes and reducing vehicle density. It is important to ensure that neighborhood residents have high accessibility to essential facilities. Additionally, designing common open areas and public spaces can foster a sense of community and belonging within the neighborhood (Kaya & Susan, 2020).

2.3 Urban Resilience Measurement Frameworks

The literature of urban resilience highlighted difficulties in measuring and applying urban resilience in practice. Measuring resilience is a challenging issue due to the lack of tools to integrate resilience into urban planning and governance practices. Chelleri (2012) states that while a systems approach has provided insights into urban systems, there is a need for more tools that can estimate and measure resilience in practice. Existing tools include risk reduction frameworks and indicator sets, but they are limited in their ability to support the measurement of resilience (ARUP & Rockefeller Foundation, 2014).

The assessment of urban resilience has predominantly focused on qualitative methods, but there is growing interest in quantitative assessment methods. These quantitative methods aim to evaluate resilience based on criteria such as area as stated by Bruneau et al. (2003), system function status as stated by Cimellaro et al. (2010), and time-based loss recovery rate as stated by Henry and Ramirez-Marquez (2012). However, the number of studies on quantitative methods is still fewer compared to qualitative methods, and the development of a unified assessment criteria for urban resilience is challenging due to unique factors such as national conditions and social development. Additionally, current research on resilience assessment methods is primarily focused on specific domains like energy and infrastructure, rather than a holistic approach (Chen, Xu, Zhao, Xu, & Lei, 2020).

Nevertheless, the development of measurable indicators is crucial for monitoring the progress of resilience-building, providing objective feedback, and making resilience tangible for decision-makers and society. Clear indicators are also essential for evaluating the effectiveness of adaptation measures and ensuring transparency and accountability in implemented measures (Feldmeyer, et al., 2019).

It is incorrect to equate development impact measures with resilience. The achievement of welfare outcomes does not necessarily imply resilience, as the latter can only be fully understood in the context of a shock or stress. It is crucial to ascertain whether the anticipated outcomes of the development process will be jeopardized by prospective shocks. The concept of resilience can be observed at various levels, from the individual to larger systems such as infrastructure and financial networks. It is of the utmost importance to analyze the sources of resilience at different scales and to examine the way they interact with one another. Costas et al. (2014), indicates that to accurately measure resilience, it is essential to consider the circumstances preceding, during, and following a shock (USIAD & Mercy Corps, 2016).

Since the concept of urban resilience has been integrated into urban planning strategies and models, several measurement and assessment methods have emerged. These methods have been developed with the aim of measuring urban resilience at a variety of scales, including country, regional and city levels. They have been developed within the context of climate change, disaster management, global pandemics, ecological, spatial and social security.

The following section presents a selection of urban resilience measurement frameworks from the existing literature.

City Resilience Index (CRI) – ARUP & Rockefeller Foundation:

The City Resilience Index (CRI) is a comprehensive tool developed by ARUP in collaboration with the Rockefeller Foundation with the objective of measuring urban resilience. The objective of the CRI is to provide an evidence-based framework for the assessment and comprehension of urban resilience at the city scale (ARUP & Rockefeller Foundation, 2014).

The framework is comprised of four dimensions and twelve objectives, which facilitate an understanding of the various aspects of resilience. Furthermore, the CRI comprises 52 indicators that facilitate the observation and measurement of urban resilience. The CRI functions as a toolkit, providing cities with the capacity to evaluate their resilience strengths and weaknesses, establish a baseline, and monitor changes over time. The overarching objective is to provide insights that can inform urban planning practices and investment models, with a specific focus on enhancing the resilience of vulnerable communities in the context of social, environmental, or economic stress and disruption. The CRI's holistic approach to resilience assessment is designed to equip cities with the tools necessary to not only withstand and recover from shocks and disturbances, but also to flourish and succeeding amid adversity (ARUP & Rockefeller Foundation, 2016).

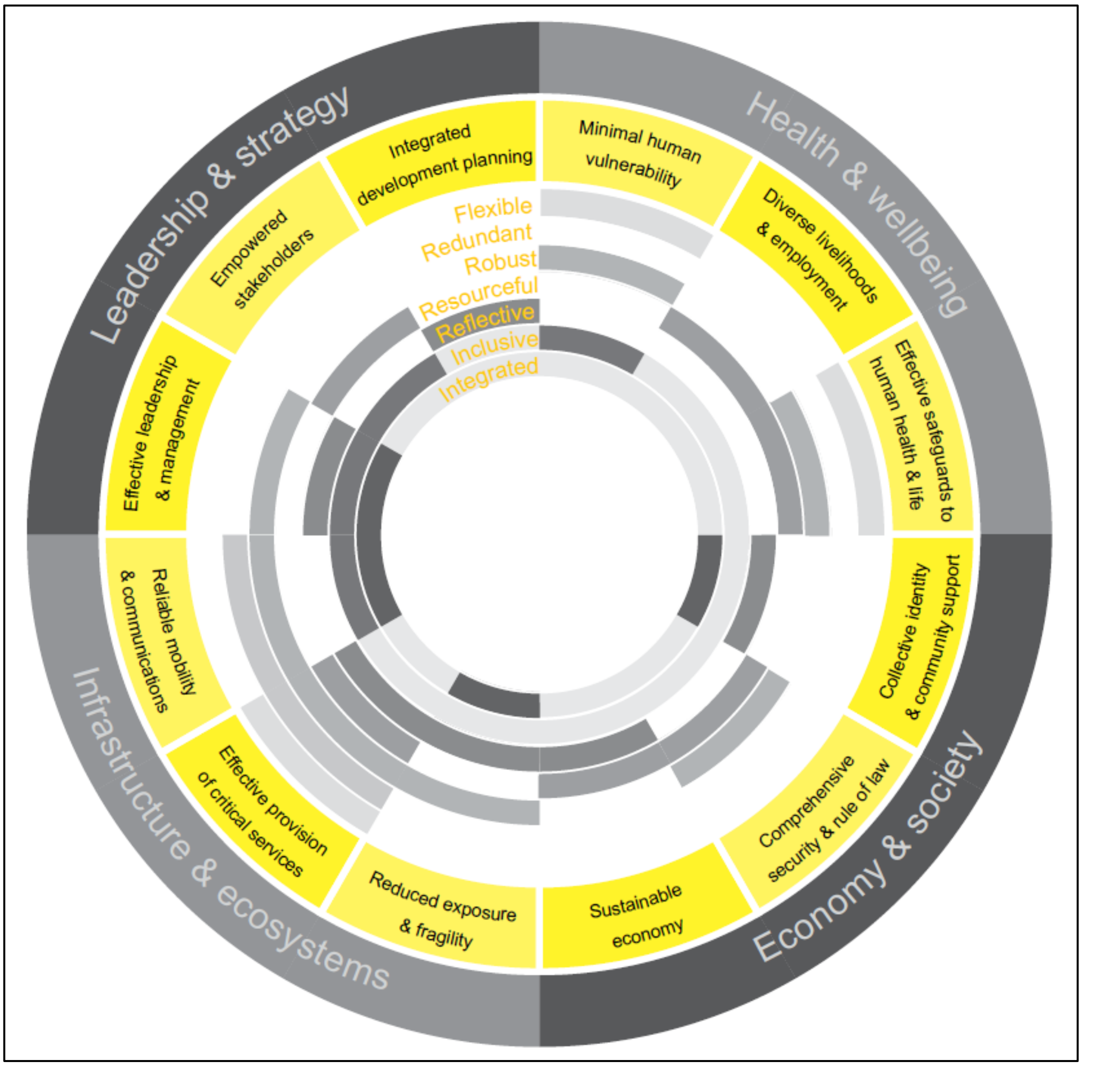

Figure 2.8. CRI Goals, Indicators and Qualities (ARUP & Rockefeller Foundation, 2016)

It is CRI's assertion that a city must possess eight essential qualities in order to become resilient. These qualities are as follows: acceptance of uncertainty and change, reflection, adaptability, robustness, resourcefulness, integration, diversity and inclusivity. All indicators identified by specialists and citizens are defined and utilized in the analysis of the pilot cities in accordance with these qualities (ARUP & Rockefeller Foundation, 2014).

The CRI is generated through six processes, beginning with the indicator determination process, which is a desk study involving specialists and citizens. In the second process, a fieldwork data analysis is carried out while questioning urban resilience means according to different stakeholders, ways to reach urban resilience, ways to measure urban resilience and lastly the effects of stakeholder dynamics on resilience outcomes (ARUP & Rockefeller Foundation, 2014). In the third and fourth processes, the measurement index is created, and the indicators are defined in sufficient detail to ensure clarity. A field study is conducted to evaluate the CRI as the concluding phase of the study.

Table 2.4 City Resilience Index Dimensions, Objectives and Indicators (ARUP & Rockefeller Foundation, 2016)

Dimensions	*Objectives*	*Indicators*
Health and well-being	Minimal human vulnerability	Safe and affordable housing, Adequate affordable energy supply, Inclusive access to safe drinking water, Effective sanitation, Sufficient affordable food supply
	Diverse livelihoods and employment	Inclusive labor policies, Relevant skills and training, Dynamic local business development and innovation, Supportive financing mechanisms, Diverse protection of livelihoods following a shock
	Effective safeguards to human health and life	Robust public health systems, Adequate access to quality healthcare, Emergency medical care, Effective emergency response services
Economy and society	Collective identity and community support	Local community support, Cohesive communities, Strong city-wide identity and culture, Actively engaged citizens
	Comprehensive security and rule of law	Effective systems to deter crime, Proactive corruption prevention, Competent policing, Accessible criminal and civil justice
	Sustainable economy	Well-managed public finances, Comprehensive business continuity planning, Diverse economic base, Attractive business environment, Strong integration with regional and global economies

Table 2.4 (continued)

Dimensions	*Objectives*	*Indicators*
Infrastructure and ecosystems	Reduced exposure and fragility	Comprehensive hazard and exposure mapping, Appropriate codes, standards and enforcement, Effectively managed protective ecosystems, Robust protective infrastructure
	Effective provision of critical services	Effective stewardship of ecosystems, Flexible infrastructure services, Retained spare capacity, Diligent maintenance and continuity, Adequate continuity for critical assets and services
	Reliable mobility and communications	Diverse and affordable transport networks, Effective transport operation & maintenance, Reliable communications technology, Secure technology networks
Leadership and strategy	Effective leadership and management	Appropriate government decision-making, Effective co-ordination with other government bodies, Proactive multi-stakeholder collaboration, Comprehensive hazard monitoring and risk assessment, Comprehensive government emergency management
	Empowered stakeholders	Adequate education for all, Widespread community awareness and preparedness, Effective mechanisms for communities to engage with government
	Integrated development planning	Comprehensive city monitoring and data management, Consultative planning process, Appropriate land use and zoning, Robust planning approval process

Climate Disaster Resilience Index (CDRI) – United Nations Framework Convention on Climate Change (UNFCC):

The Climate Disaster Resilience Index (CDRI) is a tool designed to assess the level of resilience in the city. The objective is to enhance awareness of the existing and prospective risks to the city and to inform the formulation of a comprehensive climate and disaster management plan. The measurement and mapping of resilience levels allows stakeholders to gain insight into and evaluate the city's climate and disaster-related risks (Wan Mohd Rani et al., 2018).

The CDRI assessment considers four principal sectors that are economy, society, environment, and institutions as stated by OECD (2016). These sectors are significant factors in determining a city's resilience level. In 2010, Kuala Lumpur participated in the resilience mapping coordinated by UNISDR, which revealed a moderate resilience rating across various aspects, including social, economic, institutional, and natural resilience. The assessment provides a baseline measure for understanding the current level of resilience in Kuala Lumpur and informs strategies to address the city's distinctive challenges (Wan Mohd Rani et al., 2018).

Table 2.5 Components and Subcomponents of CDRI (Shaw et al., 2010 as cited in Wan Mohd Rani et al., 2018)

Components	*Subcomponents*
Physical	Electricity, Water, Sanitation and Solid Waste Disposal, Accessibility of Roads, Housing and Land Use
Social	Population, Health, Education and Awareness, Social Capital, Community Preparedness
Economy	Income, Employment, Household Assets, Finance and Savings, Budget and Subsidy
Institutional	Mainstreaming of DRR and CCA, Effectiveness of city’s crisis management, Effectiveness of a city’s institution to respond to a disaster, Institutional collaboration with other organizations and stakeholders, Good Governance

Table 2.5 (continued)

Components	*Subcomponents*
Natural	Intensity/ Severity of natural hazards, Frequency of natural hazards, Ecosystem services, Land-use in natural terms, Environmental security and food security

Resilience to Emergencies and Disasters Index (REDI):

The Resilience to Emergencies and Disasters Index (REDI) is a methodology, developed by Kontokosta and Malik (2018), that uses urban data to measure and benchmark the resilience capacity of neighborhoods. The REDI score considers multiple dimensions of resilience, including physical, social, economic and environmental factors, to provide a comprehensive view of a community's resilience capacity. The REDI score can prioritize investment and funding needs across multiple dimensions and measure progress over time. It provides a high-resolution classification and ranking of the resilience capacity of local urban systems (Kontokosta & Malik, 2018).

The REDI score is a measure of a neighborhood's resilience, ranging from 1 to 100. It allows the resilience of a neighborhood to be compared with the average of a reference region. The score represents relative resilience capacity, with 100 being the highest. Berkes and Ross (2013) suggest that it is important to understand neighborhood resilience capacity both theoretically and practically, with an emphasis on community-based planning. The REDI methodology is recommended as a pre-screening tool for investment decisions to improve resilience capacity. It helps to identify communities that need immediate attention and where the return on investment is likely to be highest. REDI scores can also be used to evaluate resource allocation decisions and to monitor a neighborhood's resilience capacity over time. The integration of the four components of resilience capacity (physical, social, economic and environmental) allows policy makers and community organizations to prioritize resilience dimensions. In addition, the REDI score provides a benchmark for understanding and measuring local resilience capacity (Kontokosta & Malik, 2018).

Table 2.6 Indicator Variables of REDI (Kontokosta & Malik, 2018)

Components	*Indicator Variable*
Social infrastructure & community connectivity	Percent Population under 18 & over 65 years, Percent of Non-Family Households with Single Occupancy, Percent of Non-Family Households with Under 18 Occupants, Percent of Vacant Housing Units, Percent Population Over 25 with Bachelor's degree, Percent Population Over 3 Not Enrolled in School, Percent Population with no Health Insurance Coverage, Density of Adult Social Services Centers, Density of Child Social Services Centers, Density of Residential Developmental Disabilities Services Centers, Density of Libraries.
Physical infrastructure	Distance to Nearest Fire Station from Tract Center, Distance to Nearest Police Station from Tract Center, Distance to Nearest Health Services from Tract Center, Number of Subway Stations in 1-mile radius from Tract Center, Number of Evacuation Centers in 1-mile radius from Tract Center
Economic strength	Unemployed Population Over 16 in Labor Force, GINI Index for Income Inequality, Lack of Economic Diversity
Environmental conditions	Percent of Tract covered flood, Tree Density, Building Density, Percent of Census Tract's Land Use categorized as “Open Space”

<u>Neighborhood Pandemic Resilience Index (NPRI):</u>

The global pandemic has highlighted the necessity for enhanced resilience to future pandemics in urban planning and policymaking. The Neighborhood Pandemic Resilience Index (NPRI) has been developed as a means of assessing the resilience of different neighborhoods, based on a range of factors including physical, infrastructural, socioeconomic and environmental considerations. Exploratory factor analysis was employed to identify critical indicators, which were then used to construct a composite indicator framework. This permitted the calculation of resilience scores for each neighborhood, so revealing the relative performance and areas that require additional attention. The findings indicated that neighborhoods with lower resilience scores exhibited a higher prevalence of disease, suggesting that resilience may influence vulnerability to pandemics. This emphasizes the importance of socioeconomic justice and access to resources and services in addressing adverse events such as pandemics. The NPRI assessment process can be employed to facilitate future pandemic responses in cities and enhance organization and management (Lak, Hakimian, & Sharifi, 2021).

Table 2.7 Indicators for Neighborhood Pandemic Resilience Index (NPRI) (Lak, Hakimian, & Sharifi, 2021)

Dimensions	*Indicators*
Physical Dimension	Quality of residential area, Average housing area in neighborhoods, Building density Land use mix, Number of neighborhood centers, Number of Banks, Number of Chain stores, The ratio of non-built-up areas, The ratio of the areas of educational, cultural and religious centers, Number of Drugstores, Number of hospitals designated to dealing with the pandemic Access to public transportation, Access to plots and blocks, Access to health centers
Demographic Dimension	Percent of population with higher education degrees, Percent of population with pre-existing chronic diseases and health conditions (e.g., diabetes, asthma, obesity & hypertension), Percent of the elderly population (over 65), Population density, Household size
Environmental Dimension	The average number of polluted days in a year, Average levels of environmental pollution (air, water, soil), Temperature, wind speed and humidity, Average state of environmental cleanness (the amount of waste in neighborhood and water cycle)

Table 2.7 (continued)

Dimensions	*Indicators*
Infrastructural Dimension	The ratio of land uses related to health, The ratio of educational land uses, The ratio of cultural-religious places
Economic Dimension	Percent of employed population, The ratio of the population above the poverty line
Social Dimension	Place attachment to the neighborhood, Level of social capital

Disaster Resilience Assessment for High-Density Cities (HDCs):

The capacity of urban areas to respond effectively to the consequences of natural disasters has become a prominent area of interest for researchers, policymakers and urban planners. The challenges of disaster resilience vary between high-density cities (HDC), low-density cities and rural areas due to the differing environmental settings and operational factors. The necessity for different approaches and capacities to be employed in order to effectively handle emergencies in each situation is self-evident. Evacuation capabilities in high-density cities (HDCs) differ from those in low-density urban or rural areas (Sajjad, Chan, & Chopra, 2021).

The spatial structure of a complex high-density cities presents a significant challenge to the establishment of disaster-resilient neighborhoods. The capacity of neighborhoods to cultivate robust social ties through mutual interaction, resource sharing, and assistance during and after disasters serves as the defining criterion for neighborhood disaster resilience. This assessment framework presents a profiling tool for urban resilience, with a particular focus on the issues of accessibility and proximity in the context of disaster risk reduction (Sajjad, Chan, & Chopra, 2021).

Table 2.8 Indicators for Disaster Resilience Assessment for High-Density Cities (Sajjad, Chan, & Chopra, 2021)

Resilience Category	*Resilience Indicator*
Spatio-Environmental	Accessibility to nearest health services, Accessibility to Nearest ATM and Bank, Accessibility to Nearest Market and Store, Accessibility to Nearest Transport Station, Access to Nearest Parks, Green Area Ratio, Average Noise Pollution, Accessibility to Nearest Child Care Centre, Accessibility to Nearest Sports Facility
Economic	Housing Affordability Rate, Median Family Income, Energy Consumption, Female Employment Rate, Access to Free Education, Household Expenditure Rate, Unemployment Rate
Social	Average No. of Rooms per person, Youth Population, Immigration Status, Post-Secondary Education Rate, Proximity to Crime Scenes, Sense of Place, Proximity to nearest council member office

Multidimensional Resilience Index to Adapt against Climate Change:

Cities with high population density and centralized urbanization are demonstrating enhanced resilience to climate-driven hazards. Nevertheless, there is a pressing need to enhance our comprehension of urban climate resilience and to ensure the reproducibility of the multidimensional metric employed. It would be beneficial for future research to include other resilience components, such as physical and ecosystem-based service dimensions. The index highlights the necessity of incorporating the socio-cultural dimension, encompassing eco-environmental and economic elements, into the framework of urban climate resilience capacity building.

Furthermore, the index proposes a series of adaptive measures to reinforce capacities and enhance resilience, including raising public awareness, offering incentives and tax exemptions for those at significant risk, updating hazard and workforce centers, and implementing land use and population engineering in infrastructure repair and retrofitting plans. Overall, it is essential to adopt a comprehensive and inclusive approach to urban climate resilience (Jamali et al., 2023).

Table 2.9 Resilience Dimensions of Resilience Index to Adapt against Climate Change (Jamali et al., 2023)

Resilience Dimension	*Resilience Indicator*
Socio-cultural	Public awareness, Consumerism, Population density, Migration, Death rate, Life expectancy, Health overall index
Economic	Commercial land use, Poverty line, Urban worn-out areas, Accident insurance, Employment, Welfare
Inst-infrastructural	Crisis management centers, Access to health and rescue centers, Access to urban services, Infrastructure vulnerability
Eco-environmental	Water quality index, Air quality index, Green space ratio, Slope, Elevation

The Resilient Cities Index (RCI) – Economist Impact & Tokio Marine Group:

The global community is confronted with a multitude of challenges, including a notable increase in the frequency and severity of extreme weather events and a concomitant rise in the risk of cyber-attacks. It is of particular concern that urban centers are particularly vulnerable to these threats, and it is therefore crucial to understand and mitigate them to protect lives and livelihoods. The concept of resilience encompasses three stages: preparedness and mitigation, response, and recovery. The Resilient Cities Index (RCI) is a global measure of urban resilience, defining resilient cities as those capable of anticipating, adapting to, and recovering from various changes. It evaluates 25 cities across four pillars—critical infrastructure, environment, socio-institutional, and economic—using 19 indicators and 42 sub-indicators for a comprehensive analysis (Economist Impact & Tokio Marine Group, 2023).

The Resilient Cities Index (RCI) is based on four fundamental pillars, which are defined as follows:

1. The first pillar of the Resilient Cities Index (RCI) is critical infrastructure. This pillar is concerned with the resilience of essential urban structures, with the objective of reducing vulnerabilities and ensuring the continuity of services during and after disasters. Critical infrastructure is evaluated with the objectives included within this category as highways, bridges, tunnels, railways, utilities and essential buildings.
2. The environmental pillar encompasses the protection and enhancement of the natural environment, including biodiversity, ecosystems, and the quality of air, water, and soil. This encompasses the adaptation to, and mitigation of, climate change, as well as the reduction of disaster risk. The objective is to promote the sustainable management of natural resources in rapidly growing urban areas, with the dual aim of benefiting both people and the planet.
3. The socio-institutional dimension assesses the capacity of urban institutions to prepare for, adapt to, and withstand shocks, reflecting the extent to which society is prepared. It also considers the inclusivity of municipal efforts in protecting vulnerable populations during disruptions.
4. Economic dimension as fourth pillar assesses the capacity of economic systems to anticipate and withstand adverse economic shocks. A resilient

economy is characterized by a reduced exposure to risk, the capacity to withstand financial crises, and the implementation of robust economic countermeasures (Economist Impact & Tokio Marine Group, 2023).

Table 2.10 Indicators of The Resilient Cities Index (RCI) (Economist Impact & Tokio Marine Group, 2023)

Pillar	*Indicator*	*Sub-indicator*
Critical Infrastructure	Electricity	Electricity price, Electricity quality
	Water and sanitation	Water provision quality, Wastewater treatment, Water management
	Transportation	Congestion, Smart traffic management, Public transport quality, Transport electrification
	Built environment	Energy efficiency, Futureproofing the structures
	Digital infrastructure	Internet quality, Cybersecurity preparedness
Environment	Flooding	Riverine flood risk, Coastal flood risk
	Heat stress	Heat stress
	Air pollution	Air quality
	Disaster management	Hazard monitoring, Hazard management
	Decarbonization	Net zero progress, Carbon removal, Renewable energy adoption
	Waste management	Recycling and circular economy initiatives, Single-use plastic
Socio-Institutional	Digital government	E-gov portal for residents, Open data availability and accessibility
	Legal	Crime and safety, Justice and law enforcement
	Inclusivity, involvement and awareness	Income inequality, Social protection benefits, Vulnerable group integration, Culture of readiness
	Health and well-being	Health emergency response, Longevity, Work-life balance
Economic	Economic robustness	Business environment
	Exposure and risk	Economic volatility, Insurance penetration
	Innovation and entrepreneurship	AI readiness, Innovation ecosystem
	Human capital	High-skilled workforce

Urban Resilience Index for the Evaluation of Declining Areas:

The term resilience is used to describe the ability to prevent, prepare for, respond to, and recover from disasters. This is crucial for the quality of life and safety in urban regeneration areas. It is essential to gain an understanding of the physical, social and environmental characteristics of a region in order to create region-specific disaster measures. The urban resilience assessment indicators in the index are determined by current risk and vulnerability levels and the likelihood of short-term changes, rather than by historical disasters. It is acknowledged that the natural, social, physical and administrative characteristics of a region will reflect the specific factors pertinent to that area. The determination of urban resilience is based on the utilization of data that can be readily collected and assessed by practitioners. In order to facilitate comparison, indicators are developed in a manner that allows for evaluation of the impacts and outcomes of urban regeneration projects prior to and following such initiatives. The final 24 indicators are classified into two principal categories: physical and environmental indicators, which are designated as Green Resilient Infrastructure (GRI), and socio-economic indicators, which are designated as Interactive Security System (ISS) (Kim, Lee, Kim, Lee, & Choi, 2023).

Table 2.11 The Urban Resilience Evaluation Indicators in Urban Resilience Index (Kim, Lee, Kim, Lee, & Choi, 2023)

Large	*Medium*	*Small*	*Indicators*
Green Resilient Infrastructure (GRI)	Vulnerability	Disaster damage	Property damage from disaster Human life damage from disaster
		Size of vulnerable area	Special purpose district
	Adaptability	Ecological adaptability	Open space Green parks and infrastructure
		Safety of buildings and structures	Aged building Building density Structural stability
	Transformability	Scalability of community facilities	Community facilities accessibility Land ownership status
		Adequacy of response infrastructure	Road accessibility Accessibility to evacuation facilities
Interactive Security System (ISS)	Vulnerability	Population composition	Vulnerable population Population changes
		Society and economy	Economically vulnerable class Small business owners
	Adaptability	Pre-emptive response system	Customized alarm system Vacant house maintenance project
		Tailored (Emergency) support system	Emergency medical (protection) system Public safety management personnel
	Transformability	Availability of human resource	Disaster management budget Volunteer
		Risk communication activity	Resident/Business/Socio-economic organization Community activity spaces

Disaster Resilience Index for Community Resilience:

As the science of resilience is still evolving, it is vital that incremental empirical advancements are made to gain a deeper understanding of its multidimensional nature and to provide easily understandable metrics for decision-making. Regional authorities frequently pursue strategies to enhance the overall regional resilience, whereas local leaders may concentrate on district-level interventions and scores. The index sets indicators for measuring the key community characteristics that promote resilience. By establishing a baseline, it is possible to track changes in resilience over time and to compare different locations. The core indicators provide an initial overview of the patterns and contributing factors associated with disaster resilience. The subsequent phase entails a comprehensive examination of the specific capacities within each jurisdiction, with a focus on social, economic, institutional, infrastructural, and community aspects, to develop locally suitable mechanisms for disaster resilience (Cutter, Burton, & Emrich, 2010).

Table 2.12 Variables Used to Construct Disaster Resilience Index (Cutter, Burton, & Emrich, 2010)

Category	*Variable*
Social Resilience	Educational equity Age Transportation access Communication capacity Language competency Special needs Health coverage
Economical Resilience	Housing capital Employment Income and equality Single sector employment dependence Employment Business size Health Access

Table 2.12 (continued)

Category	*Variable*
Institutional Resilience	Flood coverage Municipal services Mitigation Political fragmentation Previous disaster experience Mitigation and social connectivity
Infrastructure Resilience	Housing type Shelter capacity Medical capacity Access/ evacuation potential Housing age Sheltering needs Recovery
Community Capital	Place attachment Political engagement Social capital religion Social capital – civic involvement Social capital – advocacy Innovation

Other Studies and Indicators:

- Gunawardena and Steemers (2023) develop a study that is concerned with the concept of vertical greening as a means of enhancing urban climate resilience. While horizontal greening has been a subject of interest in the past, vertical greening is now receiving greater attention as a potential solution for densely built-up cities. In order to test the hypothesis that vertical greening can improve urban climate resilience, the researchers utilized a combination of a one-dimensional vertical greening model and an urban climate simulation framework. By applying this analytical pathway, the researchers were able to estimate the impacts of vertical greening on the microclimate and energy use at the neighborhood scale. The findings of this study may inform the wider implementation of vertical greening as a green infrastructure retrofit to address heat-related risks in urban areas. The study consists of eight parameters with sub-parameters (Gunawardena & Steemers, 2023):

- Urban/suburban building block – block dimensions, floor height, assumed building use
- Simplified base building constructions – wall type, roof type
- Priming – initial construction temperature
- Building gains – lighting, occupancy, gains profile used
- Building space-conditioning – infiltration, ventilation, cooling system, heating efficiency
- Roads – material and thickness, vegetation coverage ratio
- Neighborhood – mean building height, horizontal building density ratio, vertical to horizontal area ratio, tree coverage ratio, vegetation
- Reference weather site

- Barron et al. (2019) constitute a study that highlights the significance of urban green spaces, including parks, community gardens, and tree-lined streets, in fostering the resilience and sustainability of urban environments. These green spaces, in conjunction with urban forests, provide a range of benefits to urban residents, including resilience to climate change, management of stormwater, energy conservation, and an enhanced quality of life. The study proposes the implementation of interventions that enhance green spaces at the neighborhood and block levels as part of nature-based solutions to address environmental challenges. Trees and vegetation play a vital role in providing ecosystem services that assist societies in adapting to the effects of climate change, including the reduction of greenhouse gas emissions and the mitigation of the consequences of climate change. In light of the growing recognition of the importance of urban forests and green spaces, these interventions are increasingly being considered in global discussions on climate solutions. In conclusion, the strategic enhancement of green spaces is of paramount importance for the transition of cities towards more resilient, healthier, and sustainable futures. The study proposes eight interventions and metrics to incorporate climate resilience and community health to urban planning (Barron S. , et al., 2019):

- View from within - % population who can see green on a daily basis from within buildings
- Plant entrances - trees/shrubs flanking a building entrance, % vegetation cover around building/site entrance, buildings per block with 'green' entrances
- Bring nature nearby - Horizontal and vertical distance to reach closest green space, Available green space per capita, % of population who see green on a daily basis, Level of community ownership and decision-making power, Diversity metric
- Retain the mature – Naturalness, Species richness and evenness, Perceived safety and condition, Presence of heritage tree
- Generate diversity - Diversity index of tree species, Diversity index of planted space types
- Create refuge - People who can experience cool refuge at once, % canopy cover in each site at high noon during periods of expected heat, Level of "shelter" provided by vegetation
- Connect the canopy - Active transportation around green space, Presence of physical barriers to green space

- Karşıyaka Municipality, İzmir proposes a master plan to enhance urban resilience with developing strategies for open public spaces which is constituted between 2022 and 2024. The design and management of public spaces in urban areas have a direct impact on the health of individuals and communities. The unplanned expansion of urban areas and the effects of climate change present significant challenges to public health in built environments. Cities, which are susceptible to the effects of climate change, also have a responsibility to play a part in preventing it. It is widely acknowledged that public spaces offer potential for enhancing the quality of life and resilience of urban areas. In order to develop capacity in cities, it is necessary to assess the existing capacity and conduct data inventory studies based on ecological and social criteria. The objective of the "Urban Resilience Open Public Space Master Plan" is to propose strategies and actions that will facilitate the creation of an ecological, healthy, inclusive, and circular city. The plan comprises 5 main dimensions with 23 strategies and 127 actions (Karşıyaka Municipality, 2024):

- Participation
- Green Infrastructure and Ecosystem Services – carbon capturing capacity, urban heat island effect, soil improvement, habitat quality, rainwater management / flooding, recreation potential
- Urban Mobility – walkability
- Age-friendly Urbanization
- Disaster Management

The concept of urban resilience in urban planning has given rise to the development of a range of measurement and assessment methods at varying scales. Such methods highlight the importance of urban characteristics that enhance resilience, including the incorporation of open spaces for evacuation and temporary shelter. However, high-density areas may encounter difficulties in providing these open spaces and increasing flood risk due to the expansion of impervious surfaces. The integration of green infrastructure into urban development plans is also more challenging in high-density areas (Yamagata & Sharifi, 2018).

Green corridors serve a crucial function in facilitating human interaction with the natural environment and enabling the migration of species. Furthermore, they provide vital ecosystem services to urban residents. It is of paramount importance to safeguard natural habitats within urban areas, as they play a significant role in regulating temperature, mitigating the impact of extreme events, and enhancing the well-being of urban residents. Furthermore, street connectivity is also important for the effective implementation of emergency response procedures and the safe evacuation of residents in the event of a disturbance. The creation of well-designed pedestrian spaces and connected street networks can encourage walking, which in turn can lead to energy savings, improved mental and physical health, and increased social interactions. Additionally, Fratini et al. (2012) suggests that the implementation of green and blue infrastructures, including green roofs, bioswales, rainwater harvesting systems, and permeable pavements, is of paramount importance for the regulation of the urban microclimate, the mitigation of flood risk, and the reduction of the heat island effect. To effectively manage flood risks, a combination of underground and aboveground techniques should be employed, including the use of drainage channels and permeable surfaces. The integration of green infrastructure technologies into urban development is a crucial step in the creation of sustainable and resilient cities (Yamagata & Sharifi, 2018).

The literature review, conducted with the objective of developing an understanding of the evolving concept of urban resilience, encompassed research conducted from the past to the present, as well as changing research areas and urban scales. It should be noted that the thesis study was developed in accordance with the concept of social-ecological systems, which was first used by Folke et al. in the early 2000s to describe the concept of resilience. The thesis study resulted in the creation of an evaluation index for measuring environmental and spatial resilience at the neighborhood scale. This was achieved by examining the meso-scale of the city, specifically neighborhoods and residential areas, and by considering existing urban studies on these areas.

In particular, the definition of resilience proposed by Folke et al. – that it is the capacity of a system to recover from a threat or disturbance while maintaining its core functions – formed the basis of the spatial and environmental resilience research conducted in the thesis. In this context, the indicators identified from the literature and intended for inclusion in the index were selected based on the meso-scale of the city and the socio-ecological dimension of the concept of urban resilience.

CHAPTER 3

METHOD

It is crucial to define urban resilience at all levels and to achieve safe settlements that are protected from potential risks that cities are likely to face. In order to define urban resilience, it is essential to gain a deeper understanding of the risks faced by cities at all scales and the extent of their impact. This will enable the development of effective risk management strategies.

A review of existing literature reveals a focus on urban resilience studies at the provincial and regional scales, with a limited number of studies addressing resilience at all scales of the city. These studies are typically conducted using two methods. The first method, the data set method, is designed to analyze the database in a theoretical manner, with the objective of developing a conceptual framework for urban resilience. However, given the limitations of the existing systematic database on urban resilience, it is deemed unsuitable for this thesis. As an alternative, the method of producing indices defining urban resilience and developing strategies in this field is deemed appropriate for defining urban resilience at the neighborhood scale and creating strategies, which is a significant gap in the existing literature.

The objective of this thesis is to create an index by examining existing upper scale indices to develop urban resilience strategies from part to whole by prioritizing the lower scale. In order to identify the most important indicators at the neighborhood scale, the average value for each indicator is calculated based on the results of the surveys and interviews with experts. This allowed us to prioritize the indicators.

The primary objective of this study is to determine the relative importance of the criteria identified at the upper scales in the context of developing resilient neighborhoods. Consequently, the initial stage of the methodology is to identify the urban resilience indicators at the neighborhood level. A review is undertaken of index-strategy-indicator studies conducted in previous years and in the existing literature to create the indicators. Once the indicators have been determined and grouped, an expert survey form is prepared for the data collection and evaluation stage. The indicators are then prioritized in line with the opinions of the experts and tested with fieldwork. This resulted in the creation of a spatial and environmental urban resilience index at the neighborhood scale.

3.1 Indicator Selection

In selecting indicators, it is essential to ensure that they are relevant, valid, sensitive, simple, acceptable, and objective (Dwyer et al., 2004). Two distinct approaches may be taken when selecting indicators. The first is a theoretical approach, which considers all relevant factors regardless of data availability. The second is an approach based on data availability (Simpson & Katirai, 2006). This study adopts a theoretical approach to the selection of indicators that can express the provision of urban resilience at the neighborhood scale. The use of indices to assess resilience, vulnerability to hazards and quality of life has become a popular method, as it provides quantifiable results.

A multitude of studies have been conducted in order to develop resilience assessment indices, with the objective of ensuring the resilience of urban and regional systems in the context of economic, environmental, social, spatial and institutional dynamics. These indices are designed to enable the city to withstand threats such as disasters and climate change. The issue that this thesis addresses is that the indices in question are inadequate at numerous points in terms of evaluation and measurement at the neighborhood scale, which is a smaller scale in terms of the urban scale.

Cities are susceptible to a multitude of threats. The effective implementation of resilience strategies can be achieved at lower scales; thus, the neighborhood scale is a scale that should be taken into consideration for the development of effective implementation methods of strategies. In order to assess resilient neighborhoods and identify strategies for implementation, existing resilient city and region index studies are reviewed and a draft resilience assessment index is developed. As a preliminary step, urban resilience characteristics, dimensions of the city and urban risks are defined.

Urban systems are susceptible to a multitude of vulnerabilities, encompassing a range of stressors. These include natural disasters such as floods, hurricanes, and droughts, as well as economic, technological, physical, and social stressors. Although some posit that the impact of natural stressors can be mitigated through sustainability measures, physical stressors such as earthquakes, inadequate infrastructure, and urban development contribute to heightened vulnerability. The vulnerability is compounded by factors such as dense development, impervious surfaces, and a lack of green spaces. The growth of urban areas has the potential to negatively impact natural ecosystems, as well as increase the distance between residences and workplaces. The effects of high-density development include the exacerbation of the urban heat island effect and a reduction in open and green spaces. In conclusion, it is imperative that urban systems address these vulnerabilities in order to guarantee the resilience and sustainability of cities.

The functioning of urban systems is affected by a number of social and economic factors, including the occurrence of terrorism, crime, epidemics, inequality, unemployment, poverty, a lack of investment, a lack of affordable housing, and changes in macroeconomic trends. The presence of these stressors has the potential to inflict harm upon cities and their inhabitants, thereby necessitating the formulation of strategies by urban planners and other experts to address these uncertainties. It would be more effective to shift the focus from engineering approaches to eliminating risk factors to preventing exposure and enhancing resilience through appropriate land use decisions. This is particularly important in light of the acceleration of urbanization, climate change and the emergence of new risks. By taking these factors into account and implementing proactive measures, it is possible to enhance the management of urban risks and improve urban resilience.

The negative effects of the risks faced by urban systems are evident at the meso-scale level, manifesting in spatial, physical and environmental dimensions at the neighborhood and building group levels. While indicators measuring the economic dimension of urban resilience are typically analyzed at large scales, such as regions and cities, indicators measuring the social dimension require a large target group. For this reason, the present study was limited to an examination of the equivalence and measurability of spatial and environmental resilience measures at the neighborhood scale. It may be posited that urban resilience is contingent upon the equal provision of all dynamics inherent to the city. Consequently, future studies may wish to focus on determining the necessary indicators for ensuring economic and social resilience at the neighborhood scale. The relationship between the selected indicators and the characteristics of urban resilience was established based on the definitions of the indicators derived from the literature review.

In the existing literature, a range of indices, strategies and practices have been analyzed at various scales, developed in response to the threats and stress factors that affect all spatial, environmental, social, economic and institutional dimensions of the city at all scales. These studies have been informed by a conceptual framework that acknowledges the inevitability of uncertainty and change, and that emphasizes the importance of reflection, adaptability, resilience, resourcefulness, integration, diversity and inclusiveness. These qualities are widely accepted as being central to urban resilience. In accordance with this framework and in consideration of urban risk situations, index studies and strategies conducted in recent years are examined, and indicators of significance within the scope of environmental and spatial resilience at the neighborhoods level are selected for consideration as a basis for measurement (Appendix-A).

Resilience Strategies		
Indicator	**Reference**	**Scale**
Land use and diversity Land coverage and vegetation (grey-green roads) Road connectivity Relation of dwellings to topographic features	Sharma et al. (2023)	City
Easy access to green and open space Presence of alternative routes Topographically adequate road design Ease of access to the road and facilities in case of emergency	Dinçer (2022)	City
Land use Open spaces Green corridors Street connectivity Critical infrstructures Green and blue infrstructures	Yamagat and Sharifi (2018)	City
Simplified base building constructons (wall and roof type) Building space-conditioning (cooling-heating systems) Urban/suburban building block Roads and vegetation Mean building height Tree coverage ratio	Gunawardena and Steemers (2023)	Neighborhood
Vegetation cover around building entrances Shade provisioning (canopy cover) Urban heat islands Building energy Stormwater control Air quality improvement	Barron et al. (2019)	Neighborhood
Walkable streets Local food production Solar orientation Renewable energy production Infrastructure energy efficiency Light pollution reduction Back up plans for water shortage, energy shortage and food shortage Ground stability Transit infrastructure	Uda, (2016)	City
Infrastructure and ecosystems - Effectively managed protective ecosystems Robust protective infrastructure Flexible infrastructure services Retained spare capacity Diligent maintenance and continuity Adequate continuity for critical assets and services Diverse and affordable transport networks Effective transport operation & maintenance	Arup & the Rockefeller Foundation, (2023)	City
Physical- Electricity, Water, Sanitation and Solid Waste Disposal, Accessibility of Roads, Housing and Land Use Natural- Intensity/ Severity of natural hazards, Frequency of natural hazards, Ecosystem services, Land-use in natural terms, Environmental security and food security	UNFCC, (nd.)	City
Physical infrastructure - Distance to Nearest Fire Station Distance to Nearest Police Station Distance to Nearest Health Services Number of Subway Stations in 1-mile radius Number of Evacuation Centers in 1-mile radius Environmental conditions - Tree Density Building Density Percent of Census Land Use categorized as "Open Space"	Kontokosta and Malik, (2018)	Region

Figure 3.1. Indicators Taken as Basis from Literature in Determining Neighborhood Resilience Assessment Index (Created within the scope of the thesis study)

Resilience Strategies		
Indicator	**Reference**	**Scale**
Physical Dimension - Built environment characteristics Land use Access and Infrastructure Environmental Dimension - Average levels of environmental pollution (air, water, soil)	Lak et al., (2021)	Neighborhood
Inst-infrastructural - Crisis management centers Access to health and rescue centers Access to urban services Infrastructure vulnerability Eco-environmental - Water quality index Air quality index Green space ratio Slope Elevation	Jamali et al., (2023)	City
Electricity (Electricity price, Electricity quality) Water and sanitation (Water provision quality, Wastewater treatment, Water management) Transportation (Congestion, Smart traffic management, Public transport quality, Transport electrification) Built environment (Energy efficiency, Future-proofing the structures) Flooding (Riverine flood risk, Coastal flood risk) Heat stress (Heat stress) Air pollution (Air quality) Decarbonisation (Net zero progress, Carbon removal, Renewable energy adoption) Waste management (Recycling and circular economy initiatives, Single-use plastic)	Economist Impact and Tokio Marine Group, (2023)	Region
Ecological adaptability - Percentage of open space area in urban planning facilities, Proportion of green area and other green spaces, Percentage of 20 years + old buildings , Safety of buildings and structures - Ratio of floor area of buildings in the target site, Percentage of wooden or masonry structured buildings Road accessibility - Ratio of buildings adjacent to roads with a width of 4 m or more, Number of civil defense evacuation facilities	Kim et al., (2023)	City
Housing type Shelter capacity Access/evacuation potential Housing age Sheltering needs	Cutter et al. (2010)	City
Urban heat islands Stormwater management/ flooding Walkability	Karşıyaka Municipality, (2024)	Neighborhood

Figure 3.1. Indicators Taken as Basis from Literature in Determining Neighborhood Resilience Assessment Index (Created within the scope of the thesis study) – continued

A selection of environmental and spatial resilience indicators at varying scales, sourced from existing literature, has been collated as main indicators for the expert survey. This survey is used to identify the evaluation indicators at the neighborhoods scale, as part of the research conducted for this thesis. At this stage, eight main indicators and 24 sub-indicators are identified under the main heading of environmental resilience, and nine main indicators and 21 sub-indicators are identified under the main heading of spatial resilience (Appendix-B). Furthermore, the relationship between these indicators and the qualities of urban resilience has been elucidated in detail.

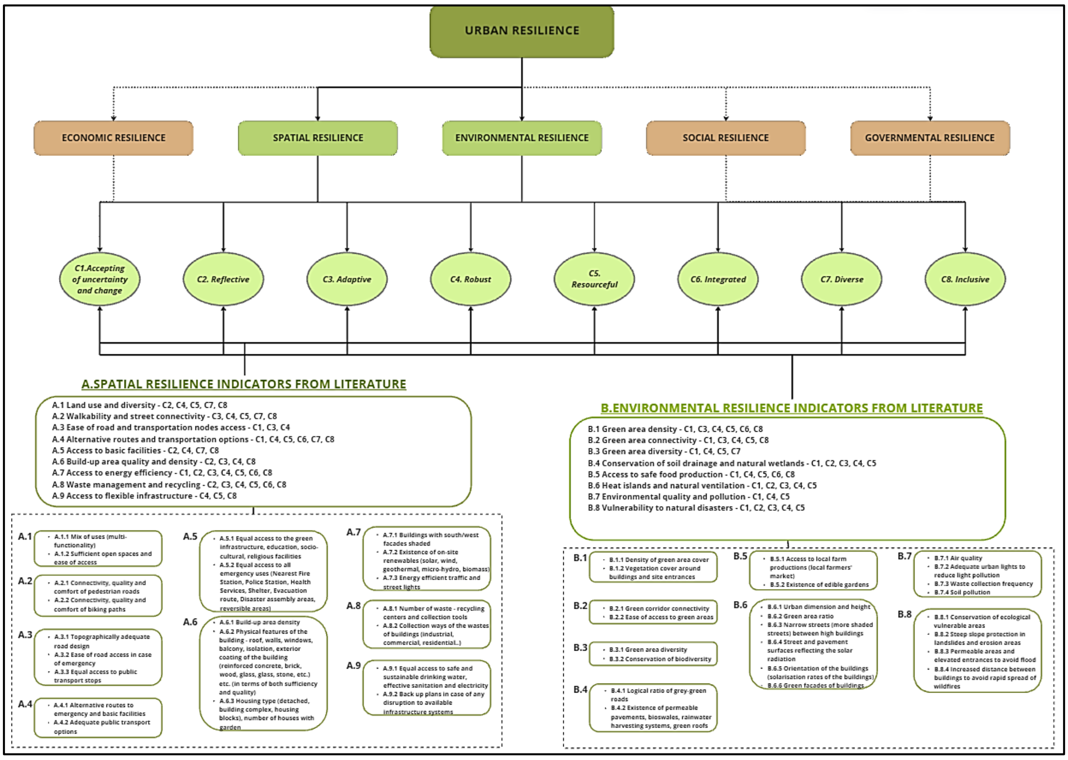

Figure 3.2. Indicators Selected for Expert Survey (Created within the scope of the thesis study)

3.2 Method of Data Collection

It is essential that the data collected and tested during indicator-based studies is accurate and reliable. After identifying environmental and spatial indicators relevant to the neighborhood scale and reflective of urban resilience based on the literature review, a survey form is developed for urban planners to include these indicators and discuss their importance. The indicators prioritized based on the survey responses are then field-tested.

3.2.1 Preparation and Implementation of Expert Survey

The survey is comprised of four sections and a total of six questions. In the initial section, the sector in which the surveyed experts are employed, their professional experience, and the duration of their work in the field of urban resilience are inquired about. In the second and third sections, the experts are asked to determine the importance of each of the indicators identified in the literature review as contributing to the resilience of the neighborhood. The experts are asked to rank the importance of 9 main indicators and 21 sub-indicators within the scope of spatial resilience, and 8 main indicators and 24 sub-indicators within the scope of environmental resilience, using a five-point Likert scale (Appendix-C). The responses are used to identify the most important indicators, which are then prioritized in measuring neighborhood resilience.

The Likert attitude scale, developed by Rensis Likert in 1932, is a method of measuring an individual's opinion or attitude towards a specific object or concept. In this scale, respondents are required to indicate the extent of their agreement with each judgement. Likert scales with two, three and six options are also employed, but the five-point scale is the most practical. The five-point Likert scale requests the respondent's opinion regarding the importance of the indicator provided in the neighborhood scale for measuring resilience (Köklü, 1995). The options for response are unimportant, slightly important, important, very important, and critical.

At the conclusion of the survey, the experts are invited to propose, in an open-ended format, any alternative resilience indicators they considered to be of significance in measuring resilience at the neighborhood scale, in addition to those already mentioned.

A survey is conducted with 50 urban planners who live in Ankara to gain insights into their experience and involvement in the field of urban planning. The participants include experts from both the public and private sectors, as well as representatives from academic institutions. The survey comprises 15 days of short face-to-face interviews. The survey reveals that 50% of the planners are employed in the private sector, 32% in the public sector and 18% in universities. The participants are asked about the duration of their professional careers, with the following results: 40% have been in their current position for two to five years, 24% for six to ten years, and the remaining percentages for longer periods. Furthermore, it is discovered that 46% of the planners have no prior experience in the field of resilience, while the remaining 54% have varying levels of experience, up to 15 years. These results provide a robust basis for the survey findings.

Table 3.1 Properties of the Participants

Participant Number	*Employed Institution*	*Professional Experiences (years)*	*Professional Experience in Urban Resilience Studies (years)*
P1	Public sector	11-15	0-5
P2	Private sector	16-20	0-5
P3	Private sector	6-10	No experience
P4	Private sector	2-5	No experience
P5	Public sector	11-15	No experience
P6	Public sector	2-5	No experience
P7	Private sector	2-5	0-5
P8	University	6-10	6-10
P9	Private sector	2-5	0-5
P10	University	16-20	11-15
P11	Private sector	2-5	0-5
P12	University	2-5	0-5
P13	Public sector	20+	0-5
P14	Private sector	6-10	0-5
P15	Private sector	2-5	0-5
P16	Public sector	11-15	No experience
P17	Private sector	2-5	No experience
P18	University	16-20	11-15

Table 3.1 (continued)

Participant Number	*Employed Institution*	*Professional Experiences (years)*	*Professional Experience in Urban Resilience Studies (years)*
P19	Private sector	2-5	0-5
P20	Private sector	2-5	No experience
P21	Private sector	11-15	0-5
P22	Private sector	6-10	No experience
P23	Public sector	6-10	0-5
P24	Public sector	6-10	No experience
P25	Public sector	6-10	No experience
P26	Private sector	6-10	No experience
P27	Public sector	2-5	No experience
P28	Private sector	11-15	0-5
P29	Private sector	6-10	No experience
P30	Private sector	2-5	0-5
P31	Public sector	20+	No experience
P32	Private sector	2-5	No experience
P33	Private sector	2-5	No experience
P34	Private sector	2-5	No experience
P35	Private sector	2-5	0-5
P36	Private sector	20+	11-15
P37	University	11-15	0-5
P38	Public sector	16-20	0-5
P39	Private sector	2-5	No experience
P40	Public sector	2-5	No experience
P41	University	6-10	0-5
P42	Public sector	16-20	No experience
P43	Public sector	16-20	No experience
P44	Public sector	2-5	0-5
P45	Private sector	2-5	No experience

Table 3.1 (continued)

Participant Number	*Employed Institution*	*Professional Experiences (years)*	*Professional Experience in Urban Resilience Studies (years)*
P46	Private sector	20+	11-15
P47	University	11-15	No experience
P48	University	6-10	6-10
P49	Public sector	16-20	0-5
P50	University	6-10	6-10

3.2.2 Identification of Indicators

Once the expert surveys have been completed, the SPSS software is used to prioritize the results obtained from sections 2 and 3, in which the importance of environmental and spatial indicators at the neighborhood scale is determined. Firstly, in order to evaluate the reliability of the data obtained, a reliability test is conducted using the SPSS program.

A reliability analysis is a method used to assess the consistency of responses to a survey with a predetermined scale. This analysis is specifically concerned with the consistency of responses to questions that can be ranked according to the scale. The primary metric employed in reliability analysis is the Cronbach's alpha coefficient (α). This coefficient is a weighted standardized mean of variation and is calculated by dividing the sum of the variances of the questions in the scale by the overall variance. The alpha coefficient ranges from 0 to 1, with higher values indicating greater reliability. In the event of a negative correlation between the questions, the reliability model is compromised. A scale is considered unreliable if the alpha value is between 0.00 and 0.40, has low reliability if between 0.40 and 0.60, and is highly reliable if between 0.60 and 1.00.

The Cronbach’s alpha coefficient is calculated as 0.949 which represents the high reliability, according to survey results (Appendix-D).

Table 3.2 Results of Reliability Analysis

Cronbach's Alpha Coefficient	*Number of Items*
0.949	44

In order to prioritize the indicators according to the responses obtained following the reliability test, the mean value for all data is calculated using the SPSS program. The mean value for all data is 3.98. Upon calculating the mean value separately for each indicator, only those indicators with a mean value above 3.98 are identified as critically important. In consequence of the survey data and SPSS calculations, it has been determined that there are ten critically important indicators within the scope of both spatial resilience and environmental resilience (Appendix-E).

Table 3.3 Mean Value of Data (Selected indicators are underlined)

Indicators	*Mean Value*
All Data	**3.98**
<u>A.1.1 Diversity of uses in the city (commerce, green space, socio-cultural facilities, etc.)</u>	<u>4.26</u>
<u>A.1.2 Sufficient open space and ease of access</u>	<u>4.72</u>
<u>A.2.1 Connectivity, quality and comfort of pedestrian routes</u>	<u>4.46</u>
<u>A.2.2 Connectivity, quality and comfort of cycle paths</u>	<u>4.32</u>
A.3.1 Topographically appropriate road design (slope, etc.)	3.90
<u>A.3.2 Ease of access to the road in case of emergency</u>	<u>4.68</u>
A.3.3 Equal ease of access to public transport stops	3.90
<u>A.4.1 Having alternative routes to emergency and basic facilities</u>	<u>4.52</u>
A.4.2 Having sufficient public transport options	3.96
<u>A.5.1 Equal access to green infrastructure, educational, socio-cultural, religious facilities</u>	<u>4.04</u>
<u>A.5.2 Equal access to all emergency uses</u>	<u>4.52</u>
A.6.1 Density of built-up area	3.78
A.6.2 Physical characteristics of the building	3.96
A.6.3 Housing type, number of houses with gardens	3.64

Table 3.3 (continued)

Indicators	*Mean Value*
A.7.1 Buildings with shaded south/west facades	3.26
A.7.2 Presence of renewable energy sources	3.92
A.7.3 Energy-efficient traffic and streetlights	3.80
A.8.1 Number of waste-recycling centers and collection vehicles	3.56
A.8.2 Collection methods for building waste	3.68
<u>A.9.1 Equal access to safe and sustainable drinking water, effective sanitation and electricity</u>	<u>4.02</u>
<u>A.9.2 Having backup plans in case of any disruption to existing infrastructure systems</u>	<u>4.34</u>
<u>B.1.1 Density of green space</u>	<u>4.38</u>
B.1.2 Vegetation around buildings and building entrances	3.38
<u>B.2.1 Continuity of green spaces</u>	<u>4.18</u>
<u>B.2.2 Ease of access to green spaces</u>	<u>4.22</u>
<u>B.3.1 Diversity of green space</u>	<u>4.00</u>
B.3.2 Conservation of biodiversity	3.88
<u>B.4.1 Grey-green infrastructure ratio</u>	<u>4.18</u>
<u>B.4.2 Presence of permeable pavements, bioswales, rainwater harvesting systems, green roofs</u>	<u>4.30</u>
B.5.1 Access to local farm products	3.22
B.5.2 Presence of edible gardens	3.62
B.6.1 Urban size and building heights	3.86
B.6.2 Narrow streets (more shady streets) between tall buildings	3.32
B.6.3 Street and pavement surfaces that reflect solar radiation	3.52
B.6.4 Orientation of buildings	3.48
B.6.5 Buildings having green facades	3.64
B.7.1 Air quality	3.96
B.7.2 Adequate urban lighting to reduce light pollution	3.80
B.7.3 Frequency of waste collection	3.78

Table 3.3 (continued)

Indicators	*Mean Value*
B.7.4 Soil quality	3.80
B.8.1 Conservation of ecologically sensitive areas	4.36
B.8.2 Protection of steep slopes in areas of landslides and erosion	4.42
B.8.3 Permeable areas and elevated entrances to prevent flooding	4.50
B.8.4 Increasing the distance between buildings	4.08

As illustrated in Figure 3.3, the calculated mean value of 3.98, representing the overall mean value of the data set, was identified as the threshold delineating the responses into two distinct categories: those that were deemed necessary to be measured at the neighborhood scale and those that were not. This value was determined through the analysis of responses obtained from the expert survey and this thesis, employing a mean value calculation method (Appendix-E).

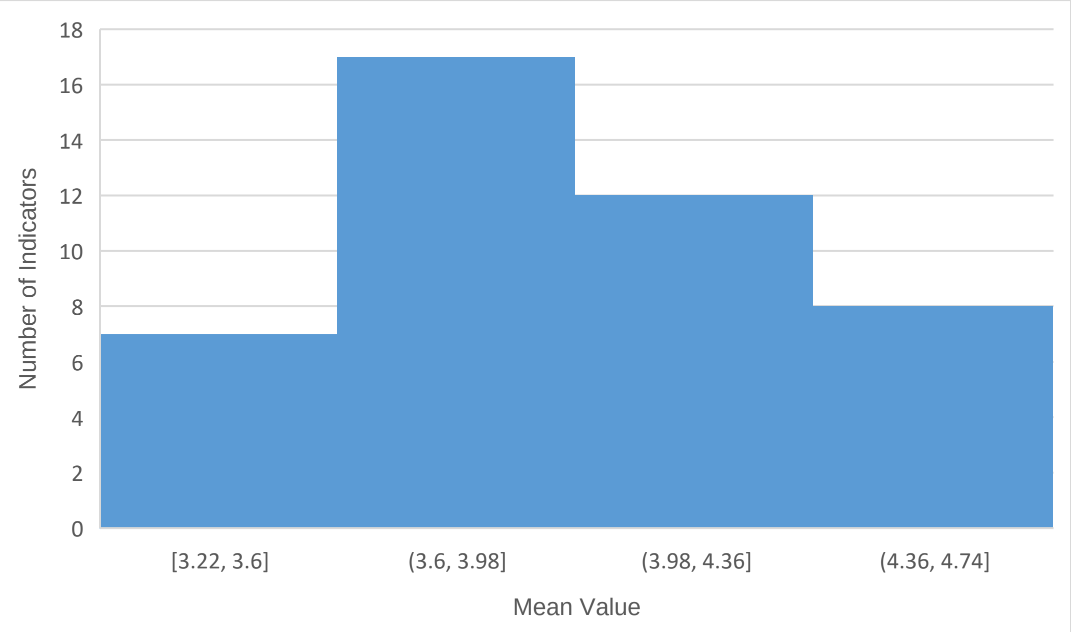

Figure 3.3. Distribution of Mean Values of Survey Responses

It should be noted that the value of 3.98 has not been calculated for similar studies planned in the literature. The threshold value may vary depending on the methodology employed in the study, the indicators examined, and the survey responses received.

3.2.3 Conducting Field Analysis

The indicators identified as critical based on the survey results are examined in two neighborhoods with distinct construction patterns and uses, allowing for a comparison of their resilience levels. In this context, the neighborhoods where field analyses are conducted are Demetevler neighborhood and İşçi Blokları neighborhood in the city of Ankara.

Development of Urban Planning in Ankara

The Turkish capital city of Ankara has undergone considerable modernization since the establishment of the Republic. The initial urban plan for Ankara, designated the Lörcher Plan, was finalized in 1924-1925, thereby conferring upon the city the distinction of being the first planned urban center in the country. However, the plan proved unable to accommodate the rapid population growth that exceeded initial projections. The Lörcher Plan encompassed the development of the Kızılay neighborhood, the construction of buildings along the boulevards leading to the Ankara station entrance and Ulus square, as well as the establishment of the residential area that is currently known as Sıhhiye-Kızılay. The initial residential areas were established in 1924; however, it was the Jansen Plan, created by Herman Jansen in 1932, that ultimately shaped the city's current urban structure. The Jansen Plan proposed the establishment of residential areas for civil servants and the creation of neighborhoods for workers (Ankara Metropolitan Municipality, 2006).

The migration of rural workers to urban areas in the 1950s was precipitated by a confluence of factors, including the increased utilization of tractors in agricultural production, the emergence of more lucrative urban wage opportunities, and the growing appeal of urban lifestyles (Geray, 2000). However, the rapidity of this demographic shift presented challenges in implementing urban planning measures. In 1957, the Yücel-Uybadin Plan was approved for Ankara with the objective of establishing a dense and uniform urban structure. However, in the 1970s, there was an increase in land values, a worsening of air pollution and a decrease in the number of available land parcels, which resulted in the city expanding beyond its original boundaries. In order to address these issues, the Metropolitan Area Master Plan Bureau initiated the formulation of the 1990 Ankara Master Plan in 1969, adopting a flexible and dynamic approach (Ankara Metropolitan Municipality, 2006).

The 'Ankara 2015' study, conducted in 1986, informed the selection of sites for public institutions, transportation organization, infrastructure systems, land prices, and industrial sites. This resulted in the advent of multi-story and detached housing in the suburbs of the city. The 2023 Capital Ankara Master Plan, based on the 'Metropolitan Municipality Law' enacted in 2004, categories public housing into various types, including entrance-controlled housing areas, housing integrated with or separate from shopping centers, and housing for high and low-income households. In addition, various forms of transformation and housing provision have emerged, including slum area transformations, earthquake-resistant transformations, and gentrification-induced housing areas (Tekeli, 2010).

Development of Urban Planning in Demetevler and İşçi Blokları Neighborhoods

The Demetevler neighborhood is situated in the Yenimahalle district of the Ankara province, to the north-west of the city center. The area of the neighborhood is approximately 87 hectares. The neighborhood is characterized by a narrow-street construction pattern, with houses situated directly on the street frontage and lacking gardens. The İşçi Blokları neighborhood is situated in the Çankaya district of Ankara, to the southwest of the city center. The neighborhood has an area of approximately 165 hectares and is characterized by housing estates situated near commercial centers.

The İşçi Blokları housing complex in Ankara, Turkey, was constructed in 1965 by the Ankara Confederation of Trade Unions Members Cooperative. The original intention was to provide affordable housing for low-income worker families. Over time, the complex expanded, and the Worker Blocks were established in 1973. The construction of these buildings involved the use of reinforced concrete and brick infill material. The housing complex is notable for the social amenities it offers, including a park, school, service buildings, and market. The Worker Blocks were initially situated at a considerable distance from the city center, near the METU campus. The complex has historically been inhabited by low-income working families and students from METU. However, in 2013, the construction of a road connecting Anadolu Boulevard and Konya Road through the METU estate led to increased attention being paid to the neighborhood. This, in turn, resulted in higher rental prices as the city expanded westward (Köse, 2019).

The history of the Yenimahalle district in Ankara, Turkey, can be traced back to 1925, when Atatürk established the Atatürk Forest Farm with the objective of improving the barren lands in the area. The district center was established in 1957 and subsequently became an independent municipality in 1984. The Demetevler area, which originated as an informal settlement in the 1960s, has undergone a significant physical transformation following the construction of apartment buildings in the post-1980s period. However, the neighborhood is confronted with a distinctive zoning issue that has yet to be entirely resolved, which has led to the emergence of illegally constructed squatter apartment buildings. Because of the absence of supervision, these buildings have reached a height of 13 floors and comprise 80–90 flats. They have been registered as fields for a period of 30 years. During the 1980s and 1990s, Demetevler evolved into a residential area for modest-income civil servants. However, with their subsequent relocation to other residential areas, a new demographic emerged (Hatipoğlu, 2008). The neighborhood is distinguished by its narrow streets, high-rise apartment buildings, and numerous structures erected in contravention of planning regulations, which were subsequently regularized through amnesty (Yenimahalle Kaymakamlığı, 2024).

The selected indicators are analyzed through fieldwork in these two neighborhoods. Information on verbal issues such as access to infrastructure facilities and risk history of the neighborhood is obtained through short interviews with neighborhood mukhtars. Information on the existing spatial and environmental characteristics of the neighborhoods is obtained through observation. Following the field study, the data are processed on the ArcGIS program and the analysis studies are completed.

Following the field study, a comparison is made between the spatial and environmental resilience levels of the two neighborhoods. Each indicator is evaluated using a quantitative metric measurement method, with the results indicating the level of resilience. The indicators are ranked on a scale of 1 to 5 using the quantitative metric measurement method. A value of 1 indicates a very poor level of resilience, 2 represents a poor level, 3 signifies an average level, 4 denotes a good level, and finally, 5 represents an excellent level of resilience. The Quantitative Metric Measurement Method, employed in the CRI study, entails the assessment of each indicator through the calculation of an average value. The resilience representations obtained for each neighborhood show the position and color of each value, indicating the corresponding score on a scale ranging from 'very poor' to 'excellent' (ARUP & Rockefeller Foundation, 2016).

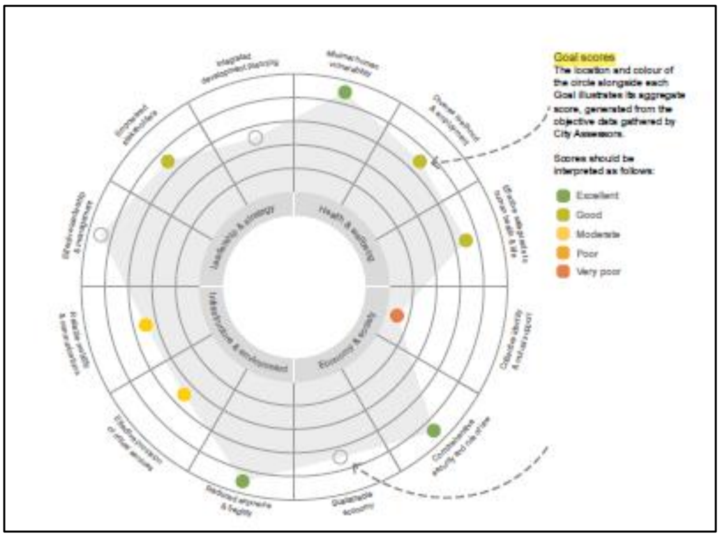

Figure 3.4. Quantitative Resilience Profile (ARUP & Rockefeller Foundation, 2016)

CHAPTER 4

SPATIAL AND ENVIRONMENTAL INDEX DEVELOPMENT FOR DEMETEVLER AND İŞÇİ BLOKLARI NEIGHBORHOODS

The indicators selected from the literature are evaluated by experts according to their importance at the neighborhood scale using a expert survey. This process resulted in the creation of a spatial-environmental assessment index at the neighborhood scale. This section presents the results of the expert surveys in detail. Subsequently, the resilience index is subjected to an empirical evaluation through an analysis of the neighborhood-scale index in a selection of field studies. The chapter concludes with a comprehensive evaluation of the results.

4.1 Results

The results of the survey, conducted in accordance with the indicators selected from the literature, the expert profiles, the rating ratios assigned to the indicators and the results obtained from the experts regarding the indicator suggestions that may be incorporated into the index, are presented herein. Furthermore, the details and results of the analysis studies conducted in the İşçi Blokları and Demetevler neighborhoods are also included under the title.

4.1.1 Expert Survey Results

In order to create an assessment index to evaluate environmental and spatial urban resilience at the neighborhood level, a survey is prepared and conducted with urban planners within the scope of the thesis. The survey includes questions that assess the importance of environmental and spatial indicators at the neighborhood scale. These indicators have been collated following an examination of existing urban resilience indices at various scales.

The survey comprises four sections and a total of six questions. The initial section of the survey requested information regarding the respondents' professional background, including their sector of employment, experience, and tenure in the field of urban resilience. The second and third sections inquire as to the significance of environmental and spatial resilience indicators at varying scales in the existing literature regarding measuring neighborhood resilience. The experts are requested to assign a ranking to the sub-indicators related to spatial and environmental resilience on a Likert scale. The respondents are invited to indicate the importance of the various indicators on a five-point Likert scale, with the following options: "not important," "slightly important," "important," "very important," and "critical." The responses assist in the identification of the most significant indicators, which are subsequently prioritized for the measurement of neighborhood resilience. Furthermore, at the end of the survey, experts are invited to suggest alternative resilience indicators that they believe are important for measuring resilience at the neighborhood level. A question is asked in an open-ended format for these additional suggestions.

The survey, which is approved by the Middle East Technical University Ethics Committee, is designed for urban planners as the thesis is a study focusing on the concept of ‘resilient urban planning’. The survey is conducted through face-to-face interviews with 50 urban planners working in the field of urban planning in the public, private and university sectors. A series of brief interviews is conducted over a period of 15 days with experts in urban planning employed in private planning offices, faculty members in universities, and experts in urban planning working in public institutions and organizations, including metropolitan and district municipalities.

Of the 50 urban planners who contributed to the study, 50% are employed in the private sector, 32% in the public sector and 18% in universities. The participants are requested to indicate the length of their professional careers. Forty percent of the participants have been in their current position for a period of between two and five years, 24 percent for a period of between six and ten years, 14 percent for a period of between 11 and 15 years, 14 percent for a period of between 16 and 20 years, and only 8 percent for a period of more than 20 years. The fact that 46 per cent of the 50 urban planners have never worked in the field of resilience, while 54 per cent have worked between 0 and 15 years, provides a robust foundation for the survey results.

A. Spatial Resilience Indicators

The term 'spatial resilience' is used to describe the ability of a city and its associated infrastructure to withstand and recover from disruptive events. This encompasses the resilience of the physical and spatial aspects of the city, as well as the man-made infrastructure, including buildings, energy networks and basic needs networks, that are integral to the functioning of the system.

In response to second question of the expert survey study, participants are asked to rate the importance of each of the following spatial features in making the neighborhood more resilient. The rating scale ranges from 1 (not important) to 5 (critical). The experts are asked to rank the 9 main indicators and 21 sub-indicators from the existing literature according to their importance.

Indicator A.1-Land Use and Diversity

Two sub-indicators, namely ‘A.1.1 – Diversity of uses in the city’ and ‘A.1.2 – Sufficient open space and ease of access’, are included in the ranking of the first main indicator. The indicator illustrating the diversity of uses in urban areas demonstrates that essential functions such as commerce, education and healthcare, which can be situated within the neighborhood in accordance with the principles of resilience. This distribution of facilities ensures that residents have access to the necessary services without the need to travel outside the neighborhood. In contrast, the sub-indicator indicating adequate open spaces and ease of access to these spaces can be stated to be of importance for urban resilience and the welfare level within the neighborhood, as areas that can serve as gathering and interaction areas for neighborhoods are of significant value in this regard.

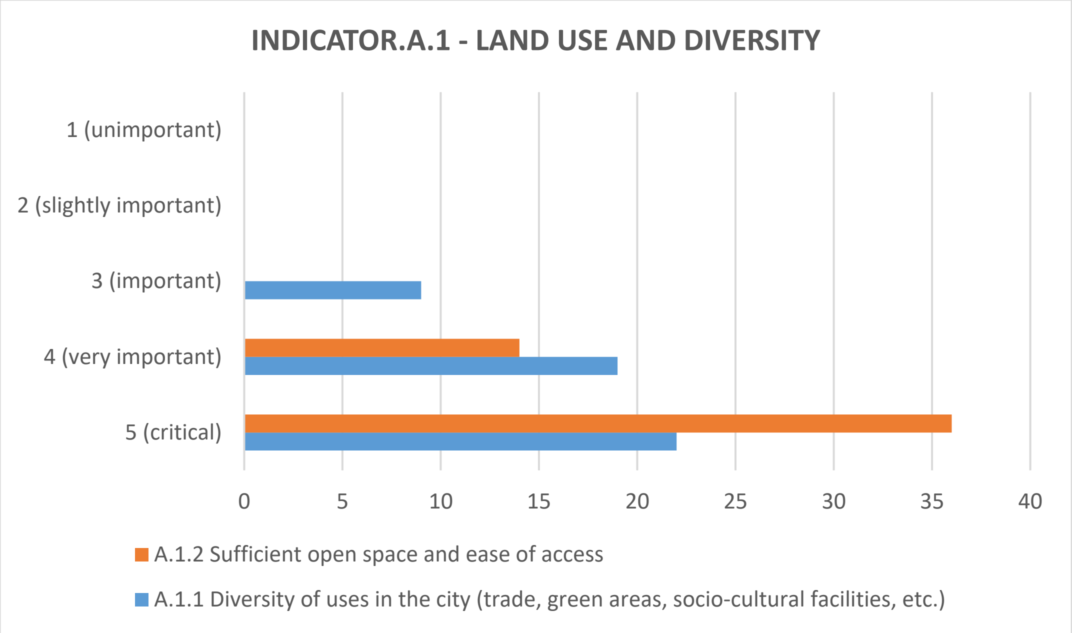

Figure 4.1. Expert Survey Results of A.1 Indicator

The results of A.1.1 demonstrate that more than 80% of experts assigned a rating of 4 (very important) and 5 (critical) to the sub-indicator, indicating its importance. The results of A.1.2 demonstrate that 72% of experts consider the indicator to be of critical importance (rating 5), while the remaining 28% consider it to be of very high importance (rating 4). Considering these findings, it can be concluded that the average value of the primary indicator, A.1, is of critical importance in ensuring spatial resilience at the neighborhood level. This is evidenced by the fact that the average value of A.1 is higher than the average value of all responses provided.

Table 4.1 Mean Value of A.1 Indicator

Indicators	*Mean Value*
A.1 Land Use and Diversity	**4.49**
Diversity of uses in the city (commerce, green space, socio-cultural facilities, etc.)	4.26
Sufficient open space and ease of access	4.72

Indicator A.2-Walkability and Street Connectivity

Two sub-indicators, namely 'A.2.1 – Connectivity, quality and comfort of pedestrian roads' and 'A.2.2 – Connectivity, quality and comfort of cycle paths', are listed under the second main indicator. The walkability of roads is of great importance to residents at the neighborhood scale, as is cycling, which represents an alternative and sustainable transportation method for shorter distances. These factors are also indicative of resilience at the neighborhood scale. This primary indicator pertains to the characteristics of resilience, namely its capacity to adapt, robustness, resourcefulness, diversity, and inclusiveness.

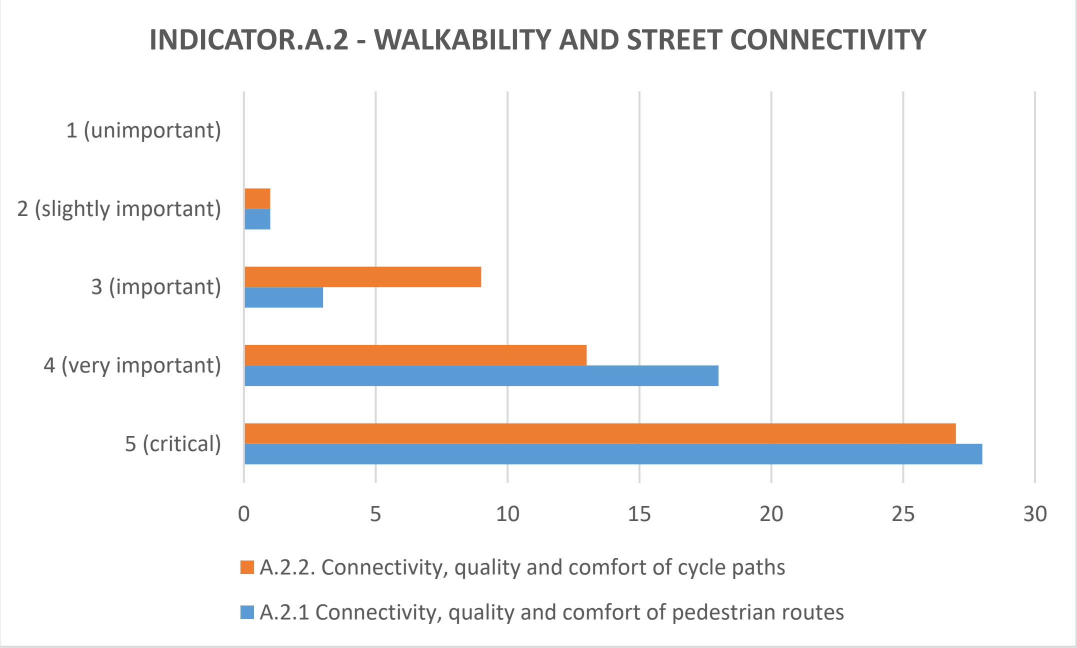

Figure 4.2. Expert Survey Results of A.2 Indicator

The results of A.2.1 indicate that over 90% of experts assigned a rating of 4 (very important) and 5 (critical) to the sub-indicator, while 80% of experts gave a rating of same to the A.2.2. In light of these findings, it can be concluded that the value of the main indicator A.2 is above the average value of all responses so, the indicator has critical importance for ensuring spatial resilience in the neighborhood.

Table 4.2 Mean Value of A.2 Indicator

Indicators	*Mean Value*
A.2 Walkability and Street Connectivity	**4.39**
Connectivity, quality and comfort of pedestrian routes	4.46
Connectivity, quality and comfort of cycle paths	4.32

Indicator A.3-Ease of Access to Roads and Transport Nodes

The third main indicator includes the following sub-indicators: 'A.3.1 Topographically adequate road design', 'A.3.2 Ease of access to the road in case of emergency' and 'A.3.3 Equal ease of access to public transport stops'. The availability of rapid access to transport systems and the road in the event of an emergency represents an indicator that ensures resilience at the urban scale. This principal indicator pertains to the acceptance of uncertainty and change, as well as the adaptive and robust characteristics inherent to resilience.

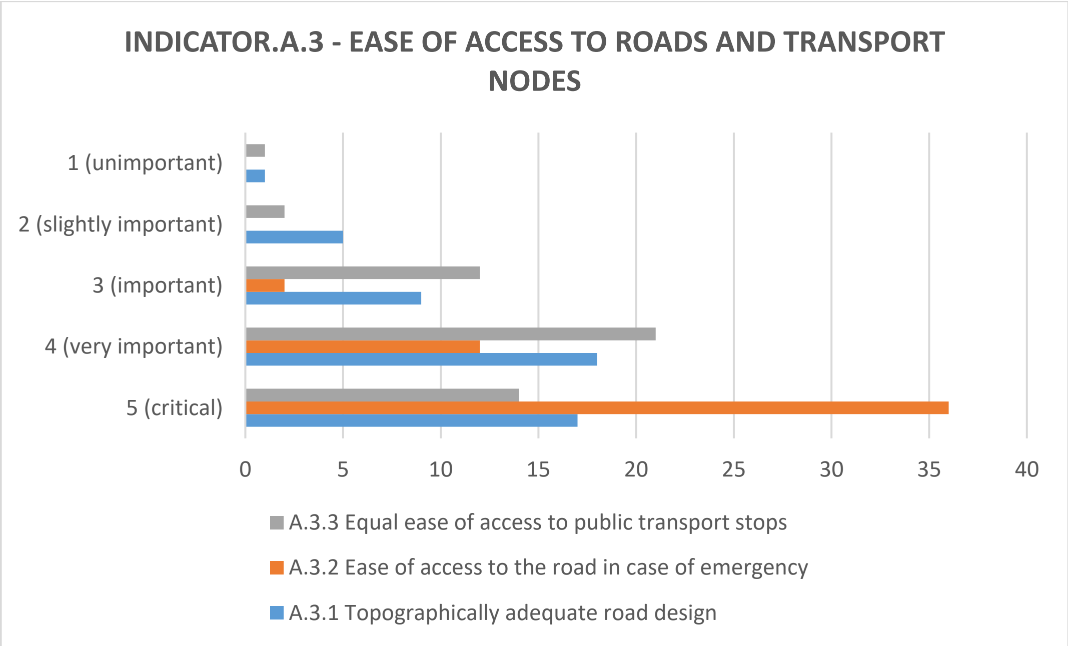

Figure 4.3. Expert Survey Results of A.3 Indicator

The results of A.3.1 indicate that 34% of experts consider the sub-indicator to be critically important, while the results of A.3.3 show that 28% of experts view it in the same light. A.3.2 is regarded as a value that should be measured on a neighborhood scale, with 72% of experts deeming it to be critically important, which represents a high average value.

Table 4.3 Mean Value of A.3 Indicator

Indicators	*Mean Value*
A.3 Ease of Access to Roads and Transport Nodes	**4.16**
Topographically appropriate road design (slope, etc.)	3.90
Ease of access to the road in case of emergency	4.68
Equal ease of access to public transport stops	3.90

Indicator A.4-Alternative Routes and Transport Options

Two sub-indicators, 'A.4.1-Alternative routes to emergency and basic facilities' and 'A.4.2-Sufficient public transport options', are specified under the fourth main indicator. The provision of alternative transport options and routes to emergency services, particularly in the event of an emergency within the city, will enhance the responsiveness of urban systems to potential risks. This main indicator pertains to the characteristics of resilience, which may be defined as follows: the capacity to accept uncertainty and change; robustness; resourcefulness; integration; diversity; and inclusion.

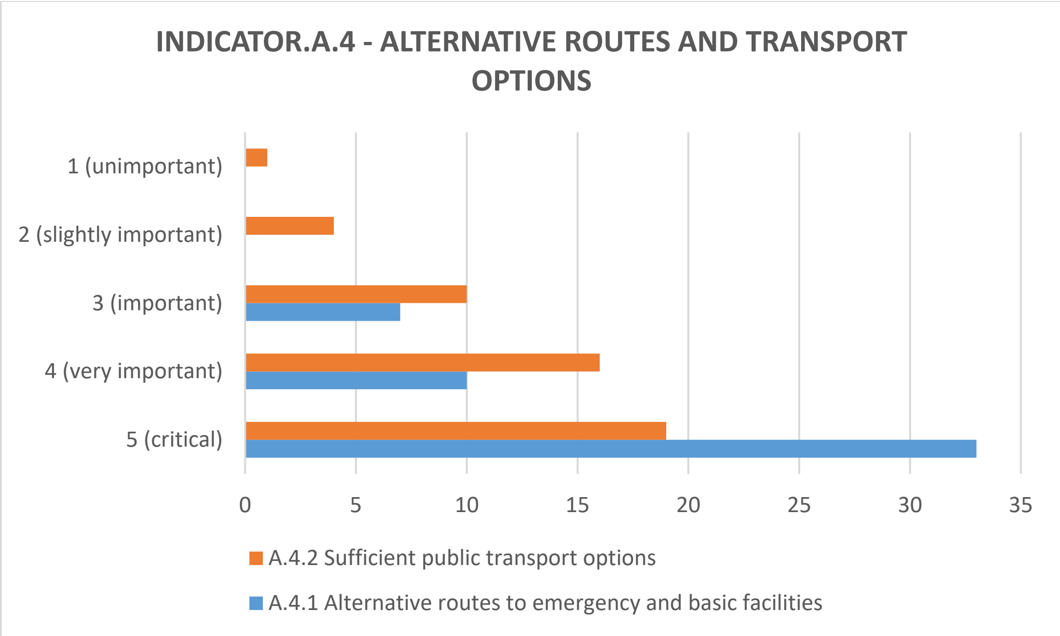

Figure 4.4. Expert Survey Results of A.4 Indicator

The results of A.4.1 indicate that 66% of experts consider this sub-indicator to be of critical importance, whereas in A.4.2 only 38% of experts consider this indicator to be of critical importance. It can thus be concluded that only sub-indicator A.4.1 is considered an indicator with a high average value and should be measured on a neighborhood scale.

Table 4.4 Mean Value of A.4 Indicator

Indicators	*Mean Value*
A.4 Alternative Routes and Transport Options	**4.24**
Alternative routes to emergency and basic facilities	4.52
Sufficient public transport options	3.96

Indicator A.5-Access to Basic Facilities

Two sub-indicators, namely ‘A.5.1 – Equal access to green infrastructure, education, socio-cultural and religious facilities’ and ‘A.5.2 – Equal access to all emergency uses’, are delineated under the fifth main indicator. It is significant that the citizens of a neighborhood need to be provided with equal access to all urban uses to continue their life. In order to optimize the level of welfare within the neighborhood, urban facilities that require daily use and emergency centers should be planned in a manner that ensures their accessibility to all residents. This can be achieved by situating these facilities in locations that are equidistant and accessible within an equal time frame for all members of the neighborhood. This main indicator pertains to the reflective, robust, diverse and inclusive characteristics of resilience.

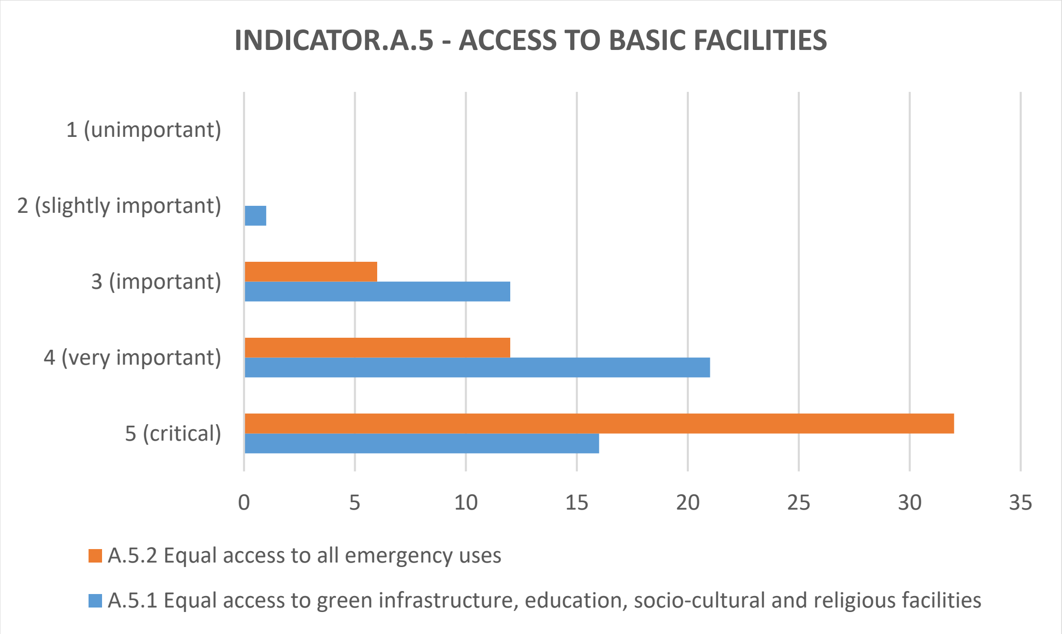

Figure 4.5. Expert Survey Results of A.5 Indicator

The results of sub-indicators A.5.1 and A.5.2 indicate that 74% and 88% of experts, respectively, rated the indicator as critical (5) and very important (4). It can thus be concluded that these two sub-indicators are considered to be of high importance and should be measured on a neighborhood scale.

Table 4.5 Mean Value of A.5 Indicator

Indicators	*Mean Value*
A.5 Access to Basic Facilities	**4.28**
Equal access to green infrastructure, educational, socio-cultural, religious facilities	4.04
Equal access to all emergency uses	4.52

Indicator A.6-Built-up Area Quality and Density

The sixth main indicator is comprised of three sub-indicators: ‘A.6.1-Density of built-up area’, ‘A.6.2-Physical characteristics of the building’ and ‘A.6.3-Housing type, number of houses with garden’. The increasing dominance of construction in urban layouts, relative to green and open spaces, is regarded as a further factor that diminishes resilience in cities. It is therefore important to monitor building density and the characteristics of built-up areas to ensure the provision of sufficient housing and equipment areas for the existing population, while also protecting green and open spaces.

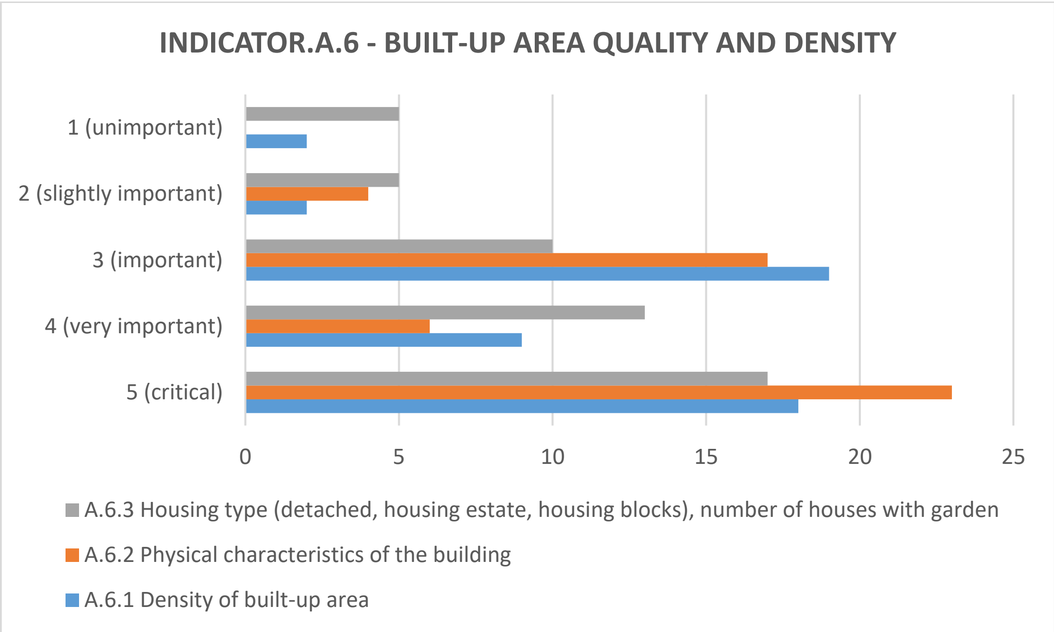

Figure 4.6. Expert Survey Results of A.6 Indicator

Considering the expert opinions, it becomes evident that the degree of importance attributed to the three sub-indicators, which are rated as critical (5) in the survey, falls below 50 per cent. Most experts indicated that these sub-indicators would not be critical in ensuring resilience at the neighborhood scale. Consequently, the low mean value of these three sub-indicators indicates that they should not be among the indicators to be measured at the neighborhood scale.

Table 4.6 Mean Value of A.6 Indicator

Indicators	*Mean Value*
A.6 Built-Up Area Quality and Density	**3.79**
Density of built-up area	3.78
Physical characteristics of the building	3.96
Housing type, number of houses with gardens	3.64

Indicator A.7-Access to Energy Efficiency

The seventh main indicator is subdivided into three sub-indicators, namely 'A.7.1 Buildings with shaded south/west facades', 'A.7.2 Presence of renewable energy resources' and 'A.7.3 Energy-efficient traffic and streetlights'. One of the most crucial factors in guaranteeing resilience and sustainability in urban environments is the incorporation of elements and strategies that ensure energy efficiency into the city itself. It is feasible to ensure energy efficiency at the neighborhood scale by orienting buildings and incorporating renewable energy sources, such as solar panels, into neighborhood infrastructure.

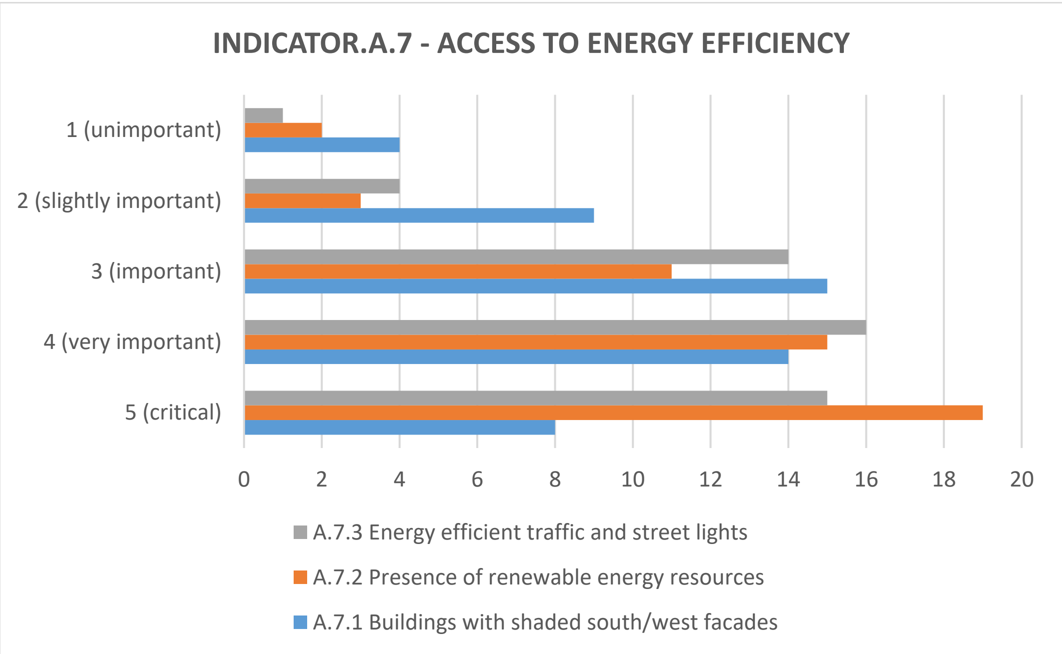

Figure 4.7. Expert Survey Results of A.7 Indicator

In the survey, the degree of importance of the three sub-indicators as critical (5) is found to be below 40% by the experts. The majority of experts concurred that these sub-indicators would not be pivotal in ensuring resilience at the neighborhood scale. Therefore, the relatively low mean value of these three sub-indicators implies that they should not be included within the set of variables to be measured at the neighborhood scale.

Table 4.7 Mean Value of A.7 Indicator

Indicators	*Mean Value*
A.7 Access to Energy Efficiency	**3.66**
Buildings with shaded south/west facades	3.26
Presence of renewable energy sources	3.92
Energy-efficient traffic and streetlights	3.80

Indicator A.8-Waste Management and Recycling

In accordance with the eighth main indicator, two sub-indicators have been identified, namely 'A.8.1- Number of waste recycling centers and collection vehicles' and 'A.8.2-Collection methods for building waste'. The effective management of waste collection and recycling is a key factor in enhancing the cleanliness, resilience and sustainability of urban areas, which in turn contributes to the overall prosperity of cities. It is of significant importance to develop and effectively implement strategies for resilient waste management at all levels of urban governance.

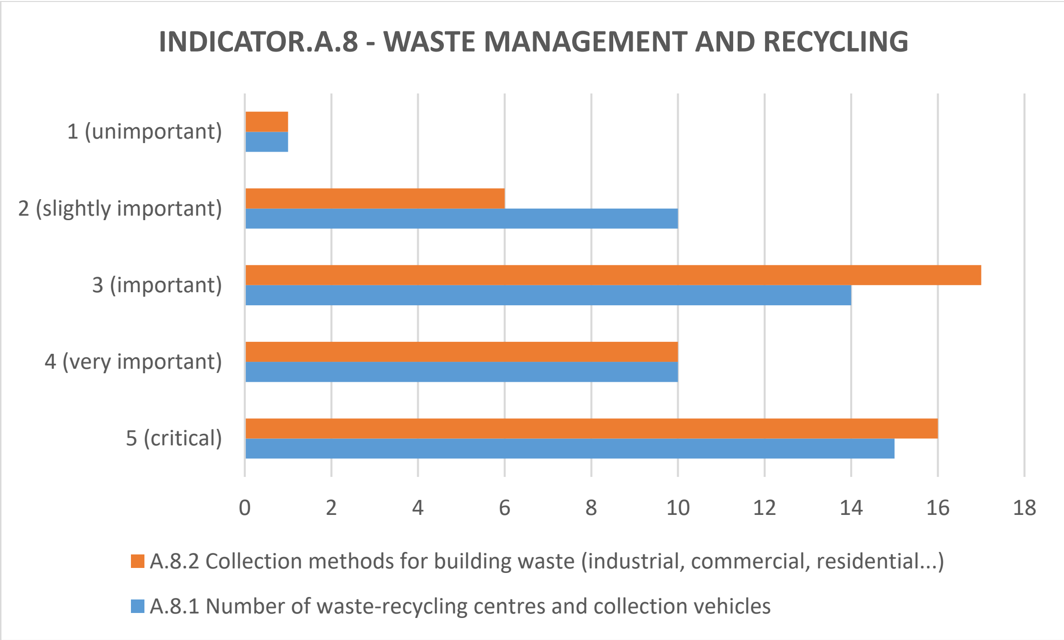

Figure 4.8. Expert Survey Results of A.8 Indicator

In the view of the experts, the two sub-indicators are considered to be of critical importance (rating of 5) by less than 35 per cent of the experts. Most of the experts stated that these sub-indicators would not be critical for ensuring resilience at the neighborhood scale. Thus, the low average value of these two sub-indicators means that they should not be among those measured at the neighborhood scale.

Table 4.8 Mean Value of A.8 Indicator

Indicators	*Mean Value*
A.8 Waste Management and Recycling	**3.62**
Number of waste-recycling centers and collection vehicles	3.56
Collection methods for building waste	3.68

<u>Indicator A.9-Access to Flexible Structure</u>

At the conclusion of the assessment process, two sub-indicators are identified under the ninth main indicator. The first of these is entitled ‘A.9.1 - Equal access to safe and sustainable drinking water, effective sanitation and electricity’ and the second is entitled ‘A.9.2 - Having backup plans in case of any interruption in existing infrastructure systems'. The equal and safe access to essential infrastructure facilities, including clean drinking water, electricity and sewerage, is a fundamental aspect of urban resilience. The existence of a robust backup plan for the recovery of this infrastructure, which may be interrupted in the event of any risk that the city may face, is also a crucial element in this context.

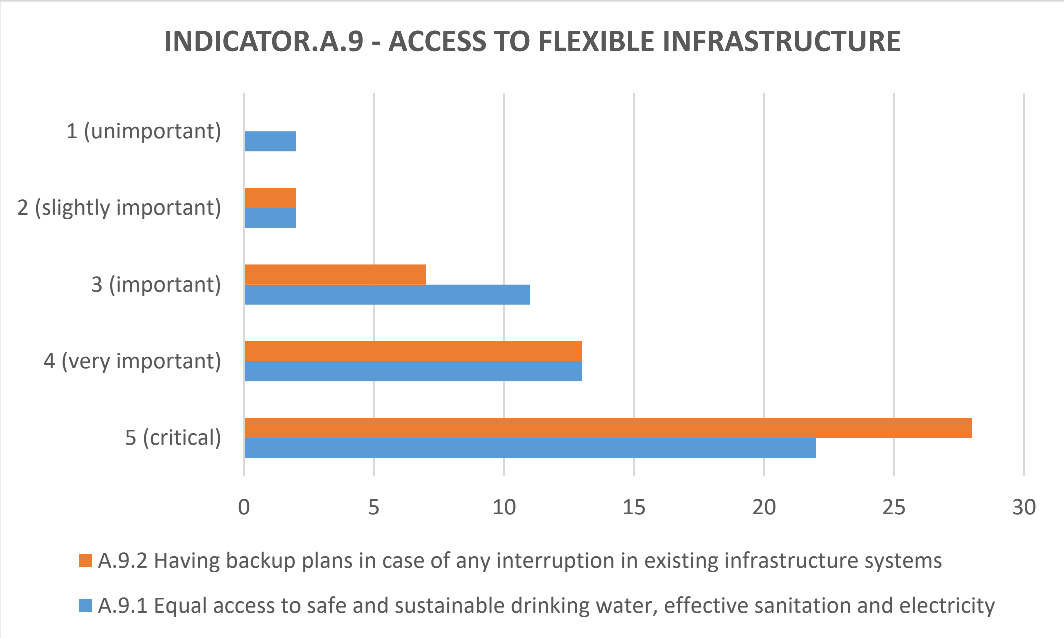

Figure 4.9. Expert Survey Results of A.9 Indicator

As evidenced by the expert opinions, the two sub-indicators are deemed critical (5) and very important (4) by over 70% of the experts. The majority of experts indicated that these sub-indicators are critical for ensuring resilience at the neighborhood scale. Experts rate the A.9.1 indicator as "critical" with percentage of 44, and the A.9.2 indicator as same with percentage of 56. It can thus be concluded that these two sub-indicators are among those that should be measured at the neighborhood scale, given their high average values.

Table 4.9 Mean Value of A.9 Indicator

Indicators	*Mean Value*
A.9 Access to Flexible Infrastructure	**4.18**
Equal access to safe and sustainable drinking water, effective sanitation and electricity	4.02
Having backup plans in case of any disruption to existing infrastructure systems	4.34

B. Environmental Resilience Indicators

The concept of environmental resilience can be defined as the capacity of an urban system to withstand and adapt to environmental pressures. This entails the implementation of strategies that safeguard the environmental integrity of the city, including the conservation of natural areas and ecosystems within and surrounding the urban landscape, the preservation of ecological balance, the promotion of biodiversity, and the mitigation of environmental pollution. These measures are crucial to ensure the resilience of the urban environment in the face of the challenges posed by rapid urbanization.

In response to the third question of the expert survey, respondents are requested to indicate the relative importance of each of the following environmental indicators in enhancing the resilience of the neighborhood. The rating scale employed ranged from 1 (indicating that the feature in question is deemed to be of minimal importance) to 5 (indicating that it is of critical importance). The experts are requested to rank the eight principal indicators and the 23 sub-indicators, as identified in the existing literature.

Indicator B.1-Green Area Density

The initial principal indicator of environmental resilience is comprised of two sub-indicators. The aforementioned indicators are "B.1.1 Green area density" and "B.1.2 Vegetation around buildings and building entrances." In the contemporary era, neighborhoods that do not have a certain size and density of buildings are vulnerable due to the lack of green space. The presence of parks, open spaces, and, at the smallest scale, the gardens of buildings, as well as trees on pavements, provides a vital opportunity for residents to relax and enjoy shaded outdoor areas within their neighborhoods. This key indicator is concerned with the acceptance of uncertainty and change, as well as the adaptability, robustness, integration and inclusion that are inherent in resilience.

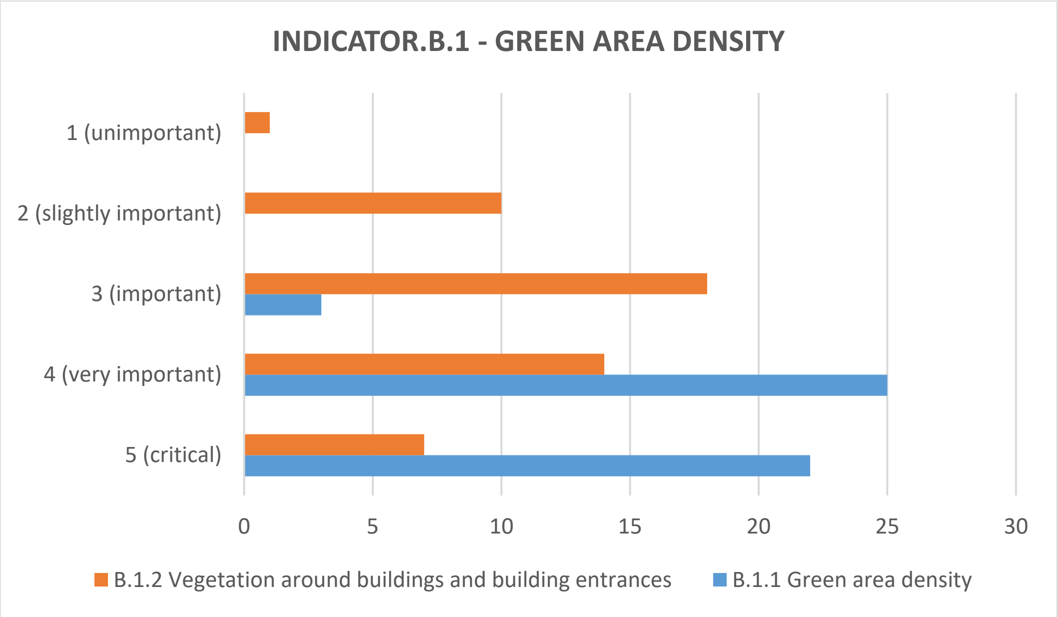

Figure 4.10. Expert Survey Results of B.1 Indicator

In regard to the responses to indicator B.1.1, 44% of respondents indicated that the indicator is significant in the formation of resilient neighborhoods. However, about indicator B.1.2, which refers to the significance of greenery clusters situated in front of buildings, only 14% of respondents indicated that this is a critical factor. The mean values obtained indicate that indicator B.1.1 will be included in the measurement index to be created for the neighborhood.

Table 4.10 Mean Value of B.1 Indicator

Indicators	*Mean Value*
B.1 Green Area Density	**3.88**
Density of green space	4.38
Vegetation around buildings and building entrances	3.38

Indicator B.2-Green Area Continuity

The second main indicator of environmental resilience is constituted by two sub-indicators. The two indicators in question are "B.2.1 Continuity of green areas" and "B.2.2 Ease of access to green areas." At the neighborhood scale, the formation of a healthy community mentality is contingent upon the availability of green spaces within walking distance of residents' homes, which affords them the opportunity to engage in social, sporting and recreational activities. It is therefore important to ensure the adequate provision and continuity of green areas, particularly at the neighborhood scale, in order to maintain the green continuity of the city and even the region. This core indicator relates to the acceptance of uncertainty and change, which are characteristics of resilience, as well as the adaptability, robustness and inclusiveness inherent in resilience.

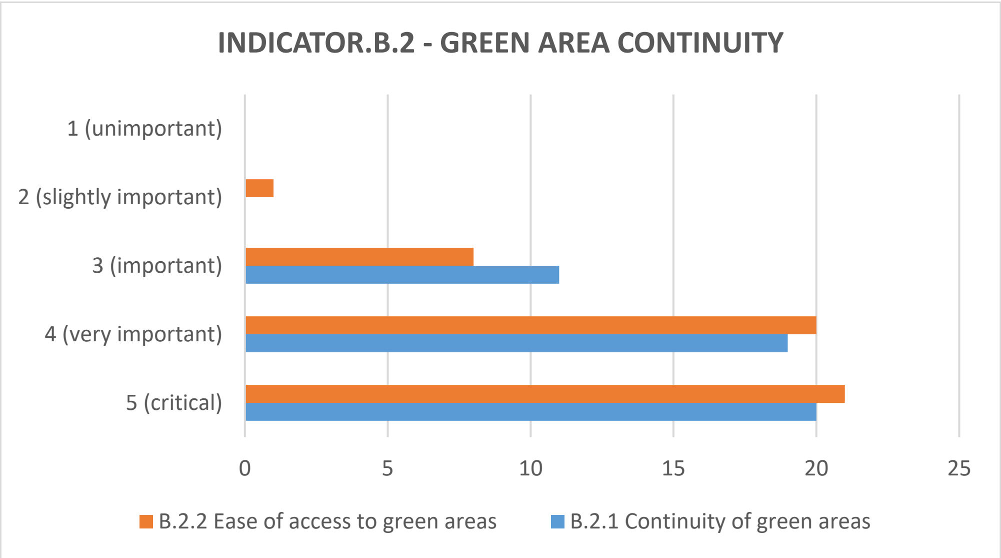

Figure 4.11. Expert Survey Results of B.2 Indicator

An analysis of the responses to both indicators B.2.1 and B.2.2 reveals that 40% of respondents consider these indicators to be significant in the formation of resilient neighborhoods. The mean values obtained suggest that the sub-indicators of B.2 will be incorporated into the index to be developed at the neighborhood level.

Table 4.11 Mean Value of B.2 Indicator

Indicators	*Mean Value*
B.2 Green Area Continuity	**4.20**
Continuity of green areas	4.18
Ease of access to green areas	4.22

Indicator B.3-Green Area Diversity

'Green area diversity', the third main indicator of environmental resilience, has two sub-indicators, namely "B.3.1 Green area diversity" and "B.3.2 Biodiversity conservation". Including different green area uses and their continuity within the neighborhood and protecting biodiversity create a resilient environment against risk situations. This core indicator relates to the acceptance of uncertainty and change, robustness, resourcefulness and diversity inherent in resilience.

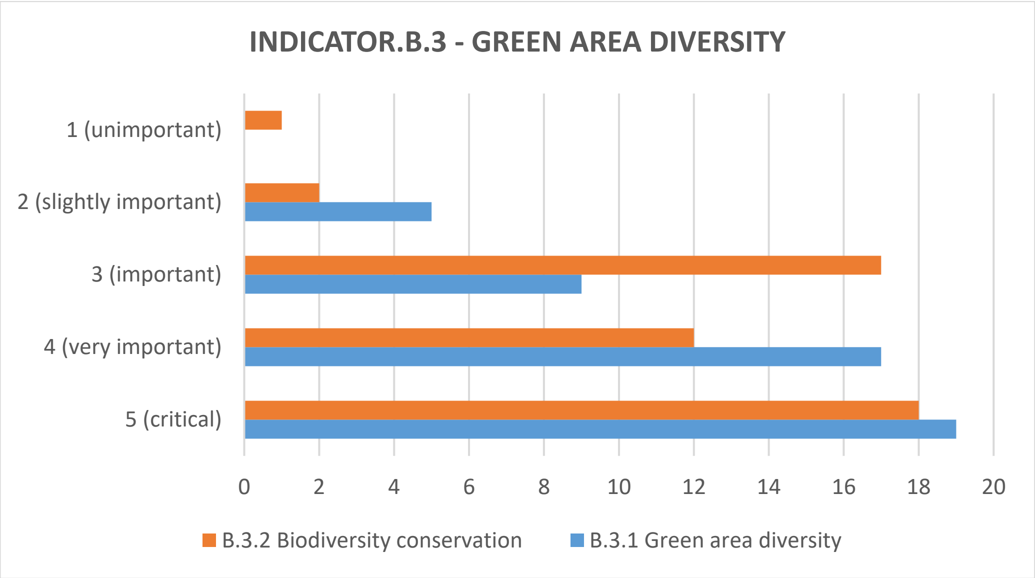

Figure 4.12. Expert Survey Results of B.3 Indicator

While the two sub-indicators exhibit a high degree of correlation in terms of their critical importance, the value assigned to indicator B.3.2 is deemed to be below average, resulting in its categorization as unimportant. In contrast, B.3.1 remained above the average and is included in the study as an environmental indicator that should be measured at the neighborhood scale.

Table 4.12 Mean Value of B.3 Indicator

Indicators	*Mean Value*
B.3 Green Area Diversity	**3.94**
Green area diversity	4.00
Conservation of biodiversity	3.88

Indicator B.4-Conservation of Soil Drainage and Natural Wetlands

The fourth core indicator of environmental resilience is comprised of two sub-indicators: 'B.4.1 Ratio of grey-green infrastructure' and 'B.4.2 Presence of permeable pavements, bioswales, rainwater harvesting systems, green roofs'. In rapidly urbanizing cities where the expansion of concrete infrastructure is a necessity to accommodate growing populations, it is crucial to implement measures to safeguard soil and natural areas at the local level. The objective of these systems is to safeguard the equilibrium between green and grey infrastructure. The former encompasses natural and green areas, whereas the latter encompasses human-made elements such as roads and buildings. In particular, the incorporation of green infrastructure, such as bioswales for rainwater drainage and the creation of green roofs on buildings, represents a crucial strategy. This core indicator is related to the capacity to accept uncertainty and change, as well as reflective, adaptive, and resourceful behavior, which are characteristics of resilience.

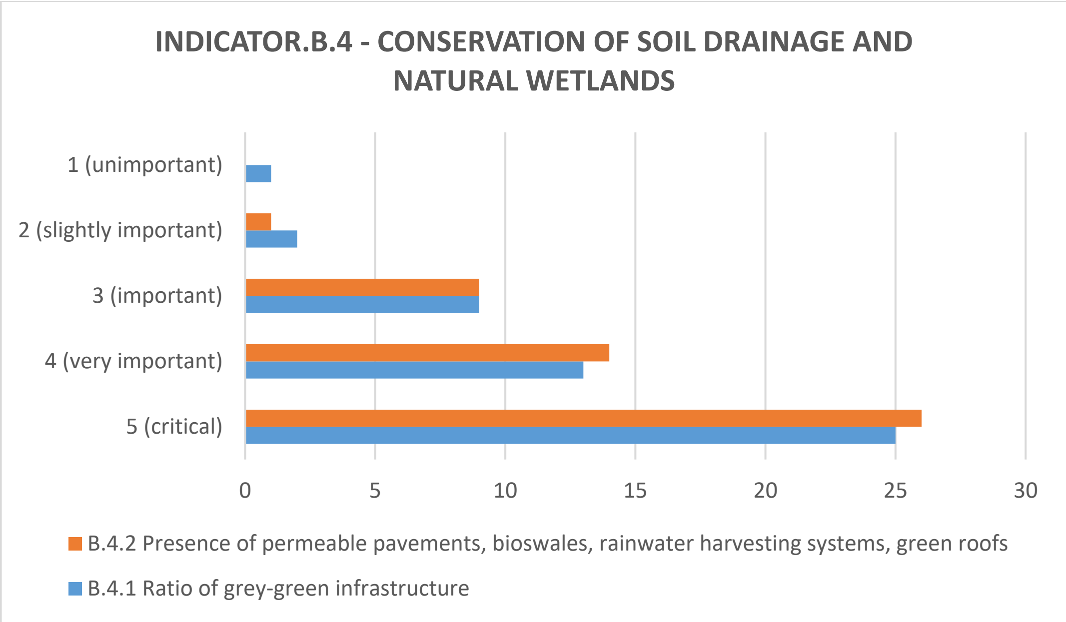

Figure 4.13. Expert Survey Results of B.4 Indicator

In this indicator, both sub-indicators are rated as of critical importance, with a value exceeding 50 per cent. The indicators remained above the average and are included in the study as environmental indicators that should be measured at the neighborhood scale.

Table 4.13 Mean Value of B.4 Indicator

Indicators	*Mean Value*
B.4 Conservation of Soil Drainage and Natural Wetlands	**4.24**
Ratio of grey-green infrastructure	4.18
Presence of permeable pavements, bioswales, rainwater harvesting systems, green roofs	4.30

Indicator B.5-Access to Safe Food

The fifth core indicator of environmental resilience comprises two sub-indicators: ‘B.5.1 Access to local farm products’ and ‘B.5.2 Presence of edible gardens’. In the contemporary era, it has become increasingly challenging to procure food that has been cultivated in a natural setting. Considering these developments, it is crucial to promote safe food-growing practices in residential and neighborhood settings, including gardens, greenhouses, pots, and other containers. Ensuring the availability of local and healthy foods in neighborhood markets is also vital for public health and a resilient, sustainable consumption pattern. This core indicator is related to the acceptance of uncertainty and change, robustness, resourcefulness, integration and inclusion, which are characteristics of resilience.

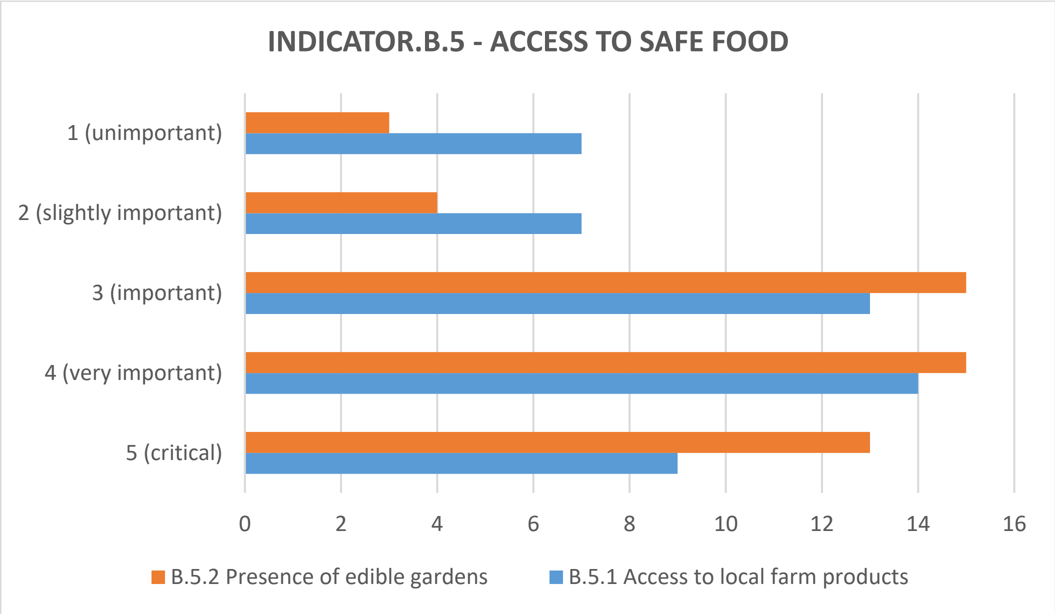

Figure 4.14. Expert Survey Results of B.5 Indicator

In this indicator, both sub-indicators are rated as critically important, with a value below 30 per cent. As a consequence of the considerable number of opinions that can be classified as unimportant or less important, the indicator is below the average and therefore not among those that should be measured at the neighborhood scale.

Table 4.14 Mean Value of B.5 Indicator

Indicators	*Mean Value*
B.5 Access to Safe Food	**3.42**
Access to local farm products	3.22
Presence of edible gardens	3.62

Indicator B.6-Heat Islands and Natural Ventilation

The sixth core indicator of environmental resilience is comprised of five sub-indicators. The initial sub-indicator, designated "B.6.1 Urban dimension and building heights," has been devised to assess the prospective impact of urban expansion and grey construction on the city in the event of a risk scenario. The second sub-indicator, 'B.6.2 Narrow streets between tall buildings', is also identified as a key area of investigation, with the aim of understanding the impact of urban design on heat of building islands and ventilation systems. The remaining three indicators, 'B.6.3 Street and pavement surfaces reflecting solar radiation', 'B.6.4 Orientation of buildings' and 'B.6.5 Green facades of buildings', must also be measured to enable the implementation of measures to mitigate the risks of climate change. The degree of solar absorption and the capacity to reflect it in the built environment is crucial for maintaining the heat of the urban island and, consequently, the surrounding environment. This core indicator pertains to the characteristics of resilience, namely acceptance of uncertainty and change, reflectiveness, adaptiveness, robustness and resourcefulness.

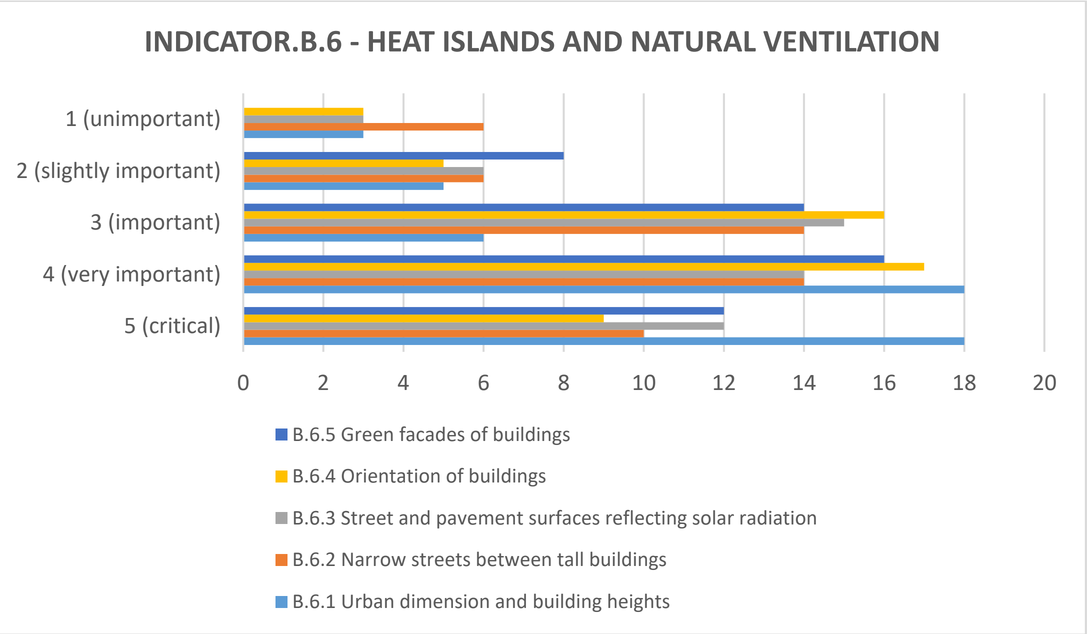

Figure 4.15. Expert Survey Results of B.6 Indicator

In this indicator, all sub-indicators have a value of less than 40 per cent and are considered by experts to be of minimal importance. Because of the prevalence of unimportant and less important opinions in the indicators, they are below the average and thus not among the environmental indicators that should be measured at the neighborhood scale.

Table 4.15 Mean Value of B.6 Indicator

Indicators	*Mean Value*
B.6 Heat Islands and Natural Ventilation	**3.56**
Urban size and building heights	3.86
Narrow streets (more shady streets) between tall buildings	3.32
Street and pavement surfaces that reflect solar radiation	3.52
Orientation of buildings	3.48
Buildings having green facades	3.64

Indicator B.7-Environmental Quality and Pollution

The seventh core indicator of environmental resilience, ‘Environmental quality and pollution’, is comprised of four sub-indicators. The following sub-indicators are thus defined: B.7.1 Air quality, B.7.2 Sufficient urban lighting to reduce light pollution, B.7.3 Waste collection frequency, and B.7.4 Soil quality. Pollution of the natural environment represents a significant risk to urban areas, with the effects of such pollution often lasting for extended periods and endangering living life. It is therefore imperative that this factor be considered as part of the concept of urban resilience. This fundamental indicator is associated with the capacity to accept uncertainty and change, as well as robustness and resourcefulness, which are essential characteristics of resilience.

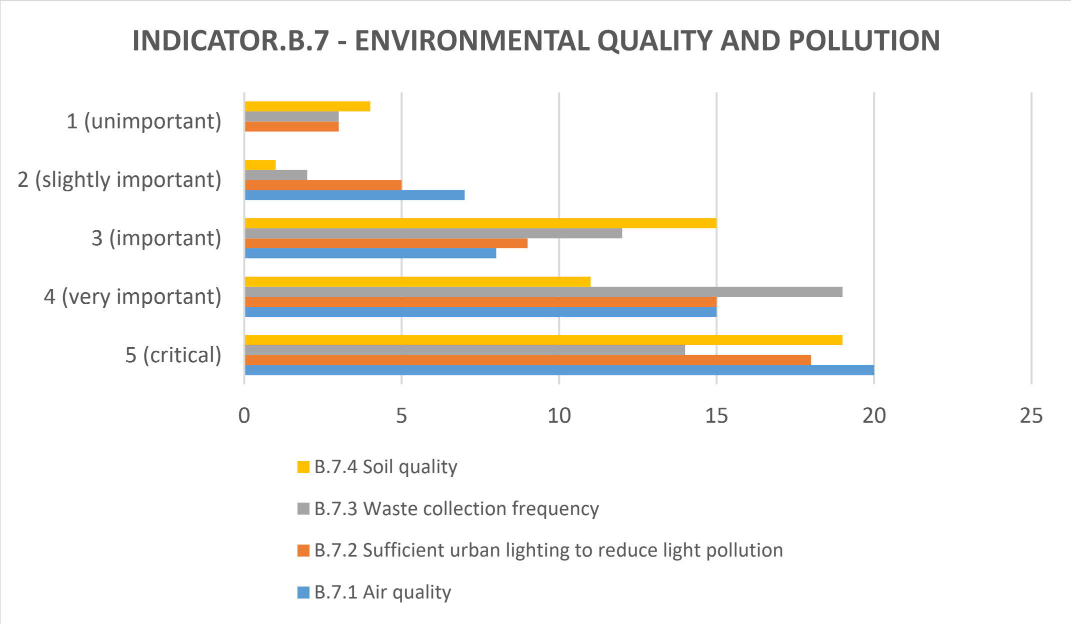

Figure 4.16. Expert Survey Results of B.7 Indicator

The high number of 'critically important' opinions for all sub-indicators, coupled with the high number of 'less important' and 'unimportant' opinions, resulted in the indicators remaining below the average value. Considering the expert opinion, indicator B.7 is not included among the environmental indicators that should be measured at the neighborhood scale.

Table 4.16 Mean Value of B.7 Indicator

Indicators	*Mean Value*
B.7 Environmental Quality and Pollution	**3.84**
Air quality	3.96
Adequate urban lighting to reduce light pollution	3.80
Frequency of waste collection	3.78
Soil quality	3.80

Indicator B.8-Vulnerability to Natural Disasters

The final core indicator of environmental resilience, ‘Vulnerability to natural disasters’, is comprised of four sub-indicators. The indicators included in this category are those that constitute a measurement method for preventing potential disaster situations and protecting the sustainability of natural areas by protecting them. The aforementioned sub-indicators are as follows: ‘B.8.1 Conservation of ecologically sensitive areas’, ‘B.8.2 Protection of steep slopes in landslide and erosion areas’, ‘B.8.3 Permeable areas and elevated entrances to prevent flooding’ and ‘B.8.4 Increasing the distance between buildings’. This core indicator is related to the acceptance of uncertainty and change, reflexivity, adaptability, robustness and resourcefulness, which are characteristics of resilience.

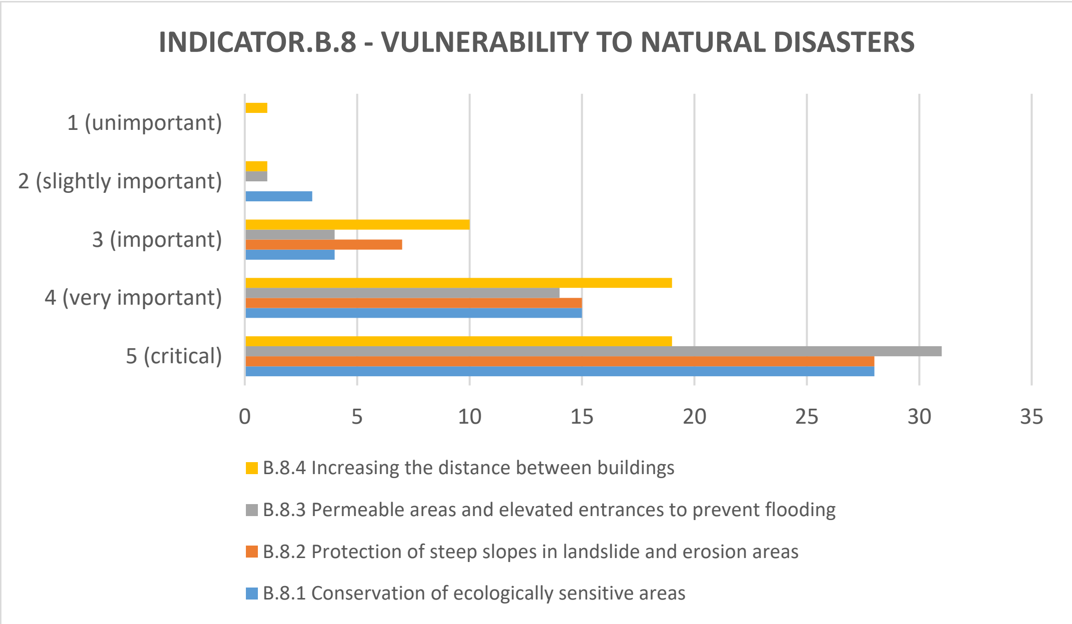

Figure 4.17. Expert Survey Results of B.8 Indicator

In this indicator, a substantial number of opinions are rated as 'critically important' or 'very important' for all sub-indicators. According to the experts, all sub-indicators are identified as environmental indicators that should be measured at the neighborhood scale.

Table 4.17 Mean Value of B.8 Indicator

Indicators	*Mean Value*
B.8 Vulnerability to Natural Disasters	**4.34**
Conservation of ecologically sensitive areas	4.36
Protection of steep slopes in landslides and erosion areas	4.42
Permeable areas and elevated entrances to prevent flooding	4.50
Increasing the distance between buildings	4.08

The expert survey concluded the spatial and environmental assessment index in the scale of neighborhood. The above-mentioned responses in second and third section of the survey that questions the importance of selected indicators from the literature are gathered in SPSS program and a mean value for all responses which is 3.98, is calculated. In the next step, mean values of responses for each sub-indicator are also calculated. The sub-indicators that have the mean value higher that 3.98 are indicated as critically important to be measured in the neighborhood. Therefore, 10 sub-indicators for each of the urban dimensions, spatial and environmental, are determined and used as the basis for field analysis to test the measurement index.

Table 4.18 Spatial and Environmental Sub-Indicators Selected Based on Expert Survey Responses

SPATIAL RESILIENCE
A.1 - Land Use and Diversity
Diversity of uses in the city (commerce, green space, socio-cultural facilities, etc.)
Sufficient open space and ease of access
A.2 Walkability and Street Connectivity
Connectivity, quality and comfort of pedestrian routes
Connectivity, quality and comfort of cycle paths
A.3 Ease of Access to Roads and Transport Nodes
Ease of access to the road in case of emergency
A.4 Alternative Routes and Transport Options
Alternative routes to emergency and basic facilities

Table 4.18 (continued)

SPATIAL RESILIENCE
A.5 Access to Basic Facilities
Equal access to green infrastructure, educational, socio-cultural, religious facilities
Equal access to all emergency uses
A.9 Access to Flexible Infrastructure
Equal access to safe and sustainable drinking water, effective sanitation and electricity
Having backup plans in case of any disruption to existing infrastructure systems
ENVIRONMENTAL RESILIENCE
B.1 Green Area Density
Density of green space
B.2 Green Area Continuity
Continuity of green areas
Ease of access to green areas
B.3 Green Area Diversity
Green area diversity
B.4 Conservation of Soil Drainage and Natural Wetlands
Ratio of grey-green infrastructure
Presence of permeable pavements, bioswales, rainwater harvesting systems, green roofs
B.8 Vulnerability to Natural Disasters
Conservation of ecologically sensitive areas
Protection of steep slopes in landslides and erosion areas
Permeable areas and elevated entrances to prevent flooding
Increasing the distance between buildings

4.1.2 Field Study Analyses

The expert survey identified 11 indicator and 20 sub-indicators as total of spatial and environmental resilience. A field study is conducted to test indicator of the created resilience assessment index in neighborhood scale. In accordance with this purpose, 20 sub-indicators are analyzed in two neighborhood that are Demetevler and İşçi

Blokları neighborhoods located in Ankara. For the purpose of comparing the resilience of both neighborhoods according to indicators determined by expert survey and mentioning the measurement and observation method used in he field study an observation sheet is created (Appendix-F).

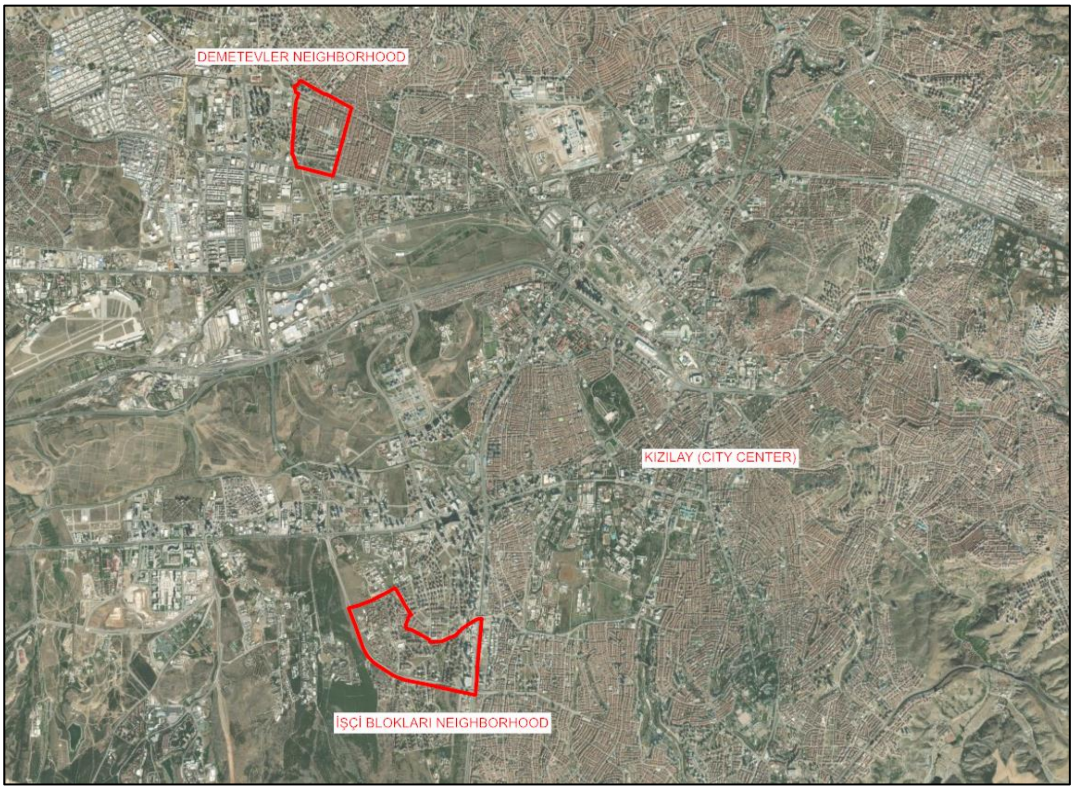

Figure 4.18. Selected Neighborhoods for Field Study

İşçi Blokları is a housing complex in Çankaya, Ankara, built in 1965 by the Ankara Confederation of Workers' Unions Members Cooperative. The cooperative initially started constructing social housing for low-income working families, but due to high demand, they expanded the area and the İşçi Blokları are established in 1973. These residential buildings are made with a reinforced concrete skeleton and brick filling material. The complex is known for its social amenities such as a park, school, service buildings, and a market. During its construction, the workers' blocks are located far from the city center, near the METU campus, and have since housed many low-income working families and METU students. However, in 2013, a road project that would connect Anadolu Boulevard and Konya Road through the METU land brought attention to the neighborhood, which now has high rental prices due to the city's westward expansion (Köse, 2019). According to the 2023 data published by the Turkish Statistical Institute (TÜİK), the population of the neighborhood is 16,869 (TÜİK, 2023).

Demetevler is a neighborhood situated within the Yenimahalle district, located in the northwestern region of the Ankara province. The area is distinguished by its narrow streets, high-rise apartment buildings, and numerous structures erected in contravention of planning regulations in the past, subsequently regularized through the granting of amnesties. The neighborhood is served by one underground railway station and two extensive public parks (Yenimahalle Kaymakamlığı, 2024). According to the 2023 data published by the Turkish Statistical Institute (TÜİK), the population of the neighborhood is 27,580 (TÜİK, 2023).

Spatial Resilience Analysis

In the neighborhood resilience assessment index, 6 indicator and 10 sub-indicators are determined for spatial resilience as shown in Table 4.18.

1- A.1 - Land Use and Diversity

The ability of the city to withstand and recover from disruptions is enhanced by the presence of diverse uses within urban areas. This facilitates the accessibility of essential equipment for residents, with many of these facilities situated within walking distance of their places of work.

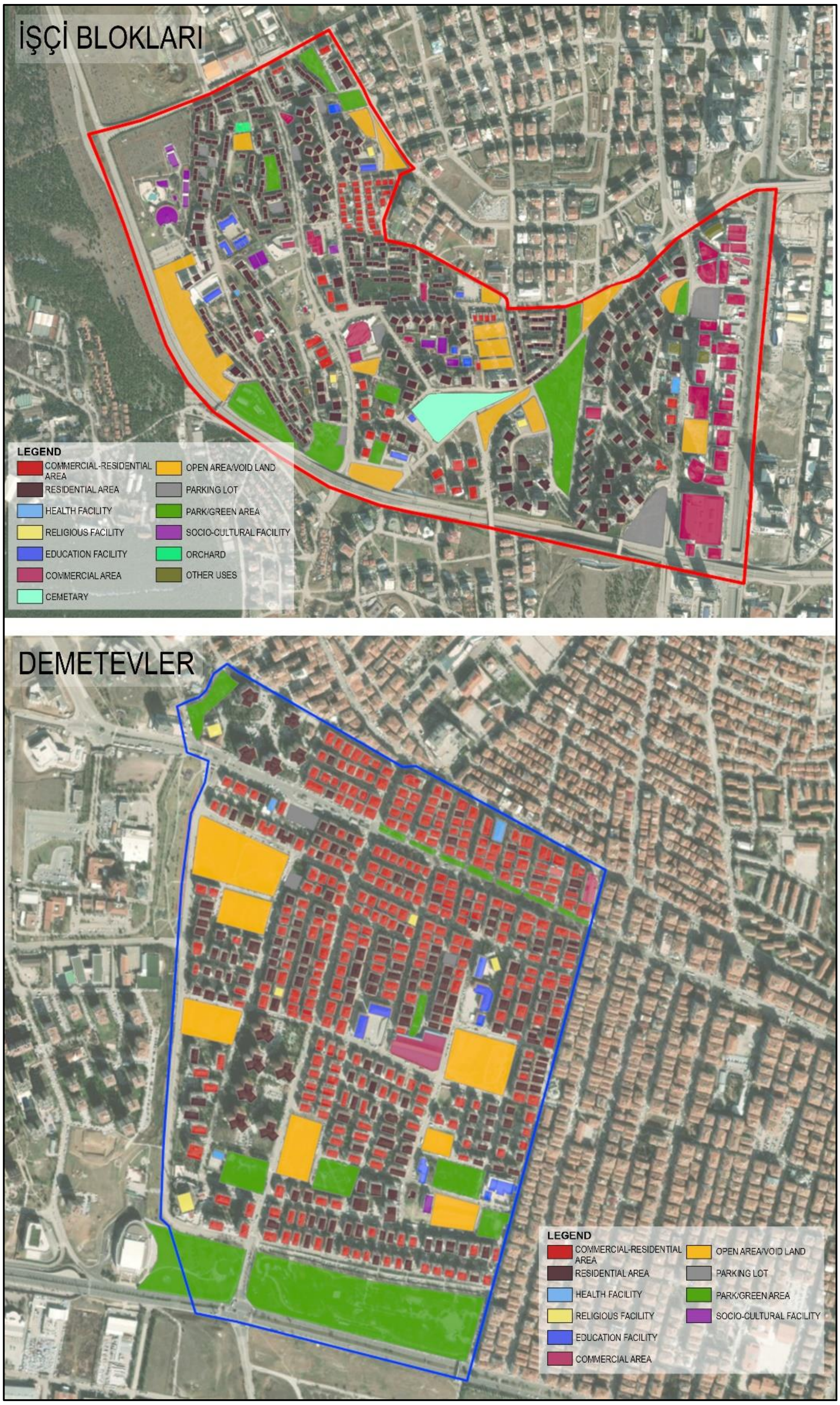

Figure 4.19. Analysis of A.1-Land Use and Diversity

The heading of spatial resilience is addressed initially through the analysis of two indicators: ‘Diversity of uses in the city’ and ‘Sufficient open space and ease of access” within the scope of land use and diversity. This analysis is conducted for both neighborhoods through observation and evaluation of available data, with the results visualized using the ArcGIS program. It can be observed that both neighborhoods demonstrate resilience with regard to land use diversity. In the Demetevler neighborhood, the diversity of uses is spread over the whole neighborhood, so the coexistence of different land and floor uses has made it more resilient than the İşçi Blokları neighborhood, where there are a variety of uses clustered in specific regions. However, the İşçi Blokları neighborhood is observed to be more resilient regarding the presence of sufficient open space.

2- A.2 – Walkability and Street Connectivity

In urban areas, the resilience of the space is enhanced by the presence of short walking distances and the continuity and quality of walking paths, particularly at the neighborhood scale. Furthermore, the provision of bicycle paths as an additional transportation option will serve to reduce vehicle traffic and, in addition, will contribute to the creation of an environmentally and spatially ordered neighborhood.

Figure 4.20. Analysis of A.2-Walkability and Street Connectivity

Indicator A.2 Walkability and Street Connectivity is analyzed in the field with two sub-indicators, namely 'A.2.1 Connectivity, quality and comfort of pedestrian routes' and 'A.2.2. Connectivity, quality and comfort of cycle paths'. A notable absence of pavements is evident in numerous areas of the district, largely attributable to the high volume of recently constructed developments within the İşçi Blokları neighborhood. Conversely, in numerous residential zones where the roadway is expansive, the pavement is situated solely on one side of the street, resulting in a narrow passageway. The only streets in the neighborhood that have wide, continuous and high-quality pavements are the main arteries.

Demetevler neighborhood has more regular and continuous sidewalks compared to İşçi Blokları neighborhood, although some sidewalks between residential areas have obstacles such as vehicle parking, electrical panels and narrow pavements. Furthermore, it is observed that bicycle lanes are only available in large park areas and do not extend beyond the boundaries of the parking area, in both neighborhoods.

3- *A.3 – Ease of Access to Roads and Transport Nodes*

In the event of a potential risk to the neighborhood within an urban setting, it is crucial that emergency services are able to gain straightforward access to residential areas. Similarly, it is vital that the inhabitants can access to the road and emergency centers in the event of an emergency evacuation.

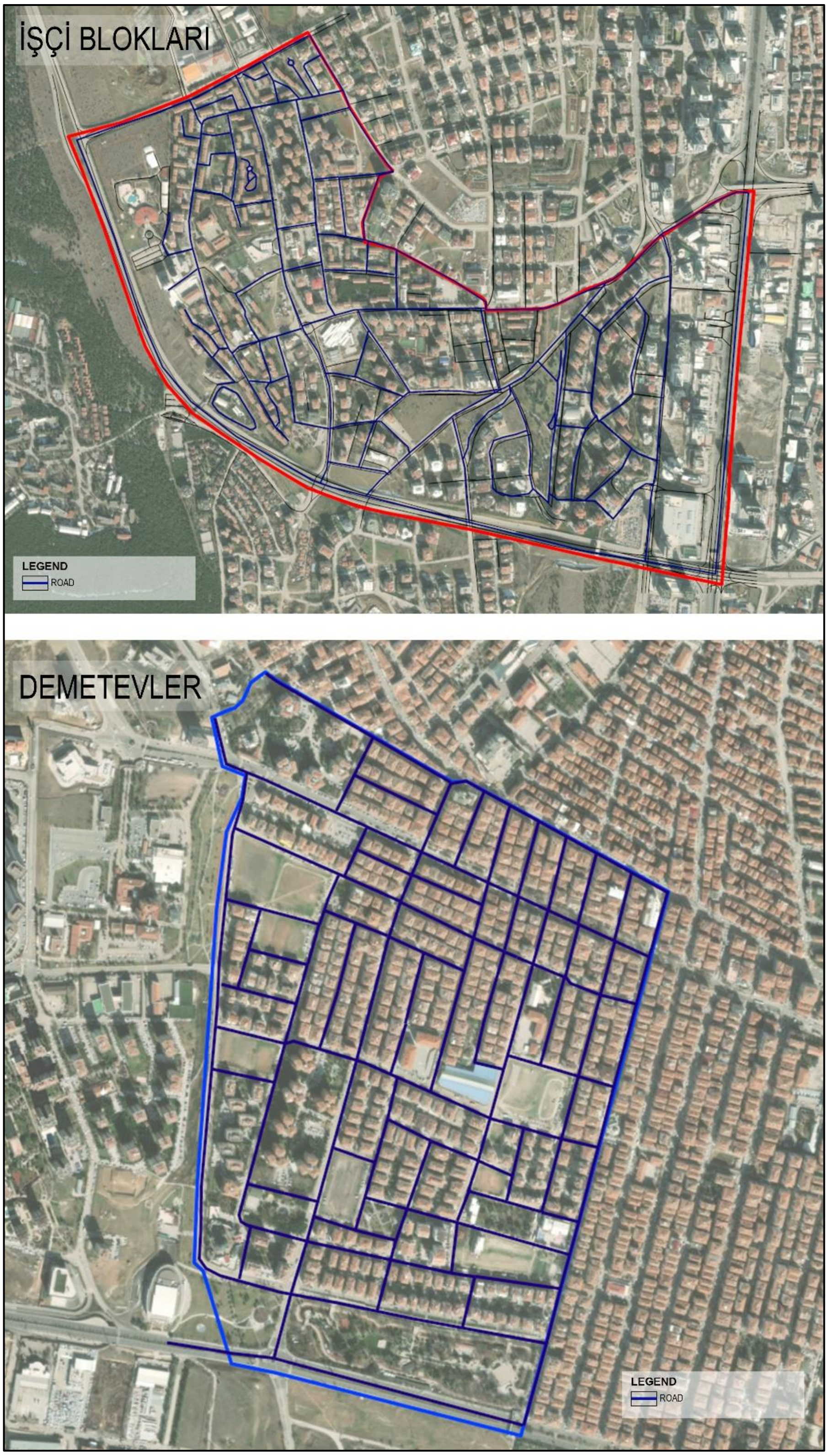

Figure 4.21. Analysis of A.3-Ease of Access to Roads and Transport Nodes

In accordance with A.3 Ease of Access to Roads and Transport Nodes, the indicator "Ease of access to the road in case of emergency" is subjected to analysis in the field as a consequence of the expert survey. The analysis is conducted by digitally mapping the roads in the ARCGIS program based on the observations made. The resilience of the Demetevler neighborhood is found to be enhanced by the regularity with which the roads are located around the housing islands and connected to the main road artery from different routes, given the relatively small size of the island and the number of houses situated in proximity to the roads. The İşçi Blokları neighborhood, situated on a more sloping terrain than Demetevler, is found to exhibit reduced resilience in terms of road access, due to the presence of extensive building clusters and housing estates.

4- *A.4 – Alternative Routes and Transport Options*

Resilient urban structure requires emergency centers such as hospitals, fire stations, police stations, disaster assembly areas to be located in places that are equally accessible to the neighborhoods and allow for a rapid response.

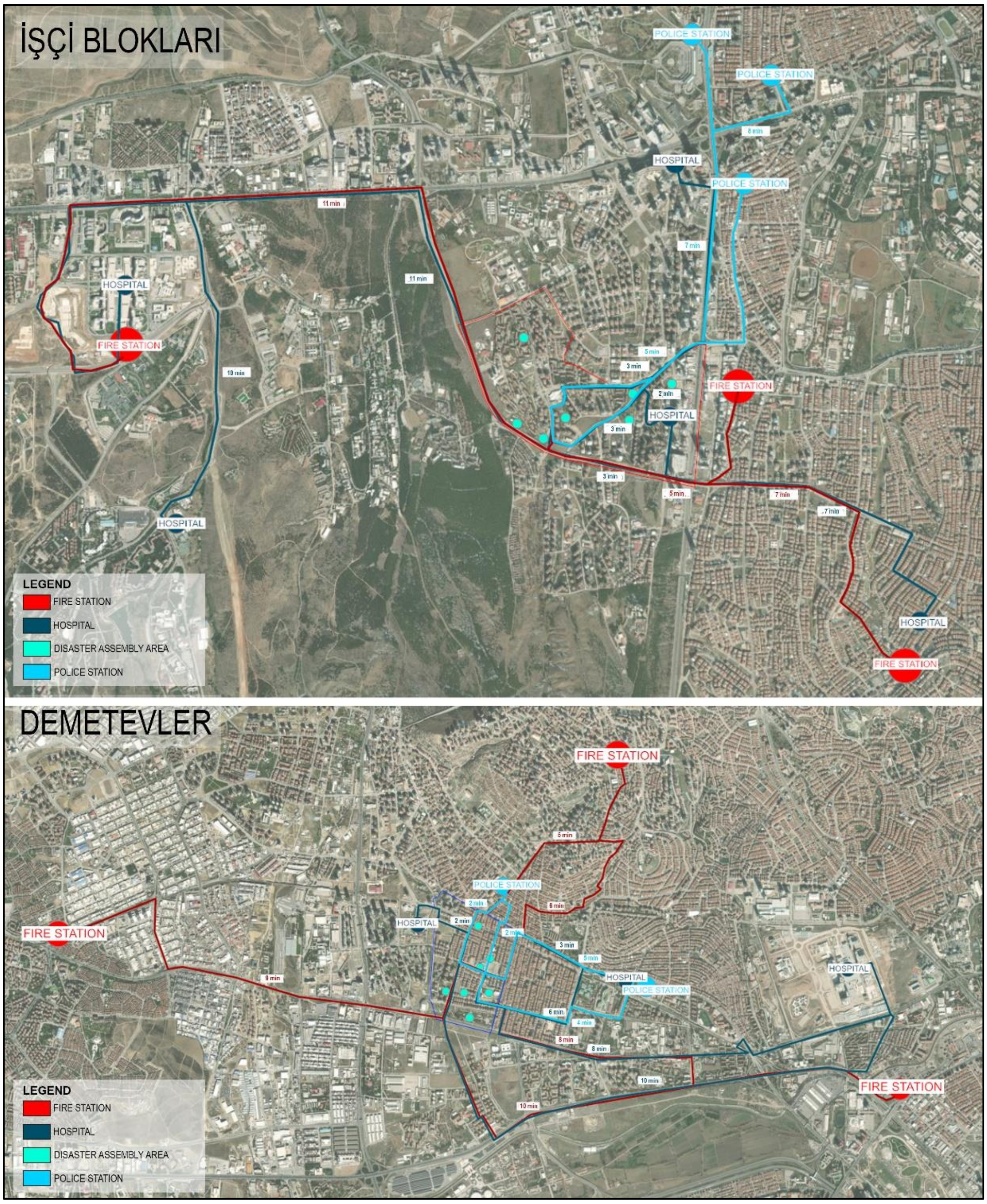

Figure 4.22. Analysis of A.4-Alternative Routes and Transport Options

In order to assess the distances to key emergency facilities within the Demetevler and İşçi Blokları neighborhoods, the indicator A.4-Alternative Routes and Transport Options is applied. This enables the calculation of distances to neighborhood centers for use in emergency situations, including hospitals, disaster assembly areas, fire stations and police stations. The İşçi Blokları neighborhood is equipped with seven disaster assembly areas and one private hospital. Additionally, there are three fire stations, four hospitals, and three police stations situated within a 10-kilometre radius. While the Demetevler neighborhood contains only seven disaster assembly areas, there are three fire stations, two police stations and two hospitals situated within a radius of 10 km.

5- A.5 – Access to Basic Facilities

One of the fundamental tenets of resilience in neighborhood systems is to guarantee that individuals have convenient access by walking to essential facilities and services, including educational, health, recreational, religious, and socio-cultural resources. These facilities and services are designed to meet basic needs and facilitate essential activities. Additionally, it is crucial to ensure that individuals can easily access critical emergency facilities and services, such as hospitals, fire stations, disaster assembly areas, and police stations.

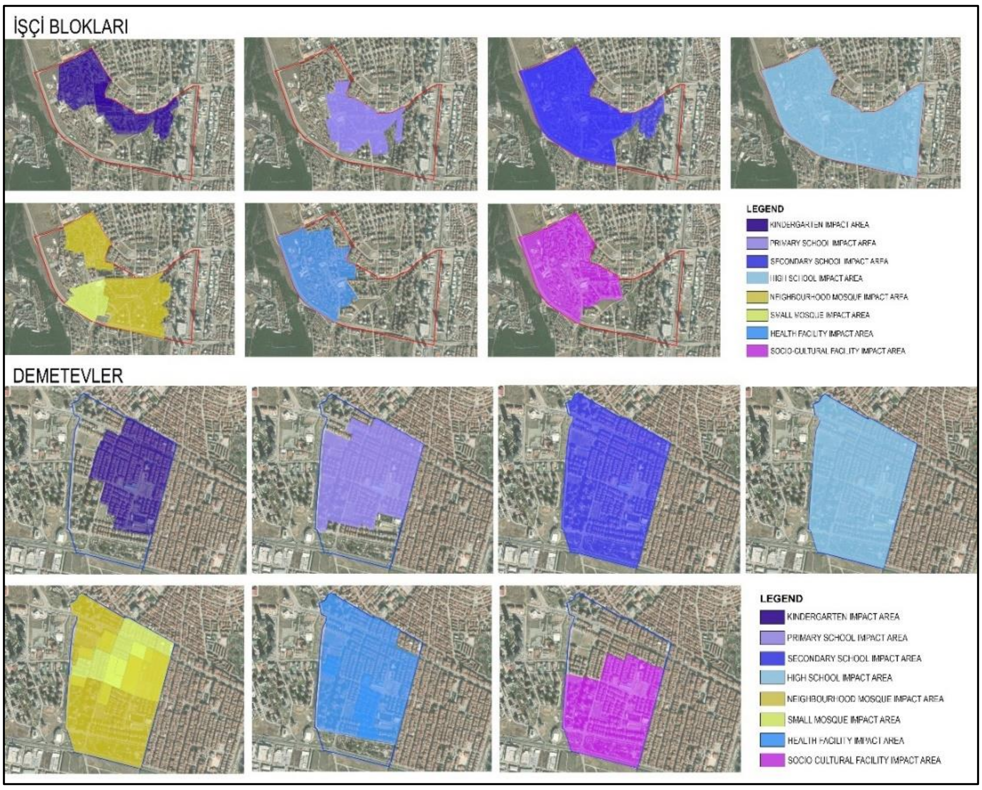

Figure 4.23. Analysis of A.5-Access to Basic Facilities

In the study area, the sub-indicators 'A.5.1 Equal access to green infrastructure, education, socio-cultural and religious facilities' and 'A.5.2 Equal access to all emergency uses' under indicator A.5 Access to Basic Facilities are subjected to analysis. The walking distance for basic facilities, including education, health, religious and socio-cultural facilities, is based on the walking distance specified in the Spatial Plans Construction Regulation. The distance is determined to be 500 metres for kindergartens, primary schools, family health centres, 1,000 metres for secondary schools, 2,500 metres for high schools, 250 metres for small mosques and 400 metres for neighbourhood mosques. The distance is assigned in accordance with the roads delineated in the ArcGIS program, and a network analysis is subsequently conducted. The area affected by the basic facilities in the neighbourhoods is illustrated in Figure 4.22. The distances of emergency facilities located outside the study area are illustrated in Figure 4.21.

It can be observed that the impact area of social facilities extends across the entire neighbourhood, with the majority of such facilities located in Demetevler. In contrast, the impact area of social facilities in İşçi Blokları is comparatively limited, due to the fact that the area is expansive, topographically diverse and characterised by an island layout with a restricted network of pedestrian routes.

6- A.9 – Access to Flexible Infrastructure

In the study areas, the indicator A.9, which pertains to access to flexible infrastructure, is subjected to analysis. This encompasses the sub-indicators A.9.1, which concerns equal access to safe and sustainable drinking water, effective sanitation and electricity, and A.9.2, which pertains to the necessity of having backup plans in case of any interruption in existing infrastructure systems. The implementation of a contingency plan is essential to guarantee the reliable provision of essential services, such as safe drinking water, electricity, and sewerage systems, which are fundamental necessities within the community. Such a plan is crucial to mitigate the potential adverse effects of prolonged disruptions or imminent risks associated with these services. By ensuring the continuity of these essential services, a community can enhance its resilience.

These sub-indicators are questioned through very short interviews with mukhtars. The questions asked to the mukhtars are as follows: 'Does the neighborhood have equal access to safe drinking water, sanitation and electricity?' and "Is there a backup plan in case of any interruption in the existing infrastructure systems (sewerage, water, electricity, transport, etc.)?". With these questions, it is questioned whether there is a part of the neighborhood that cannot access infrastructure systems and whether the neighborhood has put in place contingency plans to address any potential risks.

The mukhtar of the Demetevler neighborhood asserted that all residents have equal access to infrastructure systems. However, he also highlighted the existence of a drainage issue, whereby blockages occur in the canals due to their limited capacity when it rains. He highlighted that there is currently no long-term contingency plan in place to address this issue, but that the relevant unit is prompt in its response to open the canal and resolve the problem.

The mukhtar of the İşçi Blokları neighborhood has identified the sewerage problem as the most significant challenge currently facing the area. She stated that the configuration of the sewerage pipes, with multiple pipes situated on top of one another, results in recurrent blockages, which in turn give rise to a persistently high mosquito population. The relevant unit can provide a rapid resolution to the issue; however, when homeowners are left to address the problem independently, it has been observed that there are extended periods of inactivity in areas with a high concentration of student residences.

Environmental Resilience Analysis

In the neighborhood resilience assessment index, 5 indicator and 10 sub-indicators are determined for environmental resilience as shown in Table 4.18.

1- ***B.1 – Green Area Density***

The presence of a high density of green areas provides a source of mental relief to the local community, facilitating the creation of an area where social interaction can take place. Furthermore, the implementation of green areas can contribute to the reduction of the negative effects of climate change, including the reduction of urban heat island effects. The results of the expert surveys indicated that the study areas are analyzed with regard to the sub-indicator 'B.1.1 Green area density' only.

Figure 4.24. Analysis of B.1-Green Area Density

The results of the analysis study indicated that approximately 22 percent of the total area of the Demetevler neighborhood is comprised of green spaces, while approximately 29 percent of the neighborhood area in İşçi Blokları is also covered by green spaces. In this regard, the İşçi Blokları neighborhood may be considered to demonstrate higher resilience in terms of green area density.

2- B.2 – Green Area Continuity

The fact that the access of the neighborhood to green areas is continuous and within walking distance from the residential area provides easy access for the elderly, children, pregnant and disabled individuals. Seeing a neighborhood covered with green areas from the windows of the houses creates a mentally healthy society and also creates gathering places in the neighborhood. The sub-indicators ‘B.2.1 Continuity of green areas’ and ‘B.2.2 Ease of access to green areas’ under indicator B.2-Green Area Continuity are analyzed in the field.

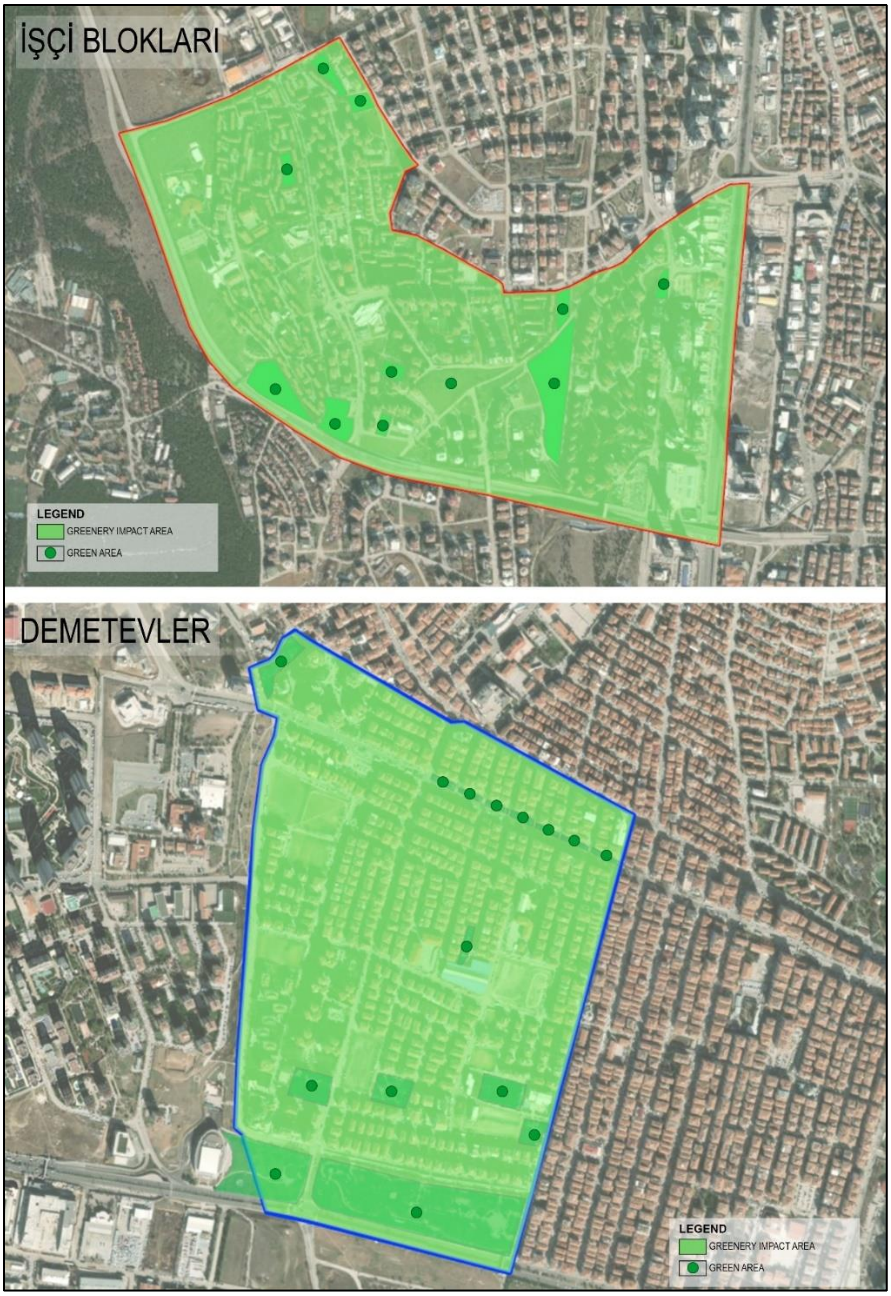

Figure 4.25. Analysis of B.2-Green Area Continuity

The impact area of parks and green spaces in both neighborhoods extends across the entire area when network analysis is conducted based on walking distance. Upon examination of the continuity of green areas, it becomes evident that parks and green spaces are situated in a more dispersed manner within the Demetevler neighborhood.

Conversely, the continuity of green areas is more apparent in the center of İşçi Blokları neighborhood.

3- B.3 – Green Area Diversity

The diversity of parks and green spaces within a neighborhood contributes to the area's environmental resilience, offering residents a range of options for utilizing these spaces. In accordance with the expert survey, the sub-indicator 'B.3.1 Green area diversity' is identified as the sole indicator of significance and measurability at the neighborhood scale within the context of green area diversity (B.3).

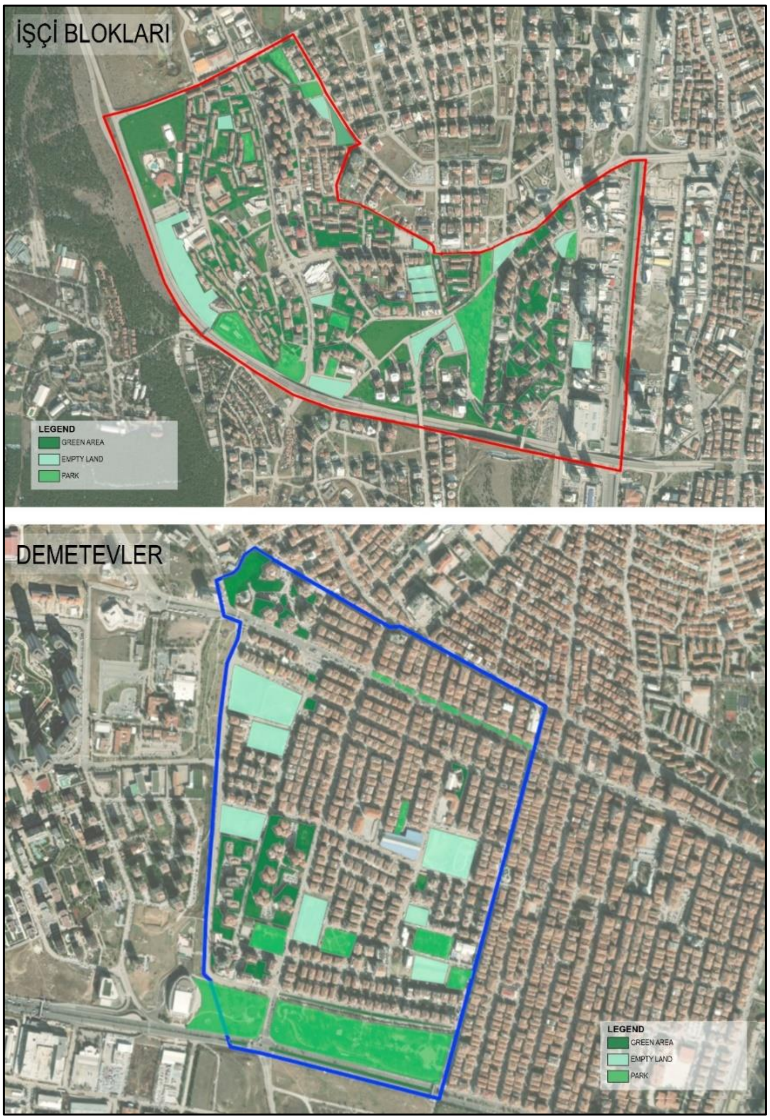

Figure 4.26. Analysis of B.3-Green Area Diversity

Upon analysis of the two neighborhoods in accordance with the aforementioned sub-indicator, it becomes evident that both exhibit a similar distribution of green area usage. However, the İşçi Blokları neighborhood displays a greater resilience than Demetevler, exhibiting a more diverse array of park typologies and green areas.

4- B.4 – Conservation of Soil Drainage and Natural Wetlands

In response to the rapid growth of urban populations, there has been a notable expansion in the construction of housing and infrastructure. This increase has the effect of disrupting the equilibrium between grey and green spaces in urban areas, thereby reducing the resilience of living environments. In order to achieve a resilient urban system, it is essential that housing and infrastructure areas are designed in integration with green areas and permeable surfaces. Furthermore, the integration of bioswale applications and drainage systems into urban areas is crucial to ensure the natural elements, such as rainwater, do not create disasters due to the lack of green areas.

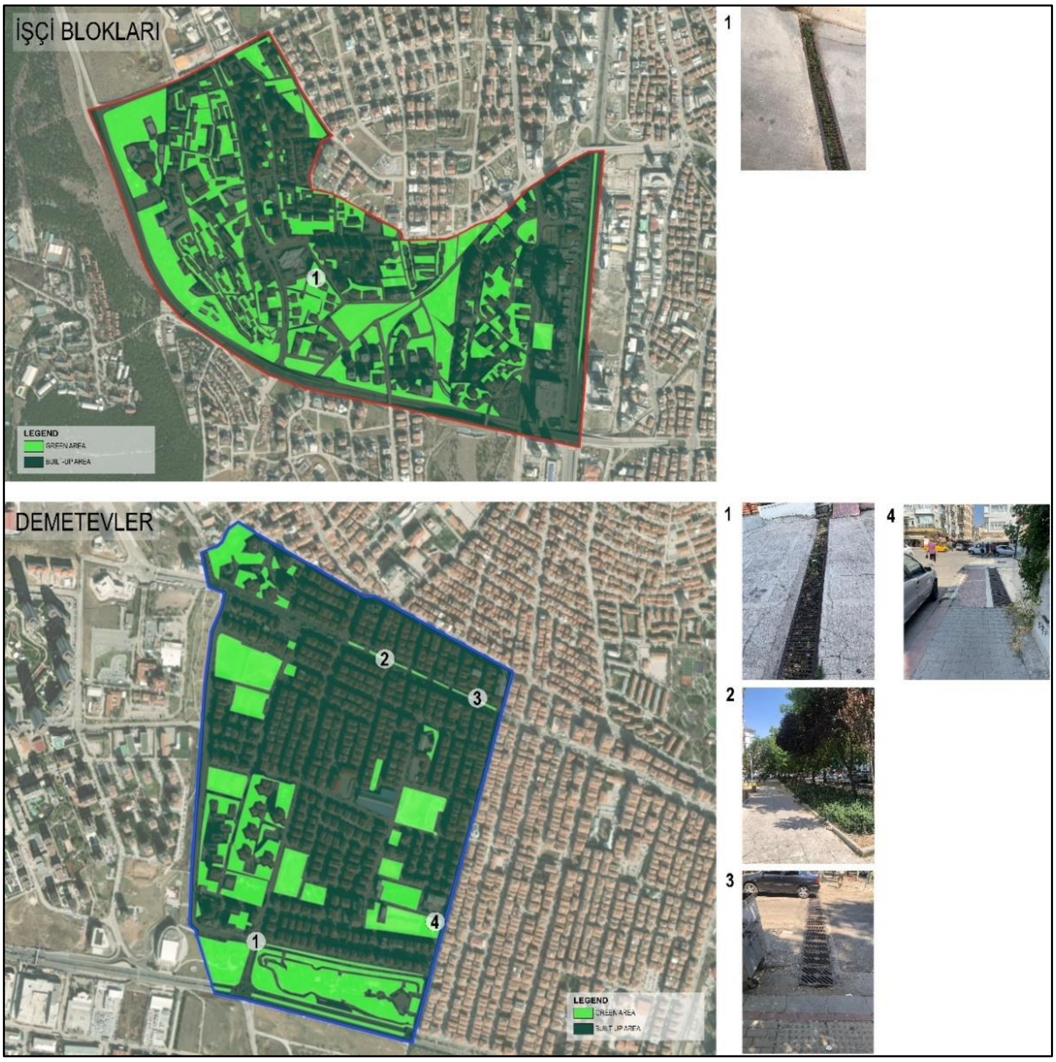

Figure 4.27. Analysis of B.4-Conservation of Soil Drainage and Natural Wetlands

In the context of indicator B.4, two sub-indicators are subjected to analysis: B.4.1, Ratio of grey-green infrastructure, and B.4.2, Presence of permeable pavements, bioswales, rainwater harvesting systems, green roofs. During the fieldwork, an analysis is conducted of the drainage systems, green practices on roads and buildings. In the İşçi Blokları neighborhood, which has a green area ratio of 29% and a built-up area ratio of 71%, only a few of these practices are observed. In the Demetevler neighborhood, the ratios of green and built-up areas are 22% and 78%, respectively. In addition to the analysis of drainage systems, the Demetevler neighborhood is also examined with regard to the implementation of bioswales and green applications on wide pavements.

5- B.8 – Vulnerability to Natural Disasters

In the contemporary era, urban settlements are increasingly susceptible to the potential adverse impacts of natural disasters. It is therefore crucial to implement the required measures in affected areas, such as those prone to erosion and landslides, which are often located within urban zones, and to take the necessary steps to safeguard protected areas. It is important to design houses elevated above the ground for rainwater overflow, which is a problem caused by heavy rainfall in the city and which is frequently seen in cities in recent days. Earthquakes, another natural disaster with a notable impact on urban areas, can cause extensive damage in environments with a high concentration of high-rise buildings.

Under indicator B.8, sub-indicators ‘B.8.1 Conservation of ecologically sensitive areas’ and ‘B.8.2 Protection of steep slopes in landslide and erosion areas’ are analyzed through short interviews with mukhtars in the neighborhoods examined. Two questions are asked to the mukhtars. First one is ‘Are there any ecologically sensitive areas (protected areas, natural protection areas, etc.) within the boundaries of the neighborhood? If so, are there any protection measures taken by the local administration or the neighborhood to protect these areas?’ and the second question is ’Are there any landslide or erosion hazardous areas or steep slopes that may pose a threat to the settlement area within the borders of the neighborhood? If so, are there any measures taken by the local administration or the neighborhood?’.

The mukhtars of the Demetevler and İşçi Blokları neighborhoods have stated that there are no protected areas or areas susceptible to erosion or landslides within the boundaries of the neighborhoods. However, the mukhtar of the İşçi Blokları neighborhood has indicated that traffic accidents occur in the steeply sloping areas of the neighborhood during the winter months, due to a lack of adequate precautions taken as a result of icing.

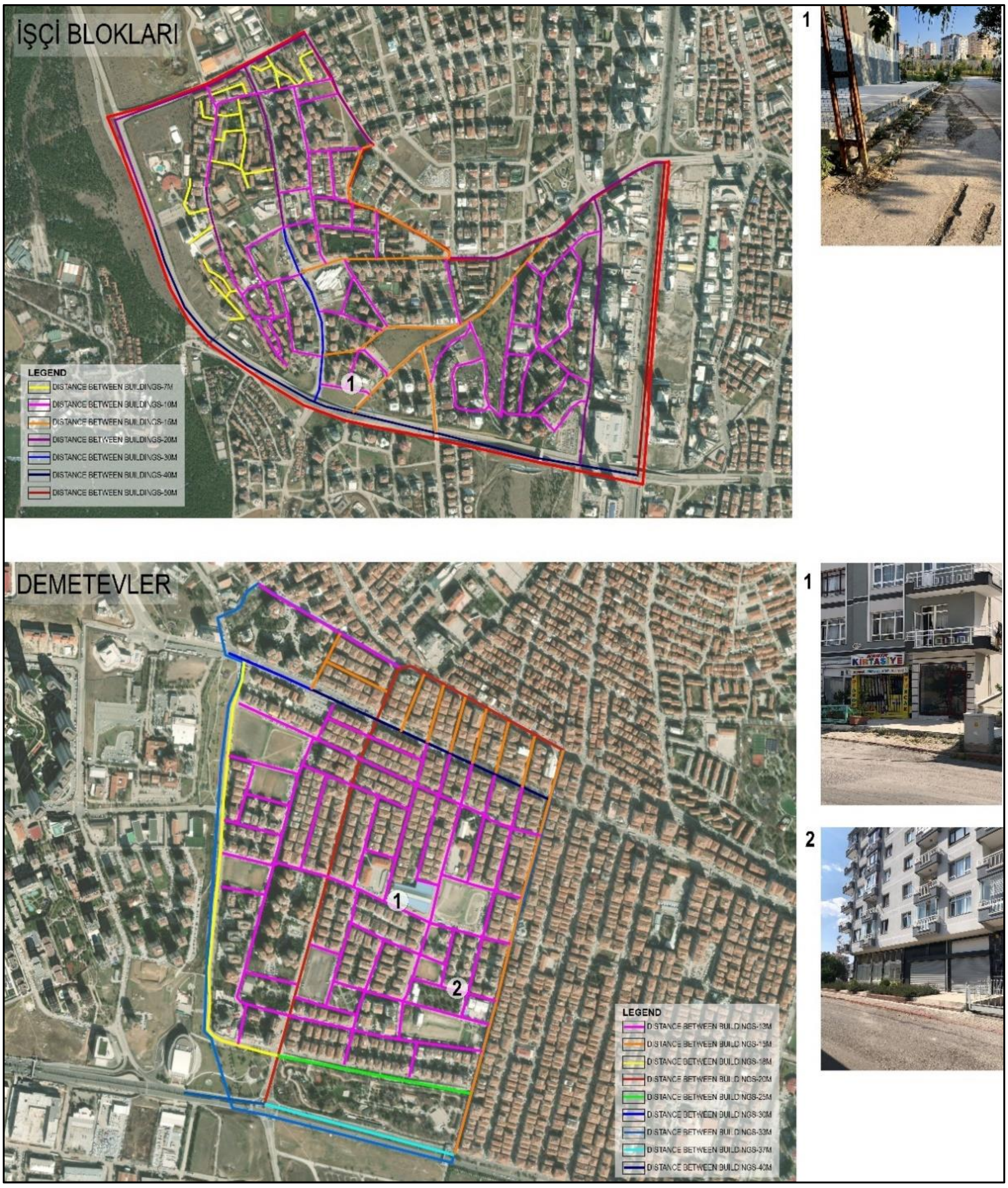

Figure 4.28. Analysis of B.8-Vulnerability to Natural Disasters

The sub-indicators 'B.8.3 Permeable areas and elevated entrances to prevent flooding' and 'B.8.4 Increasing the distance between buildings' are observed in the field. Only few dwellings with elevated entrances are identified in the İşçi Blokları and Demetevler neighborhoods.

Concurrently, the distances between the housing islands in the neighborhoods are measured and a detailed analysis is conducted to assess the potential impact of the buildings in the event of an earthquake, with particular attention paid to the most adverse scenario. In the İşçi Blokları neighborhood, the distance between the housing islands varies between 7 and 50 meters, contingent on the utilization of the road. In the central sections of the neighborhood, where residential density is high, distances of 7, 10 and 15 meters are observed. In the Demetevler neighborhood, the distance between buildings varies between 13 and 40 meters. In the inner areas, where residential density is high, the distance between buildings is typically 13 meters. The proximity of buildings with four to five stories in the Demetevler neighborhood with parcel layout represents a risk in the event of a disaster. In the İşçi Blokları neighborhood with a building block layout, the spacing between housing units is greater than in Demetevler neighborhood. This situation renders İşçi Blokları neighborhood more resilient with respect to the sub-indicator.

Comparative Analysis of Resilience

In the neighborhood resilience assessment index, 6 indicator and 10 sub-indicators as for spatial resilience and 5 indicator and 10 sub-indicators as for environmental resilience are analyzed in the field (Appendix-F). The spatial and environmental resilience levels of two neighborhoods are compared through the implementation of fieldwork. A quantitative metric measurement method is employed to assess each indicator, thereby enabling the determination of the resilience level. The indicators are assigned a ranking on a scale of 1 to 5, with 1 representing a very poor level of resilience and 5 representing an excellent level of resilience. The quantitative metric measurement method (ARUP & Rockefeller Foundation, 2016) entails the evaluation of each indicator through the calculation of an average value. The results obtained for each neighborhood are presented in a table, with the position and color of each value indicating the corresponding score on a scale ranging from 'very poor' to 'excellent'.

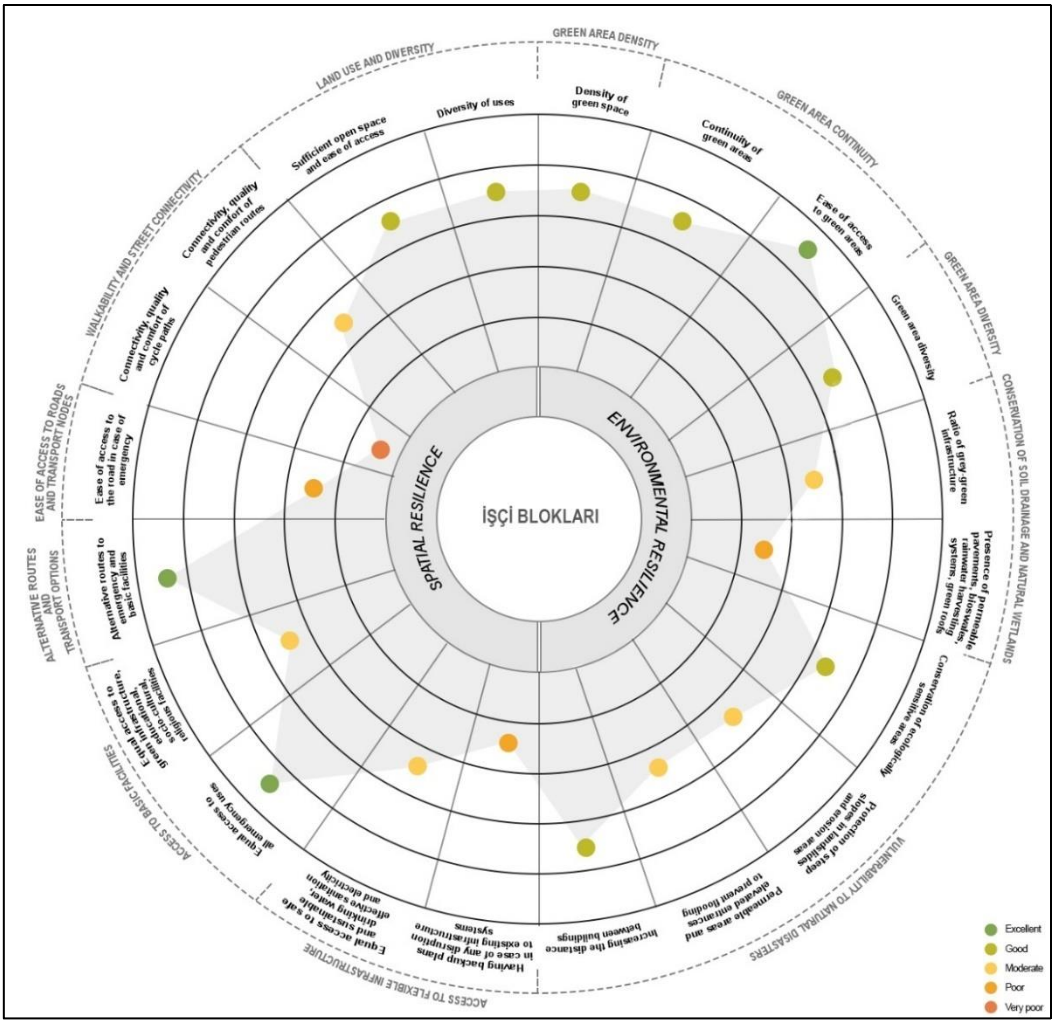

Figure 4.29. Analysis of Resilience in İşçi Blokları Neighborhood (adapted from ARUP & Rockefeller Foundation, 2016 and prepared within the scope of the thesis study)

The İşçi Blokları neighborhood is assigned a total score of 32 out of 50 based on the results of the resilience analysis, which employed a 1-very poor to 5-excellent scale to assess spatial resilience. As illustrated in Figure 4.29, the spatial resilience indicators measured in the neighborhood demonstrate a constant differentiation, indicating that there is no consistent resilience phenomenon. A more regular rhythm is observed among the environmental resilience indicators in the neighborhood. In terms of environmental resilience, the neighborhood achieved a total score of 36 out of 50.

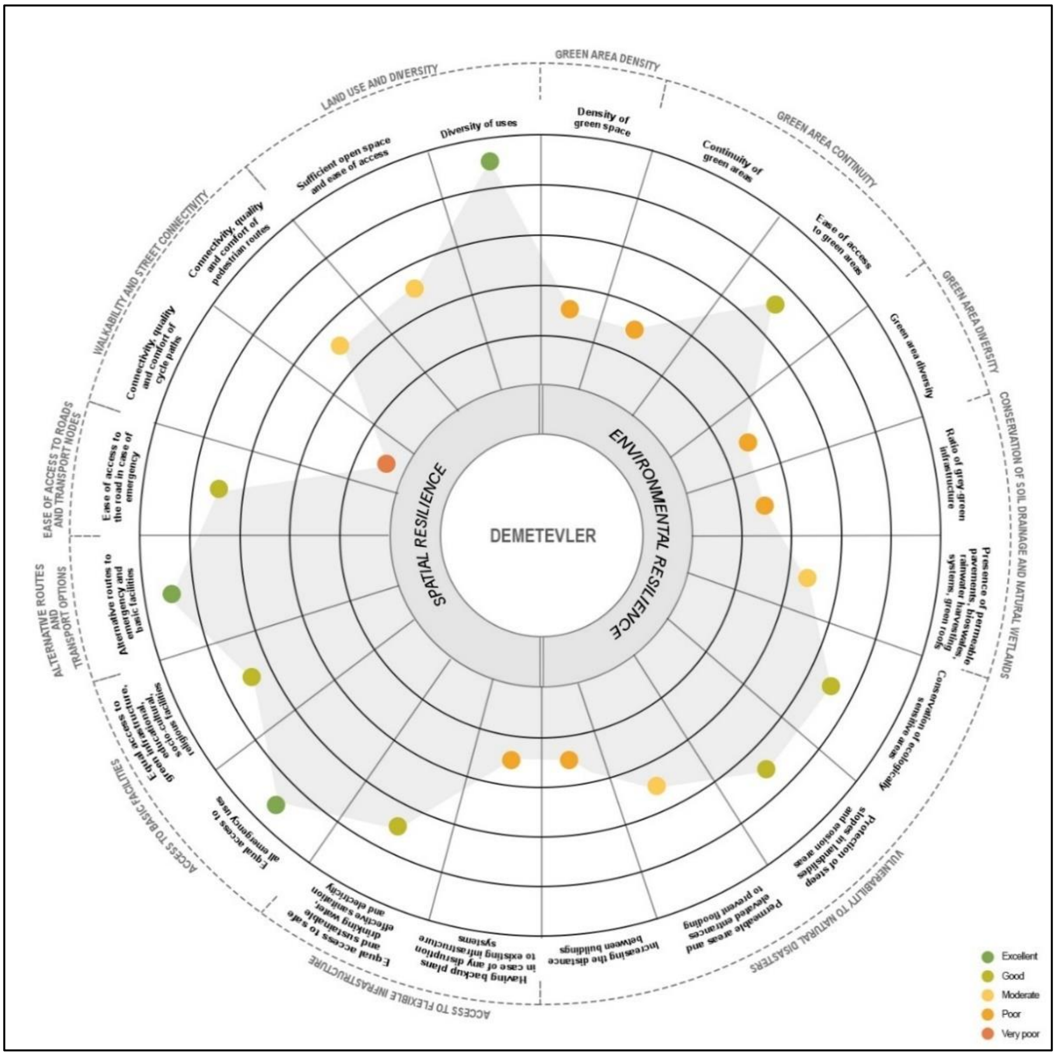

Figure 4.30. Analysis of Resilience in Demetevler Neighborhood (adapted from ARUP & Rockefeller Foundation, 2016 and prepared within the scope of the thesis study)

The resilience analysis of the Demetevler neighborhood revealed that the neighborhood attained a total score of 36 out of 50 in terms of spatial resilience. As illustrated in Figure 4.30, the spatial resilience indicators measured in the neighborhood exhibit occasional divergence despite their inherent interconnectivity. A more regular rhythm is observed among the environmental resilience indicators in the neighborhood. In terms of environmental resilience ratings, the neighborhood achieved a total score of 28 points.

A comparative analysis of the two neighborhoods within the context of resilience reveals that the İşçi Blokları neighborhood exhibits greater environmental resilience than Demetevler, characterized by the presence of regular and continuous green areas. In contrast, the Demetevler neighborhood has been identified as exhibiting greater spatial resilience, characterized by a convenient access to transportation and social infrastructure. A comparative analysis of resilience indicates a superior resilience of the İşçi Blokları neighborhood.

4.2 Evaluation

The expert survey, designed to ascertain the relative importance of the indicators identified in the literature for measuring spatial and environmental resilience at the neighborhood scale, is completed by 50 expert urban planners working in public, private and university sectors. It should be noted that 60% of these planners have more than six years of experience in planning. The indicators in the spatial resilience section of the expert survey, which consists of 9 main and 21 sub-indicators, and in the environmental resilience section, which consists of 8 main and 23 sub-indicators, are evaluated according to the degree of importance using a rating scale of 1 to 5. The indicators are selected from the literature.

In evaluating the sub-indicators of indicator A.1.1, "Land Use and Diversity," the experts accorded the highest rankings to "A.1.1 - Diversity of uses in the city" and "A.1.2 - Sufficient open space and ease of access." In the case of sub-indicator A.1.1, over 40% of the results are rated as 5 (critical), while in the case of sub-indicator A.1.2, over 70% of the results are rated as 5 (critical). The two sub-indicators, which are assigned a high value as a result of the survey, are subsequently subjected to analysis in the field. The results of the analysis indicate that the Demetevler neighborhood exhibits greater resilience in terms of land use diversity, whereas the İşçi Blokları neighborhood displays greater resilience in terms of the availability of open space.

A.2 - Walkability and Street Connectivity indicator consists of two sub-indicators: “A.2.1 - Connectivity, quality and comfort of pedestrian roads” and “A.2.2 - Connectivity, quality and comfort of bicycle roads”. For both indicators, more than 50% of the experts rated the indicator as 5 (critical). The indicator rated as critical is analyzed in the field. As a result of the analysis, it is observed that although there are narrow sidewalks, interruptions and obstacles on pedestrian roads in both neighborhoods, pedestrian roads in Demetevler neighborhood are more regular and continuous.

A.3- Ease of Access to Roads and Transport Nodes indicator consists of ‘.3.1 Topographically adequate road design’, ‘A.3.2 Ease of access to the road in case of emergency’ and ‘A.3.3 Equal ease of access to public transport stops’ sub-indicators. For sub-indicators A.3.1 and A.3.3, less than 40% of the experts rated the indicator 5 (critical), while for sub-indicator A.3.2, more than 70% of the experts rated the indicator 5 (critical). Therefore, only sub-indicator A.3.2 is analyzed in the field. According to the analysis of the ease of access to the road from residential areas, it has been determined that İşçi Blokları neighborhood is less resistant than Demetevler neighborhood because it consists of a sloping topography and large housing estates.

Indicator A.4, which aims to provide alternative routes and transport options within the city, comprises two sub-indicators: 'A.4.1-Alternative routes to emergency and basic facilities' and 'A.4.2-Sufficient public transport options'. In the survey results, over 60% of respondents identified the availability of alternative routes to emergency and basic facilities (A.4.1) as a critical requirement. The proportion of experts rating sub-indicator A.4.2, 'Sufficient public transport options', as 5 (critical) is less than 40%. Accordingly, only A.4.1 is subjected to an on-site analysis. In accordance with the analysis, the indicator pertaining to the availability of sufficient emergency facilities in a suitable proximity to the neighborhood is found to be resilient for both neighborhoods.

The A.5 - Access to Basic Facilities indicator comprises two sub-indicators, namely: The first of these is 'A.5.1 - Equal access to green infrastructure, education, socio-cultural and religious facilities', and the second is 'A.5.2 - Equal access to all emergency uses'. As a result of the expert surveys, these two sub-indicators are identified as critically important for measurement at the neighborhood scale. In the field study, indicator A.5.1 revealed that the Demetevler neighborhood exhibited greater resilience than the İşçi Blokları neighborhood in terms of the walking distance to social facilities. In terms of indicator A.5.2, both neighborhoods demonstrate resilience in terms of access to emergency facilities.

The indicators A.6-Built-up Area Quality and Density, A.7-Access to Energy Efficiency and A.8-Waste Management and Recycling within the scope of spatial resilience are not identified as critical to measure at the neighborhood scale by experts in the survey, and thus are not included in the field study. Regarding the aforementioned indicator, A.9 (Access to Flexible Structure), experts identified two sub-indicators, A.9.1 (Equal access to safe and sustainable drinking water, effective sanitation and electricity) and A.9.2 (Having backup plans in case of any interruption in existing infrastructure systems), as being of particular significance. In order to gain insight into these two indicators, interviews are conducted with neighborhood mukhtars, who are asked about access to infrastructure systems and backup plan mechanisms within their respective neighborhoods. Even though both neighborhoods have equal access to infrastructure systems, the Demetevler neighborhood is experiencing difficulties with drainage, while the İşçi Blokları neighborhood is facing a significant sewerage issue.

In the context of environmental resilience, the survey presented eight indicators and 23 sub-indicators to the experts for consideration. With regard to the first indicator, B.1 Green Area Density, the sub-indicator B.1.1 Green Area Density is identified by the experts as a key consideration, whereas the sub-indicator B.1.2 Vegetation Around Buildings and Building Entrances is not deemed a critical factor at the neighborhood scale. The data obtained from the field analysis indicated that the İşçi Blokları neighborhood exhibited greater resilience in terms of green area density.

In relation to indicator B.2, namely Green Area Continuity, the experts considered it essential to assess both sub-indicators at the neighborhood scale. The sub-indicator 'B.2.1 Continuity of green areas' is evaluated in the field, revealing that the green area continuity in the center of the İşçi Blokları neighborhood exhibited a distinctive resilience. In both neighborhoods, parks are situated in locations that are accessible on foot within a short walking distance. Therefore, both neighborhoods can be considered resilient regarding the sub-indicator 'B.2.2 Ease of access to green areas'.

The initial sub-indicator of the B.3 - Green Area Diversity indicator, 'B.3.1 Green area diversity', is identified by the experts as a key area for assessment and is subsequently evaluated in the field within the context of the index. The variety of green spaces in the İşçi Blokları neighborhood, including gardens, parks and vegetable production, has contributed to a higher level of resilience than that observed in the Demetevler neighborhood, which is characterized by a lack of diversity in green areas. The other sub-indicator, 'B.3.2 Biodiversity conservation', is not identified as a critical factor.

In accordance with the fourth environmental resilience indicator, B.4 – Protection of Soil Drainage and Natural Wetlands, the sub-indicators B.4.1 Ratio of grey to green infrastructure and B.4.2 Presence of permeable pavements, bioswales, rainwater harvesting systems, green roofs are identified in the expert survey as critical indicators to be measured at the neighborhood scale. In the field analysis, it is observed that the ratio of green area to built-up area is higher in the İşçi Blokları neighborhood, whereas the opposite is true of bioswales, rainwater harvesting systems and permeable pavement surfaces, which are higher in the Demetevler neighborhood.

In regard to the indicators B.5 (Access to Safe Food), B.6 (Heat Islands and Natural Ventilation) and B.7 (Environmental Quality and Pollution), the mean of the responses provided in the expert survey indicated that these indicators are not of critical importance for measurement at the neighborhood scale and thus are excluded from the index. Accordingly, these indicators are not incorporated into the field study.

As sub-indicators of the last environmental indicator, B.8-Vulnerability to Natural Disasters, the indicators 'B.8.1 Conservation of ecologically sensitive areas', 'B.8.2 Protection of steep slopes in landslide and erosion areas', 'B.8.3 Permeable areas and elevated entrances to prevent flooding' and 'B.8.4 Increasing the distance between buildings' are all identified by the experts as critically important at the neighborhood scale. In alignment with the sub-indicators, the findings of the field study indicate that there is no necessity for the protection of any natural areas within the two neighborhoods, and consequently, no conservation work is required in this regard.

Furthermore, it has been observed that the number of buildings elevated against the risk of flooding is low in both neighborhoods. The Demetevler neighborhood, which has a bowl-shaped structure and whose storm water channels are constantly blocked, is particularly vulnerable in this regard. Neither neighborhood exhibits any evidence of erosion risk. However, the sloping structure of İşçi Blokları renders it more susceptible to such occurrences. Ultimately, the proximity of buildings in relation to the number of floors in the area is investigated. It is found that the proximity of buildings with five floors or more in Demetevler neighborhood increases the vulnerability of this area to potential seismic activity.

In this context, the principal and subsidiary indicators included in the index for measuring spatial and environmental resilience at the neighborhood scale are as follows:

A. Spatial Resilience

- A.1 - Land Use and Diversity
    - Diversity of uses in the city (commerce, green space, socio-cultural facilities, etc.)
    - Sufficient open space and ease of access
- A.2 Walkability and Street Connectivity
    - Connectivity, quality and comfort of pedestrian routes
    - Connectivity, quality and comfort of cycle paths

- A.3 Ease of Access to Roads and Transport Nodes
    - Ease of access to the road in case of emergency
- A.4 Alternative Routes and Transport Options
    - Alternative routes to emergency and basic facilities
- A.5 Access to Basic Facilities
    - Equal access to green infrastructure, educational, socio-cultural, religious facilities
    - Equal access to all emergency uses
- A.9 Access to Flexible Infrastructure
    - Equal access to safe and sustainable drinking water, effective sanitation and electricity
    - Having backup plans in case of any disruption to existing infrastructure systems

B. Environmental Resilience

- B.1 Green Area Density
    - Density of green space
- B.2 Green Area Continuity
    - Continuity of green areas
    - Ease of access to green areas
- B.3 Green Area Diversity
    - Green area diversity
- B.4 Conservation of Soil Drainage and Natural Wetlands
    - Ratio of grey-green infrastructure
    - Presence of permeable pavements, bioswales, rainwater harvesting systems, green roofs
- B.8 Vulnerability to Natural Disasters
    - Conservation of ecologically sensitive areas
    - Protection of steep slopes in landslides and erosion areas
    - Permeable areas and elevated entrances to prevent flooding
    - Increasing the distance between buildings

A comparison is subsequently made between the two neighborhoods using the Quantitative Metric Measurement Method, based on the data obtained from the field study. In general, the İşçi Blokları neighborhood has been found to demonstrate greater resilience. However, when examined specifically, the Demetevler neighborhood has been found to demonstrate greater resilience in terms of its spatial characteristics.

CHAPTER 5

CONCLUSION

The concept of resilient cities is of critical importance in maintaining equilibrium between man-made and natural systems within densely populated urban environments. The concept of resilience encompasses a multitude of dimensions, including engineering, individual, social, physical, and ecological aspects. In order to effectively address potential hazards, risks, and threats, it is necessary to integrate sustainable technological solutions across the spatial, environmental, social, and economic spheres.

In collaboration with the Rockefeller Foundation, ARUP has delineated eight fundamental functions that collectively define a resilient city. These functions entail meeting the basic needs of a large urban population, ensuring citizen safety by addressing vulnerabilities to disasters, protecting and enhancing physical and natural assets, promoting social cohesion, understanding threats and raising awareness for rapid recovery, upholding the rule of law and justice, and supporting robust economic activity. The fulfilment of these functions enables cities to become more resilient and better equipped to handle future challenges, thereby creating a sustainable and resilient society.

The concept of urban resilience is concerned with the capacity of cities to respond and adapt to crises, shocks and stresses. The maintenance of urban resilience depends on the monitoring of historical fluctuations and the anticipation of future developments. Consequently, cities can respond in an effective manner to changes. The development of strategies for the sustained maintenance of urban resilience should be based on an analysis of the assets available to the city in question, as these assets will determine the availability of resources that can be deployed to reduce the losses caused by disasters. However, in the event of a shock or stress, a city's assets may undergo one of four changes: they may become stronger and recover more effectively, revert to their previous state, survive but become less productive, or collapse under pressure. It is therefore imperative that all assets are protected and enhanced to ensure the continued prosperity and resilience of the city.

The resilience of urban areas is contingent upon the actions of individuals and communities, the functionality of government services, and the condition of physical and environmental assets, which are frequently interlinked with larger systems. The damage caused to urban assets can have a cascading effect beyond the directly affected areas, thereby emphasizing the importance of ensuring urban resilience.

The neighborhood scale is a significant factor in urban studies and climate change interventions, as it provides an opportunity for community engagement and resilience-building initiatives. In the analysis of urban resilience, consideration should be given to a range of scales, including the city, neighborhood, parcel, large block and street network. The provision of diverse and adaptable parcels, with a balanced distribution of desired plot sizes, is of crucial importance for the construction of resilient urban structures and the implementation of efficient urban planning. Furthermore, land accessibility is of great consequence about connectivity and the realization of objectives. However, the lack of tools that integrate resilience into urban planning and governance practices presents a challenge in measuring and practically implementing urban resilience. Although the systems approach has yielded valuable insights, the development of additional tools is necessary to effectively predict and measure resilience. It is crucial to acknowledge and address the neighborhood scale to foster the creation of resilient and adaptive urban environments.

A considerable number of researchers and experts have devised urban resilience measurement indices to assess the vulnerability of urban areas, municipalities, and specific urban districts to a range of potential risks. A variety of indices have been developed to address a range of urban challenges, including climate change, natural disasters, pandemics and emergencies. The rationale behind the creation of these diverse indicators is to ascertain the deficiencies and shortcomings in urban resilience by measuring it in accordance with a multitude of crucial objectives, including enhancing the resilience of green infrastructure systems within cities, fostering community resilience, and integrating the circular economy into urban systems.

This study is comprised of five steps. The initial step presents an overview of the thesis, delineating its objective, scope, and significance. The second step is dedicated to the definition of urban resilience, tracing its development over time and highlighting the specific characteristics of cities and the potential risks they face. The theoretical framework section examines the existing literature on the definition of urban resilience at the neighborhood scale, as well as the existing measurement indices for urban resilience at different scales. The third step outlines the research methodology, including the process of selecting indicators from the literature review, the design of an expert survey, and the design of fieldwork based on the indicators chosen by the experts. The fourth step presents and discusses the findings obtained from the fieldwork. Finally, the fifth step concludes the study and offers recommendations within the context of the theoretical framework.

This field study compares the resilience of two neighborhoods in Ankara. The case studies focus on two neighborhoods in Ankara: İşçi Blokları and Demetevler. The two neighborhoods exhibit disparate structural and topographical characteristics, yet both occupy a significant position in Ankara's urban development history. By analyzing the spatial and environmental resilience of these neighborhoods, insights can be gained into their ability to withstand and recover from challenges. Since the 1920s, Ankara has undergone a series of urban planning processes aimed at accommodating its growing population. This has resulted in the emergence of multi-story houses in the suburbs and a variety of public housing options. The architectural style of Demetevler is distinctive, characterized by houses that are aligned directly to the street without gardens. The absence of zoning regulations in Demetevler has resulted in the emergence of illegal squatter settlements, which have contributed to the development of narrow streets, high-rise apartments, and buildings that violate planning regulations. In contrast, İşçi Blokları was constructed in 1965 with the objective of providing affordable housing for low-income working families and has subsequently undergone expansion to incorporate social facilities. The construction of a link road has prompted a surge in interest in the area, resulting in a notable increase in rental prices.

<u>Comparison of Conceptual Framework and Results</u>

The concept of urban resilience has been the subject of extensive evaluation in the literature, with a particular focus on its assessment, strategic planning and measurement at city and higher scales. It is regrettable that the implementation of these strategies at the lower urban scales is confined to a limited extent.

In recent times, the potential impact of threats such as pandemics has prompted the consideration of design proposals for more compact neighborhood units, where all necessary amenities can be reached on foot. However, for these designs to be implemented as strategies at the neighborhood scale, it would be more beneficial to measure the proximity of existing neighborhoods to resilience, identify their deficiencies and implement changes to enhance resilience in these areas.

All urban scales should be measured in terms of the spatial, environmental, economic, social and institutional dimensions, with modifications made to each dimension as appropriate. In this context, due to the limited time in this thesis, it is possible to provide a resource for future studies by examining only spatial and environmental dimensions at the neighborhood scale.

The presence of open space within neighborhood units and the proximity of emergency facilities to the entire neighborhood (Kontokosta & Malik, 2018) serve to enhance accessibility in the event of a disaster, thereby fostering the development of resilient spaces. This factor has enabled the incorporation of indicators that assess the proximity of emergency facilities, including disaster assembly areas, open spaces, fire stations, and police stations, within the neighborhood and its immediate vicinity.

In the indices developed at the urban scale in the context of risk situations that require people to remain within their own neighborhood boundaries, such as pandemics, land use diversity, ease of access to social facilities within walking distance (Sajjad, Chan, & Chopra, 2021), and proximity of open and green areas to residential areas (Lak, Hakimian, & Sharifi, 2021), these factors have emerged as crucial elements. Once more, planning approaches such as the compact city model and the 15-minute neighborhood model, developed for the majority of risk situations, support these factors as identified in the existing literature. In both the spatial and environmental parts of the index developed within the scope of the thesis study, important indicators such as the impact radius of facilities being within walking distance, pedestrian and bicycle paths being continuous and of high quality, and a green-built environment being compatible and proportional to each other are included and analyzed in sample neighborhoods.

The urban resilience approach is a valuable tool for urban planning, as it can enhance well-being and protect the environment. This is particularly relevant in developing countries like Turkey, where population growth and vulnerability to disasters are significant challenges. The development of a measurement method for urban resilience at the neighborhood scale is of paramount importance for the implementation of strategies at larger scales. The initial focus on neighborhoods enables the direct observation of strategies and the subsequent measurement at all relevant scales. The establishment of a spatial and environmental resilience measurement index at the neighborhood scale, as demonstrated in a thesis study with field testing, can serve as a foundation for future studies and the development of new strategies at lower scales. This highlights the importance of studies conducted at these scales and their potential influence on urban resilience.

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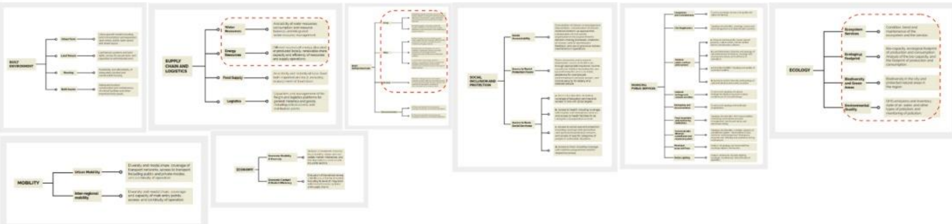
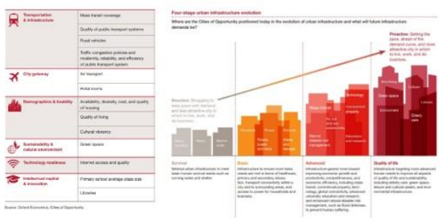
APPENDICES

A. Selected Spatial and Environmental Resilience Indicators from Literature

Example Index and by whom?	Indicators
City Resilience Index (CRI) **Arup & the Rockefeller Foundation. (2023). City Resilience Index (CRI).**	**Health and well-being** - Minimal human vulnerability (Safe and affordable housing, Adequate affordable energy supply, Inclusive access to safe drinking water, Effective sanitation, Sufficient affordable food supply), Diverse livelihoods and employment (Inclusive labour policies, Relevant skills and training, Dynamic local business development and innovation, Supportive financing mechanisms, Diverse protection of livelihoods following a shock), Effective safeguards to human health and life (Robust public health systems, Adequate access to quality healthcare, Emergency medical care, Effective emergency response services) **Economy and society** - Collective identity and community support (Local community support, Cohesive communities, Strong city-wide identity and culture, Actively engaged citizens), Comprehensive security and rule of law (Effective systems to deter crime, Proactive corruption prevention, Competent policing, Accessible criminal and civil justice), Sustainable economy (Well-managed public finances, Comprehensive business continuity planning, Diverse economic base, Attractive business environment, Strong integration with regional and global economies) **Infrastructure and ecosystems** - Reduced exposure and fragility (Comprehensive hazard and exposure mapping, Appropriate codes, standards and enforcement, Effectively managed protective ecosystems, Robust protective infrastructure), Effective provision of critical services (Effective stewardship of ecosystems, Flexible infrastructure services, Retained spare capacity, Diligent maintenance and continuity, Adequate continuity for critical assets and services), Reliable mobility and communications (Diverse and affordable transport networks, Effective transport operation & maintenance, Reliable communications technology, Secure technology networks) **Leadership and strategy** - Effective leadership and management (Appropriate government decision-making, Effective co-ordination with other government bodies, Proactive multi-stakeholder collaboration, Comprehensive hazard monitoring and risk assessment, Comprehensive government emergency management), Empowered stakeholders (Adequate education for all, Widespread community awareness and preparedness, Effective mechanisms for communities to engage with government), Integrated development planning (Comprehensive city monitoring and data management, Consultative planning process, Appropriate land use and zoning, Robust planning approval process)
Climate Disaster Resilience Index (CDRI) **United Nations Framework Convention on Climate Change (UNFCC)**	**Physical**- Electricity, Water, Sanitation and Solid Waste Disposal, Accessibility of Roads, Housing and Land Use **Social** - Population, Health, Education and Awareness, Social Capital, Community Preparedness **Economy** - Income, Employment, Household Assets, Finance and Savings, Budget and Subsidy **Institutional**- Mainstreaming of DRR and CCA, Effectiveness of city's crisis management, Effectiveness of a city's institution to respond to a disaster, Institutional collaboration with other organisations and stakeholders, Good Governance **Natural**- Intensity/ Severity of natural hazards, Frequency of natural hazards, Ecosystem services, Land-use in natural terms, Environmental security and food security
Urban Resilience Index **Suárez, M., Gómez-Baggethun, E., Benayas, J. & Tilbury D. (2016). Towards an Urban Resilience Index: A Case Study in 50 Spanish Cities. Sustainability, 8, 774.**	**Self sufficiency** **Capacity and diversity of response** - Business diversity, land use diversity, food diversity, spaces for citizen participation
Urban Resilience Index **Narieswari, L., Sitorus, S.R.P., Hardjomidjojo, H. & Putri, E.I.K. (2019). Multi-dimensions urban resilience index for sustainable city. IOP Conf. Series: Earth and Environmental Science 399.**	**Social resilience** - Educational equality (% of population with higher education (graduate from high school), % of illiterate population), Demography (% of population in productive age, % of population aged 65 years and older, % of population living in poverty, Number resident/km2), Transportation access (% of population with a vehicle (% motor)) **Economic resilience** - Business size (Ratio of large to small business), Health access (Number of physicians per 10,000 population), Market access **Infrastructure resilience** - Housing type (% of permanent housing), Recovery (Number of public schools per km2), Medical capacity (Number of hospital beds per 10.000 residents) **Institutional resilience** - Mitigation (% of Household that trust and know warning system, % of member of cooperatives), Political engagement (% of voting population participating in election) **Hazard Resilience** - Frequency (Frequency of disaster), Variety (Variety of natural disasters occurred in the area)
Resilience to Emergencies and Disasters Index (REDI) **Kontokosta, C. E. & Malik, A. (2018). The Resilience to Emergencies and Disasters Index: Applying big data to benchmark and validate neighborhood resilience capacity. *Sustainable Cities and Society 36, 272–285.***	**Social infrastructure & community connectivity** - Percent Population under 18 & over 65 years, Percent of Non-Family Households with Single Occupancy, Percent of Non-Family Households with Under 18 Occupants, Percent of Vacant Housing Units, Percent Population Over 25 with Bachelor's degree, Percent Population Over 3 Not Enrolled in School, Percent Population with no Health Insurance Coverage, Density of Adult Social Services Centers, Density of Child Social Services Centers, Density of Residential Developmental Disabilities Services Centers, Density of Libraries. **Physical infrastructure** - Distance to Nearest Fire Station from Tract Center, Distance to Nearest Police Station from Tract Center, Distance to Nearest Health Services from Tract Center, Number of Subway Stations in 1-mile radius from Tract Center, Number of OEM Evacuation Centers in 1-mile radius from Tract Center **Economic strength** - Unemployed Population Over 16 in Labor Force, Gini Index for Income Inequality, Lack of Economic Diversity **Environmental conditions** - Percent of Tract covered by Hurricane Sandy flood, Tree Density, Building Density, Percent of Census Tract's Land Use categorized as "Open Space"
Neighborhood Pandemic Resilience Index (NPRI) **Lak, A., Hakimian, P. & Sharifi, A. (2021). An evaluative model for assessing pandemic resilience at the neighborhood level: The case of Tehran. Sustainable Cities and Society, 75, 103410.**	**Physical Dimension** - Built environment characteristics (Quality of residential area, Average housing area in neighborhoods, Building density), Land use (Land use mix, Number of neighborhood centers, Number of Banks, Number of Chain stores, The ratio of nonbuilt- up areas, The ratio of the areas of educational, cultural and religious centers, Number of Drugstores, Number of hospitals designated to dealing with the pandemic), Access and Infrastructure (Access to public transportation, Access to plots and blocks, Access to health centers) **Demographic Dimension** - Percent of population with higher education degrees, Percent of population with pre-existing chronic diseases and health conditions (e.g., diabetes, asthma, obesity & hypertension), Percent of the elderly population (over 65), Population density, Household size **Environmental Dimension** - The average number of polluted days in a year, Average levels of environmental pollution (air, water, soil), Temperature, wind speed and humidity, Average state of environmental cleanness (the amount of waste in neighborhood and water cycle) **Infrastructural Dimension** - The ratio of land uses related to health, The ratio of educational land uses, The ratio of cultural-religious places **Economic Dimension** - Percent of employed population, The ratio of the population above the poverty line.
Index system of resilience of spatial elements in ESP (ecological security pattern) **Yuan, Y., Bai, Z., Zhang, J. & Xu, C. (2022). Increasing urban ecological resilience based on ecological security pattern: A case study in a resource-based city. Ecological Engineering, 175, 106486.**	The resilience of ecological sources - Habitat stability, Habitat complexity, Habitat connectivity, External conditions of ecological sources The resilience of corridor - Corridor connectivity, Internal conditions of corridor, External conditions of corridor The resilience of nodes - Node connectivity
Resilience Index **Sajjad M., Chan, J.C.L. & Chopra, S.S. (2021). Rethinking disaster resilience in high-density cities: Towards an urban resilience knowledge system. Sustainable Cities and Society, 69, 102850.**	**Spatio-Environmental** - Accessibility to nearest health services, Accessibility to Nearest ATM and Bank, Accessibility to Nearest Market and Store, Accessibility to Nearest Transport Station, Access to Nearest Parks, Green Area Ratio, Average Noise Pollution, Accessibility to Nearest Child Care Centre, Accessibility to Nearest Sports Facility **Economic** - Housing Affordability Rate, Median Family Income, Energy Consumption, Female Employment Rate, Access to Free Education, Household Expenditure Rate, Unemployment Rate **Social** - Average No. of Rooms per person, Youth Population, Immigration Status, Post-Secondary Education Rate, Proximity to Crime Scenes, Sense of Place, Proximity to nearest council member office
Urban resilience through green infrastructure **Su´arez, M., Rieiro-Díaz, A.M., Alba, D., Langemeyer, J., G´omez-Baggethun, J. & Ametzaga-Arregi, I. (2024). Urban resilience through green infrastructure: A framework for policy analysis applied to Madrid, Spain. Landscape and Urban Planning, 241, 104923.**	Diversity of people (Socio-cultural, governance system) Diversity of organised citizen groups (Socio-cultural, governance system) Diversity of businesses (Economic, governance system) Biodiversity (Ecological) Diversity of green infrastructure (Ecological) Diversity of ecosystem services (Ecological) Diversity of humanmade facilities (Socio-cultural, physical and technological, governance system) Diversity of participating people (Socio-cultural, governance system) Diversity of participating organised citizen groups (Socio-cultural, governance system) Diversity of participating economic sectors (Socio-cultural, economic, governance system) Diversity of participating public administrations (Governance system) Diversity of participating government departments (Governance system) Social networks (Socio-cultural, governance system) Multilevel and decentralised governance (Governance system) Demand of provisioning ecosystem services (Socio-cultural, ecological) Demand of regulating ecosystem services (Socio-cultural, ecological) Supply of provisioning ecosystem services (Ecological) Supply of regulating ecosystem services (Ecological) Supply of cultural ecosystem services (Socio-cultural, ecological, governance system) Social innovation (Socio-cultural, governance system) Education (Socio-cultural, governance system) Equal distribution of green infrastructure (Socio-cultural, ecological, governance system) Equal access to the benefits of green infrastructure (Socio-cultural, ecological, governance system) Sense of belonging (Socio-cultural) Political innovation (Governance system) Technical innovation (Physical and technological) Temporary impact (Socio-cultural, economic, ecological) Universal accessibility to green infrastructure (Socio-cultural, ecological) Social conflicts (Socio-cultural, governance system) Economic autonomy of the policy (Economic, governance system)

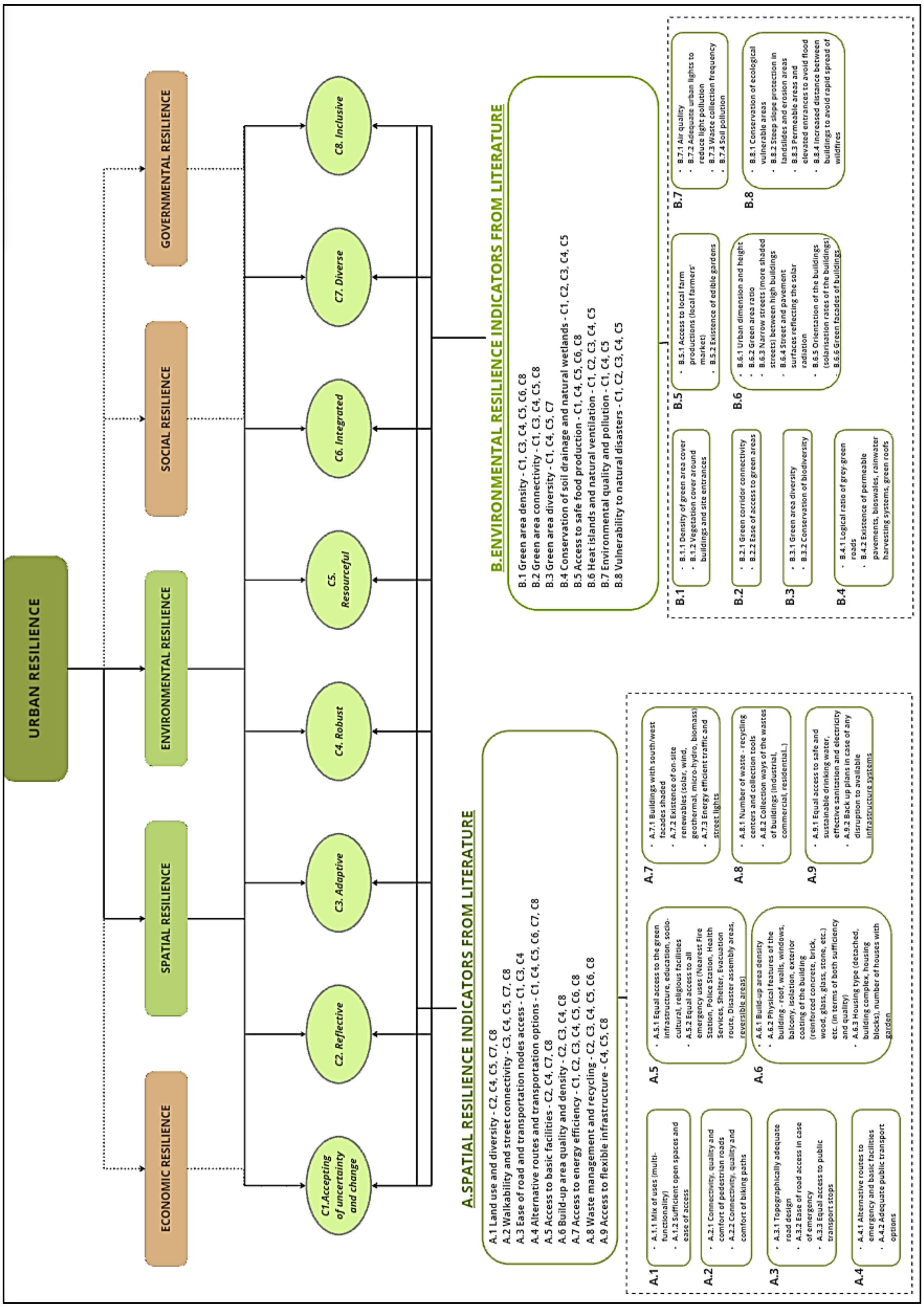
Appendix A (continued)

Example Index and by whom?	Indicators
Multidimensional Resilience Index to Adapt against Climate Change **Jamali, A.; Robati, M.; Nikoomaram, H.; Farsad, F.; Aghamohammadi, H. (2023). Urban Resilience and Climate Change: Developing a Multidimensional Index to Adapt against Climate Change in the Iranian Capital City of Tehran. Urban Sci., 7, 7.**	**Socio-cultural -** Public awareness, Consumerism, Population density, Migration, Death rate, Life expectancy, Health overall index **Economic -** Commercial land use, Poverty line, Urban worn-out areas, Accident insurance, Employment, Welfare **Inst-infrastructural -** Crisis management centers, Access to health and rescue centers, Access to urban services, Infrastructure vulnerability **Eco-environmental -** Water quality index, Air quality index, Green space ratio, Slope, Elevation
Climate Change Adaptation actions (AA) indicators **Jacob, J., Valois, P. & Tessier, M. (2022). Development and validation of an index to measure progress in adaptation to climate change at the municipal level. Ecological Indicators, 135, 108537.**	Urban temperature variation (heat islands), Built Environment, and Recreational and Heritage Sites, Green Infrastructure and Ecosystem Services, Inland Flooding, Hydrological and Geo- Hydrological Hazards at Urban Level
The Resilient Cities Index (RCI) **Economist Impact & Tokio Marine Group. (2023). Resilient Cities Index-A global benchmark of urban risk, response and recovery Methodology Report.**	**CRITICAL INFRASTRUCTURE -** Electricity (Electricity price, Electricity quality), Water and sanitation (Water provision quality, Wastewater treatment, Water management), Transportation (Congestion, Smart traffic management, Public transport quality, Transport electrification), Built environment (Energy efficiency, Future-proofing the structures), Digital infrastructure (Internet quality, Cybersecurity preparedness) **ENVIRONMENT -** Flooding (Riverine flood risk, Coastal flood risk), Heat stress (Heat stress), Air pollution (Air quality), Disaster management (Hazard monitoring, Hazard management), Decarbonisation (Net zero progress, Carbon removal, Renewable energy adoption), Waste management (Recycling and circular economy initiatives, Single-use plastic) **SOCIO-INSTITUTIONAL -** Digital government (E-gov portal for residents, Open data availability and accessibility), Legal (Crime and safety, Justice and law enforcement), Inclusivity, involvement and awareness (Income inequality, Social protection benefits, Vulnerable group integration, Culture of readiness), Health and well-being (Health emergency response, Longevity, Work-life balance) **ECONOMIC -** Economic robustness (Business environment), Exposure and risk (Economic volatility, Insurance penetration), Innovation and entrepreneurship (AI readiness, Innovation ecosystem), Human capital (High-skilled workforce)
urban resilience in residential neighborhoods **Farzane, O. J. (2021). Assessment of urban resilience in residential neighborhoods 1 (Case study: Raste-Kuche neighborhood). Int. J. Urban Manage Energy Sustainability, 2(3): 1-11.**	**Economic resilience -** Employment, Employment group, Employment scale, Equality of income in society **Institutional resilience -** Institutional bed, Institutional performance, Institutional Relations **Social resilience -** Age structure of the population, Sexual structure of the population, Level education, Amount of social capital, Health coverage **Infrastructure resilience -** Infrastructure, Transport network level, Quality of housing, Relief and treatment, Density made
Advance resilience capacity assessment and measurement concepts in rural and urban **USIAD & Mercy Corps. (2016). Urban Resilience Measurement An Approach Guide and Training Curriculum**	**Institutional -** Structure and function (Knowledge and information, Roles and responsibility, Collaboration and partnership), Planning and policy (Inclusivity, Assessment, Policy), Emergency response (Emergency plan, Early warning system, Drill practice) **Social -** Demographics (Dependency ratio, Marginal society, Migration pattern), Culture (Local tradition, Religion and belief), Social capital (Local organization, Community participation) **Human -** Health (Profile or health rate, Access and equity, Services), Education (Formal education, Knowledge management), Food and agriculture (Productivity and sufficiency, Accessibility and distribution, Quality and utilization (nutrition) **Economics -** Profile (Local market, Business and enterprises, Economic structure and profile), Financing Mechanism (Risk management, Budgeting), Livelihood (Diversity, Opportunity, Practice and policy) **Physicial -** Basic Services (Location and accesibility, Reliability and livability, Equity and equality), Critical Services (Shelter, Evacuation route, Emergency medical support), Protective Services (Equality, Standards, Maintanance) **Ecological -** Stock and species (Biodiversity, Connectivity, Adaptability), Environment (Quality, Potential sources), Landscape (Quality, Management, Services)
The urban resilience evaluation **Kim B, Lee GS, Kim M, Lee WS, Choi HS. (2023). Developing and Applying an Urban Resilience Index for the Evaluation of Declining Areas: A Case Study of South Korea's Urban Regeneration Sites. Int J Environ Res Public Health, 18;20(4):3653.**	Green Resilient Infrastructure (GRI) - Vulnerability (Disaster damage - Total amount of property damage due to disasters in last 10 years, Total casualties due to disasters in last 10 years, Size of vulnerable area - Combined area of the district), Adaptability (Ecological adaptability - Percentage of open space area in urban planning facilities, Proportion of green area and other green spaces, Percentage of 20 years + old buildings , Safety of buildings and structures - Ratio of floor area of buildings in the target site, Percentage of wooden or masonry structured buildings), Transformability (Scalability of community facilities - Number of schools + public health centers + administrative facilities + parks, Ratio of publicly owned land, Road accessibility - Ratio of buildings adjacent to roads with a width of 4 m or more, Number of civil defense evacuation facilities)
UN-HABITAT – City Resilience Profiling Programme https://unhabitat.org/sites/default/files/2021/01/crpt-guide.pdf	
Cities of Opportunity: Building the future https://www.pwc.com/gx/en/capital-projects-infrastructure/publications/assets/pwc-cities-of-opportunity-building-the-future.pdf	

Appendix A (continued)

Example Index and by whom?	Indicators
C40 Cities & Arup – C40 Cities Report on Climate Action in Megacities https://www.arup.com/perspectives/publications/research/section/climate-action-in-megacities	 
Disaster Resilience Indicators **Cutter, S. L., Burton, C. G., & Emrich, C. T. (2010). Disaster Resilience Indicators forBenchmarking Baseline Conditions. Journal of Homeland Security and Emergency Management, 7 (1).**	

B. Indicators Selected from Literature and Grouped for Expert Survey



C. Expert Survey Form

Dear urban planners,

Your answers to the questions in the survey below will be used within the scope of METU Urban Planning Master's Thesis **"Development of a Spatial and Environmental Resilience Assessment Index at Neighbourhood Scale with Reference to Existing Urban Resilience Frameworks"**. The main subject of the study is the inadequacy of urban resilience indices and strategies, which have already been developed comprehensively at the city and regional scale, in terms of measurement and implementation at the neighbourhood scale. In this thesis, it is aimed to question the importance of existing spatial and environmental resilience measurement indicators in terms of measurement and implementation at the neighbourhood scale.

The answers and information given to the questions will only be used within the scope of the thesis study and will not be shared in any other environment.

*Participation is voluntary. You can end the survey at any time. You can contact me at my e-mail address for your questions about the survey.

Thank you for your contribution to the study.

METU City Planning Master's Student
Elif Özge BÜYÜKSOY e-mail:

General Information

1. Sector in which you work as an expert: □ Public sector □ Private sector □ University
2. How long have you been working in your profession?
   □ 2-5 years □ 6-10 years □ 11-15 years □ 16-20 years □ 20+ years
3. How long have you been working on the concept of urban resilience?
   □ No study □ 0-5 years □ 6-10 years □ 11-15 years □ 16-20 years □ 20+ years

Questions

A. Spatial Resilience

Spatial resilience refers to the resilience of the physical and spatial aspects of the city and the man-made infrastructure such as buildings, energy and basic needs networks that need to be built in the system.

4. **How important** do you think each of the following spatial indicators is in making the neighbourhood more resilient (1-unimportant, 2-slightly important, 3-important, 4-very important, 5-critical)?

Sub Indicator	**5 (Critical)**	**4 (Very Important)**	**3 (Important)**	**2 (Slightly Important)**	**1 (Unimportant)**
INDICATOR.A.1 - LAND USE AND DIVERSITY					
A.1.1 Diversity of uses in the city (trade, green areas, socio-cultural facilities, etc.)					
A.1.2 Sufficient open space and ease of access					
INDICATOR.A.2 - WALKABILITY AND STREET CONNECTIVITY					
A.2.1 Connectivity, quality and comfort of pedestrian routes					
A.2.2. Connectivity, quality and comfort of cycle paths					
INDICATOR.A.3 - EASE OF ACCESS TO ROADS AND TRANSPORT NODES					
A.3.1 Topographically adequate road design					
A.3.2 Ease of access to the road in case of emergency					
A.3.3 Equal ease of access to public transport stops					
INDICATOR.A.4 - ALTERNATIVE ROUTES AND TRANSPORT OPTIONS					
A.4.1 Alternative routes to emergency and basic facilities					
A.4.2 Sufficient public transport options					
INDICATOR.A.5 - ACCESS TO BASIC FACILITIES					
A.5.1 Equal access to green infrastructure,					

Sub Indicator	5 (Critical)	4 (Very Important)	3 (Important)	2 (Slightly Important)	1 (Unimportant)
education, socio-cultural and religious facilities					
A.5.2 Equal access to all emergency uses					
INDICATOR.A.6 - BUILT-UP AREA QUALITY AND DENSITY					
A.6.1 Density of built-up area					
A.6.2 Physical characteristics of the building					
A.6.3 Housing type (detached, housing estate, housing blocks), number of houses with garden					
INDICATOR.A.7 - ACCESS TO ENERGY EFFICIENCY					
A.7.1 Buildings with shaded south/west facades					
A.7.2 Presence of renewable energy resources					
A.7.3 Energy efficient traffic and street lights					
INDICATOR.A.8 - WASTE MANAGEMENT AND RECYCLING					
A.8.1 Number of waste-recycling centres and collection vehicles					
A.8.2 Collection methods for building waste (industrial, commercial, residential...)					
INDICATOR.A.9 - ACCESS TO FLEXIBLE INFRASTRUCTURE					
A.9.1 Equal access to safe and sustainable drinking water, effective sanitation and electricity					
A.9.2 Having backup plans in case of any interruption in existing infrastructure systems					

B. Environmental Resilience

Environmental resilience refers to ensuring the resilience of the environmental aspect of the city with strategies such as the protection of natural areas and ecosystems in and around the urban system, protection of ecological balance, ensuring biodiversity and preventing environmental pollution against the threats that rapid urbanisation may bring.

5. **How important** do you think each of the following environmental indicators is in making the neighbourhood more resilient (1-unimportant, 2-slightly important, 3-important, 4-very important, 5-critical)?

Sub Indicator	**5 (Critical)**	**4 (Very Important)**	**3 (Important)**	**2 (Slightly Important)**	**1 (Unimportant)**
INDICATOR.B.1 - GREEN AREA DENSITY					
B.1.1 Green area density					
B.1.2 Vegetation around buildings and building entrances					
INDICATOR.B.2 - GREEN AREA CONTINUITY					
B.2.1 Continuity of green areas					
B.2.2 Ease of access to green areas					
INDICATOR.B.3 - GREEN AREA DIVERSITY					
B.3.1 Green area diversity					
B.3.2 Biodiversity conservation					
INDICATOR.B.4 - CONSERVATION OF SOIL DRAINAGE AND NATURAL WETLANDS					
B.4.1 Ratio of grey-green infrastructure					
B.4.2 Presence of permeable pavements, bioswales, rainwater harvesting systems, green roofs					
INDICATOR.B.5 - ACCESS TO SAFE FOOD					
B.5.1 Access to local farm products					
B.5.2 Presence of edible gardens					

Sub Indicator	5 (Critical)	4 (Very Important)	3 (Important)	2 (Slightly Important)	1 (Unimportant)
INDICATOR.B.6 - HEAT ISLANDS AND NATURAL VENTILATION					
B.6.1 Urban dimension and building heights					
B.6.2 Narrow streets between tall buildings					
B.6.3 Street and pavement surfaces reflecting solar radiation					
B.6.4 Orientation of buildings					
B.6.5 Green facades of buildings					
INDICATOR.B.7 - ENVIRONMENTAL QUALITY AND POLLUTION					
B.7.1 Air quality					
B.7.2 Sufficient urban lighting to reduce light pollution					
B.7.3 Waste collection frequency					
B.7.4 Soil quality					
INDICATOR.B.8 - VULNERABILITY TO NATURAL DISASTERS					
B.8.1 Conservation of ecologically sensitive areas					
B.8.2 Protection of steep slopes in landslide and erosion areas					
B.8.3 Permeable areas and elevated entrances to prevent flooding					
B.8.4 Increasing the distance between buildings					

6. Do you have any suggestions for alternative resilience indicators that you would like to add in terms of which factors should be prioritised to prevent or minimise the potential negative impacts of future risks on the resilience of neighbourhoods (open-ended question)?

D. Reliability Test of Responses of Expert Survey

```
RELIABILITY
  /VARIABLES=M_1 M_2 M_3 M_4 M_5 M_6 M_7 M_8 M_9 M_10 M_11 M_12 M_13 M_14 M_15 M_16
M_17 M_18 M_19 M_20 M_21 C_1 C_2 C_3 C_4 C_5 C_6 C_7 C_8 C_9 C_10 C_11 C_12 C_13 C_14
C_15 C_16 C_17 C_18 C_19 C_20 C_21 C_22 C_23
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=SCALE HOTELLING
  /SUMMARY=MEANS.
```

Reliability

[DataSet1] D:\Yüksek Lisans\TEZ\anket sonuclar.sav

Scale: ALL VARIABLES

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
,949	,948	44

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3,980	3,220	4,720	1,500	1,466	,149	44

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
175,12	599,700	24,489	44

E. Mean Value of Responses of Expert Survey

```
MEANS TABLES=M_1 M_2 M_3 M_4 M_5 M_6 M_7 M_8 M_9 M_10 M_11 M_12 M_13
M_14 M_15 M_16 M_17 M_18 M_19 M_20 M_21 C_1 C_2 C_3 C_4 C_5 C_6 C_7 C
_8 C_9 C_10 C_11 C_12 C_13 C_14 C_15 C_16 C_17 C_18 C_19 C_20 C_21 C_
22 C_23
  /CELLS=MEAN COUNT STDDEV.
```

Means

Descriptive Statistics

	Mean	Std. Deviation	N
Diversity of uses in the city (commerce, green space, socio-cultural facilities, etc.)	4,26	,751	50
Adequate open space and ease of access	4,72	,454	50
Connectivity, quality and comfort of pedestrian routes	4,46	,706	50
Connectivity, quality and comfort of cycle paths	4,32	,844	50
Topographically appropriate road design (slope, etc.)	3,90	1,055	50
Ease of access to the road in case of emergency	4,68	,551	50
Equal ease of access to public transport stops	3,90	,931	50
Having alternative routes to emergency and essential facilities	4,52	,735	50
Having adequate public transport options	3,96	1,049	50
Equal access to green infrastructure, educational, socio-cultural, religious facilities	4,04	,807	50
Equal access to all emergency uses	4,52	,707	50
Density of built-up area	3,78	1,112	50
Physical characteristics of the building	3,96	1,068	50
Housing type, number of houses with gardens	3,64	1,321	50
Buildings with shaded south/west facades	3,26	1,175	50

Appendix E (continued)

Presence of renewable energy sources	3,92	1,104	50
Energy-efficient traffic and street lights	3,80	1,030	50
Number of waste-recycling centres and collection vehicles	3,56	1,181	50
Collection methods for building waste	3,68	1,115	50
Equal access to safe and sustainable drinking water, effective sanitation and electricity	4,02	1,097	50
Having backup plans in case of any disruption to existing infrastructure systems	4,34	,872	50
Density of green space	4,38	,602	50
Vegetation around buildings and building entrances	3,38	1,028	50
Continuity of green spaces	4,18	,774	50
Ease of access to green spaces	4,22	,790	50
Diversity of green space	4,00	,990	50
Conservation of biodiversity	3,88	1,023	50
Grey-green infrastructure ratio	4,18	1,004	50
Presence of permeable pavements, bioswales, rainwater harvesting systems, green roofs	4,30	,839	50
Access to local farm products	3,22	1,298	50
Presence of edible gardens	3,62	1,141	50
Urban size and building heights	3,86	1,195	50
Narrow streets (more shady streets) between tall buildings	3,32	1,269	50
Street and pavement surfaces that reflect solar radiation	3,52	1,165	50
Orientation of buildings	3,48	1,092	50
Buildings having green facades	3,64	1,025	50
Air quality	3,96	1,068	50

Appendix E (continued)

Adequate urban lighting to reduce light pollution	3,80	1,212	50
Frequency of waste collection	3,78	1,093	50
Soil quality	3,80	1,212	50
Conservation of ecologically sensitive areas	4,36	,875	50
Protection of steep slopes in areas of landslides and erosion	4,42	,731	50
Permeable areas and elevated entrances to prevent flooding	4,50	,735	50
Increasing the distance between buildings	4,08	,922	50

F. Observation Sheet Used in Field Study

INDICATORS	MEASUREMENT	NEIGHBORHOODS	
		DEMETEVLER	İŞÇİ BLOKLARI
A. Spatial Resilience			
A.1.1 Diversity of uses in the city (commerce, green space, socio-cultural facilities, etc.)	Percentage of uses compared to residential uses	82%	75%
A.1.2 Sufficient open space and ease of access	Percentage of open space area in the whole neighborhood area	17%	21%
A.2.1 Connectivity, quality and comfort of pedestrian routes	Number of disconnected and narrow pedestrian roads	Low	High
A.2.2 Connectivity, quality and comfort of cycle paths	Number of continious cycle paths	Low	Low
A.3.2 Ease of access to the road in case of emergency	Physical availability of each buildings in every building block to road	High	Low
A.4.1 Having alternative routes to emergency and basic facilities	Number of emergency facilities (fire station, police station, hospital, disaster assembly areas, etc.) within a 10-minute drive of the centre of the neighbourhood	8	11
A.5.1 Equal access to green infrastructure, educational, socio-cultural, religious facilities	The impact area of each facilities measured with the walking distance specified in the Spatial Plans Construction Regulation	Extend across the whole	Limited
A.5.2 Equal access to all emergency uses	Similarity of the journey duration of all emergency facilities close to the neighborhood center	Similar	Similar
A.9.1 Equal access to safe and sustainable drinking water, effective sanitation and electricity	Number of neighborhood residents can access to safe and sustainable drinking water, effective sanitation and electricity	All residents of the neighborhood	All residents of the neighborhood
A.9.2 Having backup plans in case of any disruption to existing infrastructure systems	Number of backup plans in case of any disruption to existing infrastructure systems	None	None
B. Environmental Resilience			
B.1.1 Density of green space	Percentage of green space area in the whole neighborhood area	22%	29%
B.2.1 Continuity of green spaces	Number of connected green spaces	5	9
B.2.2 Ease of access to green spaces	The impact area of green spaces measured with the 500 m walking distance	Extend across the whole	Extend across the whole
B.3.1 Diversity of green space	The variety and number of types of areas used as green areas in the neighbourhood	Low	High
B.4.1 Grey-green infrastructure ratio	Percentage of grey and green area	Green area ratio of 22% and built-up area ratio of 78%	Green area ratio of 29% and built-up area ratio of 71%
B.4.2 Presence of permeable pavements, bioswales, rainwater harvesting systems, green roofs	Number of permeable pavements, bioswales, rainwater harvesting systems, green roofs, etc. implementations	4	1
B.8.1 Conservation of ecologically sensitive areas	Number of ecologically sensitive areas in the neighborhood	None	None
B.8.2 Protection of steep slopes in areas of landslides and erosion	Number of steep slopes in areas of landslides and erosion in the neighborhood	None	Presence of high slope roads
B.8.3 Permeable areas and elevated entrances to prevent flooding	Number of elevated building entrances	2	1
B.8.4 Increasing the distance between buildings	Distances between buildings according to their heights	13 meters distance between 4-5 storey buildings	10 and 15 meters distance between 3-4 storey buildings

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