Research Article

ICONARP
International Journal of Architecture and Planning
Received: 26.12.2022 Accepted: 31.07.2024
Volume 12, Issue 2/ Published: 31.12.2024
DOI: 10.15320/ICONARP.2024.293 E- ISSN:2147-9380

ICONARP

Urban Resilience Index Study on Ankara Metropolitan Area

Şeyma Elif Dincer*
Özge Yalçıner Ercoşkun**

Abstract

Nowadays, urban planning, urban resilience, and climate change issues are discussed differently within the frame of developing and changing technological conditions. Studies on climate change, disasters, environmental data, and effective use of resources indicate that cities are responsible for exceeding their ecological limits. Cities are both the source of these problems and the most affected in terms of threats to urban residents and urban infrastructures. As a result of the uncertain and ever-changing risks brought on by urbanization and population growth worldwide that put pressure on cities in a variety of interconnected and complex ways perceptions of the preparedness and safety of cities are evolving. To manage these issues, new paradigms are needed. There is no consensus on the concept of urban resilience and methods for applying this concept in urban areas. In this research, how to create a relationship between existing approaches, theories, and practices in the field of urban resilience is discussed. The necessity to include resilience in numerical measurement techniques and planning applications and how these application methods will be operated was explained. In the process of creating a planning decision support system to ensure urban resilience, indicators that would provide input to measurement and index studies were researched, and new indicators were proposed. In this study, a formula for the urban resilience index was determined, and analyses that would provide input to the planning in Ankara metropolitan districts according to these indicators and urban resilience characteristics were put forward through geographic information systems. According to these studies, Gölbaşı was determined to be the district with the highest urban resilience index and Keçiören as the district with the lowest.

Keywords:
Climate change, Decision support systems, Geographical information systems, Index studies, Urban resilience.

* City and Regional Planning, Faculty of Architecture, Gazi University, Ankara, Türkiye. (*Corresponding author*)
Email: seymaelifsirin@gmail.com

**City and Regional Planning, Faculty of Architecture, Gazi University, Ankara, Türkiye.
Email: ozgeyal@gazi.edu.tr

To cite this article: Dincer, Ş.E., & Yalçıner Erçoşkun, Ö. (2024). Urban Resilience Index Study on Ankara Metropolitan Area. *ICONARP International Journal of Architecture and Planning,* 12 (2), 504-532. DOI: 10.15320/ICONARP.2024.293

INTRODUCTION

The idea of resilience is closely related to the fundamental principles of sustainability. Although not used interchangeably, the principles that contribute to sustainability also have positive effects on resilience (Ercoşkun, 2012). Over the past decade, the concept of resilience has been explored across various scientific fields and decision-making processes (Coaffee, 2013). In general, resilience is analyzed within four categories: ecology, disaster and conservation planning, social and institutional, and economic. The concept of socio-ecological resilience, which highlights the relationship between the ecosystem and society, is particularly noteworthy as it plays a crucial role. The origin of resilience in the ecological sense dates back to the 1970s when it was defined as the ability of a system to self-heal and improve following damage or deterioration (Holling, 1973). This definition was later expanded to encompass the field of urban ecological resilience, which studies the capacity of cities and urban systems to absorb extreme climate events or gradual climate changes and the associated risks, while maintaining their essential characteristics (Ernstson et al., 2010; Maru, 2010). Disaster and risk reduction-based approaches focus on reducing the vulnerability of cities, their infrastructure, and residents (especially disadvantaged groups) to unexpected hazards and minimizing their economic impacts while improving infrastructure.

Social and institutional-based approaches to resilience place emphasis on the capacity of societies to adapt to unexpected risks, transparency, participation, collective learning, and preparedness. In the economic realm, resilience refers to the ability of regional and urban economies to withstand uncertain risks. The socio-ecological approach integrates ecosystem functions and social dynamics to manage the adaptation of cities to new processes and to create resilient cities (Lambin, 2005; Andersson, 2006).

The study of resilience spans across multiple scientific fields and decision-making processes, with a particular focus on the interplay between the ecosystem and society. The various approaches to resilience aim to improve the capacity of cities, their residents, and economies to withstand and adapt to the effects of climate change and associated risks.

The concept of resilience is widely recognized as a key factor in enabling systems and societies to withstand and effectively respond to the adverse effects of disasters, hazards, and risks (UNISDR, 2009). It is important to note that the focus of resilience is not solely on reducing losses in the face of a given risk, but rather on improving the overall performance of a system in the face of such threats.

If we consider cities as a system, urban resilience can be defined as a can be conceptualized as a multidisciplinary framework for analyzing and addressing the challenges faced by cities. This framework highlights the key attributes of cities that allow them to be reactive, adaptable, recoverable, regenerative, and transformable in the face of various risks

DOI: 10.15320/ICONARP.2024.293

and hazards. By examining these attributes, it becomes possible to not only diagnose problems, but also generate effective solutions to them.

The characteristics of urban resilience have been well documented in the literature. Some of the key features include robustness (Wardekker, de Jong, Knoop, & van der Sluijs, 2010), speed and efficiency in response, diversity (Walker & Salt, 2006), backup redundancy, environmental awareness, repetitive processes (Brown et al., 2012), integration, effectiveness, adaptability (Eraydın & Taşan-Kök, 2013), coping mechanisms, sensitivity to changing conditions, coordination (Arup, 2014), flexibility, and equality (Bahadur et al., 2010). These characteristics all play important roles in enabling cities to respond effectively to the risks and hazards they face.

It is worth noting that the concept of resilience is often viewed as a solution tool for addressing the broader global challenges posed by climate change. Given the inevitable impacts of climate change on cities and urban dwellers, especially in large cities, it is important that urban resilience becomes a priority for policymakers, planners, and stakeholders. By understanding the key features of urban resilience and working to enhance them, cities can become more resilient, better equipped to respond to the adverse effects of climate change, and more capable of thriving in the face of these challenges.

The notion of resilience, and the complementary concept of vulnerability, hold tremendous practical significance in addressing the challenges posed by climate change. In the context of urban areas, resilience has been conceptualized as a city's ability to mitigate the effects of climatic events and conditions, and to develop the means of effectively coping with these disruptions. This capability encompasses the maintenance or improvement of various elements of the urban environment, including physical infrastructure, social institutions, the natural environment, and governance structures.

While previous efforts in this field were largely focused on forecasting and preventing adverse effects, the emphasis has shifted towards preparation and adaptation in the face of high uncertainty. There exist numerous resources and materials, such as action plans, guidebooks, case studies, and reports, aimed at promoting resilience in response to climate change (UNISDR, 2012). However, there remains a lack of clear relationships between the definitions of resilience used in these resources, and the implementation plans developed from them.

To truly ensure the resilience of cities and their populations, it is necessary to determine levels of resilience, and to develop quantitative frameworks and methods for enhancing resilience in the face of extreme weather events and other ecological, social, and economic disasters. This is a critical step in reducing the exposure and vulnerability of cities and their inhabitants to the impacts of climate change.

In urban planning, the objective is to lay the foundation for the formulation of a vision and strategy for targeted development. Development plans are created to articulate a clear vision of the future and to achieve these development goals. However, from the perspective of resilience, traditional planning methods are inadequate in addressing the ever-evolving risks and uncertainties associated with constantly changing socio-ecological systems in cities (Yamagata & Sharifi, 2018). To address these deficiencies, the integration of resilience into urban planning requires the development of innovative methodologies.

The concept of resilience-based planning is a bottom-up approach that is equipped to handle the dynamic and ever-changing risks and uncertainties in cities. It is sustainable, future-oriented, and provides a new perspective on urban planning processes, allowing for the sharing of information and development of a shared understanding (Yamagata & Sharifi, 2018). This approach is adaptable to unexpected changes, produces city-specific solutions, and provides coordination.

Key features and criteria related to land use planning, such as density, mixed use, accessibility, permeability, and multifunctionality, affect the resilience and vulnerability profiles of cities and have implications for evacuation planning, flood risk management, energy and water consumption, the urban heat island effect, and social justice (Yamagata & Sharifi, 2018). By integrating resilience into urban planning, cities can be better equipped to address the challenges posed by climate change and to achieve their development goals.

The integration of resilience into urban planning practices, adaptation to climate change, and disaster management is crucial in promoting and strengthening the ecosystem. Ecosystem protection and enhancement play a critical role in mitigating the effects of future disasters, creating a natural threshold that helps absorb their impacts.

The concept of nature-based solutions has recently gained recognition as an effective approach for enhancing urban resilience. This approach emphasizes an ecosystem-based method with three distinct phases: preservation, renewal, and reproduction of existing ecosystem services. The benefits of nature-based solutions for urban resilience are multi-faceted, including reduction of river flood and heat stress risks, resource generation, tourism and recreation opportunities, carbon storage, and improved human health.

The World Bank (2022) highlights the key nature-based solutions that contribute to urban resilience, including bioretention areas, built and natural inland wetlands, river floodplains, mangrove forests, salt marshes, sandy shores, urban forests, terraces and slopes, river and stream renaturation, building solutions, open green spaces, green corridors, and urban agriculture. These solutions offer a range of benefits, such as reducing flood risk, mitigating heat stress, generating resources, promoting tourism, storing carbon, and improving human health.

The integration of resilience into urban planning, climate change adaptation, and disaster management through the use of nature-based solutions is crucial in promoting and strengthening the ecosystem. The ecosystem-based approach offers a range of benefits that contribute to

DOI: 10.15320/ICONARP.2024.293

enhancing urban resilience and protecting communities from the impacts of future disasters. Urban resilience is the capacity of individuals, communities, institutions, businesses and systems in cities to function, adapt, grow and transform in the face of stress and shocks.

This study approaches urban resilience from a socio-ecological perspective, emphasising the interaction between human systems and ecological systems in urban environments. Integrating resilience thinking into urban planning will address the shortcomings of traditional planning. It is important to recognise that threats cannot always be avoided because future conditions are unpredictable. It is necessary to try to understand the complexities and uncertainties inherent in urban planning as dynamic and constantly evolving social-ecological systems.

The main objective of this research is to establish the relationship between existing approaches, theories and practices on the concept of urban resilience and the methods of its application in metropolitan areas and to create a spatial decision support system. The necessity of incorporating urban resilience into quantitative measurement techniques and planning applications and how to operate these application methods are explained. In the process of creating a planning decision support system to ensure urban resilience, indicators that will provide input to measurement and index studies have been investigated and new indicators have been proposed.

RESEARCH METHOD

Determining the resilience levels of cities is one of the basic conditions for creating resilient cities. Along with the need for applied quantitative research, an analytical method is needed to understand the uncertainties that cities face and to determine their strengths and weaknesses.

Urban resilience is a complex and multifaceted concept that is measured through a variety of approaches specific to particular aspects of urban systems. The assessment of urban resilience has attracted worldwide attention. Understanding how to assess the level of resilient cities or how to scientifically quantify urban resilience helps academics to transform theory towards the practical construction of resilient cities. As a new research topic, there are few studies in this field and there is no common standard for measurement. These methods include assessing the robustness of infrastructure, the adaptability of social systems and the sustainability of environmental practices.

(Kong et al., 2022) categorised the techniques for measuring urban resilience as follows;

- Indicators and Indices
- Simulation Models
- Case Studies and Comparative Analysis
- System Dynamics
- Social Network Analysis (SNS)

- Optimisation Models
- Geographic Information Systems (GIS).

Table 1. Recent Urban Resilience Index Studies Table.

Source	Study	Model	Indicators
Cutter et al., 2008	DROP (disaster resilience of place)	Schematic model	Ecologic, social, economic, institutional, infrastructure, community capital
Cutter et al., 2010	Disaster Resilience Indicators for Benchmarking Baseline Conditions	0-1 Normalization, Cronbach's alfa, mean, total resilience, score	Social, economic, institutional, infrastructure, community capital
Arup, 2012	Urban Resilience Index	Scoring 1-5	Health and wellbeing, economy and society, infrastructure and environment, leadership and strategy
Cutter et al., 2014	The Geographies of Community Disaster Resilience	0-1 normalization, Cronbach's alfa	Social, institutional, ecologic, community capital, economic
Suárez et al., 2016	Towards an Urban Resilience Index: A Case Study in 50 Spanish Cities	Shannon entropy index, 0-10 scoring, 0-1 normalization. R=$\frac{Hb+Hf+Hlu+LA21}{EF/Area}$	Economic diversity, land use diversity, food variety, Local Agenda 21 process, ecological footprint
Fu, Xin, & Wang, Xinhao, 2018	Integrative Urban Resilience Capacity Index (IURCI)	Normalization, weight, Delphi, entropy IURC= ∑(i=1)^n 〖xi*xw〗	Ecological and physical condition, economical condition, community capital, institutional services

In addition, there are other assessment methods used in various urban resilience domains. Rose, A. (2004) pioneered the use of general equilibrium (CGE) models to assess economic resilience in urban systems. This quantitative approach provided a comprehensive framework for analyzing economic impacts and recovery processes. Li, Y., et al. (2018) introduced a multi-stage framework for evaluating abrupt changes in resilience status within urban socio-environmental systems. This method combined quantitative resilience value calculations with qualitative tipping point analysis to identify early warning signals. Zheng, Y., et al. (2018) explored the relationship between resilience and development through a mixed-methods approach. Combining expert consultation and exploratory factor analysis, this study provided insights into the complex interplay between these two factors. Tang, Y., et al. (2020) and Chen, Y., et al. (2021) employed network models to assess transportation resilience. These quantitative models allowed for the analysis of network vulnerabilities and system-wide impacts of disruptions. Liu, Y., et al. (2020) utilized life cycle assessment to evaluate infrastructure

DOI: 10.15320/ICONARP.2024.293

resilience. This approach provided a comprehensive perspective on the environmental impacts and sustainability of infrastructure systems. Bixler, R., et al. (2020) linked metropolitan networks to resilience planning and implementation through a combination of interviews and social network analysis. This mixed-methods approach offered valuable insights into stakeholder perspectives and network dynamics. Sweetapple, C., et al. (2019) demonstrated the impact of increasing resilience on sustainability in the design and operation of seweage systems. Their work involved capturing a wide range of potential futures and identifying tipping points, showcasing the application of scenario planning and resilience assessment in infrastructure systems (as cited in Li et al., 2023).

Indices and models have been developed in the literature for the understanding the level and the measurement of resilience (Table 1). Indices are approaches that make observations and measurements by reducing more than one set of indicators to a single numerical range.

Indicators play a crucial role in the assessment and evaluation of resilience, as they provide a means for making comparisons and determining rankings of the relevant measurements. In the context of urban planning, the use of resilience indicators and indices is particularly significant in the creation of a decision support system. To be effective, these indicators must possess certain key attributes. Firstly, they must have a proven track record of use in scientific and field studies, demonstrating their reliability and validity. Secondly, they must be universally applicable, able to be used across a range of contexts and situations. Thirdly, they must be directly linked to the concept of resilience, providing meaningful and relevant information. Finally, they must be able to be obtained from widely available, national sources (Cimellero, 2016).

In the resilience literature, indicators are typically classified into five categories: physical (Adger, 2000), social (Lin, 2006), ecological (Cutter et al., 2007), economic (Fernandez et al., 2013), and institutional structure (ARUP, 2015). In this study, the authors sought to develop a set of indicators specific to Turkish cities, arranging them based on their relevance to urban resilience and the data that could be obtained. These indicators were further analyzed and classified into three main categories: physical space, environment and climate, and socio-economic structure. The data of Built area (impermeable ground), Green Area m2 per person, Land use business/housing ratio, Number of buildings at risk of flood (Q100), Impermeable floor (Ha) indicators were created using geographical information systems.

A comprehensive list of indicators that were used in the index study is presented in Table 2. Notably, a number of special indicators were also proposed to address disaster risk and climate change issues, such as meteorological data, values related to consumption and waste, and indicators of flood risk specific to the region being studied. The inclusion of these unique indicators underscores the authors' recognition of the importance of considering the local context and specific hazards in the planning and assessment of urban resilience.

Table 2. Urban Resilience Indicators.

Physical Space Indicators	Impact on Urban Resilience	Literature
Planning		
Built area (impermeable ground)	Negative	Oecd 2021, Eurostat
Green Area m2 per person	Positive	Cutter et al, 2008
Land use business/housing ratio	Positive	Sharifi &Yamagata, 2014
Disaster Risk		
Number of floods	Negative	Burton, 2015
Emergency reporting rate	Negative	Cutter et al., 2008
Construction in flooded areas (100 Years)	Negative	Burton, 2015
Total number of incidents (fire department)	Negative	Cutter et al., 2008
Environmental and Climate Indicators	Impact on Urban Resilience	Literature
Environmental performance value	Positive	Şeker et al., 2020
Presence of sites	Positive	Cutter et al.,2008
Meteorological data		
Monthly maximum temperature (°C)	Negative	EPA,2021, URL 13
Average number of days with maximum temperature 30 °C and above	Negative	EPA, 2021, URL 13
Average number of days with minimum temperature -20 °C and below	Negative	EPA, 2021, URL 13
Monthly maximum rainfall (Mm=Kg÷M²)	Negative	EPA, 2021, URL 13
Air quality value	Negative	Cariole et al., 2018; Monterio et al., 2017
Consumption and Waste	Impact on Urban Resilience	Literature
Water consumption	Negative	Muller, 2017
Solid waste amount	Negative	Sharifi et al., 2017
Amount of recycled waste	Positive	Sharifi et al., 2017
Vehicle ownership rate	Negative	McBain et al., 2017
Natural gas consumption	Positive	Muller, 2017
Indicators of Socio-Economic Structure	Impact on Urban Resilience	Literature
Demographic structure		
Population density	Negative	Ehrlich et al., 2018;Sharifi et al., 2021
Persons under 20 or Over 65	Negative	Sharifi &Yamagata, 2014; Morrow, 2008
Proportion of divorced persons	Negative	Sharifi & Yamagata, 2014
Number of higher education graduates	Negative	Norris et al., 2008; Morrow, 2008
Human development index ranking	Positive	Şeker et al., 2020; UNİHDI. 2021
Governance and transparency value	Positive	Şeker et al., 2020; Cutter, 2014
Economic Structure	Impact on Urban Resilience	Literature

DOI: 10.15320/ICONARP.2024.293

Poverty rate	Negative	Norris et al., 2008; Morrow, 2008
Tenant household ratio	Negative	Cutter et al., 2008; Norris et al., 2008; Morrow, 2008
Sale price	Positive	Cutter,2010; Burton, 2015; Morrow, 2008
Rental price	Positive	Cutter,2010;(Burton, 2015; Morrow, 2008
Number of people receiving social assistance	Negative	Burton, 2015; Morrow, 2008

The composite indicator approach was used to determine the indicators in the index developed specifically for cities (Nardo et al., 2005). This method includes the steps of choosing the spatial analysis scale, determining the characteristics of the resilience, determining the indicators, normalizing the data, entering the data into the index, and visualizing the results with geographic information systems. Normalization of indicators after determination was made with a minimum-maximum scaling between 0 and 1 where 0 points indicated the worst ranking for each indicator, and 1 point was the best ranking. Values in between were scaled in this range (Cutter et al., 2010; Etsy et al. 2005). The maximum value of the true value of the indicators is calculated as follows: Indicator equals (Actual Value- Minimum Value) / (Maximum Value- Minimum Value) if it is positive in terms of urban resilience. The maximum value of the actual value of the indicators is calculated as follows: Indicator equals (Actual Value-Maximum Value) / (Minimum Value-Maximum Value). Calculated values are shown in Tables 3, 4, and 5.

Table 3. Environment and Climate Indicators Results.

Environment and Climate Indicators Normalized Values									
Indicator	Altındağ	Çankaya	Etimesgut	Gölbaşı	Keçiören	Mamak	Pursaklar	Sincan	Y. Mahalle
Water consumption m3	0.73	0.00	0.60	0.97	0.34	0.61	1.00	0.64	0.36
Max. temperature (°C)	0.98	1.00	0.00	0.75	0.25	0.90	0.98	0.50	0.55
Average number of days with maximum temperature 30 °C and above	0.09	0.48	0.10	1.00	0.65	0.29	0.54	0.00	0.14
Average number of days with minimum temperature -20 °C and below	1.00	1.00	0.91	0.82	0.66	1.00	1.00	0.00	0.86
Monthly maximum precipitation (Mm=Kg÷M²)	1.00	0.94	0.54	0.52	0.21	1.00	0.00	0.76	0.81
Number of vehicles per household	1.00	0.37	0.63	0.00	0.78	0.96	0.41	0.78	0.30
Air quality index	0.20	0.33	0.26	1.00	0.02	0.48	0.81	0.26	0.00
Solid waste tons/year	0.73	0.00	0.55	1.00	0.20	0.53	0.99	0.42	0.38
Recycled waste tons/year	0.63	1.00	0.50	0.07	0.71	0.38	0.12	0.49	0.70

Environmental performance value	0.58	0.74	0.69	0.71	0.00	0.36	0.47	0.32	1.00
Natural gas consumption m3	0.15	1.00	0.52	0.02	0.77	0.12	0.00	0.21	0.62
Protected area (Ha)	0.03	1.00	0.54	0.97	0.00	0.60	0.00	0.14	0.55

Table 4. Physical Space Indicators Results.

Physical Space Indicators Normalized Values									
Indicator	Altında ğ	Çankay a	Etimesgu t	Gölbaş ı	Keçiöre n	Mama k	Pursakla r	Sinca n	Y. Mahalle
Number of floods	0.86	0.82	0.97	1.00	0.00	0.87	0.94	0.99	0.09
Total number of incidents (fire department)	0.28	0.00	0.64	0.91	0.15	0.43	1.00	0.52	0.07
Number of emergency warnings	0.53	0.00	0.71	0.80	0.50	0.54	1.00	0.77	0.38
Number of buildings at risk of flood (Q100)	0.79	0.43	1.00	0.89	0.31	0.90	0.93	0.29	0.00
Green area ratio	0.55	1.00	0.65	0.01	0.46	0.39	0.09	0.00	0.50
Impermeabl e floor (Ha)	0.75	0.00	0.48	0.64	0.67	0.61	1.00	0.68	0.33
Workplace/ housing ratio	0.37	0.09	0.33	0.11	0.00	0.06	0.16	0.99	1.00

Table 5. Socio-Economic Conditions Indicators Results.

Socio-Economic Conditions Indicators Results									
Indicator	Altındağ	Çankay a	Etimesg ut	Gölbaş ı	Keçiöre n	Mama k	Pursakla r	Sinca n	Y. Mahalle
Number of undergraduat e and graduate school graduates	0.09	1.00	0.43	0.04	0.41	0.21	0.00	0.13	0.50
Population density person/ha	0.71	0.65	0.48	1.00	0.44	0.00	0.58	0.74	0.28
Total population under 20 and over 65	0.67	0.10	0.48	1.00	0.00	0.35	0.97	0.49	0.34
Number of people with Green Cards	0.00	0.78	0.89	1.00	0.55	0.30	0.98	0.54	0.46
Poverty rate %	0.00	0.91	1.00	0.05	0.64	0.45	0.47	0.69	0.79
Tenant household ratio %	0.00	0.17	0.62	1.00	0.53	0.52	0.64	0.72	0.35
Sale price TL/M2	0.00	0.94	0.53	1.00	0.35	0.21	0.54	0.23	0.68
Rental price TL/M2	0.25	1.00	0.63	1.00	0.25	0.13	0.13	0.00	0.63

DOI: 10.15320/ICONARP.2024.293

Divorced person ratio %	0.62	0.00	0.54	0.60	0.94	0.58	1.00	0.80	0.57
Governance transparency value	0.37	1.00	0.47	0.43	0.85	0.41	0.00	0.48	0.92
Human development index	0.34	1.00	0.27	0.23	0.41	0.16	0.00	0.17	0.57
Number of people receiving social assistance	0.25	0.87	0.79	1.00	0.14	0.00	0.95	0.44	0.70

The index values of the indicators whose weights are considered equal are calculated by taking the arithmetic average of the normalized values of the indicators and the index values for three different indicator sets (physical space, environment and climate, and socio-economic structure) (Table 6). The index score of the indicator sets was created for each district, and these scores were totaled to obtain the urban resilience index score (Cutter et al., 2010) as follows: Urban Resilience Index Score = Physical Space Index Score + Environment and Climate Index Score+ Socio-Economic Structure Index Score.

Additionally, features of the Arcgis Pro 2.9 software and geographic information systems were used while obtaining indicators and creating thematic maps. In this study, data from the Copernicus Portal Urban Atlas were used which is land cover/use data produced from satellite images with a precision of 1/10,000 scale. The spatial data obtained from this data, after selecting the areas such as green areas and residential areas with "select by attribute," a separate layer was created with the "export" feature process. By using the "select by location" tool, the area calculations of these areas were made using the "field calculator" tool. The calculation of the numerical data of the areas was combined with the tables of the data obtained from the geographical district borders and the institutions, and the data calculated through the program were combined with the attribute table in the program. Then, thematic coloring was done with the "graduate color" process in the demonstration section. The unique aspects that distinguish this study from other methods are the implementation of this method at the district level in the city of Ankara in Turkey to create a holistic urban perspective and decision support system with climate change and urban planning data. This pioneering study adopts a socioecological perspective and employs an index study to investigate the spatial distribution of urban resilience in Ankara, Turkey. The study highlights the city's vulnerability to extreme heat events and flooding,

ICONARP – Volume 12, Issue 2 / Published: 31.12.2024

exacerbated by the increasing prevalence of impermeable surfaces. For the first time, a comprehensive set of district-level resilience maps has been developed for the Ankara metropolitan area, providing valuable insights for urban planning and decision-making. The study's unique contribution lies in its integration of index and risk assessment approaches, enabling the creation of a spatial decision support system that can guide resilience-building strategies.

FINDINGS AND DISCUSSION

The results of the sub-indicator sets created to reach the urban resilience index ranking are listed below. The district with the highest environment and climate Index is Çankaya while the districts with the lowest are Keçiören and Sincan, according to these results. The district with the highest socio-economic structure index is Çankaya while the districts with the lowest are Altındağ and Mamak. The district with the highest physical space index is Pursaklar, and the district with the lowest is Keçiören (Table 6, Figure 1,2,3). An urban resilience index comparison was created for the central districts of Ankara using the index calculations. In the urban resilience index ranking, the highest district is Gölbaşı, and the lowest district is Keçiören (Table 7, Figure 4).

Table 6. Index Results of Indicator Groups.

Name of the District	Environment and Climate Index	Socio-Economic Structure Index	Physical Space Index
Altındağ	0.59	0.28	0.59
Çankaya	0.66	0.70	0.33
Etimesgut	0.49	0.59	0.68
Gölbaşı	0.65	0.69	0.62
Keçiören	0.38	0.46	0.30
Mamak	0.55	0.28	0.54
Pursaklar	0.53	0.52	0.73
Sincan	0.38	0.45	0.60
Yenimahalle	0.52	0.57	0.34

DOI: 10.15320/ICONARP.2024.293

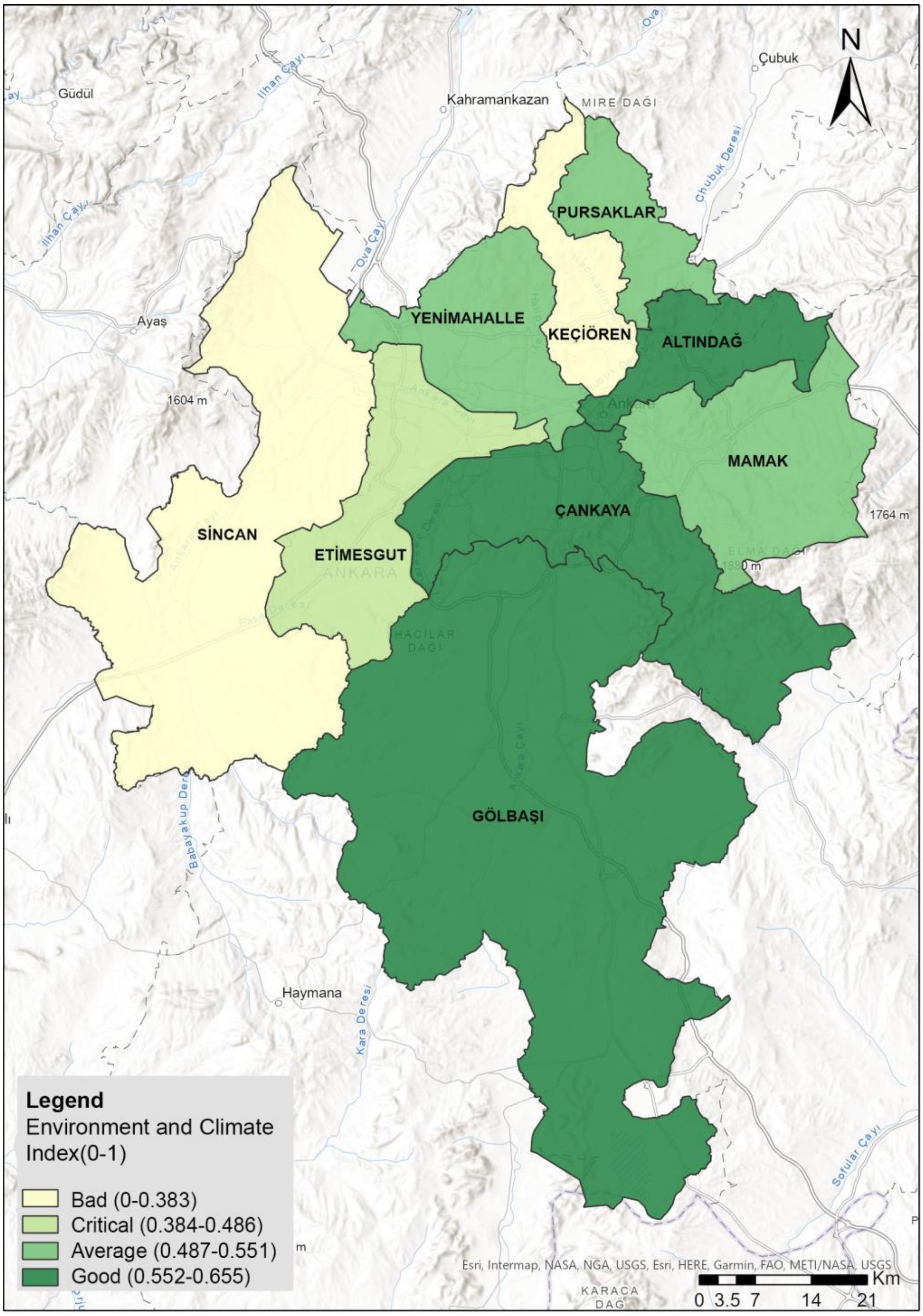

Figure 1. Environment and Climate Index Map,2022.

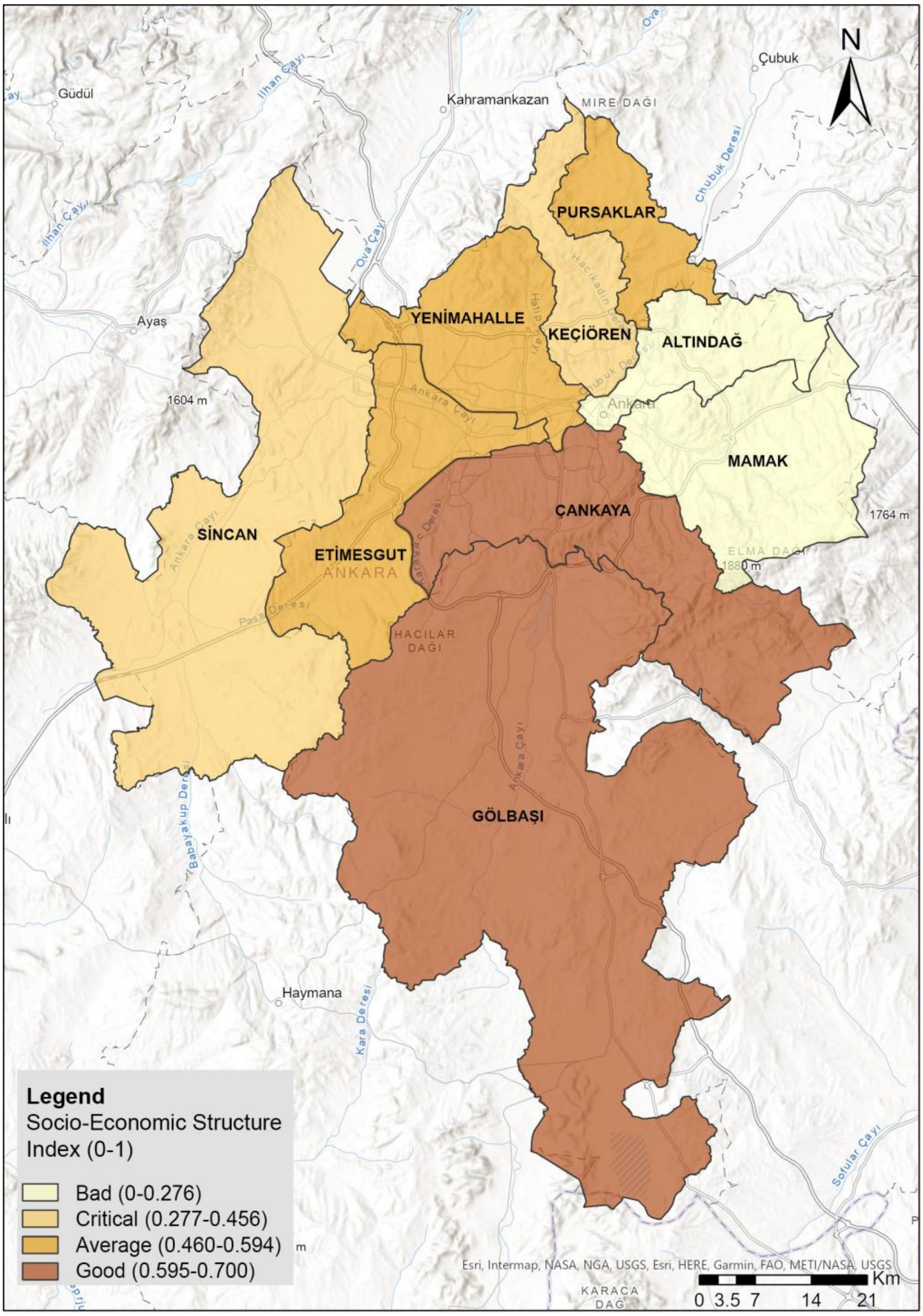

Figure 2. Socio-Economic Structure Index Map,2022.

DOI: 10.15320/ICONARP.2024.293

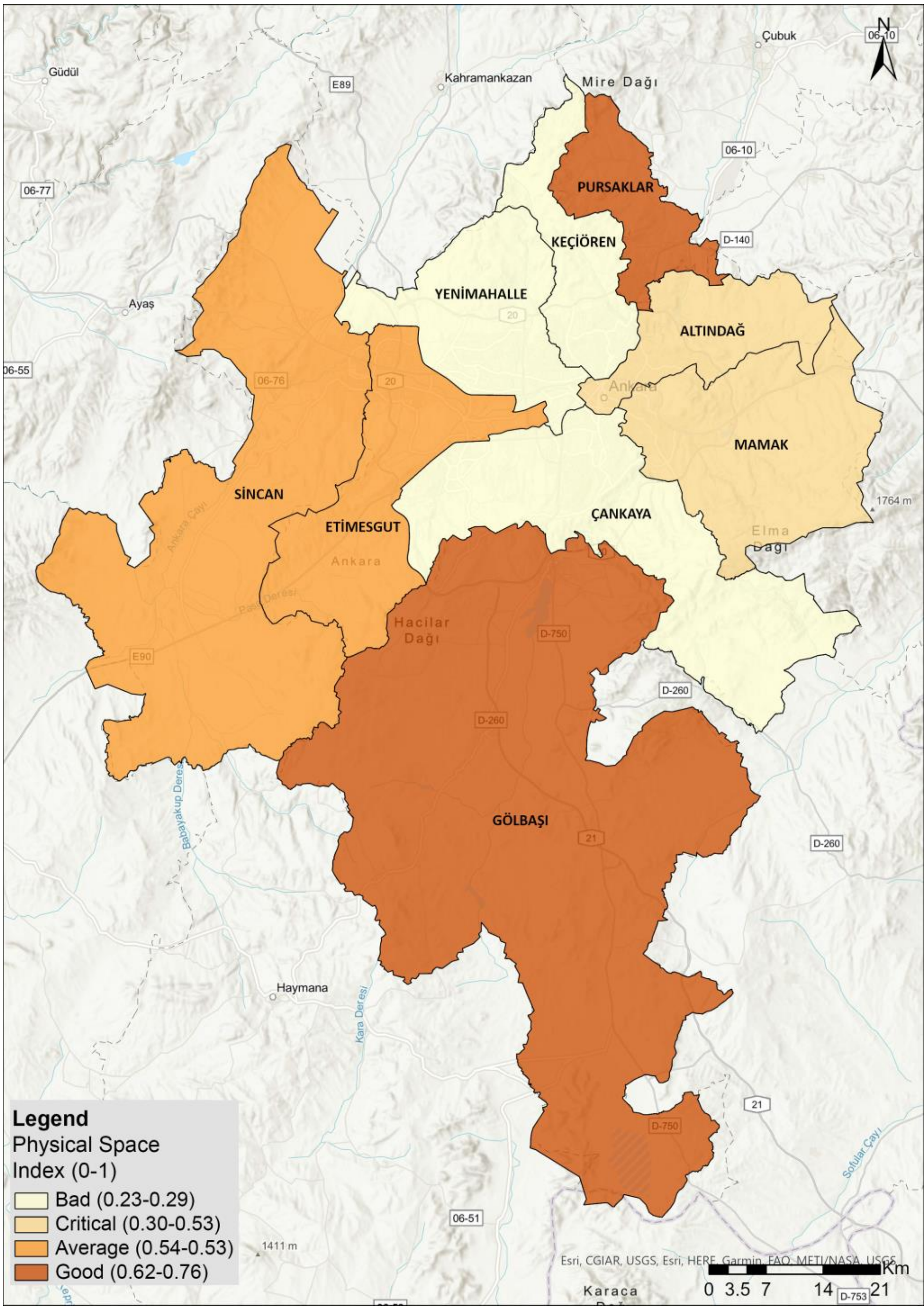

Figure 3. Physical Space Index Map,2022.

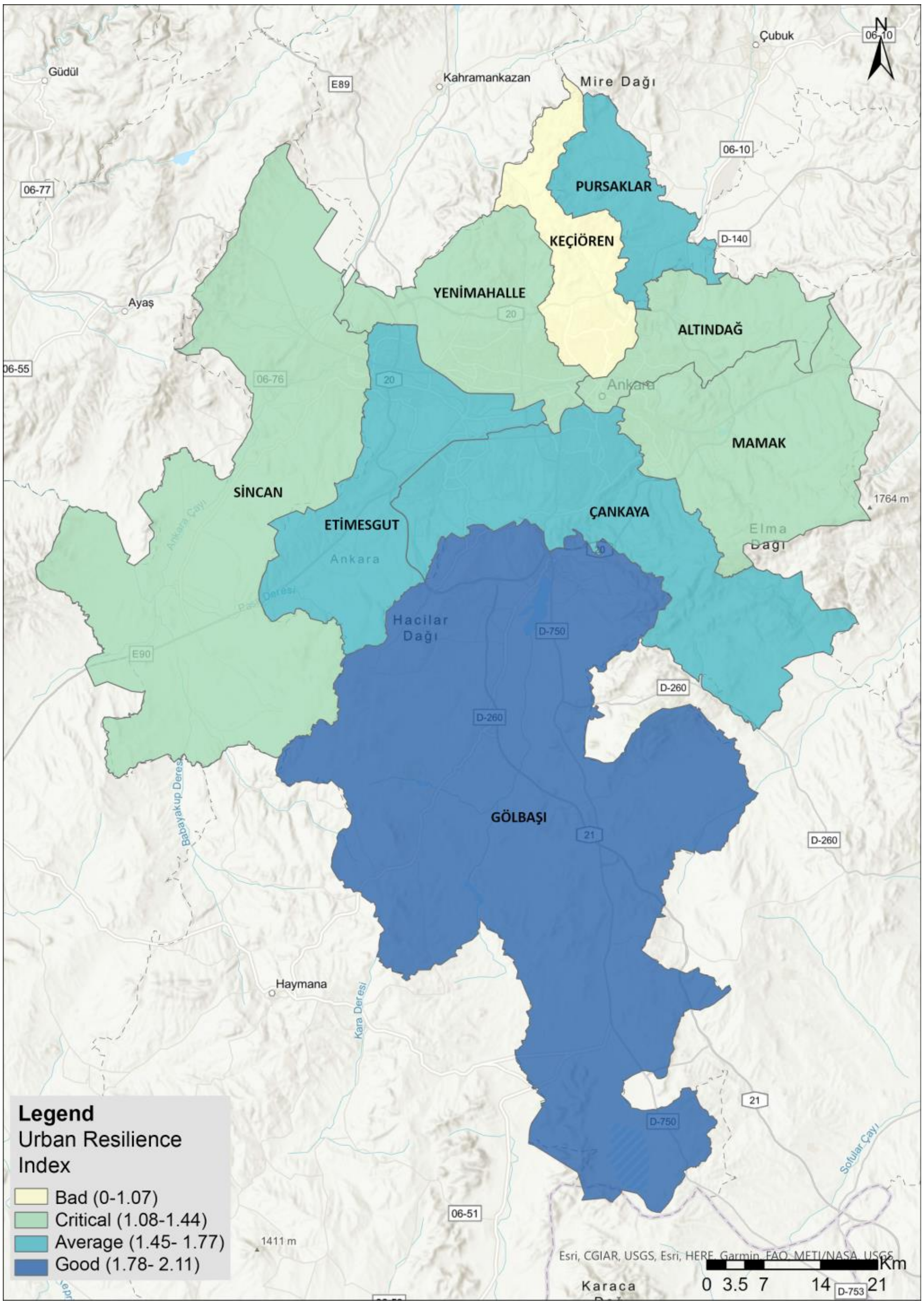

Figure 4. Urban Resilience Index Result Map,2022.

DOI: 10.15320/ICONARP.2024.293

Table 7. Urban Resilience Index Results.

Name of the District	Urban Resilience Index
Altındağ	1.46
Çankaya	1.69
Etimesgut	1.76
Gölbaşı	1.97
Keçiören	1.14
Mamak	1.37
Pursaklar	1.78
Sincan	1.43
Yenimahalle	1.43

According to the results of the research, when the lowest (the last three in each sub-title between 00.00 and 0.10) and the highest (he first three in each sub-title between 0.90 and 1.00) indicators of Ankara central districts are examined, it is possible to make a comparison showing the lowest and highest values and their strengths and weaknesses for each district.

The Gölbaşı district, which has the highest urban resilience index, comes to the fore in air quality due to its low population, low consumption values, and the presence of a special environmental protection zone that includes Mogan Lake; and other values are in the first place with the remaining average values.

The reason the Çankaya district, which is the district with the highest socio-economic resilience, has medium values in urban resilience is its low physical space index. Due to the high density of buildings and high population, there is an increase in temperature values due to high consumption values and high level of impermeable ground; thus, the Çankaya district has medium values contrary to expectations. Etimesgut, which is another district with a medium value, has a low risk of flooding because it is more planned compared to other districts, but its temperature values are high because it creates an urban heat island effect due to insufficient green space. The Pursaklar district, which is the last district with a medium value, has lower consumption values than other districts due to its low population and the fact that it is a newly established district. This district, located on the airport road that develops in parallel with the transportation axes and has a form defined as urban sprawl, falls behind in the rankings due to the lack of green areas.

The lack of natural areas in the Altındağ district, which is of sensitive value, causes an increase in temperatures in an arid climate. Its low

ICONARP – Volume 12, Issue 2 / Published: 31.12.2024

economic level also causes fossil fuel consumption. In the Mamak district, which has a sensitive value, high population density creates inadequacy of infrastructure and municipal services. Being one of the districts with a low socio-economic level and one of the districts in the process of transformation, Mamak also has extreme climate values due to the lack of proper infrastructure, lack of natural areas, and insufficient green areas. The fact that the district of Sincan, which has a sensitive value, has the lowest rate of green area and natural area causes extreme weather events. Keçiören, the district with the lowest urban resilience index, is in the lowest ranking in Ankara with its existing dense building stock and high population, insufficient green areas, excess consumption values, and high number of floods despite not being in a floodplain (lack of infrastructure). These results indicate the multifaceted nature of urban resilience and reveal which areas have deficiencies.

Critical literature suggests that in practice, resilience is often used as a comprehensive term for future preparedness without a clear interpretation of what it means or how certain interventions or system characteristics can improve it. Although theoretical discussions on resilience have been extensively researched, methodological challenges persist with the implementation of the concept. The necessity of measuring resilience is crucial, particularly in determining which method is applicable and in identifying vulnerable points. The problems with measuring resilience are primarily twofold: one being conceptual and the other being methodological. The conceptual issue arises from the lack of a shared understanding of what resilience means and the limitation of evaluating it with a single number or result, given that it is a dynamic process that changes over time. Despite criticisms regarding the overly reductionist nature of measuring urban resilience with indicators and indexes, which limits its perspective on issues, it remains a powerful tool in terms of simplifying complexity, providing a means for identification and monitoring, defining structures, and offering comparisons.

To overcome the epistemological illusion created by indexes, which provide only scientific knowledge and instrumental analyses, a need exists to restructure urban resilience studies with strong theoretical and empirical tools. Conceptualizing the built environment as a multifaceted and interconnected system that encompasses ecological, sociocultural, economic, and governance dimensions is therefore necessary to fully grasp the interconnections, synergies, exchanges, contradictions, tensions, and future reasonable scenarios or trends.

According to research findings, the main problems and issues of the city of Ankara are related to its physical infrastructure and urban form, as well as flawed policy and planning decisions, and ongoing administrative problems. Based on the resilience index results of the metropolitan districts of Ankara, the key problem areas are the physical infrastructure and past land-use decisions that still have an impact.

DOI: 10.15320/ICONARP.2024.293

Another important issue that needs to be addressed in the context of the resilience of the metropolitan districts of Ankara is the incompatibility between the changing administrative approaches and the old and new approaches. Although climate change adaptation, promoting bicycle use, and green urban planning initiatives are promising, the reality of planning processes, the lack of adaptation to individual contexts, and the failure to consolidate them without broad and deep participation, reveals significant problems. Political and economic issues in developing countries are also an important topic to be examined under the theme of urban resilience. When interpreting the resilience index results of Ankara, the most important factors for Gölbaşı district to obtain the highest values are its relatively limited urban sprawl, natural conservation areas, and special environmental protection zones, which restrict development and provide the highest green area ratio in the city. On the other hand, the intense urbanization in Keçiören, insufficient green areas, and inadequate infrastructure pull it back in the rankings. The more densely built-up and impermeable an urban area is, the more vulnerable it becomes. Car-focused transportation increases impermeable surfaces and leads to floods and deaths. When these data are updated over time, it is evident that different results can emerge within the framework of social dynamics, relationship networks, and local knowledge, provided that the current and planned climate and flood plans are implemented, and the urban resilience work is re-evaluated within the context of local stakeholders and expert opinions.

CONCLUSIONS

The biggest obstacle to resilience is the inadequacy of open and green spaces in existing housing areas in areas with low resilience in this study which was conducted in the central districts of Ankara. Suggestions for planning solutions to the problems in the districts with the lowest resilience are listed above.

In Altındağ district lowest resilience area is socio-economic structure index. Solution Suggestions for Altındağ district are ;

• Create new business areas, increase community centers, strengthen public transportation to the center in order to raise the economic level

• Increase local governments' incentives and assistance for renewable energy and natural gas in order to reduce fossil fuel consumption

• Increase green areas (to prevent surface warming) and increase permeable floors.

In Çankaya district lowest resilience area is physical space index. Solution suggestions for Çankaya district are;

• Increase green areas (preventing surface warming) and increase permeable floors

• Increase the continuity and access to green areas to create carbon sink areas

• Implement and supervise the Çankaya municipality "sustainable energy action plan" actions

• Close the valleys to construction

• Create a rail system to support public transportation and reduce carbon emissions.

In Etimesgut district lowest resilience area is environment and climate index. Solution suggestions for Etimesgut district are;

• Increase green areas (preventing surface warming) and increase permeable floors

• Increase the continuity and access of green areas to create carbon sink areas

• Support public transportation with a rail system which would reduce carbon emissions.

In Gölbaşı district lowest resilience area is physical space index. Solution suggestions for Gölbaşı district are;

• Strengthen the city center and public transportation (to reduce vehicle ownership and reduce carbon emissions)

• Increase pedestrian access by encouraging mixed use

• Take measures to slow down urban traffic on intercity roads

• Protect the wetland ecosystem between Eymir and Mogan Lakes

• Keep the lakes alive by saving the aquifers feeding the lakes from the pressure of construction

• Increase the number of community centers.

In Keçiören district lowest resilience area is physical space index. Solution suggestions for Keçiören district are;

• Prevent urban growth approaching the ring road,

• Protect remaining valleys and catchments

• Make a healthy and ecological transformation in housing areas through urban scale reinforcement areas

• Increase green areas (preventing surface warming) and increase permeable floors,

• Increase the continuity and access of green areas to create carbon sink areas

• Evaluate rainwater

• Increase infrastructure services and arrange city streams as green infrastructure

DOI: 10.15320/ICONARP.2024.293

• Increase pedestrian access by encouraging mixed use.

In Mamak district lowest resilience area is socio-economic structure index. Solution suggestions for Mamak district are;

• Create new business areas and increase community centers in order to raise the economic level and strengthen public transportation to the center

• Avoid increasing building density

• Increase the continuity and access to green areas to create carbon sink areas

• Plan the Hatip Stream and Bentderesi surroundings as a green infrastructure

• Provide a healthy and ecological transformation in housing areas through urban scale reinforcement areas.

In Pursaklar district lowest resilience area is socio-economic structure index. Solution suggestions for Pursaklar district are;

• Limit construction and increase open green areas (preventing surface warming) and increase permeable floors,

• Increase the continuity of green areas and access to these areas in order to create carbon sink areas

• Establish community and education centers.

In Sincan district lowest resilience area is environment and climate index. Solution suggestions for Sincan district are;

• Increase green areas (preventing surface warming) and increase permeable floors

• Increase the continuity and access of green areas to create carbon sink areas

• Create incentives for a rail system and public transportation for business trips

• Increase social facilities.

In Yenimahalle district lowest resilience area is physical space index. Solution suggestions for Yenimahalle district are;

• Increase green areas (preventing surface warming) and increase permeable floors

• Increase the continuity and access of green areas to create carbon sink areas

• Create a green transformation (eco-renovation) of industrial areas

• Use Atatürk Forest Farm for food production

• Establish an effective public transport system

ICONARP – Volume 12, Issue 2 / Published: 31.12.2024

• Activate existing green areas (the district has large areas of wasteland

• Evacuate buildings in flooded areas and plan a green space system over city streams.

Suggestions for designed solutions to these problems are nature-based. The less nature is interfered with and the more the design is created according to nature, the rate of being affected by climate change and disasters will be minimized. The resilient urban planning approach proposals that have been created are as follows:

• Interaction between temporal and spatial scales

• Mixed use

• Compact city form

• Highly connected transport system (sustainable public transport, digital ticketing, online navigation services)

• Intelligent, digitized utilities and applications

• Building types and urban rooms with low service costs, reduced environmental footprints

• Planning redundancy and resilience of critical infrastructure and systems

• Increasing the efficiency and safety of technical and industrial systems and processes including production, transportation, communication and construction infrastructure and systems to increase energy efficiency and reduce environmental footprints

• Active participation

• Protecting and developing natural systems (including climate) and areas of environmental, historical, and cultural importance

• Nature-based approaches.

According to the results obtained, suggestions for the city of Ankara in order to create green infrastructure and provide nature-based solutions in order to provide urban resilience are listed above at three intervals.

Short Term;

- Increasing green areas
- Rehabilitation of the existing green system
- Planting the environment of existing transportation axes
- Systematic inventory studies of existing green areas with information systems
- Implementation and supervision of the Ankara Climate Action Plan, Ankara Bicycle Master Plan, and Green City Plan

Medium Term;

DOI: 10.15320/ICONARP.2024.293

• Preparation of environmental plan and master zoning plans from an ecological perspective

• Creating a natural structure analysis which is one of the basic conditions of planning, in terms of information systems in an accessible and manner that is easily developed (slope, aspect, wind)

• Planning city streams and surroundings as open green areas

• Revealing urban streams and transforming their the ground around them into permeable structures

• Increasing investments in rainwater collection and wastewater recycling

• Making plan notes and arrangements preventing construction over city streams and their environment in development plans

• Increasing green roof, green wall, and other applications supporting urban agriculture

• Increasing urban forests and urban farms (food self-sufficiency)

• Creating green corridors that connect green infrastructures with each other and with the city

• Increasing public transportation and urban mobility by providing integration between transportation systems

• Making a sustainable mobility action plan

• Establishing a city information system (creating data by considering ecological boundaries)

Long Term;

Relocation of construction away from water resources, valleys, and floodplains

• Creation of backtracking and continuity of data systems and efficiency of GIS infrastructure

• Increasing the public transport and metro system

• Reduce carbon emissions by 40% by signing the Agreement to Be a Green Capital and President's Agreement.

When we examine urban resilience theoretically and practically, transforming resilience from a conceptual dimension into concrete urban interventions is a challenging process. The necessity to measure resilience is important in determining which method is applicable and at which points there are vulnerabilities. In this study, a methodology was developed to determine the resilience of cities with the proposed index. With this method, index calculation data and indicators, which can be reused and diversified in other studies, are arranged so that they can be arranged and reused for different purposes. Indicators in different fields offer a holistic analysis by drawing attention to the multifaceted structure of urban planning. This index, which is a guide for city planners, can be used to reveal the strengths and weaknesses of a city and to use it as a tool for special project areas and plan studies. Identifying the areas in need of improvement in the city is useful for finding priority areas in public policies and for monitoring and comparing changes with geographic information systems in the temporal dimension. Digital technologies, geographic information systems and smart city applications add a temporal dimension to urban planning and offer an up-to-date solution to the participation processes and feedback mechanism problems that are often targeted as not being implemented. This index study is unique and important in terms of creating a decision support system for urban planners.

It is important to adopt a bottom-up approach in resilient urban planning decision processes and to evaluate the information obtained from indices and geographical information systems in the axis of social dynamics, political conditions, relationship networks without removing the glasses of social sciences and to create a decision process by synthesising all these conditions.

Since there is no information system on resilience in Ankara metropolitan area, this study has created a spatial decision support system with 35 maps produced in geographical information systems and an inventory that can be a reference for future researchers has been obtained.

The resilience value obtained with this index provides a comparative perspective on the need for improvement and is useful for the identification of priority planning areas. The physical, ecological, economic and social results obtained from this index are an important decision support system for public policy decision processes. This index offers a wide range of applications for planning decision processes. It is useful for tracking progress, identifying needs, intervention or mitigation processes, monitoring change and making comparisons. Decision support systems are the ability to collect, process, contextualise and present data to transform big data into useful information for the planning process. For the healthy functioning of these processes, all institutions should produce their data in the same standards, work in cooperation and apply the concept of transparency. Open data helps public officials to make evidence-based decisions that serve all citizens and improves the ways of sharing information, providing services and monitoring results. The way for urban planning to adapt to today's change and development processes is to include new paradigms in planning processes and to produce solution-oriented, rational and objective plans.

SYMBOLS

∑ Sum of values

(°C) Celsius degree temperature unit

(Mm=Kg. Amount of precipitation in kilograms per 1 M2

DOI: 10.15320/ICONARP.2024.293

TL Turkish lira

M2 Square meter

Ha Hectares of area (10,000 m2)

NOTES

This manuscript was produced from the corresponding author's doctoral thesis, titled “Development Of Urban Resilience Index: A Case Study On Ankara Metropolitan Area”, completed at Gazi University in 2022. The second author (Prof. Dr. Özge Yalçıner Ercoşkun) is the thesis advisor of the corresponding author.

REFERENCES

Adger, W. N. (2000). *Social and ecological resilience: are they related? Progress in Human Geography, 24(3), 347–364.* doi:10.1191/030913200701540465

Andersson, E. (2006). *Urban Landscapes and Sustainable Cities. Ecology and Society,*
11(1). doi:10.5751/es-01639-110134

Arup, Rockefeller Foundation. (2012).City Resilience Index https://www.arup.com/perspectives/publications/research/section/city-resilience-index, Accessed 10 March2022.

Arup, Rockefeller Foundation. (2015). https://www.rockefellerfoundation.org/wp-content/uploads/City-Resilience-Framework-2015.pdfP Accessed 10 March 2022.

Bahadur, Aditya, Ibrahim, Maggie, & Tanner, Thomas. (2010). *The résilience renaissance ? Unpacking of resilience for tackling climate change and disasters (Strengthening Climate Resilience Discussion Papers No.* 1). Brighton, UK.

Bixler, R. P., Johnson, S., Emerson, K., & Nabatchi, T. (2020). Linking metropolitan networks to resilience planning through mixed methods. *Journal of Urban Affairs*, 42(4), 514-531.

Brown, Katrina. (2012). Policy Discourses of Resilience. In Mark Pelling, David Manuel- Navarrete, & Michael Redclift (Eds.), *Climate Change and the Crisis of Capitalism: A Chance to Reclaim, Self, Society and Nature* (pp. 37–50). Oxon, UK: Routledge.

Burton, C. G. (2014). *A Validation of Metrics for Community Resilience to Natural Hazards and Disasters Using the Recovery from Hurricane Katrina as a Case Study. Annals of the Association of American Geographers*, 105(1), 67–86.doi:10.1080/00045608.2014.960039

Cariolet, J.-M., Colombert, M., Vuillet, M., & Diab, Y. (2018). *Assessing the resilience of urban areas to traffic-related air pollution: Application in Greater Paris. Science of The Total Environment, 615, 588–596.* doi: 10.1016/j.scitotenv.2017.09.334

Chen, X., Liu, Y., & Zhang, J. (2021). Network model for transportation resilience assessment. *Transportation Research Part A: Policy and Practice*, 144, 1-15.

Cimellaro, G. P. (2016). *Resilience Indicators. Geotechnical, Geological and Earthquake Engineering, 49–69.* doi:10.1007/978-3-319-30656-8_3

Coaffee, J. (2013). *Rescaling and Responsibilising the Politics of Urban Resilience: From National Security to Local Place-Making. Politics,* 33(4), 240-252.

Cutter, S.L., Johnson, L.A., Finch, C., Berry, M. (2007). The US hurricane coast: increasingly vulnerable? *Environment 47 (7)*, 8–20.

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). *A place-based model for understanding community resilience to natural disasters. Global Environmental Change, 18(4), 598–606.* doi: 10.1016/j.gloenvcha.2008.07.013

Cutter, Susan L.; Burton, Christopher G.; and Emrich, Christopher T. (2010) "Disaster

Resilience Indicators for Benchmarking Baseline Conditions," Journal of Homeland

Security and Emergency Management: Vol. 7: Issue 1, Article 51. DOI: 10.2202/1547-7355.1732

Cutter, S. L., Ash, K. D., & Emrich, C. T. (2014). *The geographies of community disaster resilience. Global Environmental Change, 29, 65–77.* doi: 10.1016/j.gloenvcha.2014.08.005

EPA, U. S, (2017). Evaluating Urban Resilience to Climate Change: A Multi-Sector Approach (Final Report), U.S. Environmental Protection Agency, Washington, USA.

EPA, U.S. (2021) Climate Change Indicators, https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves.

Eraydin, A., Taşan-Kok, T. (2013). Resilience Thinking in Urban Planning. In Ayda Eraydin, A., T. Taşan-Kok (Eds.), (Vol. 106). Dordrecht: Springer Netherlands.

Ercoşkun, Ö.Y. (2012). A Paradigm Shift towards Urban Resilience, *Green and Ecological Technologies for Urban Planning: Creating Smart Cities*, Editor: Ercoşkun Ö.Y., IGI Global, Hershey, PA, USA,1-16.

Ehrlich, D.; Kemper, T.; Pesaresi, M.; Corbane, C. (2018). *Built-up area and population density: Two Essential Societal Variables to address climate hazard impact. Environmental Science & Policy, 90(), 73–82.* doi: 10.1016/j.envsci.2018.10.001

Ernstson H, van der Leeuw S, Redman C, Meffert D, Davis G, Alfsen C, Elmqvist T.(2010). *Urban transitions: on urban resilience and human-dominated ecosystems. AMBIO: A Journal of the Human Environment* 10 1007/s13280-010-0081-9.

Esty, D. C., Levy, M., Srebotnjak, T., & de Sherbinin, A. (2005). *2005 Environmental sustainability index: Benchmarking national environmental stewardship*. New Haven: Yale Center for Environmental Law & Policy. http://www.yale.edu/esi/. Accessed 5 June 2022.

Fernandez N., Kim, S.J., Morsy, Z., Novak, V.M., & Shiraishi, K. (2013). Improving Urban Resilience in Coastal Eco-Cities: System Integration, Coastal Eco-cities LRF Collegium 2013 Series I.

Fu, Xin; Wang, Xinhao (2018). *Developing an integrative urban resilience capacity index for plan making. Environment Systems and Decisions, (), –* .doi:10.1007/s10669-018-9693-6

Holling, C. S. (1973). *Resilience and stability of ecological systems. In Annual Review of Ecology and Systematics* 4, 1–23.

Kong, L., Mu, X., Hu, G., & Zhang, Z. (2022). The application of resilience theory in urban development: a literature review. Environmental Science and Pollution Research, 29(33), 49651–49671. https://doi.org/10.1007/s11356-022-20891-x

Li, Y., Fang, C., & Sun, Z. (2018). Multi-stage framework for urban socio-environmental resilience evaluation. *Ecological Indicators*, 93, 1096-1105.

Li, J., Shen, L., Liao, S., Sang, M. (2023). Urban Resilience: A Systematic Review. In: Li, J., Lu, W., Peng, Y., Yuan, H., Wang, D. (eds) Proceedings of the 27th

DOI: 10.15320/ICONARP.2024.293

International Symposium on Advancement of Construction Management and Real Estate. CRIOCM 2022. Lecture Notes in Operations Research. Springer, Singapore. https://doi.org/10.1007/978-981-99-3626-7_25

Lin, P. L. (2006),*Urban Resilience: Energetic Principles and A Systems Ecology Approach.* Available athttp://www.ntpu.edu.tw.

Liu, J., Xu, W., & Zhang, Z. (2020). Life cycle model for assessing infrastructure resilience. *International Journal of Disaster Risk Reduction*, 44, 101437.

Maru, Y. (2010). Resilient regions: clarity of concepts and challenges to systemic measurement systemic measurement. Socio- Economics and the Environment Discussion, CSIRO Working Paper Series. http://www.csiro.au/files/files/pw5h.pdf.

McBain, B., Lenzen, M., Albrecht, G., & Wackernagel, M. (2017). Reducing the ecological footprint of urban cars. International Journal of Sustainable Transportation, 12(2), 117-127. doi:10.1080/15568318.2017.1336264

Monteiro, A.; Vieira, M.; Gama, C.; Miranda, A. I. (2017). Towards an improved air quality index. Air Quality, Atmosphere & Health, 10(4), 447–455. doi:10.1007/s11869-016-0435-y

Morrow, B. (2008). Community resilience: a social justice perspective (the community and regional resilience initiative research report 4). Community and Regional Resilience Initiative, Oak Ridge

Muller, M. (2007). Adapting to climate change: water management for urban resilience.

Environment and Urbanization, 19(1), 99–113. doi:10.1177/0956247807076726

Muller, B. (2011). Urban and Regional Resilience: A New Catchword or a Consistent Concept for Research and Practice. German Annual of Spatial Research and Policy 2010, (Springer-Verlag Berlin Heidelberg).

Nardo, M., M. Saisana, A. Saltelli, S. Tarantola, A. Hoffman ve E. Giovannini (2005)

'Handbook on constructing composite indicators: methodology and user guide', OECD

Statistics Working Paper by, STD/DOC(2005) 3, see Publications and Documents at http:// www.oecd.org/.

Norris, F. H., Stevens, S. P., Pfefferbaum, B., Wyche, K. F., Pfefferbaum, R. L. (2007).

Community Resilience as a Metaphor, Theory, Set of Capacities, and Strategy for Disaster Readiness. American Journal of Community Psychology, 41(1-2), 127–150. doi:10.1007/s10464-007-9156-6

OECD (2021), Green Growth Indicators, https://data.oecd.org/biodiver/built-up-area.html. doi: 10.1787/7c06b772-en (Accessed 08 June 2021)

Rose, A. (2004). Economic resilience to disasters: Multilevel analysis of production networks in Japan. *Journal of the American Planning Association*, 70(3), 313-327.

Sharifi, Ayyoob & Yamagata, Yoshiki. (2014). Major principles and criteria for development of an urban resilience assessment index.

Sharifi, A.; Roosta, M.; Javadpoor, M. (2021) Urban Form Resilience: A Comparative Analysis of Traditional, Semi-Planned, and Planned Neighborhoods in Shiraz, Iran. Urban Sci. 2021, 5, 18.

Suárez, M., Gómez-Baggethun, E., Benayas, J., & Tilbury, D. (2016). Towards an Urban Resilience Index: A Case Study in 50 Spanish Cities. *Sustainability*, *8*(8), 774. doi: 10.3390/su8080774

Sweetapple, C., Fu, G., & Butler, D. (2019). Identifying tipping points in urban resilience and sustainability: A wastewater case study. *Environmental Science & Technology*, 53(23), 13662-13670.

Şeker, M., Ozan, C., Yaman, B. (2020) *YERELLEŞEN İNSANİ GELİŞME İnsani Gelişme Endeksi – Büyükşehirler (İGE-B) İnsani Gelişme Endeksi – İlçeler (İGE-İ 2020*, İngev Istanbul.

Tang, J., Wang, X., & Zhang, Y. (2020). Evaluating transportation network resilience under multiple hazards. Journal of Transportation Engineering, Part A: Systems, 146(8), 04020088.

UNISDR (2009)Terminology on Disaster Risk Reduction. United Nations International Strategy for Disaster Risk Reduction, Geneva.

UNISDR (2012). How to make cities more resilient: A handbook for local government leaders. Geneva: United Nations.

Walker, H. B., Salt, D., (2006). *Resilience thinking: sustaining ecosystems and people in a changing world*, Island Press.

Wardekker, J. A., de Jong, A., Knoop, J. M. ve van der Sluijs, J. P. (2010). *Operationalising a resilience approach to adapting an urban delta to uncertain climate changes. Technological Forecasting and Social Change,* 77(6), 987–998.

World Bank. (2021), Nature Based Solutions, https://naturebasedsolutions.org (Accessed 10 March 2022).

Yamagata, Yoshiki; Sharifi, Ayyoob (2018). [Lecture Notes in Energy] Resilience-Oriented Urban Planning Volume 65 || Resilience-Oriented Urban Planning. 10.1007/978-3-319-75798-8(Chapter 1), 3–27. doi:10.1007/978-3-319-75798-8_1

Zheng, X., Wang, L., & Li, Q. (2018). *Relationship between resilience and development: A mixed method approach*. *Sustainability*, 10(2), 356.

Resume

Şeyma Elif DİNCER completed her primary and high school education in İstanbul. In the same year, she entered the Yıldız Technical University, Faculty of Architecture, Department of City and Regional Planning. She graduated in 2013 with the title of city planner. In 2013, she started his master's degree in Mimar Sinan Fine Arts University, Institute of Science, program of Urban Design. She graduated in 2016 with the title of master city and regional planner. She worked as city planner between 2013 and 2015. In 2022, she completed her doctorate at Gazi University, Institute of Science, Department of City and Regional Planning with a thesis "Development Of Urban Resilience Index: A Case Study On Ankara Metropolitan Area". She has written papers on urban planning and urban resilience. Her research interests include urban resilience, urban design, geographical information systems, electoral geography and transportation planning.

Özge YALÇINER ERCOŞKUN is a professor in the City and Regional Planning, Department of the Gazi University, Ankara, Turkey. She graduated from the City and Regional Planning Department of the Istanbul Technical University in 1998. She completed her master's studies in the Geodetic and Geographic Information Technologies Department of the METU in 2002. She got her Ph.D. degree from the City and Regional Planning Department of the Gazi University in 2007. She has attended several national and international congresses; summer schools and workshops related to ecological urban planning and geographic information systems. She has written 4 books and more than 100 papers on sustainable urban design and ecological and smart urban planning, resilient cities, sustainable

DOI: 10.15320/ICONARP.2024.293

transportation and geographic information technologies. She worked as a researcher in many national and institutional projects. She has awards about sustainability and urban growth, sustainable tourism.