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Urban Vulnerability Assessments to Climate Change for Members of the European Healthy Cities Network in Turkey: A Case Study

Türkiye'deki Avrupa Sağlıklı Şehirler Ağı Üyeleri için Iklim Değişikliğine Karşı Kentsel Kırılganlık Değerlendirmeleri: Bir Vaka Çalışması

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Öne Çıkanlar / Highlights

▪ Kentsel dayanıklılığın iklim değişikliği etkilerine karşı güçlendirilmesi	▪ Strengthening urban resilience to climate change impacts
▪ Kentsel kırılganlıkların iklim değişikliği etkilerine karşı değerlendirilmesi	▪ Assessing urban vulnerabilities to climate change impacts
▪ Avrupa Sağlıklı Şehirler Ağı üyesi olan Türkiye şehirlerinin iklimsel kırılganlıklarının araştırılması	▪ Research on the climatic vulnerabilities of Turkish cities that are members of the European Healthy Cities Network

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Özet

İklim değişikliğinin kentsel sürdürülebilirlik üzerinde önemli olumsuz etkileri olduğu bilimsel bir gerçektir. Özellikle insan ve kent sağlığı üzerindeki artan etkileri yerleşim yerlerini daha savunmasız hale getirmektedir. Bu nedenle merkezi hükümetler düzeyindeki eylemler önemlidir, ancak yerel yönetimlerin iklim değişikliğinin azaltılması ve uyumunda daha önemli rolleri vardır. Ancak iklim değişikliği ile mücadele konusunda bilgi ve teknik kapasite eksikliği yerel yönetimler için en büyük sorundur. Bu bilgi eksikliğini gidermek için ölçüm ve izlemeye dayalı eylem ve kapsayıcı yönetişim sistemleri gerekmektedir. Kentler için nitel ve nicel kırılganlık değerlendirmesi için birçok araç ve yöntem bulunmaktadır. Kentsel iklim etkilerine karşı kırılganlığı değerlendirmek için ilgili literatürlerde Gösterge Tabanlı Kırılganlık Değerlendirmeleri (IBVAs) önerilmektedir. Bu çalışma, Türkiye Sağlıklı Kentler Birliği üyesi 40 yerleşim yeri/kentte IBVAs yöntemi kullanılarak kentlerin iklim değişikliğine karşı kırılganlık düzeyini belirlemeyi amaçlamaktadır. Elde edilen bulgular, incelenen kentlerin kırılganlık kategorilerine göre dağılımının sırasıyla Yüksek Kırılganlık 0, Orta Kırılganlık 5, Düşük Kırılganlık 32 ve Dayanıklılık 3 şeklinde olduğunu göstermektedir. Bu sonuca göre incelenen kentlerin büyük çoğunluğunun iklim değişikliğine karşı düşük kırılganlık düzeyinde olduğu görülmektedir. Ayrıca, kentlerde alt parametrelere ilişkin en büyük eksikliklerin Kentlerin Kurumsal ve Organizasyonel Kapasiteleri alanında olduğu, bunu sırasıyla Kentlerin Genel Özellikleri ve Yapılı Çevre alanlarının izlediği belirlenmiştir. Bu durum, yerel yönetimlerin iklim değişikliği ile mücadele yeteneklerinin geliştirilmesi için Kurumsal ve Organizasyonel Kapasiteleri ile Yapılı Çevre uygulamalarının güçlendirilmesinin önemini ortaya koymaktadır.

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Abstract

It is a scientific fact that climate change has significant negative impacts on urban sustainability. The increasing effects, especially on human and urban health, make settlements more vulnerable. Therefore, actions at the central government level are important, but local governments have even more critical roles in climate change mitigation and adaptation. However, the lack of knowledge and technical capacity regarding combating climate change is the biggest problem for local governments. Measurement- and monitoring-based action and inclusive governance systems are required to address this knowledge gap. There are many tools and methods for qualitative and quantitative vulnerability assessment for cities. Indicator-Based Vulnerability Assessments are recommended in the relevant literature for assessing vulnerability to urban climate impacts. This study aims to determine the vulnerability level of cities to climate change by using the IBVAs method in 40 settlements/cities that are members of the Healthy Cities Association of Turkey. The findings show that the distribution of the examined cities according to vulnerability categories is as follows: High Vulnerability 0, Medium Vulnerability 5, Low Vulnerability 32, and Resilience 3. According to this result, the vast majority of the examined cities are observed to be at a low vulnerability level to climate change. Furthermore, it has been determined that the biggest shortcomings regarding sub-parameters in cities are in the area of Institutional and Organizational Capacities of Cities, followed by the General Characteristics and Built Environment areas, respectively. This situation reveals the importance of strengthening both Institutional and Organizational Capacities and Built Environment practices for developing the capacities of local governments in combating climate change.

1. INTRODUCTION

Climate change, one of the most significant environmental problems on a global scale, disproportionately affects urban areas. Factors such as increasing economic activities, unplanned urbanization, and population growth create a complex interaction between the causes and consequences of climate change (Das et al., 2024). This interaction has adverse effects on urban infrastructure, social systems, and natural ecosystems, seriously threatening urban sustainability. This situation emphasizes the need for cities to increase their resilience and adaptation to the effects of climate change (Çobanyılmaz and Yüksel, 2013; Lobo et al., 2023).

The concept of urban vulnerability expresses how susceptible cities are to the adverse effects of climate change (Dale et al., 2020). The assessment of urban vulnerability is considered a fundamental step in understanding the potential impacts of climate change on cities and developing appropriate adaptation strategies (Lanlan etal. 2024). Many international organizations, such as the World Bank, consider conducting studies to determine the level of climate-related urban vulnerability an urgent issue. Therefore, they recommend the use and dissemination of scientifically accepted methods to be used in climate-related urban vulnerability assessments (World Bank, 2009; Prasad et al., 2009; Leichenko, 2011).

According to the Intergovernmental Panel on Climate Change (IPCC), climate-related vulnerability assessments in cities are an important starting point for risk assessment, and it is stated that urban vulnerability assessments will help disaster risk management and building resilience against a changing climate (Tapia et al., 2017; Connelly et al., 2018). Other international organizations that have conducted significant studies and issued warnings on this issue include Local Governments for Sustainability (ICLEI), the Covenant of Mayors, the International City/County Management Association (ICMA), United Cities and Local Governments (UCLG), UCLG World Organization (UCLG - MEWA), the Local Government Association (LGA), the International Union of Local Authorities (IULA), the United Towns Organisation (UTO), and the World Health Organization European Healthy Cities Network (WHO-EHCN).

When local governments are evaluated in this context, they play a significant role in mitigating and adapting to the effects of climate change (Stolte et al., 2024; Lanlan et al., 2024). This increases the responsibilities of municipalities in combating climate change (Rosenzweig et al., 2015; Türe & Ar, 2018). However, it is observed that many local governments do not have sufficient information, human and financial resources, and the necessary technical and organizational capacity to effectively combat climate change (Simonet and Leseur, 2019). These deficiencies constitute significant obstacles to the implementation of effective climate actions (Kay et al., 2018; Mehryar et al., 2022).

On the other hand, municipalities that want to take an active role in this process by conducting vulnerability assessments and measurements face significant difficulties in understanding the dynamics and complexity of urban areas (Gauthier, 2023). However, municipalities committed to implementing urban climate action plans and policies need methods that produce systematic data to conduct vulnerability assessments. In this context, although there are many methods defined in the literature, there are still debates regarding the applicability and effectiveness of these methods (Broto & Bulkeley, 2013; Hunt & Watkiss, 2011; Stolte et al., 2024). However, Indicator-Based Vulnerability Assessments (IBVA) are recommended for assessing vulnerability to climate impacts in cities (Tapia et al., 2017; Füssel, 2010; Hinkel, 2011; Lim, 2001).

This study aims to determine the vulnerability levels of cities in Turkey that are members of the World Health Organization European Healthy Cities Network to climate change and to offer solutions by addressing information and capacity gaps in this regard. Towards this aim, vulnerability analyses against climate change were conducted using the Indicator-Based Vulnerability Assessment (IBVA) method. By emphasizing the importance of urban vulnerability assessments and offering recommendations to strengthen the roles of local governments in combating climate change, this study aims to contribute to the literature and practice.

2. MATERIAL AND METHOD

This research has been prepared with the participation of 40 members from 70 cities which are members of the Turkish Healthy Cities Association (WHO-EHCN). These cities represent about 50% of Turkey's population (Figure 2.1).

In this study, we used a survey by Çobanyılmaz & Yüksel (2013), considering the literature of the World Bank (2009) to determine the vulnerability status of urban components against the effects of climate in the IBVAs framework. The scope of the survey is organized according to main and subheadings that can measure urban vulnerabilities and adaptive capacity according to their scope. At the urban level, IBVAs typically focus on (i) specific cities or sub-cities characteristic areas according to a predefined set of climate hazards (ii) potential receptors of climate impacts, including specific communities and social groups or subsystems of the built environment as follows; infrastructures or other components (Tapia et al., 2017; Çobanyılmaz & Yüksel, 2013; Connelly et al., 2018; Lim, 2001; World Bank, 2010; 2011).

The questions in this questionnaire were answered by the relevant units of the municipality and the authorized staff based on official documents (EURASAT, 2017; TUİK, 2017). The input of the survey data was uploaded to the official website of the Turkey Healthy Cities Association by the authorized institution coordinator of the relevant municipality. The study is based on information obtained from these data.

The scope and key criteria of this research are as follows (Dodman et al., 2015);

- *General Characteristics of Cities;* location of city, settled population, gross national product per capita, etc.
- *Socio-economic Structure;* unemployment rate, rate of child / disabled person / poor and old, etc.
- *Built-Environment;* squatting rate, green space rate, flood risk, etc.
- *Physical infrastructure;* drinking water, solid waste, energy, health, etc.
- *Environment;* air quality, water quality, climate, biological diversity, etc.

- *Organizational Structure of Institutions;* management and strategies of climate change, risk management, disaster management, etc.

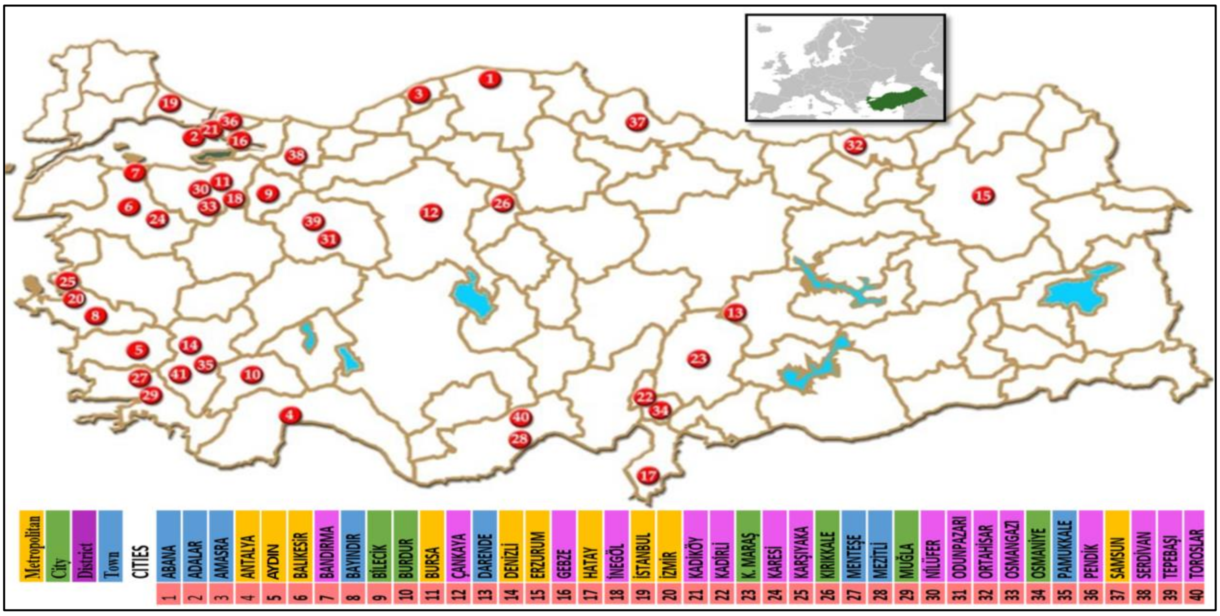

Figure. 2.1. *The locations of the Turkish Healthy Cities Association member cities participating in the research*

This survey has the structure to evaluate the qualitative/quantitative characteristics of urban ecosystem components such as physical geography, social, economic, environmental, institutional, and spatial factors. This method is based on the scoring system for the indicators and sub-indicators of cities and provides an approach to the vulnerability level of cities due to climate change. Qualitative indicators were prepared according to the answer Yes/No. Quantitative indicators based on numerical data with different metric units should be converted to non-unit values. Thus, numerical data obtained from different metric units and official records; It can only be evaluated by converting into non-unit measurable indicators based on specific value ranges determined by mean, limit, standard, and percentages (Çobanyılmaz & Yüksel, 2013; World Bank, 2009)

The scores obtained from each sub-category were converted to percentages and a 4-level vulnerability classification scale was established between 0-100%. These; Resilient 0-25% (R), Low Vulnerability 26-50% (LV), Medium Vulnerability 51-75% (MV), and High Vulnerability 76-100% (HV), (Tapia et al., 2017; World Bank, 2009); Campbell-Lendrum & Corvalán, 2007, Lim, 2001; Shepherd, 2013; USAID, 2017; Mehrotra et al., 2009).

3. THE RESEARCH FINDINGS AND DISCUSSION

Vulnerability, in general, is defined to the extent that a city is prone to adverse effects of climate change, including climate variability and excesses. Vulnerability is a function of some city features, including or physical geography that makes the city susceptible to climate changes a city's location, especially proximity to the sea, topography, or other physical features of the landscape. Demographic factors that also determine the degree of vulnerability of a city include population size and composition, population density, size of the city, socio-economy, quality of infrastructure, type and quality of its built environment, land use, regulations, governance structure, and the like (Mohiddin et al., 2017).

Assessing the current state of urban components mentioned above will contribute to understanding the strengths/weaknesses of cities against climate change and to implement appropriate policies to become a climate-friendly city (Füssel & Klein, 2006; Tonmoy et al., 2014). Therefore, it is imperative to evaluate the sensitivity of cities to form new policies for climate disasters (Downing et al. 2001). Some work is being done on climate change in Turkey, but this process is still at the beginning of the road.

Report on Global Climate Risk Index (CRI) According to the 2019 report, Turkey is ranked 72 among 193 countries (Eckstein, 2017). The number of extreme climatic events in 2023 was 1475. Number of extreme weather events in Turkey by year are given in Figure 3, (State Meteorological Service, 2023).

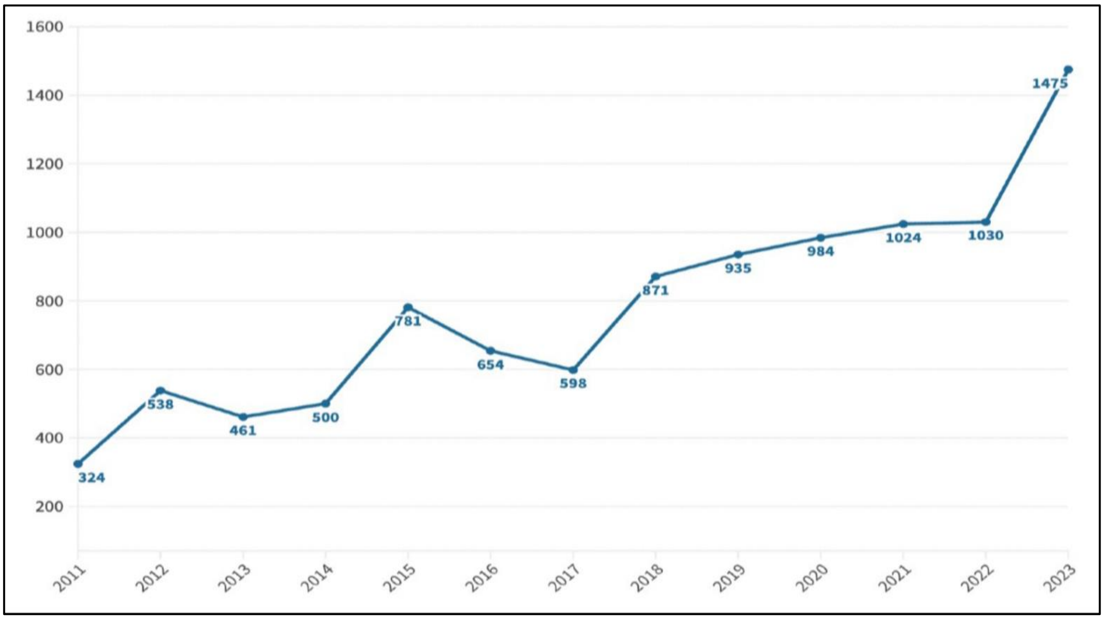

Figure 3. *Number of extreme weather events in Turkey by year*

In this context, the results of this study are presented under the relevant headings according to different city categories (Çobanyılmaz & Yüksel, 2013; Tapia et al., 2017). The increase of numerical value in the graphs indicates that the city has a high vulnerability in terms of being damaged from climate change; the decrease in the numerical value indicates a decrease in vulnerability.

3.1. General Characteristics of Cites

The vulnerability is a function of many city features, including physical geography, which makes the city sensitive to climate; In particular, proximity to the sea, topography, landscape, and demographic characteristics change the status of a city. Due to its geographical location and physical geographical conditions, Turkey is in a climate-sensitive state. The degree of this sensitivity varies according to the locations and demographics of the cities. Moreover, it is now impossible to change the location preference made in the past. Therefore, it should be considered in assessing the vulnerability of cities to climate change (OECD, 2014). The amount of a community's social capital should be positively correlated to community resilience by providing a safety net that can help individuals cope with the disaster and recover from it more quickly. The scores of the cities included in this study in terms of their general characteristics of cites are shown in Figure 3.1.1.

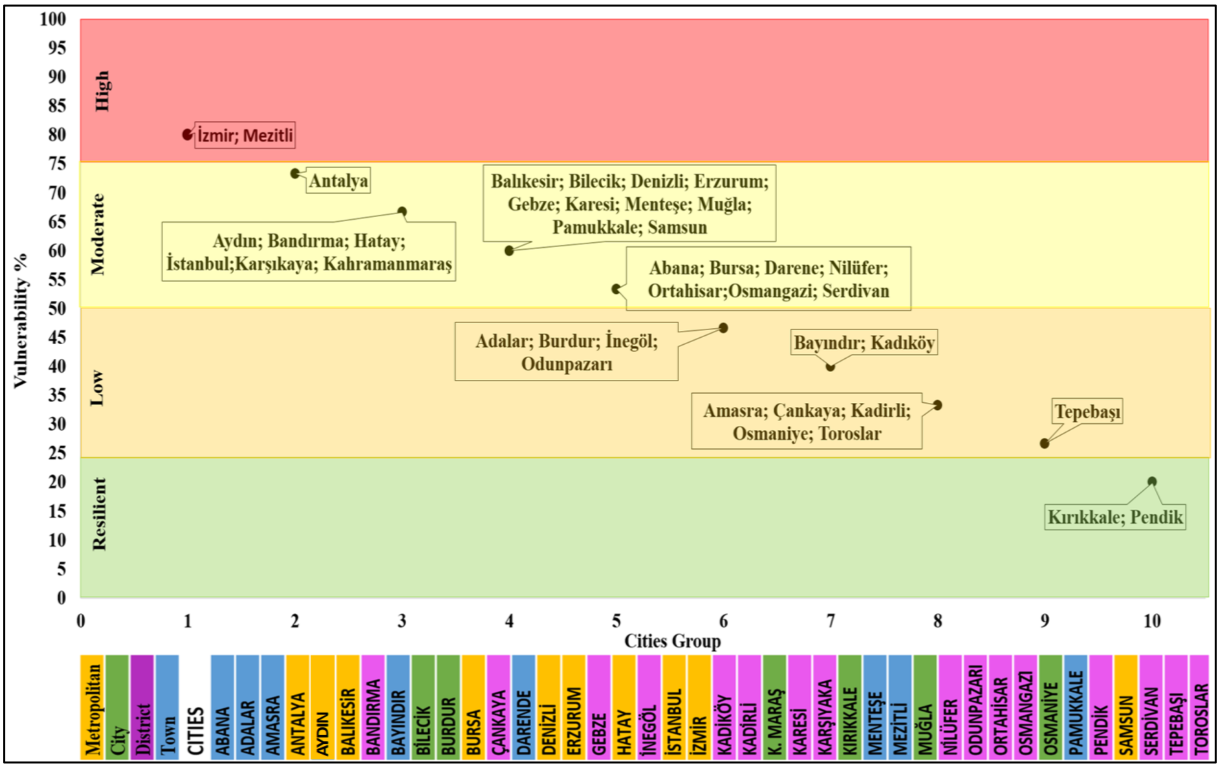

Figure 3.1.1. *Vulnerability scores according to the general characteristics of cities*

3.2. Socio-economic Structure

The socio-economic vulnerability component in this survey contributes equally to climate change risks along with climate hazards (Tapia et al., 2017; Lim, 2001; Mehrotra et al., 2009). Different communities and individuals are exposed to different hazard risks, even in the same area or region. There are some problems and difficulties in defining the socially vulnerable population in the context of climate change. The parameters used to determine the social security deficit should at least give an idea (Vincent, 2004; Katic, 2017). Therefore, household surveys are an important tool for collecting various social security vulnerability data (Ge & Zhang, 2017). The status of the cities participating in this survey in terms of their socio-economic structure is shown in Figure 3.2.1.

3.3. Built Environment

The physical components and human activities of the areas built in urban centers also interact with other climatic factors. Therefore, the vulnerabilities of cities exposed to the same climatic factors vary depending on the characteristics of the built environment (Wilby, 2007). For example, the built environment of a city may become more vulnerable if it is not built to tolerate excessive rainfall and is exposed to intense illegal construction. While the presence of large green areas with balanced distribution in the city mitigates these effects, especially the slums, low-code settlements, and industrial areas, transportation networks, freshwater reserves, and electricity distribution centers are primarily built-in environmental elements. Related infrastructure features are evaluated under a separate heading (Wilbanks & Fernandez, 2014). The distribution of cities by built-in environmental vulnerability levels and groups are shown in Figure 3.3.1.

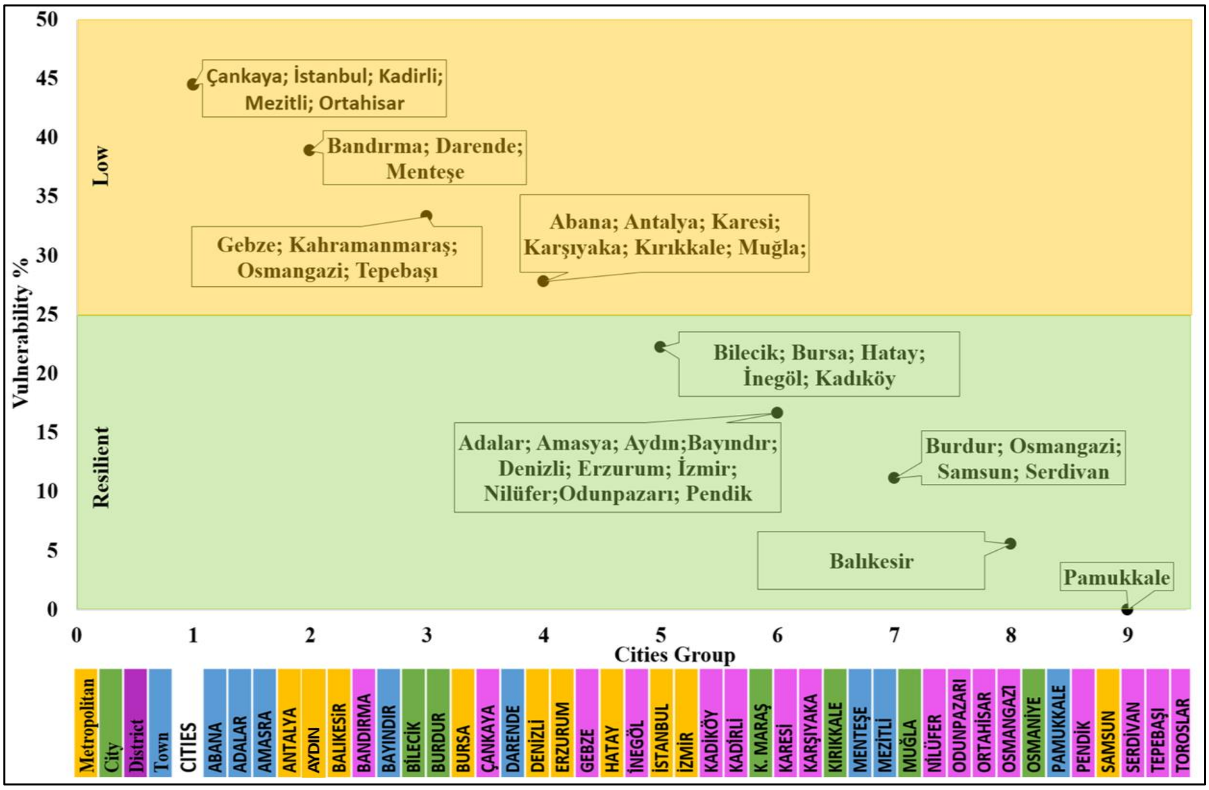

Figure 3.2.1. *Vulnerability according to the socio-economic condition of cities*

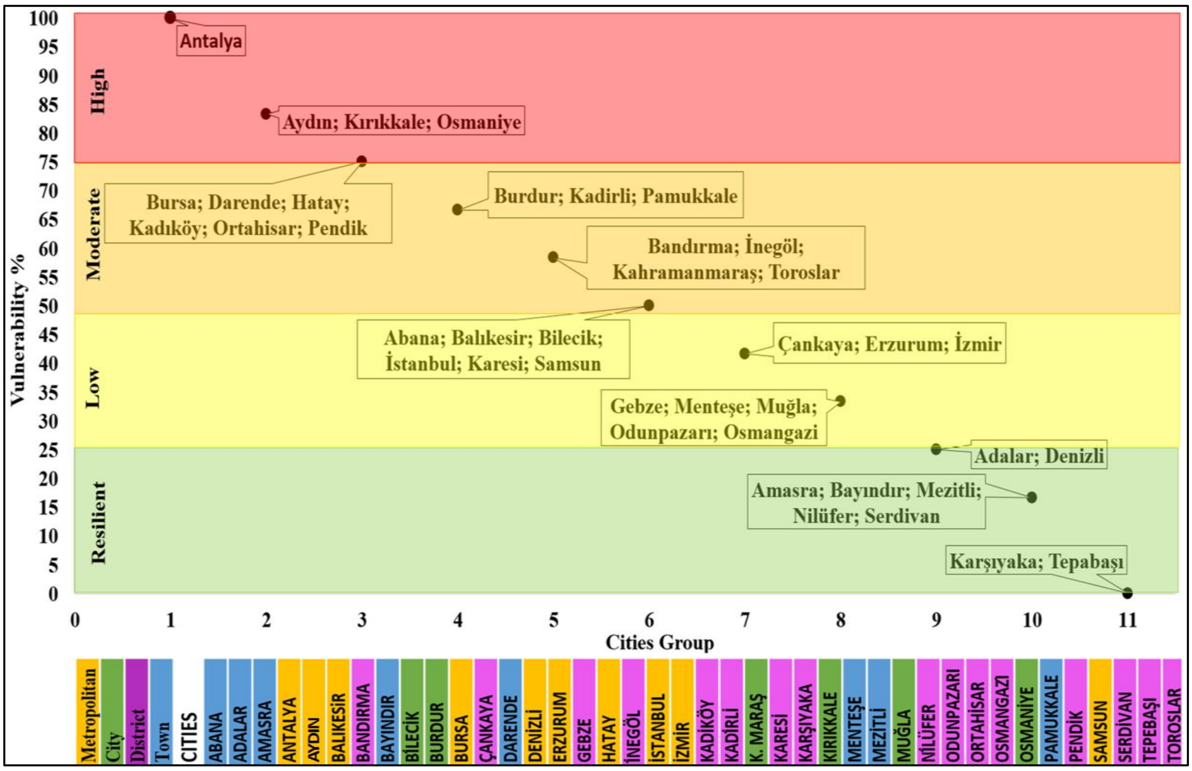

Figure 3.3.1 *Vulnerability scores according to built-environment of cities*

3.4. Physical infrastructure

Urban infrastructure systems are highly interactive and interdependent, although they often appear individually. Urban infrastructures include buildings and green spaces, energy systems, transportation systems, water systems, wastewater and drainage systems, communication systems, health systems, industrial structures, and other human design and construction products aimed at providing human support services (Wilby, 2007).

These systems can reduce the risks of climate change, increase resilience to potential impacts, and reduce the magnitude and intensity of impacts with a range of adaptable behaviors (Wilbanks, & Fernandez, 2014). The vulnerability levels and group distribution of cities depending on the infrastructure systems consisting of these very important components for the possible effects of climate change are given in Figure 3.4.1.

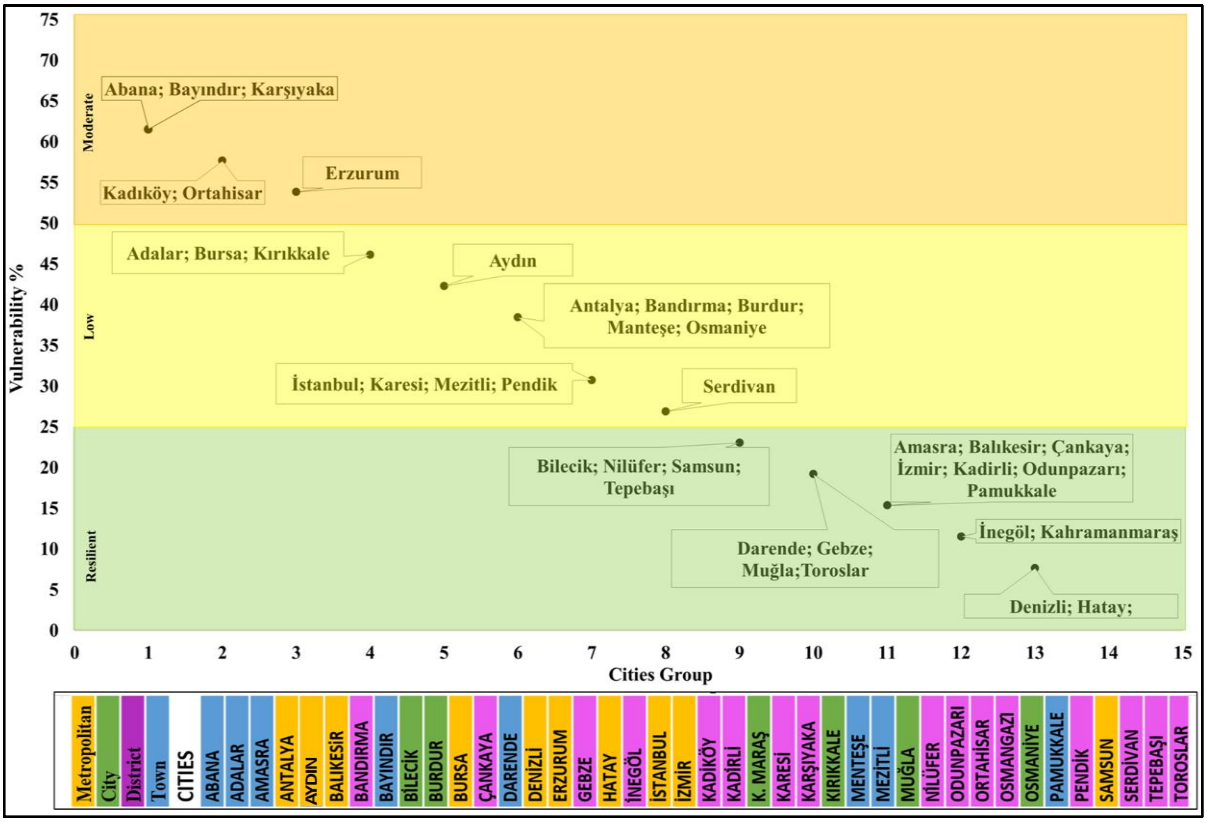

Figure 3.4.1. *Vulnerability and risk scores according to the physical infrastructure condition of cities*

3.5. Environment

Since environmental issues such as energy, green areas, treatment, and infrastructure are examined under previous headings, air/water quality, heat islands, and biodiversity in cities are evaluated in this heading. These indicators are factors that have important effects on quality of life and health conditions. If the environmental parameters of the cities do not meet the required standards, climate vulnerability will increase. For this reason, determining the environmental characteristics of the cities is very important both for their negative contribution to climate change and for the reduction of climate effects (Tayanc et al., 2009; Lee &Van de Meene, 2013). Besides, urban environment indicators should be taken into account in monitoring their future trends (Button, 2002).The distribution of cities by environmental vulnerability levels and groups are shown in Figure 3.5.1.

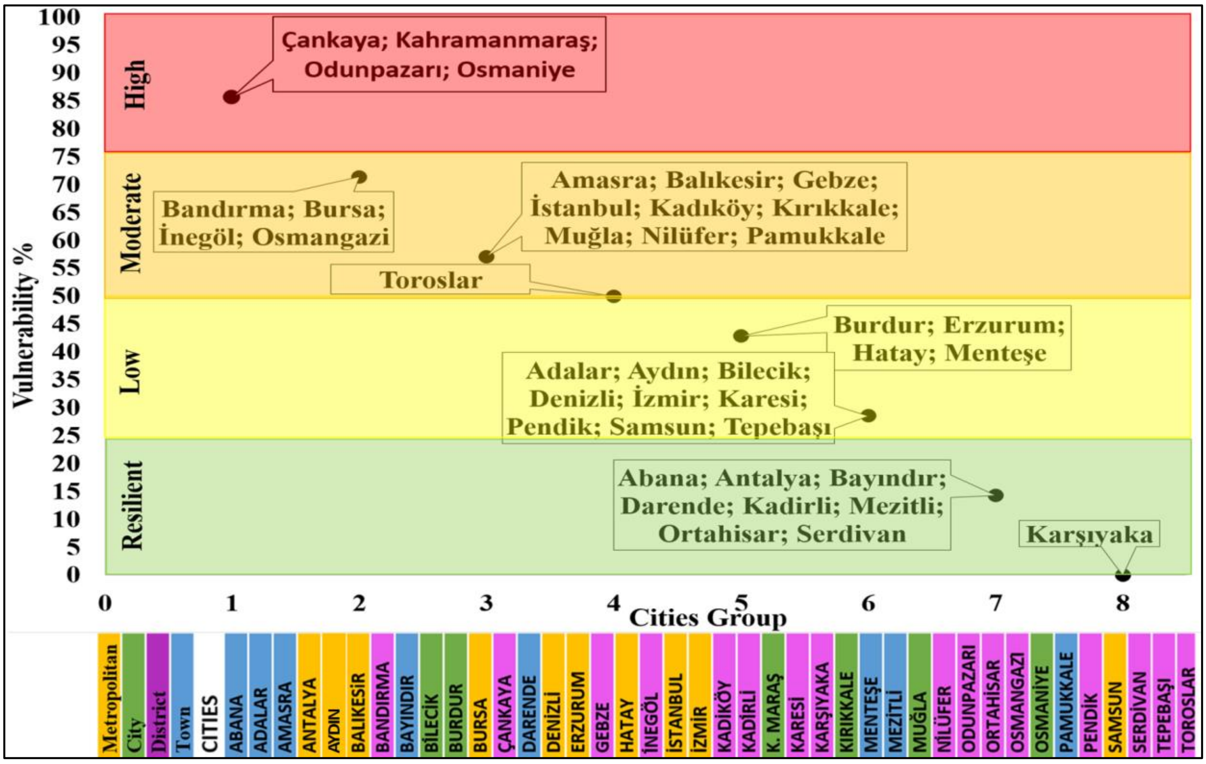

Figure 3.5.1. *Vulnerability and risk scores according to the environmental condition of cities*

3.6. Organizational Structure of Institutions

The institutionalization of urban adaptation practices to climate change is gradually becoming widespread. Thus, despite prolonged failures in generating international responses to climate change, the urban scale has started to become apparent that relatively concrete actions are possible. However, current studies on this issue are largely based on case studies and policy analysis of local adaptive responses in single cities (Button, 2002; Mukheibir & Ziervogel, 2007; Kay et al. 2018). More holistic assessments show that the cross-systemic effects of both climates change itself and adaptation strategies require that we coordinate policy responses across multiple cities (Bastin et al., 2019; Aylett, 2015). In this respect, determining the level of institutional organization in the face of climate events of many settlements is important in terms of understanding the level of organization of the cities in the same country (Figure 8). The figure was created depending on whether municipalities have administrative preparations for climate change, such as planning and management systems, adaptation strategy reports, public awareness programs, collaborations with NGOs, funds, disaster warning systems. When cities are analyzed under the Organizational Structure of Institutions heading, they are divided into 9 groups in 4 different categories (Figure 3.6.1.).

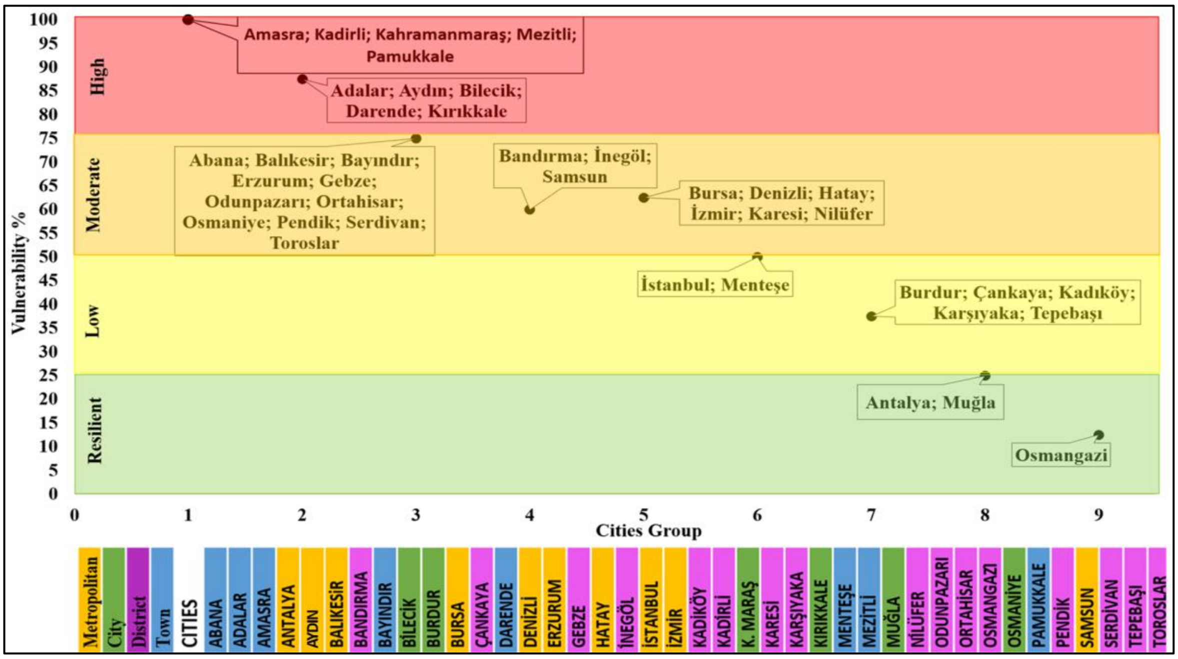

Figure 3.6.1. *Vulnerability and risk scores according to the Organizational Structure of Institutions cities*

3.7. Vulnerability and risk groups based on the total scores of cities from different sub- categories

Since the cities evaluated in this study have different characteristics, the scores they receive from each subcomponent also change their distribution according to the vulnerability categories (Zhang, et al., 2019). To evaluate the results of the cities with a holistic approach, it is necessary to analyze them according to the sum of the scores they get from each subcomponent (Figure 3.7.1.).

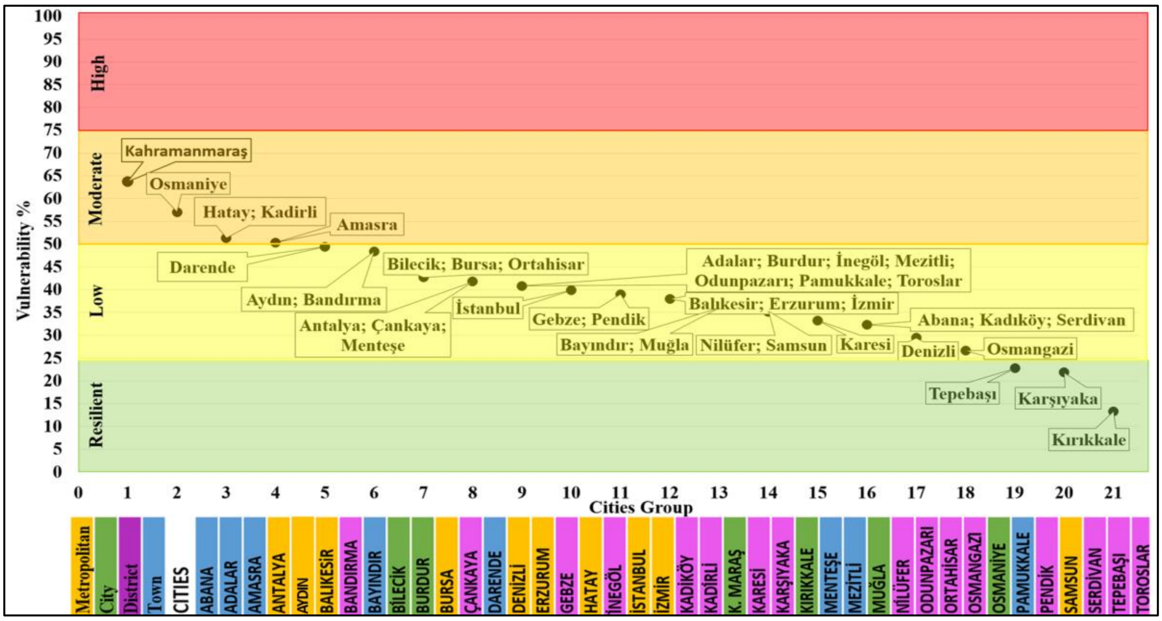

Figure 3.7.1.*Vulnerability and risk groups based on the total scores of cities from different categories spending*

3.8. Evaluation of cities according to average total score connected to each sub-categories

Under this subtitle, mean values were taken for each sub-parameter of all cities and these parameters were evaluated in terms of vulnerability (Figure 3.8.1.). According to the results obtained, The Organizational Structures of Urban Institutions is determined to be the biggest factor that increases vulnerability to climate effects in terms of the majority of cities. This means that municipalities and other stakeholders in these cities are not aware of the seriousness of the situation and have no action plans.

However, in this context, the adequacy of the organizational structures of urban institutions constitutes a basis for the success of all sub-parameter. Another problematic issue is the Built-Environment. For this reason, especially municipalities have to take this into consideration in their new investments in order to tolerate the negative effects of climate on cities.

It is an important parameter in terms of vulnerability to climate effects in the General Features of the cities. It is almost impossible to change the geographical and ecological conditions of the city, which was chosen as a settlement in the past. In addition, demographic and sectoral characteristics should be taken into account in managing the process. In Figure 10, it is seen that the vulnerability rate that may arise from the General Characteristics of the Cities is quite high in terms of the relevant cities. At the very least, the situation should be taken into consideration when new city development plans are being made.

After the above parameters, Environmental and Physical Infrastructure are followed respectively. Physical Infrastructure is concerned with the competence of urban systems such as transportation, communication, sewage, water, electricity, and natural gas. The environment is an expression of urban characteristics such as wastes, biodiversity, clean water/air/soil, and climate. It is observed that the Socio-Economic Status has the least vulnerability to climatic events among all urban sub-parameters.

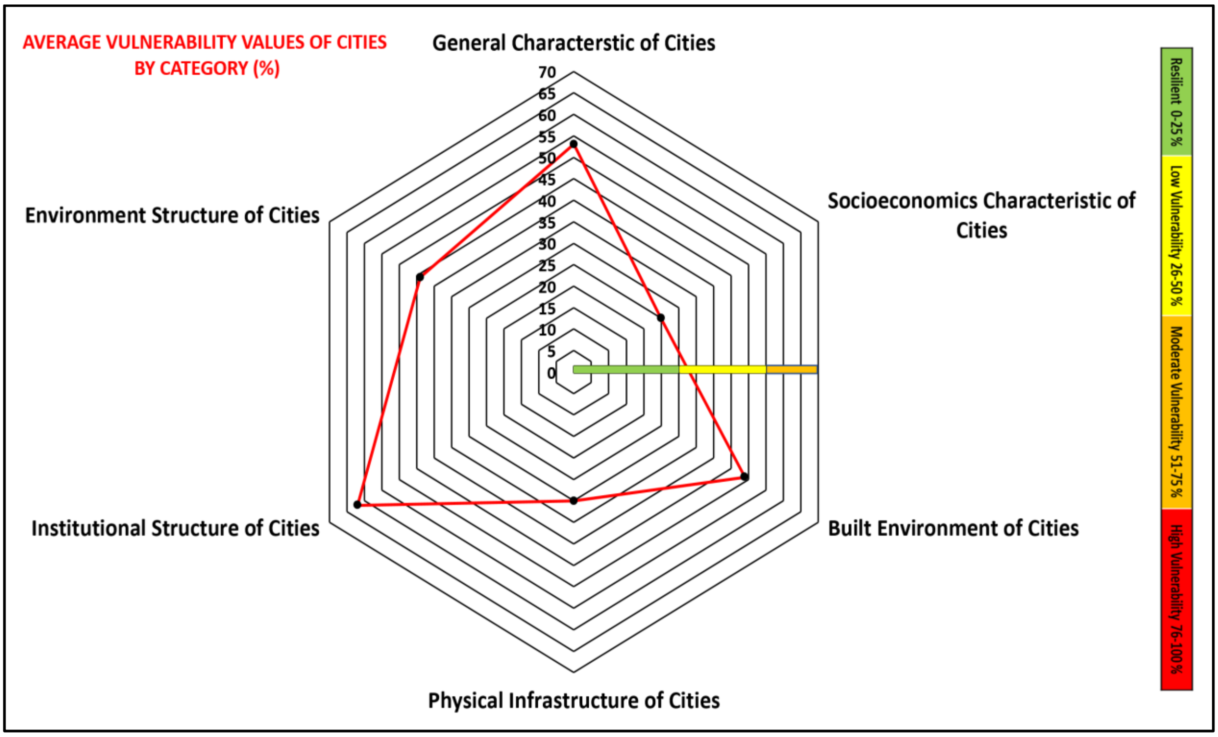

Figure 3.8.1. *Evaluation of cities according to total score connected to each urban categories*

4. CONCLUSION

To reduce urban vulnerability to climatic impacts, a new perspective is needed that can evaluate all health, social, economic, physical, environmental, and political factors together (De Sherbinin et al., 2007). In this context, actions at the level of governments are important, but municipalities have more important roles in climate change mitigation and adaptation (Cash & Moser, 2000). Therefore, it is imperative to implement action plans and policies based on urban vulnerability analysis for all global environmental problems that cause negative effects such as improving urban conditions and health and reducing social inequality for urban authorities aiming to be a sustainable and healthy city. The correct and effective implementation of these policies depends on benefiting from the results of the studies put forward by scientific methods on the current status of the different components that make up the cities. However, there are not enough studies about how this affects the climate of cities in Turkey (Balaban, 2012; Tayanç, M., & Toros, 1997). In our study, it shows that the cities are quite weak in terms of institutional and organizational structures.

In Turkey, it is negatively affected by climate change as many other countries, It also wants to contribute to climate change efforts as a member of WHO-EHCN. When these 40 settlements are analyzed by vulnerability categories, it is seen that they show distribution as HV: 0, MV: 5, LV: 32, and R: 3, respectively. It can be considered optimistic that there are no settlements in HV and the number in MV. However, the fact that the number of settlements in the LV category is very high, seems to be relatively positive compared to others but indicates that urban dynamics will need to be further strengthened. The desired situation in this process is the increase in the number of cities in the R category. When a general evaluation of cities in terms of sub-parameters is made, it is seen that the biggest deficiency is in the Organizational Structures of Urban Institutions (the basis for the success of all sub-parameter), followed by General Characteristics of the Cities and Built-Environment, respectively. These results provide general information about cities, but they are not sufficient to understand the strengths and weaknesses of each city. Considering vulnerability assessments for each sub-parameter will contribute more to the development of appropriate policies.

5. ACKNOWLEDGEMENT

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