International Journal of Arts and Social Science
ISSN: 2581-7922,
Volume 9 Issue 8, August 2026

Assessment of Tokat city's resilience to climate change using fishbone technique

Nihal Zengin[1*], Ruşen Yamaçlı[2]
[1]*Department of Architecture and Urban Planning, Zile Vocational School, Tokat Gaziosmanpaşa University, Tokat, Türkiye,*
[2]*Department of Architecture, Eskisehir Technical University, Eskisehir, Türkiye,*

ABSTRACT : *When disasters in cities, thought to be caused by climate change, are re-analyzed alongside the city's characteristic features, the resilience of the city and its constituent systems come to the forefront. The city's and its systems' ability to respond to sudden shocks and stressors is crucial to ensuring the city's sustainability. In this article, in order to enable the city of Tokat to be resilient to the negative impacts of climate change in its sustainable development goals, the problem-cause-sub-cause identification method was performed using the Fishbone Diagram Method, the causes were grouped according to their urgency and importance using the Eisenhower Matrix, and a strategic action plan proposal was presented. The aim is for this proposal to serve as a basis for local governments in medium-sized cities.*

KEYWORDS: *Climate change, Fishbone Technique, Resilience, Sustainability, Tokat.*

I. INTRODUCTION

Cities are experiencing waves of migration driven by employment opportunities. According to the United Nations, more than 70% of the world's population will live in cities by 2050 [1]. This increase is expected to pave the way for changes in urban planning and demographics. The rapidly increasing building stock, produced as a solution to the housing problem of the rapidly growing population in cities, increases the rate of construction on land, which is considered an urban resource. As the building stock increases, the heat trapped on building surfaces and roofs builds, leading to the formation of an urban heat island. Recent analyses and research have emphasized that solar heat is stored for longer on wall surfaces than on roofs and the ground [2]. This research reveals that the rapidly increasing building stock resulting from urbanization produces latent heat and contributes to climate change. In addition, the building materials, construction techniques, and building form chosen for the designed building have been shown to be effective in forming the urban heat island [3]. Therefore, it should not be forgotten that the decisions made during the design phase will directly affect the formation of the urban heat island and should be included in the analysis. In this way, the formation of the urban heat island should be prevented, climate change adaptation and mitigation efforts should be undertaken, and thermal comfort should be achieved.

The relationship between cities and climate change needs to be recognized globally, and local-level efforts need to be accelerated. Every intervention, adaptation, and mitigation effort at the local level will pave the way for sustainable steps for cities worldwide. Including climate and energy analyses in the planning and design phase is crucial. The primary goal of cities on the path to sustainable development is to reduce their dependence on non-renewable energy and plan climate change-resilient settlements. Since Turkey is located in the

Mediterranean basin, it is among the countries most affected by global warming and climate change due to the expected 2°C global temperature increase. Due to Turkey's location and geographical characteristics, each region in the country is expected to be affected differently by global warming and climate change. For example, the arid and semi-arid climate prevailing in Central Anatolia and the Southeastern regions is expected to lead to negative consequences, such as desertification, in the coming years, while the semi-humid climate prevailing in the Aegean and Mediterranean regions is expected to cause problems, such as water scarcity [4]. In light of this information, presenting the relationship between global warming and climate change and cities, approaching the problem with a comprehensive perspective, and creating a basic framework for climate change-resilient and sustainable cities is urgent and important for Turkey. It should be remembered that each city has different characteristics and vulnerabilities. With the basic framework outlined in this article, each city is expected to develop, adapt, and refine its critical systems on the path to becoming climate change-resilient and sustainable.

II. MATERIALS AND METHODS

The material for this research article is the city of Tokat. Tokat is located in the Central Black Sea Region of Turkey; it is bordered by Samsun to the north, Amasya to the west, and Sivas to the southeast. The city is situated on the line connecting the Black Sea, the Mediterranean, and the Middle East. It is also located on the connection line between Europe and the Caucasus and the Middle East. It has 12 districts, including the city center. According to the population census data dated December 31, 2023, it has a population of 612,674 [5]. With its population capacity, Tokat is considered a medium-sized city. Because *"...a core/central city of 50,000 and the settlements surrounding it, forming a city as a whole, with settlement clusters ranging from an area population of 100,000 to an urban area population of 750,000...",* is defined as a medium-sized city [6]. Figure 1 presents the location of Tokat city and its districts within Turkey.

Figure 1. Location of Tokat city and its districts within Türkiye [7].

Looking at the climate data for the city of Tokat, it is influenced by the climates of both the Central Black Sea Region and the Central Anatolian Region, given its location in both regions. Therefore, it can be said that the city has a transitional climate, situated between the Black Sea and Central Anatolian climates [8]. According to data from the General Directorate of Meteorology, Tokat is classified as a semi-arid-semi-humid climate [9]. As one moves north and closer to the Black Sea, winters become milder, and summers become hotter. In the city's central part, winters are mild, while summers are cool. The southern parts of the city, facing the Central Anatolian Region, exhibit the continental climate typical of the region, with particularly cold and harsh winters.

The aim of this study is to develop a resilient and sustainable city model for medium-sized cities with characteristics similar to those of Tokat, incorporating fundamental principles and a strategic action plan for climate change-resilient and sustainable cities. The methodology used in the study and its flowchart are shown in Figure 2.

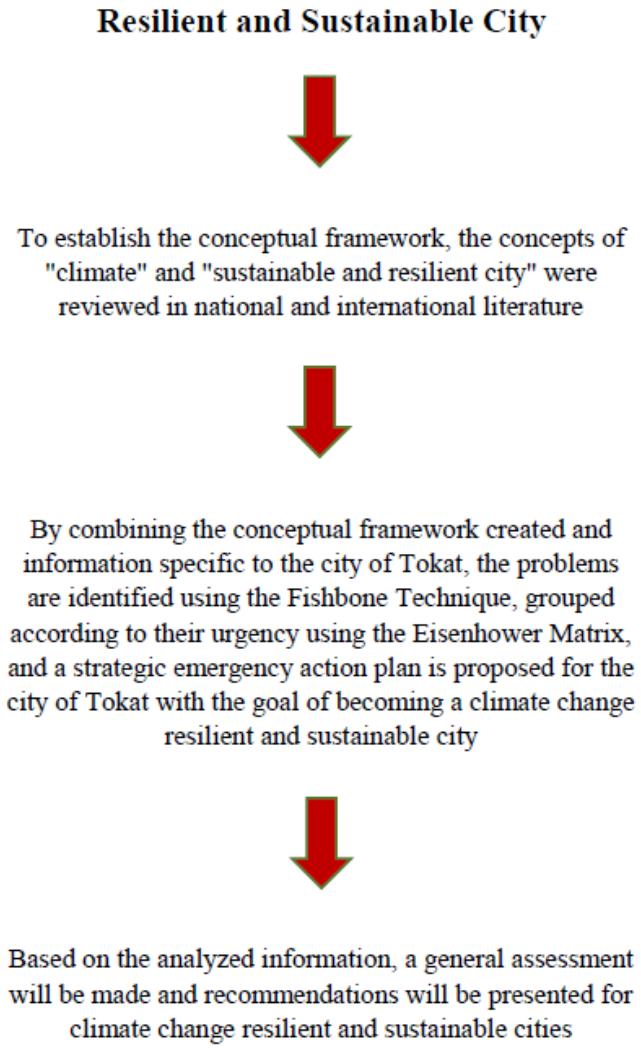

Figure 2. Flowchart of the method used in the article (Author's work).

This article establishes a conceptual framework by conducting an in-depth literature review of climate change, sustainability, and resilience, aiming to provide a model for climate-resilient, sustainable cities. The information obtained from the literature review was then evaluated in the context of the medium-sized city of Tokat, selected as the field study, based on national and international examples of best practices. The city's characteristic and vulnerable points were identified. As a result of this evaluation, the problem of Tokat's ability to become a climate-resilient and sustainable city, its main causes, and the sub-causes contributing to these problems were determined using the Fishbone Diagram. The urgency and importance of the causes and sub-causes in solving the problem were grouped using the Eisenhower Matrix. A strategic action plan proposal is presented to increase resilience to global warming and climate change in Tokat and thus create sustainability. The goal is for this proposal to serve as a basis for local governments in medium-sized cities.

One of the techniques that allows for the systematic examination of problems is the method known as the "Fishbone Technique," which is widely used. This technique was first used in Japan in the application of quality circles. Because this technique allows the systematization of assumptions about problems and their causes, it is now used across many disciplines. The basis of this method is to identify the main causes of the problem, write them down, and then identify and present the underlying causes that contribute to them. After this stage, alternative solutions that address the underlying causes are considered to eliminate the main cause [10]. The

agreed-upon alternative solutions are examined in detail, and the necessary actions are presented in a "Flowchart." The stages of the Fishbone Technique are shown in Figure 3.

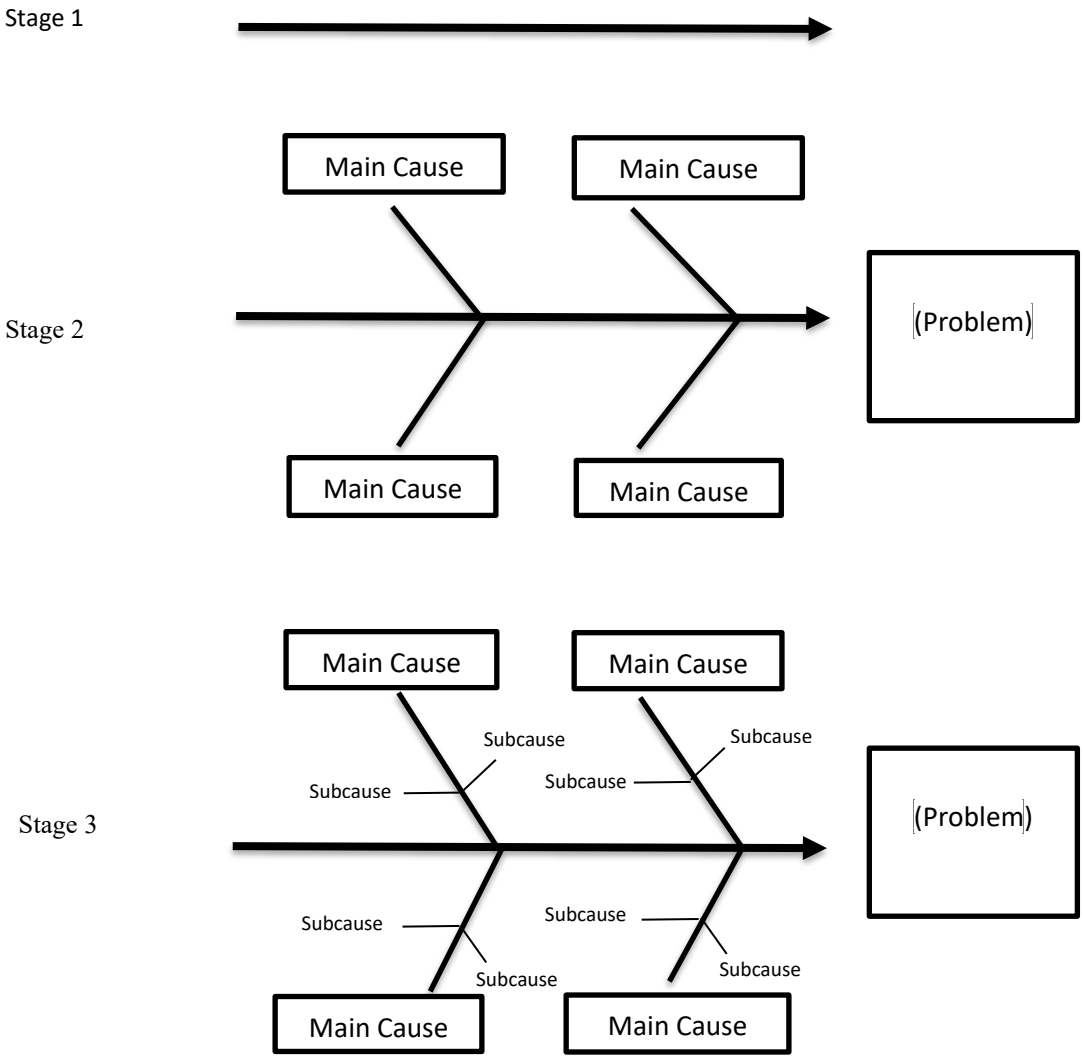

Figure 3. Steps of the Fishbone Technique.

There are various methods for systematically conducting the decision-making process in response to an identified problem. Within the scope of this article, it is suggested that the "Eisenhower Matrix" be used by stakeholders in the decision-making process to eliminate the causes and sub-causes identified through the Fishbone Technique, which was used to develop the model presented for resilient and sustainable cities. This model was used by former US President Gen. D. Eisenhower and is still used today. The Eisenhower decision-making process matrix provides a systematic framework for the effective and efficient use of time, for prioritizing actions after a decision, and for implementing them promptly without delay [10]. Thus, it is foreseen that the creation of strategic emergency action plans, the identification of priority areas in adaptation, mitigation, and response efforts to climate change, and the creation of flowcharts will proceed more systematically.

The Eisenhower matrix is classified according to two fundamental dimensions: urgency and importance. This classification reveals four different situations. Figure 4 summarizes the Eisenhower matrix.

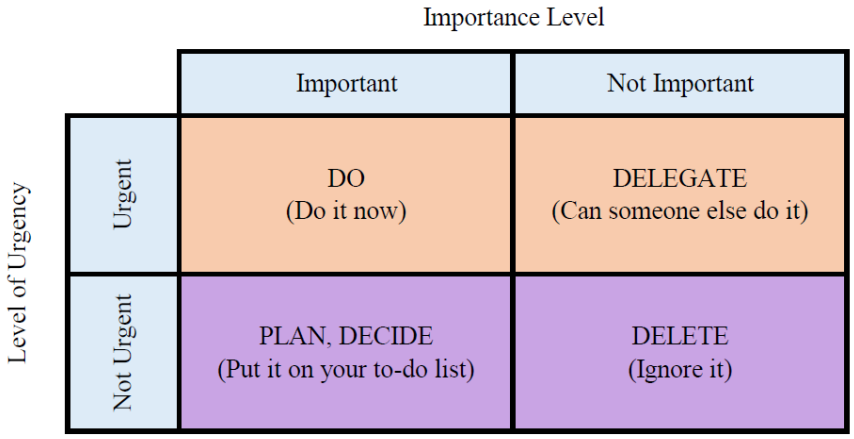

Figure 4. Eisenhower matrix.

According to the Eisenhower matrix shown in Figure 4:

1. Situation: Urgent and important (make a decision and implement it immediately),
2. Situation: Urgent but unimportant (delegate the decision to others/subordinates),
3. Situation: Not urgent but important (make a decision within a suitable timeframe),
4. Situation: Not urgent and unimportant (don't bother with these, don't allocate time to them).

In the Eisenhower matrix, time planning and efficient use are essential. By identifying priority areas for intervention, it is possible to produce quick solutions [10].

III. FINDINGS

Climate is defined as the assessments obtained as a result of observations made in a specific geographical area over a long period of time, which help to form an opinion about the general condition of the area. In addition, climate also affects the vegetation and characteristic weather events of the geographical area where observations are made. Global warming and the climate change it brings are defined as the increase in the average surface temperature of the world and the changes in climate systems as a result of the greenhouse effect caused by greenhouse gases released and accumulated in the atmosphere as a result of human-caused activities such as increased use of fossil fuels, deforestation, changes in land use over time, and increased industrial activities [11].

Although the vast majority of recent climate change is thought to be the result of human activities, it can sometimes occur naturally. The increasing effect of greenhouse gases accumulating in the atmosphere on the Earth's surface inevitably leads to a rise in temperature. Events caused by solar flares alter the energy flow between the atmosphere and the Earth's surface. This allows us to gain knowledge about past and potential future climate events [12].

Irregularities in rainfall patterns, floods, landslides, storms, and migration movements caused by climate change negatively affect individuals and the city's economy. For this reason, the resilience of cities is of great importance in climate change mitigation, adaptation, and response efforts. Resilience is the ability of a city and its critical systems to respond to sudden shocks and stresses. Resilience is crucial for the sustainability of critical infrastructure and superstructure systems against potential natural disasters in the city. A resilient city can protect itself against the negative consequences of natural disasters or climate change and ensure the sustainability of its processes through resilient systems. To prevent potential negative events in the city from escalating into catastrophes, local governments need to prepare urgent, strategic plans. Potential disasters due to climate change have a greater impact, especially in unplanned urban settlements. When implementing adaptation, mitigation, and response efforts related to climate change in cities, it is essential to prioritize the inclusion of these disadvantaged areas within the city [13, 14]. It is stated that resilience is a key point for the continued sustainability of the city [15]. The concepts of resilience and adaptation are interconnected or used interchangeably in the fight against climate change. Adaptation can be defined as the activity or outcome of an activity undertaken to minimize the negative consequences of climate change. In short, it can be defined as helping build the city's resilience and its

critical systems. Resilience and adaptation are crucial for reducing and eliminating the negative impacts of climate change. While adaptation efforts follow a specific pattern and yield results over time, resilience involves the system producing solutions within its capabilities to counter negative events and responding quickly. It is also important for mitigating the negative economic impacts of climate change in the city. In the event of a disaster, the ability of individuals within a community to act together and with awareness—in short, to achieve societal resilience—is crucial for mitigating its effects as quickly as possible. The efforts of local and central governments, the creation of a climate of trust, and leadership strategies play a significant role in fostering communities' ability to act together. It is predicted that when a climate of trust is established between individuals and the government, there will be fewer casualties and less loss of life and property. To create resilient, sustainable urban areas, it is essential to cultivate individuals' knowledge, awareness, and sense of belonging. Resilient and sustainable urban areas are defined as settlements that utilize technology, are innovative, and possess socio-ecological urban critical systems [16]. According to UN-HABITAT [19], the resilient and sustainable city analyzed in this thesis should possess six fundamental characteristics. These characteristics are summarized in Table 1.

Table 1. Characteristics of a resilient and sustainable city.

Fundamental Characteristics	Explanation
Adaptability	It refers to the ability to take precautions against potential risks, create alternatives, and adapt by turning a crisis into an opportunity.
Permanency	It refers to the ability to protect oneself and create a backup mechanism for the sustainability of critical systems.
Inclusıvıty	It refers to the ability to ensure equality in society by emphasizing social cohesion and societal resilience, and by protecting particularly disadvantaged groups affected by climate change.
Holistic	Considering the city in all its aspects, enabling interdisciplinary studies, adopting the principle of partnership and participation, and fostering positive, resilient, and sustainable transformation in the city and society are all characteristics that define this approach.
Reflexive	The city learns from its past negative experiences and supports new knowledge because it is aware that past events affect the city's present. It aims to positively influence the city through sudden shocks and stressful situations, expressing its reflective nature.
Transformability	This refers to the process of anticipating risks and threats and taking action to minimize or even eliminate adverse conditions, and generating innovative solutions for the future, all in order to create a positive impact and build resilience in the city.

The resilience of a city and its critical systems to potential or sudden shocks and stressors is crucial for its sustainability. First and foremost, ensuring a city's sustainability requires that its critical systems have a resilient structure. The ability of cities to provide resilient and sustainable basic urban services, to develop this capability, and to increase their capacity is vital for sustainable development.

The city of Tokat has hosted different civilizations throughout its history. The nations that dominated Tokat and its surroundings gave this region different names. Komana, Dokat, Dar'ün-Nasr, and Tokat are names that have been recorded in history and are well known. However, among these names, the name "Tokat" has been more widely accepted, used, and continues to be used. It is thought that the name "Tokat" was used in the sense of "Tok-kat," meaning walled city, or "Tok-at," meaning well-fed horse [17]. It is accepted that the first settlement of the city of Tokat was the village of Komana Pontika, located approximately 9 km east of the city and today known as the Gümenek region. This region is described by Strabo as "on an important trade route coming from Asia" [18]. From the moment the city of Tokat was established around the castle, it began to attract trade from the

Komana Pontika region into its own region (Figure 5). The region where the city of Tokat is located is of geopolitical importance because it lies along routes connecting settlements in the interior of Turkey to the Black Sea. Furthermore, the rugged terrain and the presence of plains fed by the Çekerek, Yeşilırmak, and Kelkit rivers have long drawn interest to the region and made it an important settlement area [19].

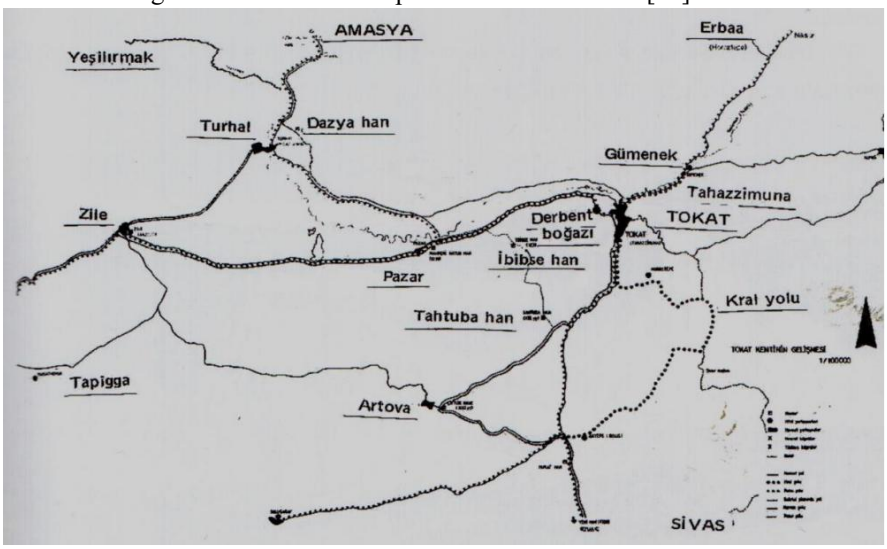

Figure 5. Tokat city and its trade route connections [20].

The spatial structure and economy of Tokat city were shaped by its status as a border city during the Middle Ages. For over a thousand years, from the Roman to the Seljuk periods, Tokat remained a border city. The city's defenses were carried out within the castle walls, and all aspects of city life revolved around the castle. Throughout history, it has hosted various civilizations. Because the castle was located at the intersection of trade routes, the city's spatial layout was shaped around it [21]. Urban development and spatial change have been observed on the eastern slopes of the hill where the castle is located (Figure 6).

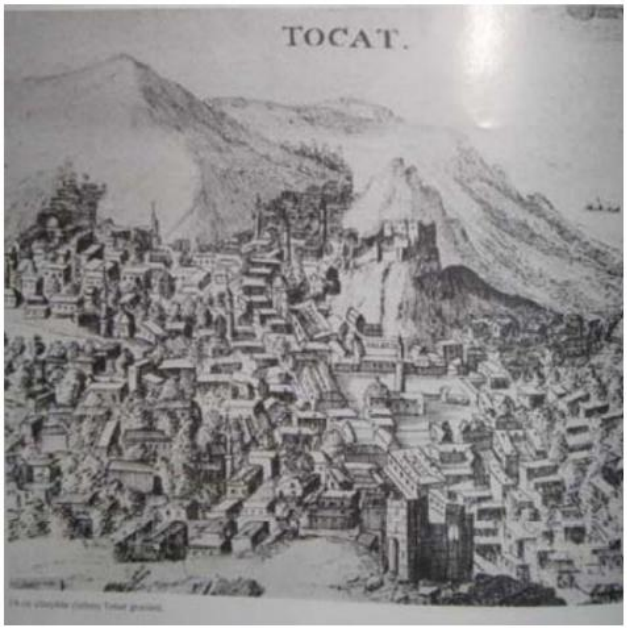

Figure 6. Urban development and spatial change of the city of Tokat [21].

The city of Tokat was located at the crossroads of a trade route that encompassed Anatolia along the east-west and north-south axes during the Seljuk period [22]. Due to the intense trade activity in and around Tokat during the Seljuk era, 11 inns and 1 caravanserai were built to accommodate caravans. Furthermore, the settlement areas and the entrance to Tokat Castle were situated on a rocky outcrop on the south-facing side of the castle. This

location suggests that the settlement areas benefited from sunlight and were protected from the prevailing northerly winds, while the rocky ground was considered a safe area against earthquakes. Looking at the climate data for Tokat, the city is influenced by the climates of both the Central Black Sea Region and the Central Anatolian Region, given its location in both regions. Therefore, it can be said that the city has a transitional climate, situated between the Black Sea and Central Anatolian climates [8]. According to data provided by the General Directorate of Meteorology, Tokat city is classified as having a semi-arid-semi-humid climate [9]. As one moves north and closer to the Black Sea, winters become milder and summers hotter. In the city's central part, winters are mild, while summers are cool. The southern parts of the city, facing the Central Anatolian Region, exhibit a continental climate, typical of the region, with particularly cold and harsh winters. The average highest temperature recorded in Tokat city between 1929 and 2024 was 29.9°C in August. The average lowest temperature was -1.5°C in January. Furthermore, the hottest day was recorded on July 30, 2000, with a temperature of 45.0°C. The coldest day was recorded on January 20, 1972, with a temperature of -23.4°C. May has the highest number of rainy days, while August has the highest number of sunny days. The prevailing wind in the city is the northeast wind [9].

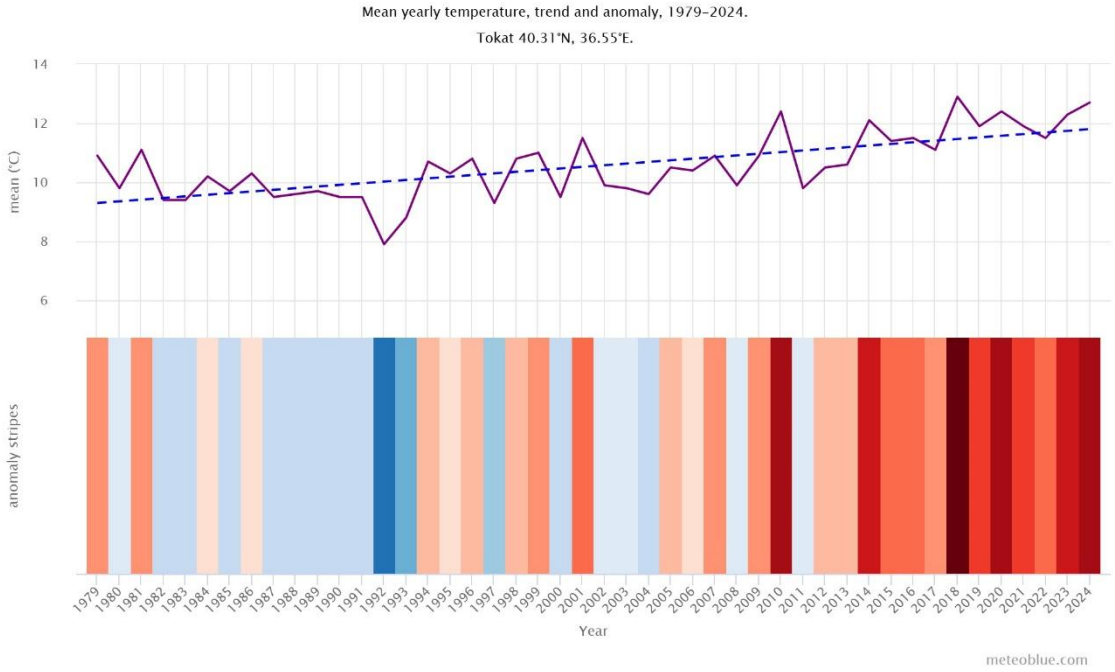

Figure 7. Varying temperature values for the city of Tokat 1979-1924 [23].

Figure 7 shows temperature values for the city of Tokat between 1979 and 2024. The dashed blue line in this figure represents the expected temperature trend due to climate change. The colored bands below the figure represent the average temperature of each year. Blue bands represent colder years, while red bands represent warmer years, and the temperature degree is shown with a purple line. Accordingly, it can be seen that the city of Tokat has experienced temperature values exceeding the expected change, especially after 2014, in line with the expected temperature trend under climate change. This indicates that the air in Tokat has warmed. It is possible to say that the city of Tokat is also affected by global warming and climate change.

The Yeşilırmak River, which flows through the city, and its tributaries have significantly influenced the formation of Tokat's urban structure. Consequently, the city has developed around the Yeşilırmak River and its tributary, the Behzat Stream. Urban development has occurred along the east-west axis of the Behzat Stream and along the north-south axis of the Yeşilırmak River. While less urban development is observed along the eastern axis at the intersection of the Yeşilırmak and Behzat Streams due to the city's topographical structure, urban development is predominantly concentrated along the western axis, as the topography allows. The city's form has shifted towards the north-south axis as a result of urban development projects undertaken and improved during the Republican era. The connecting roads between Sivas and Samsun along this axis have been influential in this

development. Since the 2000s, with increased construction activity, new residential areas have opened up north of the Yeşilırmak River, and the city has begun to grow in this direction. The historical/old city center has faced dense construction, and new development has occurred along the city's western and northern axes.

Following the 1999 Gölcük earthquake in Turkey, construction activity nationwide increased. In Tokat, a medium-sized city, construction activity also increased with the opening of new development areas north of the Yeşilırmak River. The city's transformation and development have again occurred in the northern direction. As a result of migration from rural areas to the city, the population grew rapidly, creating a housing shortage. This led to a surge in construction activity and housing production, particularly in the early 2000's. The northern part of the city has stood out with its rapidly increasing housing stock in recent years. Housing production in the northern part of the city is shown in Figure 8.

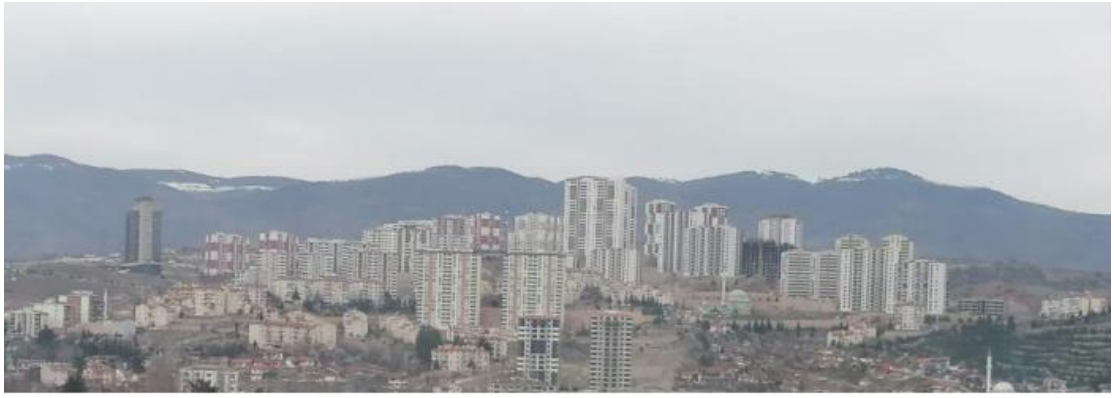

Figure 8. Residential settlement in the northern part of the city [24].

Due to the city's development to the north, older residences in this area are being included in urban transformation projects, and new housing construction continues. Figure 9 shows the combination of urban transformation housing units and those not yet included in the transformation project in the northern part of the city.

Figure 9. Coexistence of housing units produced within the scope of urban transformation and those not yet included in the transformation in the northern part of the city [24].

In Tokat, the increasing construction activity over the years has led to changes in materials, construction techniques, and especially facade materials used in building envelopes, moving away from natural materials. Technologically advanced heating, ventilation, and air conditioning (HVAC) systems are also evident in traditional residential architecture. In particular, in the historical city center of Tokat, the growing building stock has exacerbated the urban heat island effect, with air conditioning systems often installed to create indoor comfort. This situation leads to increased energy consumption, which in turn increases emissions and air pollution. Furthermore, it distorts the city's skyline. Given the city's semi-arid-semi-humid climate, the rapid increase in

concrete blocks, moving away from traditional residential architecture, is expected to increase greenhouse gas emissions, contributing to global warming and climate change, and to alter the regional climate. Additionally, it is anticipated that the construction of buildings to address the housing problem of the rapidly growing population will increase the carbon footprint of the building stock before, during, and after construction. Moreover, it seems likely that the city's infrastructure, a critical system, will be insufficient due to the rapid construction of these buildings.

When evaluating the disaster vulnerability of Tokat, a city in the central Black Sea Region, "earthquakes" rank first. Due to the region's geological location, the city center and its surroundings have experienced major earthquakes throughout history, resulting in loss of life and property. Tokat is situated on the North Anatolian Fault Zone. Seismically, this fault line is still active today. Figure 10 shows the North Anatolian Fault Zone and the location of Tokat [7].

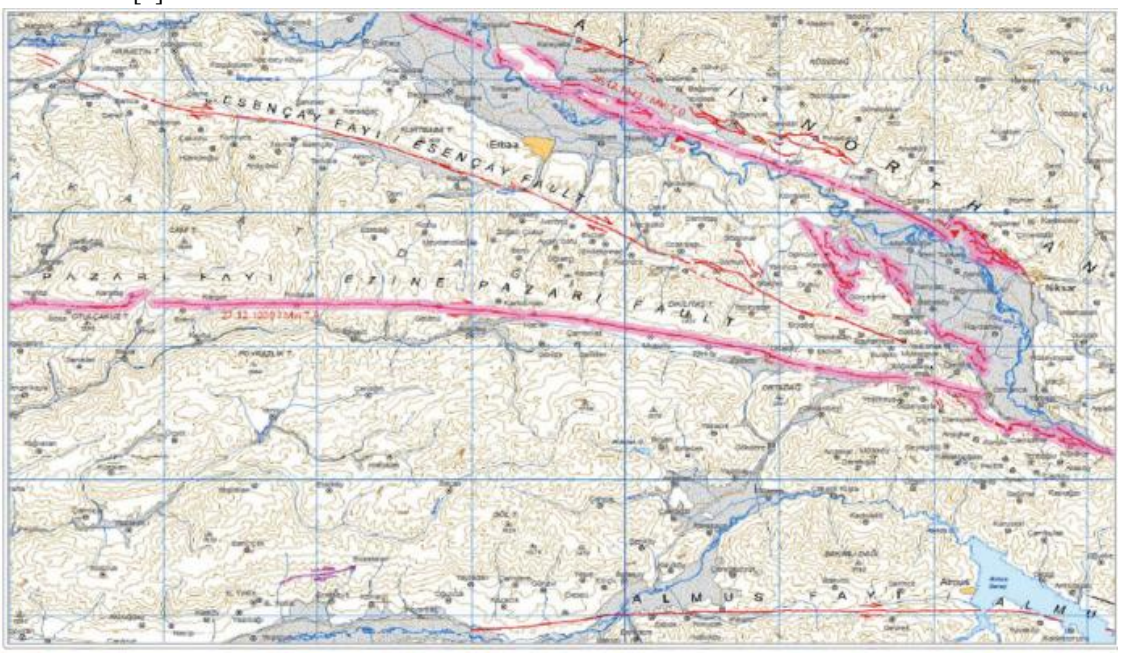

Figure 10. Location of the North Anatolian Fault Zone and the city of Tokat [7].

The North Anatolian Fault Zone is characteristically a right-lateral strike-slip fault, passing 50 km north of the city center of Tokat. This fault zone starts near Muş/Varto in the east and extends westward to the Gulf of Saros. Historically, the city of Tokat experienced an earthquake in 1498, described as a "small apocalypse." This earthquake caused significant damage to Tokat and its surroundings [25]. Further earthquakes occurred on this fault zone, resulting in loss of life and property: a 7.9 magnitude earthquake centered in Erzincan on December 26, 1939; a 7.0 magnitude earthquake centered in Erbaa-Niksar on December 20, 1942; and a 7.2 magnitude earthquake centered in Ladik-Tosya on November 26, 1943 [7]. Following these earthquakes, efforts were made to create a new urban fabric. Following this earthquake, the development of Tokat, which was a medium-sized city, was hampered. Furthermore, the fact that the Sivas-Samsun railway line, which was prevalent in Anatolia during the early years of the Republic and contributed to the development of cities, did not pass through Tokat but instead passed through the Turhal district to the west, further hindered the city's development [26]. In addition to the earthquake, Tokat experienced a fire disaster in 1914. In this fire, residential and commercial areas, mostly inhabited by people of Armenian and Greek origin, were destroyed [27].

When examining Tokat's vulnerability to disasters, after the earthquake, which ranks first, it is seen that, due to the city's location, landslides and floods are also among the disasters experienced. According to a report prepared by the Tokat Provincial Disaster and Emergency Management Directorate, besides earthquakes, landslides, rockfalls, and floods are among the natural disasters likely to occur in Tokat [7].

Tokat is a medium-sized city with a development trend. Interventions related to the city should be made by learning from negative historical events and preparing for potential future challenges. Only in this way can the

resilience and sustainability of critical systems in Tokat be ensured. This is also important for the city's sustainable development. In this context, the problem of Tokat's resilience and sustainability in the face of climate change has been analyzed using the Fishbone Diagram method. The analysis is shown in Figure 11.

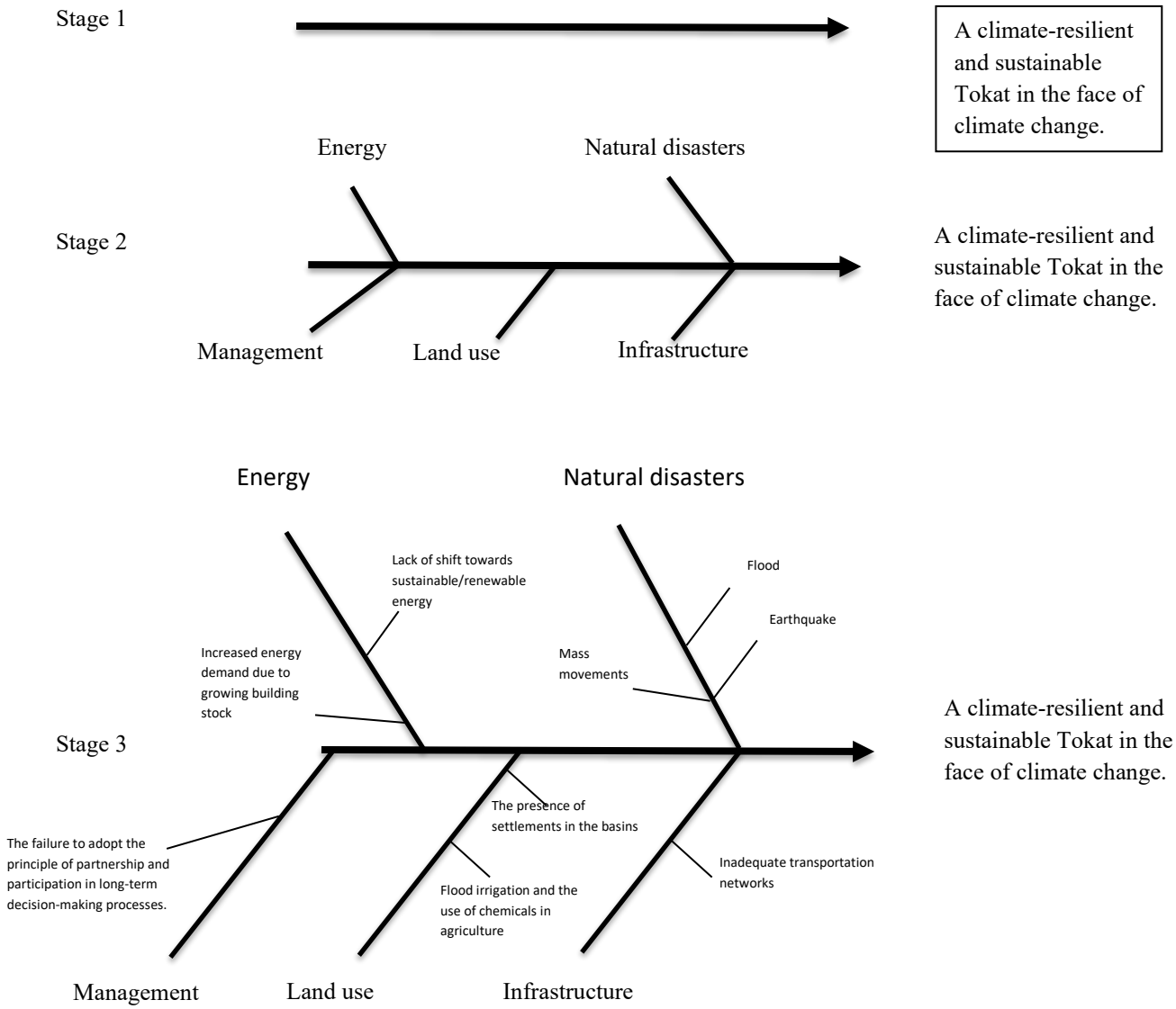

Figure 11. Main and sub-causes affecting the climate change resilience and sustainability of Tokat city using the Fishbone Diagram method.

Figure 11 shows the problem of Tokat city's ability to be resilient and sustainable in the face of climate change, and the main and sub-causes that contribute to this problem. Accordingly, due to its geographical location and soil structure, Tokat city is most close to the problem of natural disasters. Earthquakes, landslides, and floods are prominent natural disasters. The main energy cause is the lack of a shift towards sustainable/renewable energy in the city, and the increasing energy demand along with the growing building stock. The increase in greenhouse gas emissions accumulating in the atmosphere due to increased energy consumption directly affects the negative consequences of climate change. In existing locations, the intensive use of HVAC systems affects both the increase in greenhouse gas emissions and the city's skyline. The main infrastructure cause is the inadequacy of transportation networks. Due to its location, the city connects many provinces. However, the inadequacy of the

city's internal transportation networks, the increase in private vehicle use due to population growth, and the persistent use of fossil fuels result in the city's infrastructure systems being insufficient. The main cause of land selection is; The city of Tokat, located on an active fault line, faces several challenges, including the construction of areas on fault lines, the planning of settlements in basins, the conversion of agricultural land into urban areas, and especially the continued use of flood irrigation and chemicals in agriculture. A key administrative factor is the failure of local governments to adopt the principles of partnership and participation in long-term decision-making processes.

For Tokat to become a climate change-resilient and sustainable city, local governments need to address the main and sub-causes identified using the Fishbone Diagram. It is anticipated that grouping all causes, prioritizing the city's characteristic and vulnerable features, in climate change adaptation, mitigation, and response efforts will enable quick solutions without delay. In this context, grouping the causes according to their importance and urgency is crucial. The Eisenhower matrix, explained in the methodology section of this article, was used for this grouping (Figure 12).

Importance Level

Level of Urgency	Important	Not Important
Urgent	The rehabilitation of riverbeds, the absence of settlements on active fault lines, the construction of retaining walls based on project specifications due to mass movements, the use of renewable energy sources, and the establishment of an urban management system are all important measures.	Working with the private sector on waste management, strengthening urban transportation networks, designing bicycle paths.
Not Urgent	Improving agricultural practices by raising awareness in society, holding informational meetings during the decision-making process, determining areas to be opened for construction using threshold analysis method, and working together with the university.	DELETE (Ignore it)

Figure 12. Grouping of necessary actions in Tokat city using the Eisenhower matrix.

The Eisenhower decision-making process matrix provides a systematic framework for the effective and efficient use of time, prioritizing actions after a decision and implementing them immediately without delay. This is expected to facilitate a more systematic approach to developing strategic emergency action plans, identifying priority areas in climate change adaptation, mitigation, and response efforts, and creating flowcharts.

IV. EVALUATION AND RECOMMENDATION

Carbon emissions, resulting from the use of non-renewable energy sources, have rapidly increased with the rise of industrial activities since the industrial revolution. The primary step in combating, adapting to, and mitigating climate change, whose effects are concretely seen on a global scale, is to shift towards the use of renewable resources. Furthermore, the use of renewable resources is one of the most effective models created for sustainability. Increased carbon emissions resulting from growing populations and industrial activities in cities negatively contribute to climate change. Cities are in a vicious cycle, both negatively contributing to climate change and being affected by its negative consequences. In short, cities are both victims and perpetrators of climate change. Therefore, building planning is a priority in cities for adaptation, combating, and mitigating climate change. Integrating solar energy into building design is crucial in the use of renewable resources. Low energy demand should be included in planning decisions for new building designs in cities. In existing buildings, climate change adaptation, mitigation, and reduction efforts, particularly through facade insulation of the building envelope, the use of solar panels on the roof, and thermal insulation of windows, reduce greenhouse gas emissions released and accumulated in the atmosphere. The use of green roofs in building design is considered an effective and efficient solution for reducing the urban heat island effect and enabling energy savings. Alternatively, the use

of light-colored materials is presented as an alternative solution for reducing the heat island effect. This will reduce the temperature resulting from the heat absorbed by the city and its systems, decreasing the need for heating, cooling, and air conditioning (HVAC) systems. Consequently, a decrease in the amount of greenhouse gases released into the atmosphere is likely. The article includes suggestions based on literature and field research to demonstrate the applicability of the proposed model to different cities, serving the article's objective. Specifically, the Fishbone Diagram method used in the article allows for the identification of the causes and underlying reasons for climate change-related problems in cities, thus enabling rapid solutions. This method allows for the creation of a general problem-main cause-sub-cause framework to establish a model for climate change-resilient and sustainable cities. Figure 13 shows the main causes identified using the Fishbone Diagram method for addressing the issue of climate change-resilience and sustainability in Turkish cities.

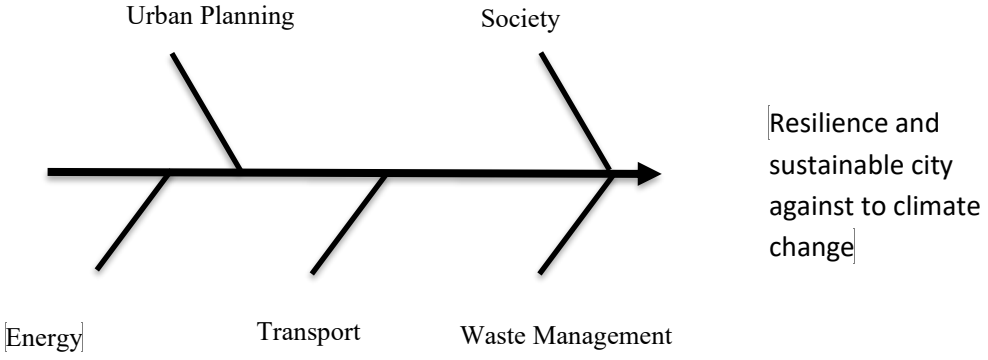

Figure 13. Problems and main causes faced by cities in Turkey in the face of climate change.

Cities contribute to climate change and also suffer from its negative consequences. In climate change mitigation, adaptation, and response efforts, identifying the problem first, and then analyzing the root causes and underlying factors, is considered crucial to prevent wasted time on the path to a solution. Figure 17 shows the main causes affecting a city's ability to be resilient and sustainable in the face of climate change, using the Fishbone Diagram method. It is suggested that the root causes, which constitute the main causes, be determined according to the characteristic features and vulnerable points of the analyzed settlement. According to this method, the main causes that contribute to the problem can be grouped under five main headings: urban planning, community, energy, transportation, and waste management. In this context, to solve the problem:

Urban Planning

Use of digital tools, adoption of design approaches dominated by renewable energy, maximizing the use of green infrastructure and areas, creation of common areas open to everyone, increasing green space per capita, inclusion of rooftop gardens in design, increasing the length of walking areas within the city, creating green corridors in the city, expanding urban agriculture, developing and making the city's infrastructure resilient against floods, snow, and extreme weather events, protecting agricultural areas, creating a special regulation for coastal cities, not constructing enclosed parking lots near the coast in coastal cities, not building on fault lines.

Community

Adopting the principle of participation and partnership in the community, establishing a city management system based on the principle of partnership and participation, establishing cultural facilities that conduct studies on sustainability at the neighborhood level, raising public awareness and understanding in all studies related to climate change, providing training, providing incentives and grants for local solution-oriented projects, establishing climate change units by local governments and working in coordination with the public.

Energy

Efficient and effective use of energy, providing grants and incentives for increasing and renovating the energy efficiency of buildings, reducing greenhouse gas emissions from buildings, implementing green roof and

wall applications, shifting towards renewable energy sources, using smart technologies, improving air quality by reducing greenhouse gas emissions, reducing energy consumption from the existing building stock, encouraging the use of renewable energy sources in new buildings through incentives and regulations, adopting flexible design in building design, increasing energy production from solar energy.

Transportation

Reducing motorized vehicle transportation, encouraging alternative transportation methods such as walking and cycling, increasing the share of public transportation in transportation, increasing the number of streets closed to motorized vehicle traffic, reducing the use of fossil fuels.

Waste Management

Improving solid waste management and increasing prevention, recycling, and reuse practices, reducing the amount of daily food waste, recycling construction waste, selecting low-carbon materials in building renovation applications and reusing the resulting materials, establishing waste sorting and composting facilities are necessary.

Suggestions have been developed under five main reasons within the scope of this article for the creation of climate change-resilient and sustainable cities. It is suggested that the sub-causes that cause the main reasons be determined according to the characteristic features, location, and vulnerable points of the relevant settlement. It is recommended that the problem of the city, analyzed using the Fishbone Diagram, be grouped according to its urgency and importance using the Eisenhower Matrix in order to be solved. After analyzing the causes and sub-causes for the solution of the problem in the relevant settlement, grouping with the Eisenhower Matrix and solving it urgently by local and central governments is of great importance.

In the fight against climate change, whose effects are concretely felt on a global scale, the active role of local government and the city's contribution to adaptation and mitigation efforts are of great importance. In this context, the strategic emergency action plan proposal presented in this article for the medium-sized city of Tokat, developed for implementation in different cities and serving as a guide, is of significant importance. Figure 14 shows the strategic emergency action plan proposal.

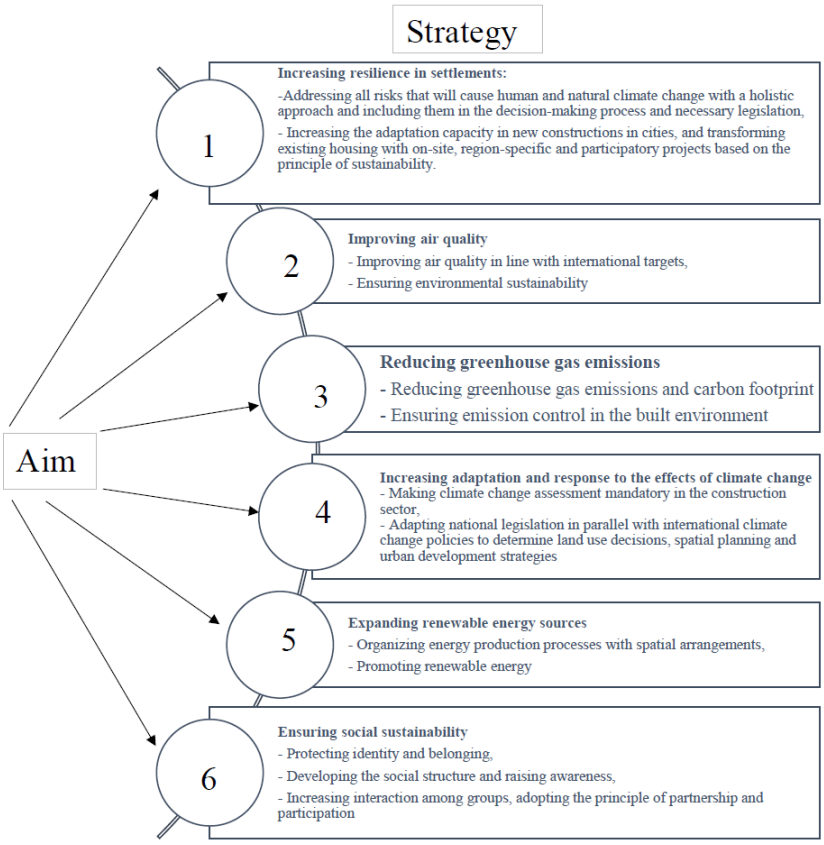

Figure 14. Proposed strategic emergency action plan.

It is foreseen that progress will be made in reducing greenhouse gas emissions and carbon footprints if the strategies determined for the objectives included in the prepared strategic emergency action plan are implemented. With this implementation, it is aimed to reduce Turkey's total emission value thanks to these interventions made by local administrations in each city. It is foreseen that the greenhouse effect will decrease and the negative contribution to climate change will be eliminated by reducing the greenhouse gas accumulation in the atmosphere by reducing the total emission value.

V. CONCLUSION

The irregularities in the rainfall regime, floods, landslides, storms and migration movements caused by climate change in cities negatively affect both individuals and the city economically. For this reason, the issue of urban resilience is important in climate change mitigation, adaptation and reduction efforts. Resilience can be defined as the ability of the city and its critical systems to respond to sudden shock and stress situations. Resilience is important for the sustainability of critical infrastructure and superstructure systems against possible natural disasters in the city. A resilient city can protect itself against natural disasters or negative impacts arising from climate change and ensure the sustainability of the process thanks to its resilient systems. Local governments need to prepare urgent and strategic plans to prevent potential disasters in the city. Potential disasters due to climate change have a greater impact, especially in areas with unplanned settlements within cities. When implementing climate change adaptation, mitigation, and reduction efforts in cities, these deprived areas should be prioritized. Resilience is considered a key factor for the continued sustainability of a city. The concepts of resilience and adaptation are interconnected or used interchangeably in the fight against climate change. Adaptation can be defined as the activity or outcome of an activity undertaken to minimize the negative impacts of climate change. In summary, it can also be defined as helping to build the resilience of the city and the critical systems that constitute it. Resilience and adaptation are important for mitigating and eliminating the negative effects of climate change. While adaptation efforts have a certain order and results are achieved over time, resilience, on the other

hand, involves the system producing solutions within its capabilities to the negative event it encounters and responding quickly. It is also important for eliminating the negative economic consequences experienced in the city due to climate change. In the event of a disaster, the ability of individuals in society to act together and with awareness, in short, the achievement of social resilience, is important for eliminating the effects of the disaster as quickly as possible. The work done by local and central governments, the environment of trust created, and leadership strategies play a very large role in the formation of the ability of societies to act together. In this way, it is foreseen that when an environment of trust is established between individuals and the administration, there will be fewer casualties and less property damage.

It is foreseen that progress will be made in reducing greenhouse gas emissions and carbon footprints if the strategies determined for the objectives included in the prepared strategic emergency action plan are implemented. With this implementation, it is aimed to reduce Turkey's total emission value thanks to these interventions made by local administrations in each city. It is foreseen that the greenhouse effect will decrease and the negative contribution to climate change will be eliminated by reducing the greenhouse gas accumulation in the atmosphere by reducing the total emission value.

VI. Acknowledgements

This article is produced from Nihal ZENGİN's PhD Dissertation entitled "A model for resilient and sustainable cities against climate change: The Tokat example", which was completed in 2026 in the Architecture Programme of Eskisehir Technical University under the supervision of Prof. Dr. Rusen Yamaçlı. The authors have reviewed and edited the output and take full responsibility for the content of this publication.

REFERENCES

Journal Papers:

[1] UN-HABITAT. (2016). *Urbanisation and development.* Emerging Futures.

[2] Krüger, E. L., Minella, F. O., & Rasia, F. (2011). Impact of Urban Geometry on Outdoor Thermal Comfort and Air Quality From Field Measurements in Curitiba. *Building and Environment(46),* doi:https://doi.org/10.1007/s00484-015-1109-4

[3] Johansson, E., & Emmanuel, R. (2006). The influence of urban design on outdoor thermal comfort in the hot, humid city of Colombo, Sri Lanka. *International Journal of Biometeorology(51), s. 119-133.* doi:https://doi.org/10.1007/s00484 006-0047-6

[4] Öztürk, K. (2002). Küresel İklim Değişikliği ve Türkiye'ye Olası Etkileri. *G. Ü. Gazi Eğitim Fakültesi Dergisi, 22(1), s. 47-65.*

[5] https://data.tuik.gov.tr/Bulten/Index?p=49685

[6] Özgür, H. (2005). Türkiye'de orta ölçekli kentsel alanların yönetimi sorunu. H. Özgür, & M. Kösecik (Dü) içinde, *Yerel Yönetimler Üzerine Güncel Yazılar-1: Reform (s. 471-498).* Ankara: Nobel Yayın Dağıtım.

[7] https://tokat.afad.gov.tr/kurumlar/tokat.afad/E KUTUPHANE/Il-Planlari/Tokat_IRAP.pdf

[8] Ünal, Ç. (2004). *Şehir Coğrafyası Açısından Tokat*. Erzurum: Aktif Yayınevi.

[9] https://www.mgm.gov.tr/iklim/iklim siniflandirmalari.aspx?m=TOKAT

[10] Koçel, T. (2020). *İşletme Yöneticiliği: Yönetim ve Organizasyon, Organizasyonlarda Davranış, Klasik-Modern-Çağdaş Yaklaşımlar* (18 b.). İstanbul: Beta Basım Yayım Dağıtım.

[11] Türkeş, M. (2008). Küresel İklim Değişikliği Nedir? Temel Kavramlar, Nedenleri, Gözlenen ve Öngörülen Değişiklikler. *İklim Değişikliği ve Çevre, 1(1), s. 26-37.*

[12] Houghton, J., Y., D., Griggs, D., Noguer, M., van der Linden, P., Dai, X., . . . C.A., J. (2001). Climate Change 2001 The Scientific Basic. Cambridge University Press, *Contribution Of Working Group I To The Third Assessment Report Of The İntergovernmental Panel On Climate Change.*

[13] Shaw, R. (2011). Climate And Disaster Resilience In Cities. Community, *Environment And Disaster Risk Management(6).*

[14] Kavanoz, S. E. (2020). Kentsel Direnç Kavramı Üzerine. *Kent ve Çevre Araştırmaları Dergisi, 2(1), s. 5-24.*

[15] UN HABITAT. (2018). City Resilience www.unhabitat.org/urbanresilience
[16] Tóth, A., & Feriancová, L. (2013). Green Infrastructure: From Global To Local (Cilt 2). *Nordic Journal of Architectural Research.*
[17] Erdem, S. (1986). Tokat Kelimesi Üzerine Düşünceler. *Türk Tarihinde ve Kültüründe Tokat Sempozyumu, Temmuz, (s. 11-16).* Ankara: Gelişim Matbaası, Bildiriler Kitabı.
[18] Strabon. (1969). Coğrafya (Geographika), Kitap XII, Bölüm I-II-III. (A. Pekman, Çev.) İstanbul: İstanbul Üniversitesi Edebiyat Fakültesi Yayınları.
[19] Şimşirgil, A. (1990). *Osmanlı Taşra Teşkilatında Tokat*. Yayımlanmamış Doktora Tezi. İstanbul: Marmara Üniversitesi Sosyal Bilimler Enstitüsü Tarih Bölümü Yeni Çağ Tarihi Bilim Dalı.
[20] Aksulu, I., & Kuntay, O. (2013). *Kimlikli Kent Tokat*. Ankara: Hazırlık-Baskı.
[21] Aktüre, S. (1978). 19. *Yüzyıl sonunda anadolu kenti mekansal yapı çözümlemesi.* Ankara: ODTÜ Mimarlık Fakültesi Baskı Atölyesi
[22] Açıkel, A. (2012). *Tokat (Cilt 41).* Türkiye Diyanet Vakfı Basımevi.
[23] https://www.meteoblue.com/tr/hava/historyclimate/change/tokat_t%c3%bcrkiye-cumhuriyeti_738743
[24] Zengin, N., & Yamaçlı, R. (2022). Orta Ölçekli Kentlerde Yerel Yönetimler İçin İklime Duyarlı Tasarım Modeli: Tokat Örneği. *İDEALKENT, 13(37), s. 1330-1357*. doi:https://doi.org/10.31198/idealkent.1126050
[25] Asarkaya, H. (1941). *Osmanlılar Zamanında Tokat*, Cilt I. Tokat Matbaası.
[26] Tuncel, M. (2012). Bugünkü Tokat. *İslam Ansiklopedisi, 41, s. 219-223.*
[27] Cinlioğlu, H. T. (1973). Osmanlılar Zamanında Tokat, *Cilt IV. Tokat: Tokat Matbaası., 112-116.*