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Prevention of Urban Heat Waves by Using Planning Tools: Torbalı Example

Research Article

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Abstract

Climate crisis is a modern era problem that is mainly attributed to human activities. It alludes to severe and abrupt changes in climate brought on by an increase in different gases in the atmosphere, such as drought, desertification, and unequal precipitation. The main factors causing this crisis include greenhouse gases, fossil fuels, agriculture and farming activities, population growth and construction. Rapid urban development caused by population growth can increase climatic threats by accelerating the loss of green space. At the same time, carbon emissions, which increase in proportion to the growing population, are also a part of this crisis. Increasing carbon emissions and ecosystem weakness in urban areas trigger an environment where heat waves are frequently experienced. Urban heat waves usually occur in densely populated cities, where hot and humid weather conditions are prolonged and intense. This is defined as an increase in the daily maximum temperature by 5°C or more above the average temperature recorded for a year for 5 consecutive days. Increasing temperatures under the influence of urban heat waves can bring serious health risks for people. High temperatures cause health problems such as dehydration, dehydration,

sunstroke and are especially dangerous for vulnerable groups such as cardiovascular elderly and children. In addition, the environmental impacts of these air waves cannot be ignored. Warming air can reduce air quality and lead to increased air pollution. The increase in energy demand can increase the risk of power outages and increase energy consumption, further deepening environmental impacts.
Urban heat waves are triggered by environmental factors, climate change and human interactions in urban areas. This becomes more pronounced as urban areas are covered with thermally absorbent surfaces, especially materials such as asphalt and concrete, which increase temperatures more, and this effect is defined as "urban heat island". Heat waves are experienced more intensely especially in metropolitan areas. It is important for cities and local governments to take measures to combat climate change and protect public health. Protecting green areas, increasing open spaces, and integrating sustainability principles into urban planning are critical in mitigating the effects of urban heat waves. In this context, among the effective factors to prevent heat waves, providing air flow throughout the city and creating sufficient shade, reducing carbon emissions, turning to renewable energy sources, recycling hard-to-degrade wastes, and promoting public transport systems are the most important tools to help reduce the effects of urban heat waves. The aim of this study is to examine whether planning tools can be used to build resilience against urban heat waves, a common problem in metropolises. For this purpose, the province of Izmir, the metropolis with the third largest population in Turkey, has been selected. It is aimed to create an urban planning approach that provides resistance to heat waves in Torbalı Central district, which attracts attention with its organised industrial zones and high-speed rail system connections in İzmir province. Future research is expected to be able to benefit from the study's model application. It is foreseen that this model can be used in more detailed and realistic studies with full-time data and can contribute to urban heat waves-oriented planning processes.
In order to develop a strategic planning approach for urban settlements, it is proposed to work at the Master Plan scale. In this planning process, the functional identities of the land pieces, zone types and the sizes and development directions of the settlement areas were emphasised. The Master Plan has been accepted as a principled document that determines the basic decisions for the Torbalı settlement to have a resilient structure against urban heat waves. Spatial analytical data compiled through geographical information systems were used to create the problem definition at this scale. Torbalı Central district has been rebuilt with heat wave resistance in mind, in accordance with the Principles on the Construction of Spatial Plans of the Regulation on the Construction of Spatial Plans (Mekânsal Plan Yapım Yönetmeliği Mekânsal Planların Yapımına Dair Esasları). The new urban design is based on three main components: green areas, transport circulation system and population density. This strategy aims to provide protection against heat waves while meeting the requirements of the Master PlanThe study's findings will provide the Torbalı/Merkez district with measures to avert heat waves and strengthen its resistance to them. The new urban configuration includes holistic social facilities and urban infrastructures with balanced population densities. This holistic strategic spatial plan demonstrates that urban planning tools can be an effective instrument for building adaptation and resilience to heat waves.
Keywords: *Master Plan, Urban Heat Waves, Planning Tools, İzmir, Torbalı*

1. INTRODUCTION

With the effect of the accumulating population, cities are becoming more important and confronting settlements with sudden situations and stresses. Today, the new challenge of cities is shaped by the focus on taking rapid action against unusual situations, producing quick solutions and adapting to the new normal order. Preventing the decline in the quality of life in the process of uncontrolled population growth, changes in the ecosystem, decrease in biodiversity, negative effects of climate change, and inadequacy of cities despite various needs are considered as important topics today. With this perspective, urban planners and decision-makers focus on strategic and spatial plans that are suitable for the subjective structure of the city, that recognise the risks and crises of the city well, that observe the balance between protection and utilisation of resources, that offer alternatives and flexibility in the implementation process. All plans that do not define the subjective risks of the city well, do not offer alternative solutions and are not flexible are plans with low implementation capacity, weak in terms of resource utilisation and high consumption. Adaptation to urban stress and disasters, solving problems and transformation vary depending on the subjective capacities of cities. In resilient cities, the system has a flexible, changeable and transformable structure that can adapt to sudden internal or external shocks (Ersavaş, 2020: 1015). Regardless of the cause of stress or disaster, every city needs to plan well in order to increase its resilience against multiple shock and stress sources that may be experienced. At this point, the best solution is to construct a spatial urban plan with a resilient city vision.

The concept of resistance is synonymously defined as endurance, resistance, strength (TDK, 2021). Cities are living spaces built on systems. Urban systems have a complex structure consisting of dynamic interactions between interconnected components (Koren et al., 2017: 1). The fact that cities are built on systems brings with it the need for these systems to be as durable and flexible as possible. Resilience is the capacity of an exposed system, community, or society to withstand, absorb, adapt, and recover from the consequences of the danger in a timely and effective manner to safeguard its essential structures and functions (UNISDR, 2009: 24; Koren et al., 2017: 1). Based on this definition, urban resilience can be defined as cities that can transform, change and develop themselves according to the new situation in the face of changing conditions and maintain their functions in economic, institutional, environmental and social fields (Öztürk & Demirel, 2021). While the OECD defines resilient cities as cities that can positively transform their structures and means in the face of future economic, environmental, social or institutional shocks, absorb, improve, prepare for and recover from shocks (OECD, 2018), the Resilient Cities Network defines resilient cities as cities that have the capacity to cope, adapt and grow with any risk, hazard or crisis that arises, regardless of the source, whether expected or unexpected, by all stakeholders in the cities (Resilient City, 2021). The ability of the urban system and all the socio-ecological and socio-technical networks that comprise it to either quickly recover from a threat or maintain desired functions, adapt to change, and quickly transform systems that limit current or future adaptive capacity is referred to as urban resilience. (Meerow, Newell, Stults, 2016.) In the simplest terms, the expected reactions of cities to problems and threats that may be experienced can be defined as urban resilience.

The focus of resilient cities is on man-made disasters like nuclear, biological, and chemical accidents, transportation accidents, industrial accidents, accidents brought on by overcrowding, migrants and displaced persons, etc., as well as sudden natural disasters like earthquakes, floods, water floods, landslides, rock falls, avalanches, storms, tornadoes, volcanoes, fires, etc. In a sense, climate crisis, which constitutes the top heading of slow-developing disasters, has also taken its place among the issues that are in the focus of resilient cities. "Climate crisis" refers to sudden and extreme changes in the climate, such as drought, desertification, and uneven precipitation, caused by an increase in the rates of various atmospheric gases. It is acknowledged that the unchecked use of non-renewable resources worldwide is the root cause of the climate catastrophe, and it is expected to create irreversible harm. The global catastrophes of 2020 and 2021 demonstrate just how severe the effects of the climate problem will be. Human activity is clearly the main cause of the climate crisis. Greenhouse gases, fossil fuels, agriculture and allied industries, population growth, and the built environment are the main contributors to the climate issue. The rapid loss of natural spaces, the effects of population growth, and the sophisticated development that is taking place could all be contributing factors to climate dangers. Climate hazards could be sparked by the sophisticated building that is occurring, the impact of population increase, and the quick disappearance of green spaces. The need for action to achieve zero carbon and greenhouse gas emissions is frequently stressed. Heat waves are commonly noticed as a result of rising carbon emissions in constructed metropolitan environments and the slow deterioration of the ecological system. A heat wave is a heat wave when the daily maximum temperature rises 5°C or more above the average temperature recorded for 1 year for 5 consecutive days. The main factors that will prevent heat waves are ensuring air flow in cities and creating sufficient shade, developing strategies to reduce carbon emissions to zero throughout the city, increasing the use of renewable resources to be used in urban systems, recycling wastes that take a long time to decompose in nature and directing the transport system to public transport.

The carbon emission rate, which rises in direct proportion to population growth, is one of the reasons contributing to the climate problem. Heat waves are commonly noticed due to the rise in carbon emissions in urban developed environments and the debilitation of the ecological system. (Figure 1). Heat waves affect human health, living comfort, productivity, cause fatalities and death, forest fires, poor air quality, excessive consumption of electricity and water. Heat waves affect urban resilience positively and negatively in terms of social, economic and ecological aspects.

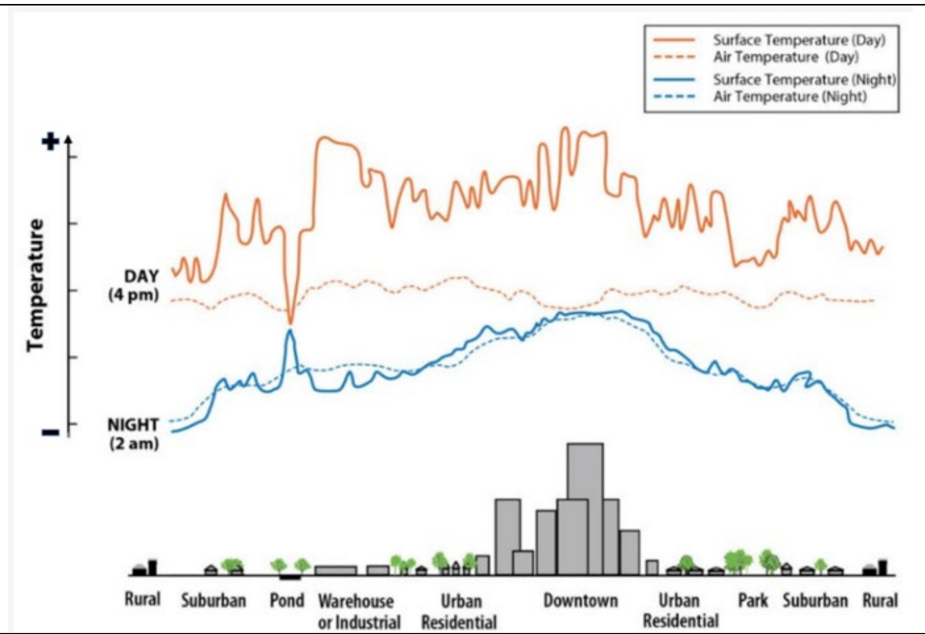


Figure 1. Effect of air temperature in different urban textures (Source : URL-1, 2022)

Urban heat island effect reduction and the creation of more livable cities can be achieved by reducing heat waves in urban areas, integrating public transportation and bicycle routes into transportation, implementing green roof applications, and building social facilities and urban infrastructures that function holistically with balanced population densities in urban morphology. In order to reduce the heat wave, green areas that will absorb carbon should be protected and increased. Urban gaps and open spaces should be increased and designed with local planting as holistic and accessible recreational activity areas. Development areas for settlements should be designed by considering meteorological parameters. It should be the responsibility of decision makers to produce green and blue strategies of cities with this focus.

The purpose of this research is to determine whether it is possible to use planning methods to prevent climate change, which is acknowledged as a global catastrophe. In order to achieve this goal, the plan uses planning techniques specific to the Torbalı Central neighborhood of Izmir in order to reduce the effects of the expected dangers to a manageable level and take the necessary precautions against heat waves. Two hypotheses were put forward for the study:

H1- An Urban Heat Wave Resilient City plan can be created.

H2- Planning tools can be used to create a city resistant to urban heat wave.

In this regard, it has been acknowledged that working at the Master Plan scale is necessary. The principal zone kinds, development orientations, settlement area sizes, and general land use for urban settlements are all highlighted in this scaleIt is also the place where the tenets that guide the settlement are decided. Geographic information systems have been used to collect the geographical analytical data required by the relevant scale for the Torbalı settlement and to clearly define the problem. Within the framework of the spatial plan making regulation and the principles on the making of spatial plans, Torbalı Central district has been reconstructed within the framework of climate resilience.

2. MATERIALS & METHODS

Within the scope of the study, literature research on resilient cities and prevention of heat waves was conducted in the first stage. In the second part, the data (land use, topography, prevailing wind, temperature, population density, social facilities availability and accessibility, green areas availability and accessibility, etc.) required to be collected at the scale of Master Development Plan presented by the Zoning Law No. 3194 and Spatial Plans Construction Regulation for the study area determined within the borders of the central district of Torbalı province were evaluated and a problem definition was put forward with a resilient city vision focused on the prevention of heat waves. Afterwards, a problem definition was put forward by approaching Torbalı campus through spatial analytical data and geographical information systems. In the third part; recommendations on resilient urban planning for Torbalı Centre district are presented within the framework of the principles for the construction of spatial plans.

3. ANALYSIS AND FINDINGS

The study area Torbalı is located in the south-east of Izmir province in the west of the Aegean region. Torbalı is surrounded by Gaziemir, Buca, Kemalpaşa, Bayındır, Tire, Selçuk and Menderes (Figure 2). Torbalı district is located in the west of the Aegean Region and has an area of 600 km² in the southeast of Izmir.

Figure 2. Torbalı urban settlement satellite image

In the district, where the Mediterranean climate is dominant, summers are hot and dry and winters are mild and rainy. In this direction, when we look at the average temperature and precipitation graph of Torbalı district for the last 30 years, the temperature is 36 degrees in June, July and August. The average precipitation in those months is at minimum level. The highest amount of precipitation is observed in November-December and January (Figure 3).

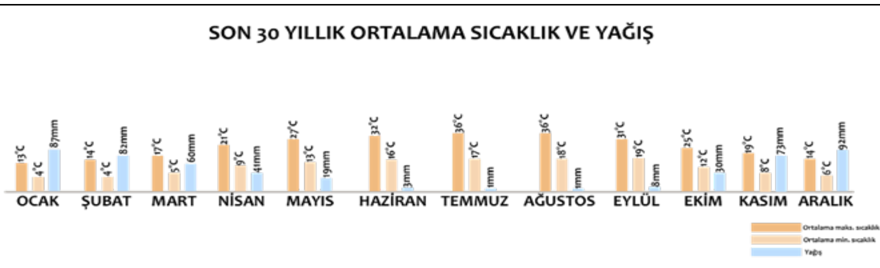


Figure 3. Torbalı 30-year Temperature and Precipitation Graph (Source: Meteorojoji Genel Müdürlüğü, 2021)

The 2021 population of the settlement is 201,476 people. Looking at the population graph of Torbalı, there is a 60% increase from 120 thousand people to approximately 200 thousand people in the period from 2006 to 2020. As a result of the increasing population, access to social facilities and urban infrastructure in the settlement has been insufficient. Along with the problems caused by the increasing population, these deficiencies increase the vulnerability of the central district of Torbalı with dangers such as natural disasters and climate change (Figure 4).

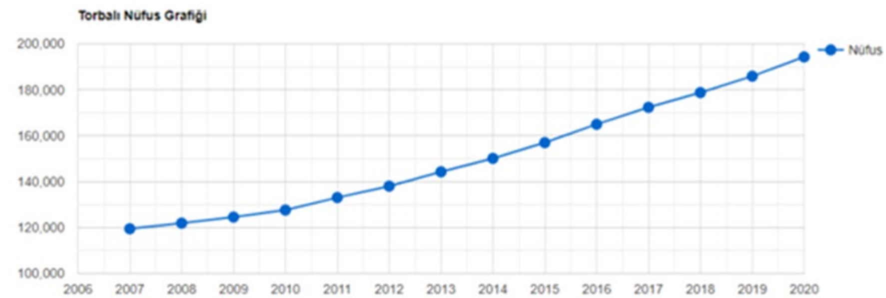


Figure 4. Population graph of Torbalı 2006-2020 (Source: www.tuik.gov.tr , www.endeksa.com/tr)

When the current land use of the study area is analysed, the city periphery of Torbalı is surrounded by agricultural lands and there is a developed industry within the settlement. Having agricultural lands working with industry makes Torbalı open to development. There is an industrial zone in the north of the settlement, a residential area in the centre, a mass trade area in the south and agricultural land surrounding the settlement. The district generally has a flat land structure. It is seen that it is an agriculture and industry orientated settlement. There is a hydrogeological asset in the northeast of the site, but this hydrogeological asset is not active (Figure 5).

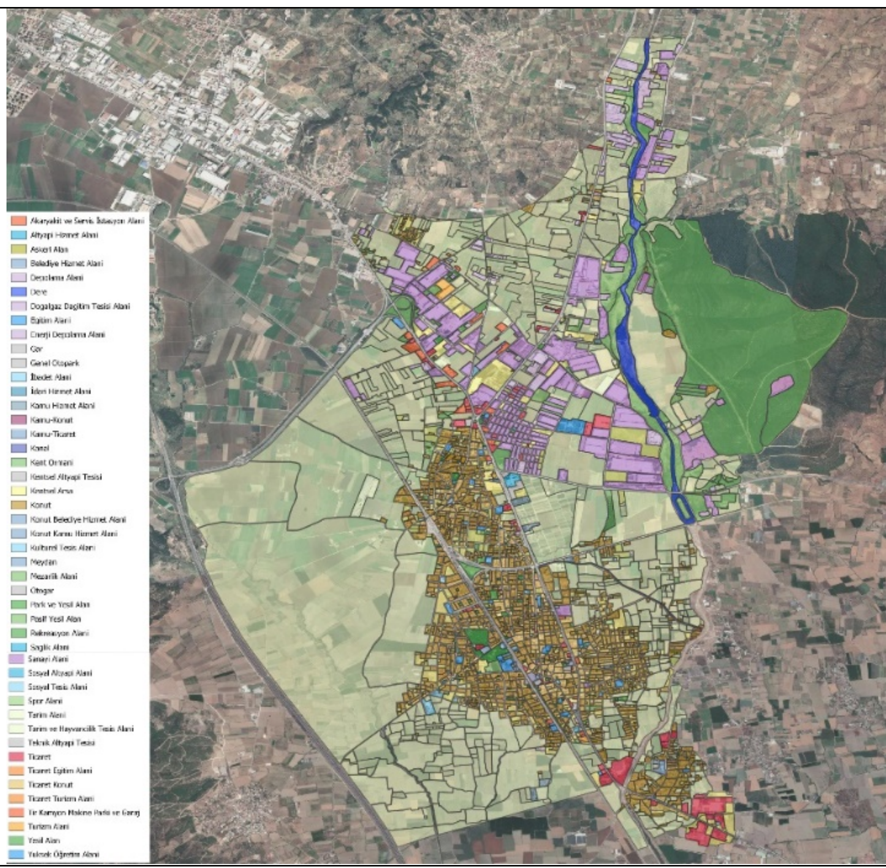


Figure 5. Torbalı Land use map

When the transport structure of Torbalı central settlement is examined, İzmir-Aydın motorway constitutes the main road connection of the settlement. The settlement provides İzmir connection with the light rail railway line following the north-south-east artery. However, it is seen that the transport hierarchy is not properly connected and that İZBAN and İzmir-Aydın motorway divide the city into three. At this point, it is possible to say that both pedestrian and road access is restricted and the city is divided into three main parts (Figure 6).

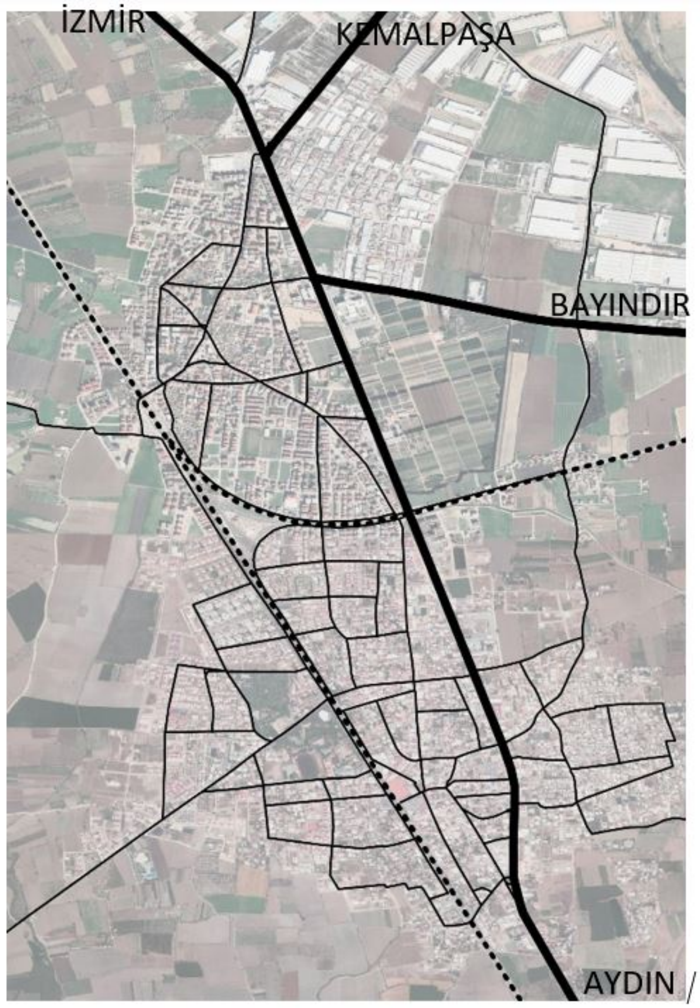


Figure 6. Torbalı's current transport system

In line with the walking distances accepted within the framework of the Spatial Plans Construction Regulation (Mekansal Planlar Yapım Yönetmeliği), the existence and accessibility of social reinforcement areas were examined through Quantum GIS programme. According to the analyses, there are 7 kindergartens, 36 primary schools, 15 secondary schools and 16 high schools in the central district of Torbalı. Educational areas are concentrated in the centre of the district. There are areas where access to primary and secondary school education areas in Torbalı district is insufficient (Figure 7).

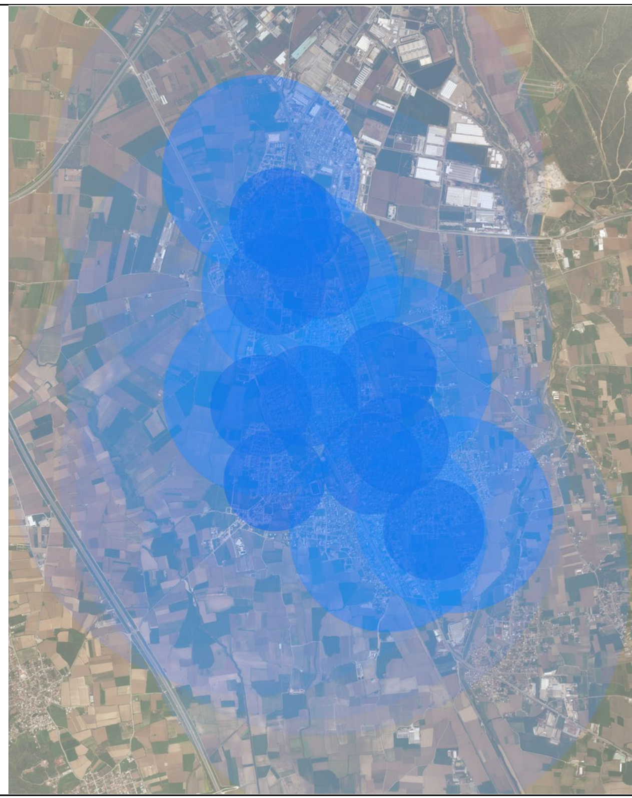


Figure 7. Accessibility of Education Areas

Similarly, in line with the service radius analysis of primary health care areas, it is seen that there are neighborhoods that cannot receive services (Figure 8).

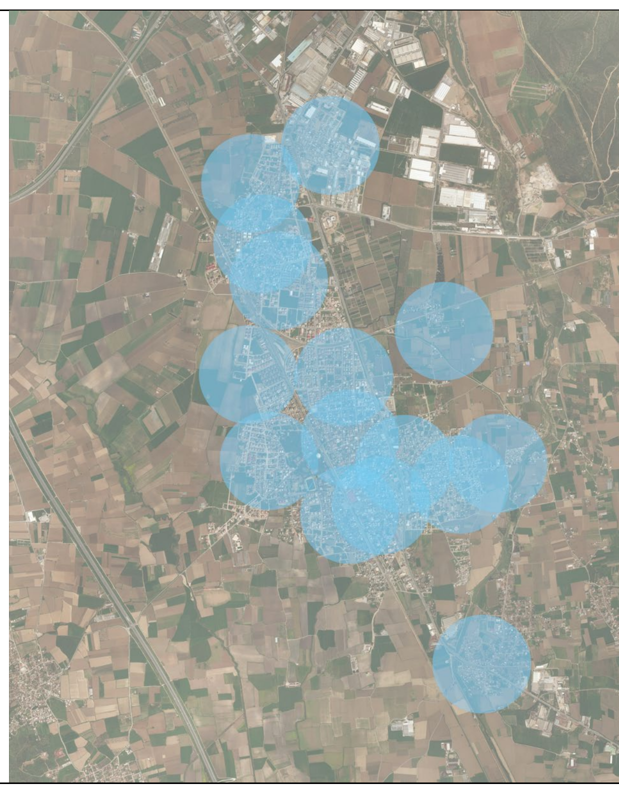


Figure 8. Accessibility of Worship Areas

When the areas of worship are evaluated; it is seen that access is insufficient in the south and north of the settlement. The fact that access to social reinforcement areas is limited shows that daily life needs are met by car or public transport, not on foot.

When the existence and accessibility of green areas, which are of primary importance in mitigating urban heat waves, are examined, it is seen that there is no access in the central region, which forms the built environment of the area, and the amount of green areas per capita is insufficient. This inadequacy shows that both in the city as a whole and at the neighbourhood scale, urbanites cannot access recreational activities and lack the minimum amount of green space required for healthy environments.

In terms of social reinforcement, in summary, the settlement has not been able to develop spatially despite intensive migration, and the standards of access to social reinforcements and urban infrastructure have been insufficient.

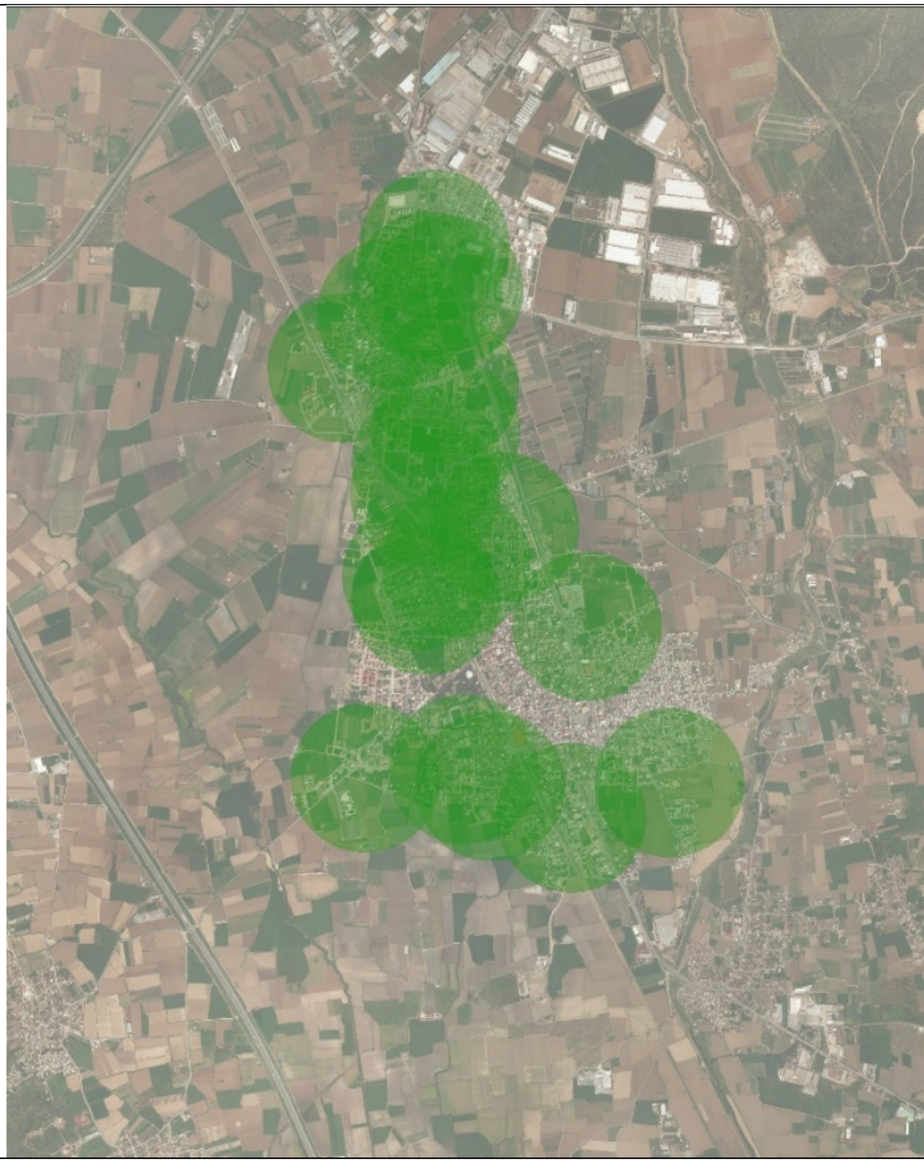


Figure 9. Green Space Accessibility

A temperature analysis was carried out to measure the urban heat for the study area. Looking at the temperature in the afternoon, it is seen that the temperature in the north of the settlement is approximately 35 degrees in the afternoon, similarly, the temperature in the centre of the settlement is 35 degrees in the afternoon. In addition, the temperature in the built-up area is approximately 30 degrees. On the other hand, as expected in agricultural areas, the temperature in the area forming the natural structure is 29 degrees.

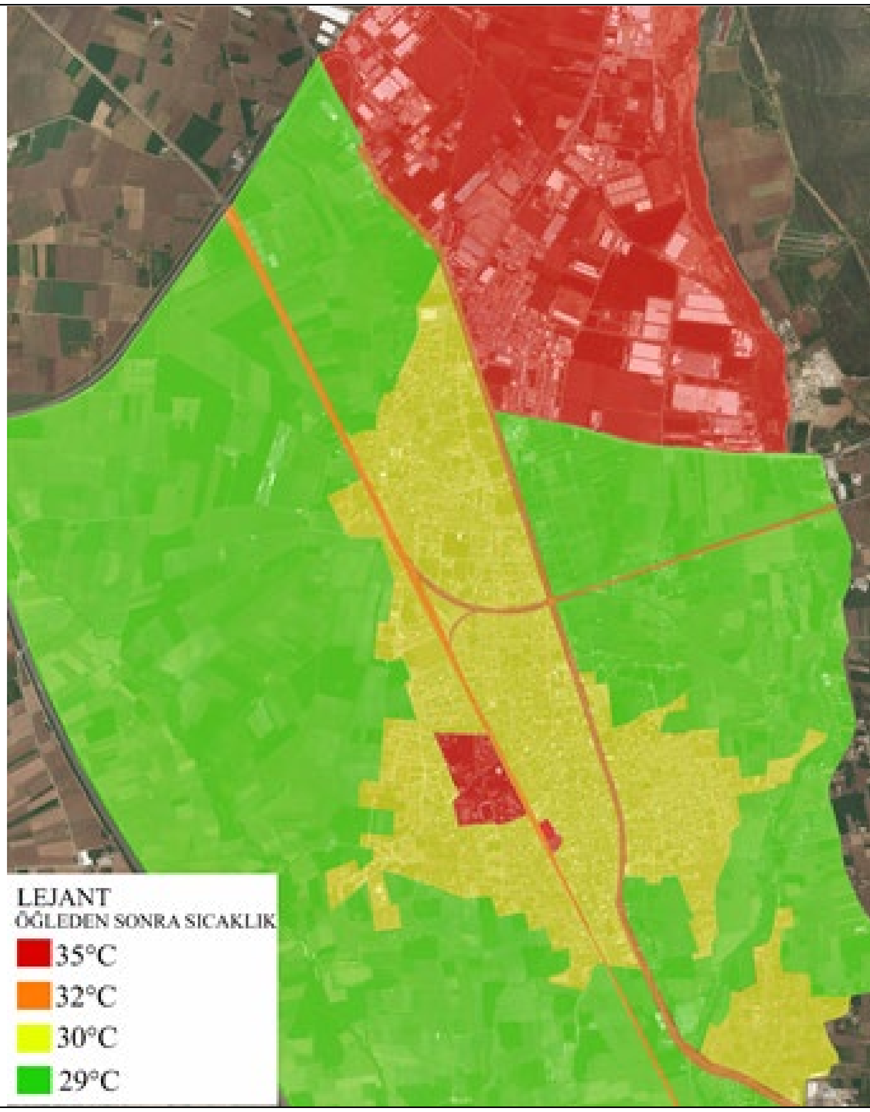


Figure 10. 2020 Torbalı Temperature Analysis

It is seen that the general air quality of Torbalı is generally at a medium level. It has been determined that the air quality is poor in the north due to harmful gases emitted from industrial facilities. In the regions where agricultural areas are located, air quality is generally good (Figure 11).

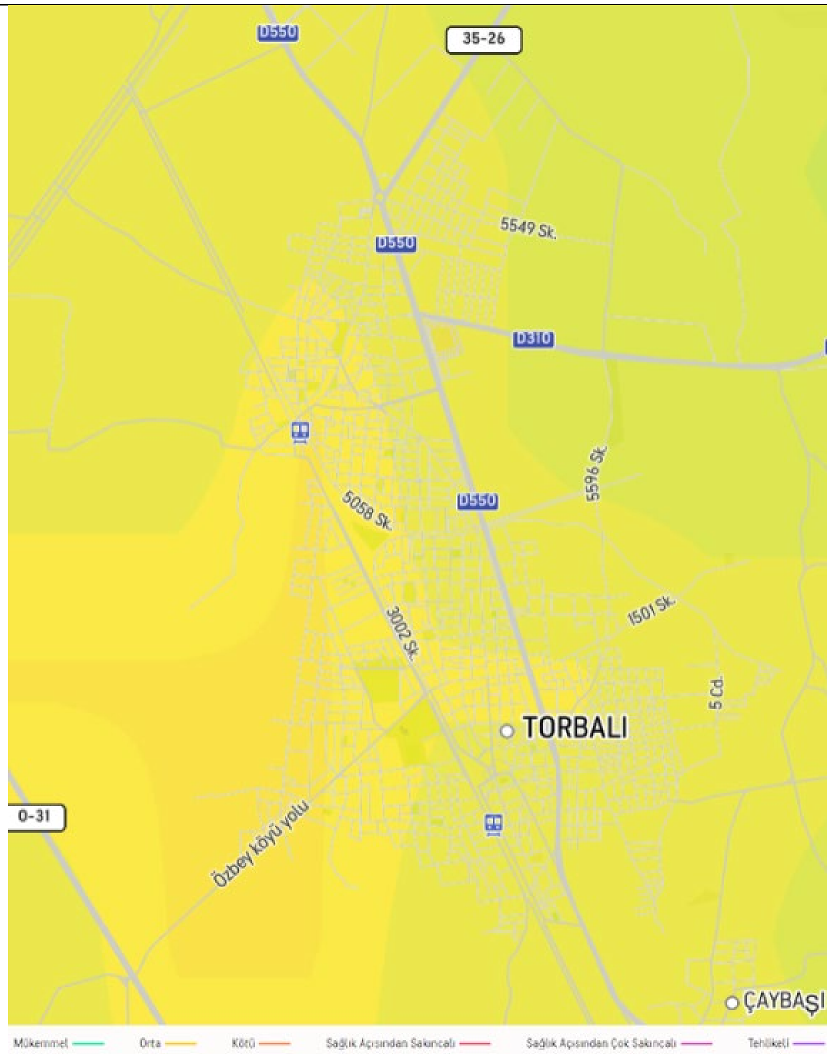


Figure 11. 2020 Torbalı Air Quality Analysis

4. ASSESSMENT

By evaluating the analytical data, two alternative master development plans were presented for Torbalı centre settlement within the framework of the Spatial Plans Construction Regulation (Figure 12-13). In the 1st master development plan, the borders of the existing industrial area of 307.5155 hectares were preserved and food industry facilities were selected to serve the industrial zone by adhering to the targets within the industrial area. In addition, a recovery facility to serve in the industrial area has been planned in order to store and recycle the solid wastes in the industrial area. The existing boundaries of the urban forest within the borders of the study area have been preserved. A recreational area has been planned within the borders of the urban forest. By preserving the existing agricultural areas, it is aimed to improve soil health with ecological agriculture system. The problems of the settlement areas in the existing area have been identified and determined as renovation areas. In the residential areas to be renovated, construction provisions will be applied. It has been decided to make analyses against disaster risk before building in the development housing areas to be constructed and to construct the buildings in accordance with the disaster risk. The park planned in Torbalı neighbourhood shown in the plan will be designed as a recycling park by selecting the materials to be used from recycled materials or materials that require less energy both in transport and production. Likewise, the parks planned in Atatürk Neighbourhood and Ertuğrul Neighbourhood will be designed as sustainable parks and water collection parks by focusing on seasonal changes, maintaining the vitality of the park throughout the year, and aiming to retain and reuse the water available throughout the park.

In the second alternative plan, the industrial zone is kept fixed in the north and the mass trade area is connected to the green circulation within the built-up area. Since there is an access problem to the area, social facilities, service areas and trade areas have been made accessible together with the green circulation integrated with transportation. In order to prevent the heat wave, agricultural areas have been protected and green areas have been increased. The prevailing wind direction blows from the north-east of the city. In order to prevent the effect of heat waves and the effect of poor quality air from the industry on residential areas, the area to be afforested is planned to surround the periphery of the city. In both plans, housing groups are planned gradually in terms of population density.

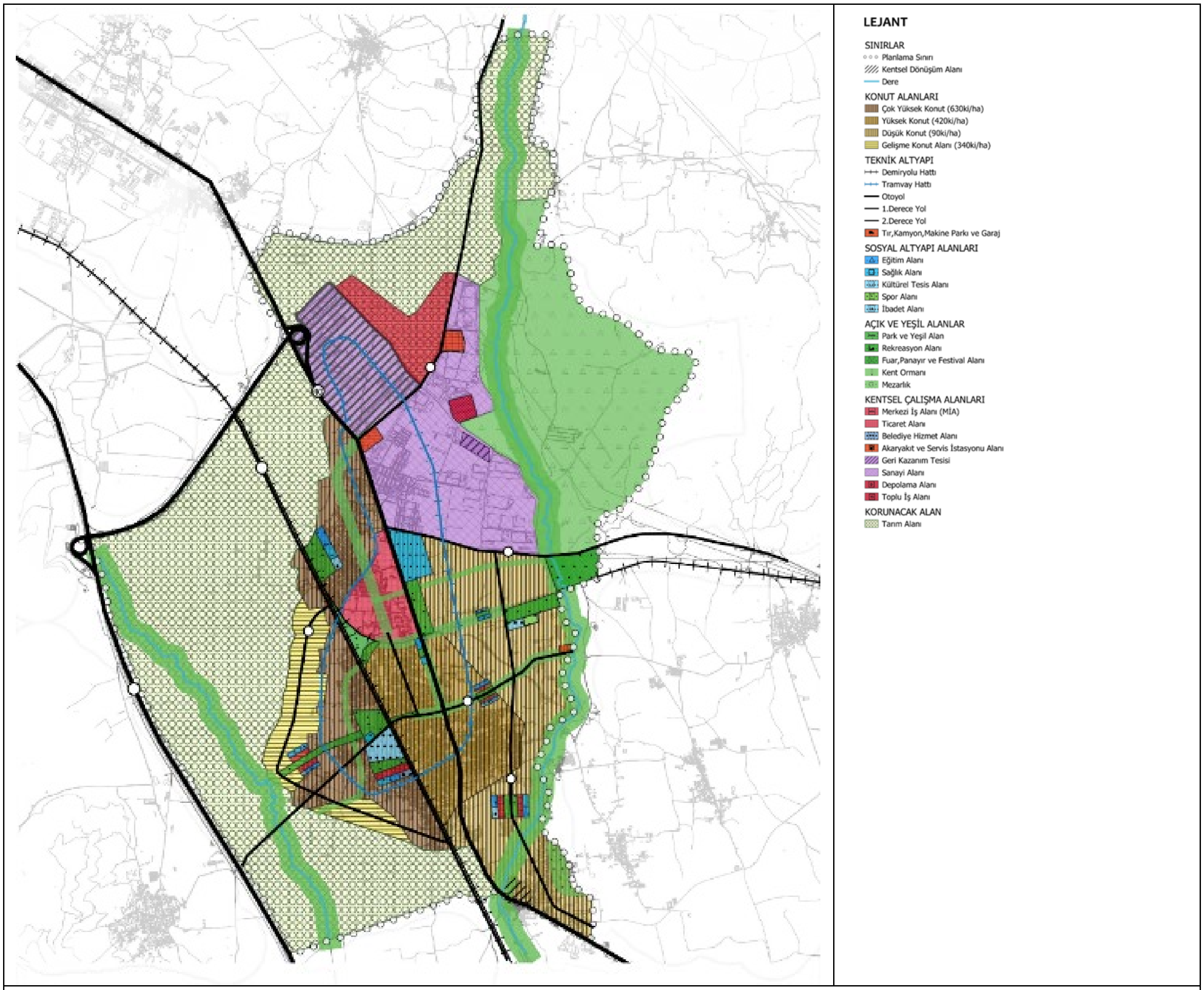


Figure 12. 2042 Torbalı Centre District Master Plans Alternative 1

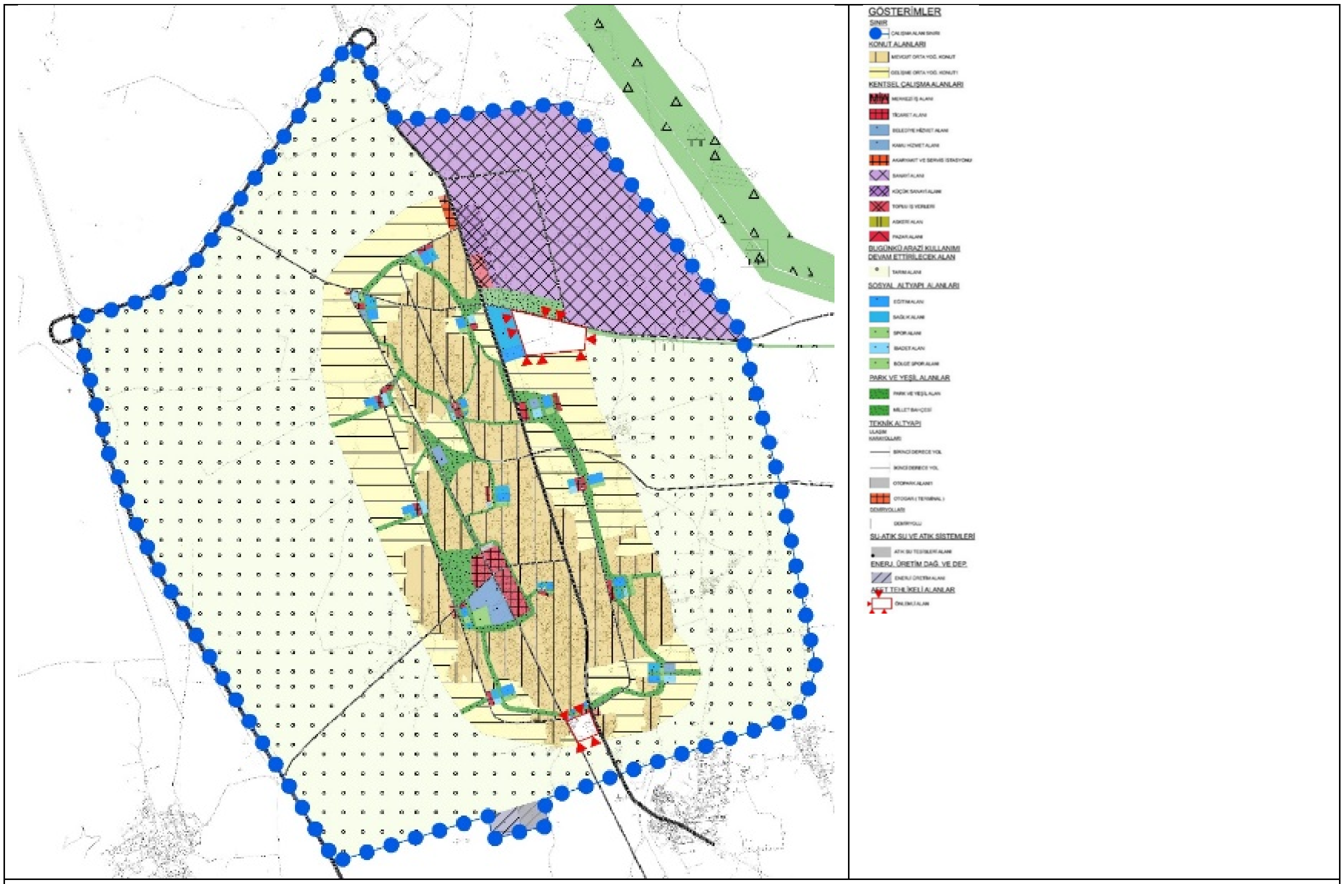


Figure 13. 2042 Torbalı Centre District Master Plans Alternative 2

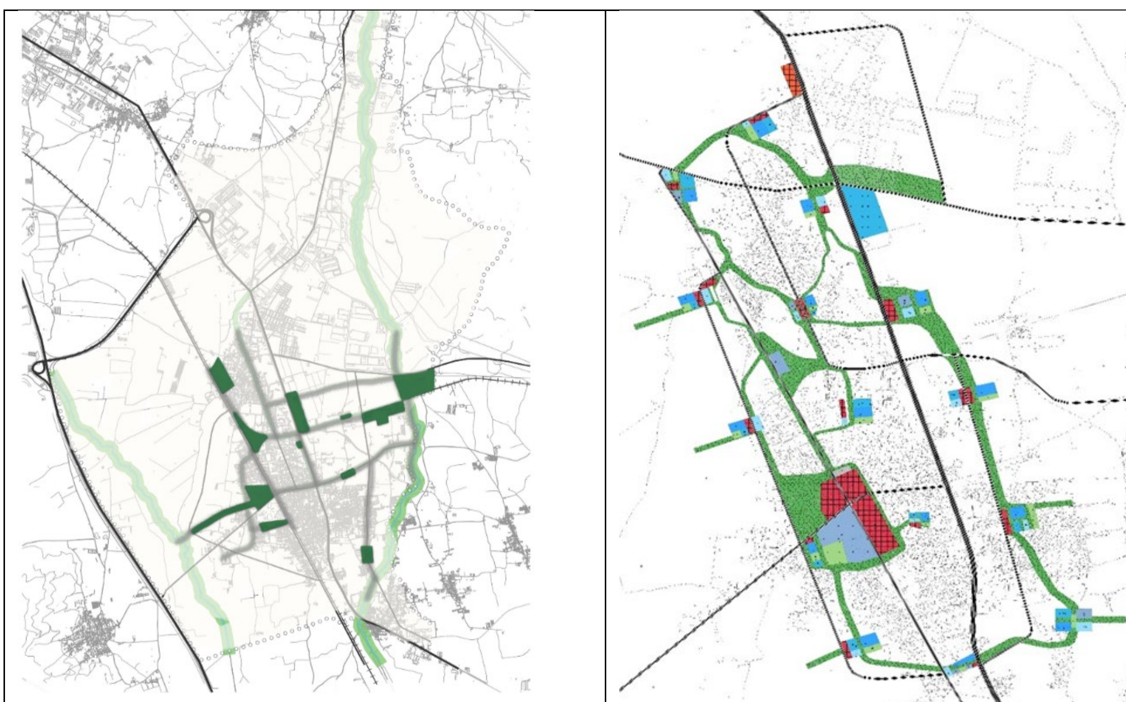
Spatial and policy strategies to prevent heat waves were also evaluated. Spatial strategies were evaluated in the focus of morphological view, transportation planning, green circulation system, and policy objectives were evaluated in the focus of economic, management, community and ecological. When we look at the transport planning proposals; public transport, bicycle and tram types are evaluated. In both plans, it is aimed to reduce the use of private vehicles and provide accessibility with a focus on public transport in the transport plan (Figure 14).

Masterplan Alternative 1 | Masterplan Alternative 2

Figure 14. Transport proposals for the plans

In order to reduce carbon emissions, cycling is considered topographically appropriate and an integrated network of public transport and cycling is planned.

In order to prevent heat wave effects, it is also important to eliminate the insufficiency of existing green areas and to provide an integrated green circulation. In order to reduce the urban heat island effect, green circulation system green corridors covering neighbourhood units have been planned and non-motorised vehicle access in the city has been facilitated. These green corridors also form a holistic transport system with bicycle and pedestrian routes (Figure 15).



Master Plan Alternative 1 | Master Plan Alternative 2

Figure 15. Green circulation system related to the plans

The amount of green space per capita required by the Regulation on the Construction of Spatial Plans has been increased above the qualifications (Table 1), the effect of urban heat waves has been tried to be reduced, and green foci have been selected within walking distance on the basis of accessibility criteria. In this way, it is ensured that the city dwellers can fulfil their recreational activity needs on foot.

Table 1. Green area assets and sizes of Master Plan 1 and Master Plan 2

PLAN	*YEAR*	*NUMBER*	*AREA (HA)*
MASTER PLAN-1	*2020- GREEN FIELD*	*20*	*8 HA*
	2045- GREEN FIELD	*18*	*12 HA*
MASTER PLAN-2	*2020- GREEN FIELD*	*20*	*8 HA*
	2045- GREEN FIELD	*21*	*18 HA*

Within the framework of the resilient city implementation guide for Torbalı district, policies have also been developed in terms of economy, governance, community and ecological resilience (Figure 15).

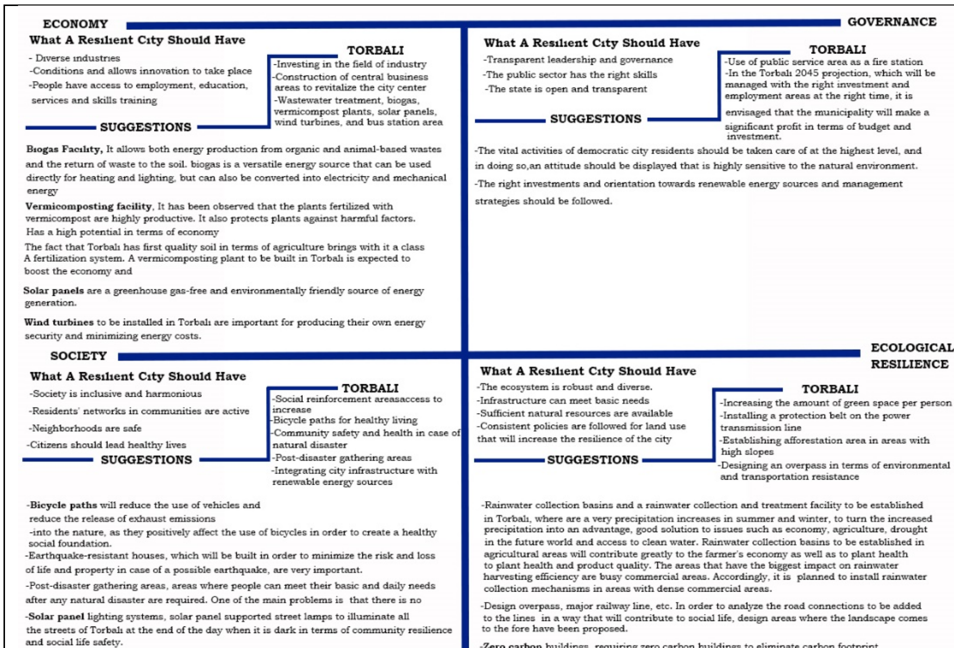


Figure 15. 2042 Hot weather resilient city Torbalı political strategies

5. RESULTS

Considering the analyses made and the development potential of the central district of Torbalı, the spatial strategy plan targeted for 2042 was designed within the whole of the resilient city vision and components focused on preventing heat waves. The purpose of this research is to determine whether the heat waves caused by climate change, which are acknowledged as a global emergency, may be mitigated in accordance with planning instruments. In line with this purpose; the hypotheses of the study were verified and a city resistant to urban heat waves could be created and planning tools could be used to create a city resistant to urban heat waves.

In line with the vision of Torbalı resilient to heat waves, expert transformation in the field of industry in the economic focus, creation of a central business area to revive the city centre, wastewater treatment, biogas and vermicomposting facilities, solar panels, wind turbines are planned in the environmental focus. In the management focus, orientation to renewable energy resources with the right investments and management strategy should be followed. In the community focus, suggestions have been made for Torbalı to increase access to social facilities, to build bicycle paths for a healthy and sustainable life, and to integrate the city infrastructure with renewable energy sources. In order to provide an ecological focus in the city, it has been suggested to increase the amount of green space per capita, to make areas to be afforested in areas with high slope and to make a protection belt for the energy transmission line. In this study, it has been analyzed how to create resilient cities in cities experiencing heat waves against climate change and how planning tools can be used against climate change. This examination was carried out through the city of Torbalı, and it is thought that all the strategies discussed through the settlement can also be used for other cities to apply against climate change.

6. CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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