ADAPAZARI CLIMATE CHANGE ADAPTATION STRATEGY AND ACTION PLAN

Interreg NEXT Black Sea Basin
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LAP BLACK

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ABBREVIATIONS

AHP	Analytic Hierarchy Process
AR5	IPCC Fifth Assessment Report
AR6	IPCC Sixth Assessment Report
CBS	Geographic Information Systems
FAO	Food and Agriculture Organization of the United Nations
IPCC	Intergovernmental Panel on Climate Change
LAP	Local Climate Adaptation Plan
LULC	Land Use / Land Cover
MCDA	Multi-Criteria Decision Analysis
MGM	Turkish State Meteorological Service
NDC	Nationally Determined Contribution
NUTS-2	Nomenclature of Territorial Units for Statistics, Level 2
RCP	Representative Concentration Pathways
SEGE	Socio-Economic Development Index
SES	Socio-Economic Status
SKA	Sustainable Development Goals
TÜİK	Turkish Statistical Institute
UNFCCC	United Nations Framework Convention on Climate Change
YUSEP	Local Adaptation Strategy and Action Plan

EXECUTIVE SUMMARY

ADAPAZARI
CLIMATE CHANGE
ADAPTATION STRATEGY
AND
ACTION PLAN

1. Introduction

Climate change, which has become a global crisis, is pushing the Earth's ecological boundaries while making its impacts felt with increasing severity at regional and local scales. Particularly, regions with unique humid climates like the Black Sea Basin have entered a process of serious transformation in the face of changing temperature and precipitation regimes. For Sakarya—a province with a strategic location in northwestern Turkey—these global and regional risks have combined with intense urbanization and land-use pressure to evolve into a multidimensional threat. Indeed, findings regarding social perception and risk awareness reveal that this multifaceted threat is felt strongly not only through technical analysis but also within the context of daily life and economic security at the local level.

Urban centers in the region, particularly Adapazarı, are becoming increasingly vulnerable to extreme weather events due to the disrupted climatic balance. The "Adapazarı Climate Change Adaptation Plan," prepared to increase the district's resilience against these threats, serves as a strategic roadmap that translates global goals into local action. Developed in line with the principles of the United Nations Climate Change Adaptation Framework and the European Green Deal, this plan offers a data-driven and holistic adaptation strategy to secure the future of Adapazarı. This framework aligns with society's expectations for participatory and locally-owned adaptation processes in the fight against climate change.

2. Methodological Approach

Vulnerability and risk analyses were conducted across three main axes: climatic hazards (exposure), the potential to be affected by these hazards (sensitivity), and the system's ability to cope (adaptive capacity).
These components were spatially modeled within a Geographic Information Systems (GIS) environment and analyzed using the "Weighted Indexing Method." Based on the results, the vulnerability levels of various sectors (low-medium-high) were mapped, allowing priority areas where adaptation actions must be implemented most urgently to be defined through concrete data. Furthermore, perceptions and evaluations emerging at the local scale demonstrate that technical findings regarding extreme weather events, economic losses, and health impacts largely align with local community perceptions.

3. Climatic Findings

Temperature Trends
During the 1990–2020 period, the annual average temperature increased by 1.3°C, and the number of days with temperatures exceeding 35°C in the summer season has doubled. By 2050, the average temperature increase is projected to reach +2.5°C (under the RCP4.5 scenario). Due to the 'urban heat island' effect, the temperature difference in city centers reaches +3°C compared to rural areas.

Precipitation Regime and Floods
While no significant change has been observed in the total amount of precipitation, the intensity and duration of rainfall have changed significantly. Short-term heavy precipitation has increased by 45% in the post-2000 period; flood events and surface runoff have intensified. Serdivan, Adapazarı center, and Karasu districts stand out as regions with high flood risk..

Drought and Water Resources
The average flow rate of the Sakarya River has decreased by 15% over the last 10 years, and the groundwater level has dropped by 1.5 meters. Soil moisture has decreased by 12%, and the duration of drought periods has increased significantly. This situation directly impacts agricultural production, ecosystem balance, and energy generation.

4. Sectoral Findings

Urban Areas and Infrastructure
The urbanization rate has increased by 35% in the last 20 years, and the ratio of impervious surfaces has reached 45%. The existing drainage infrastructure remains insufficient to handle sudden precipitation events; an average of 15 flood events are reported annually. The urban

Adaptation Strategies:
- Green–blue infrastructure integration, permeable surfaces, rain gardens
- Installation of disaster early warning systems
- Increasing the urban green space ratio to 15%

Agriculture and Forestry
60% of agricultural lands are under risk of drought and erosion.
The yield loss rate in corn, wheat, and hazelnut production ranges between 10% and 20%.
The risk of fire in forest areas is increasing along with seasonal temperature rises.

Adaptation Strategies:
- Smart irrigation systems, sensor-supported yield planning
- Promotion of drought-resistant seed varieties
- Recycling of agricultural waste and bioenergy production

Water Resources Management
Groundwater extraction is increasing, and water quality indicators are declining.
The flood corridors along the Sakarya River have lost their natural functions.

Adaptation Strategies:
- Groundwater monitoring networks
- Rainwater harvesting infrastructure
- Ecological restoration of river corridors

Energy and Industry
Increasing temperatures have increased energy demand (cooling load) by 10%.
Energy production and consumption are expanding the carbon footprint.
Industrial zones are vulnerable to floods and power outages.

Adaptation Strategies:
- Promotion of renewable energy investments
- Energy efficiency standards in industrial zones
- Optimization of production processes through wastewater recovery

Biodiversity and Ecosystem
Habitat loss has been observed in the Sakarya River delta and around Lake Sapanca.
A 25% decrease in fish populations has occurred due to warming and pollution.
The recession of wetlands is affecting bird migration routes.

Adaptation Strategies:
- Nature-based solutions (wetland restoration, green buffer zones)
- Updating management plans for protected areas
- Awareness programs on the economic value of ecosystem services

Transportation and Infrastructure
Extreme precipitation and temperature increases are causing deformation in road infrastructure.
Transportation disruptions are extending emergency response times.

Adaptation Strategies:
- Climate-resilient material and design standards
- Roads with integrated rainwater drainage
- Emission reduction through railway system investments

Public Health and Social Vulnerability
Heatwaves have a direct impact on health; the rates of heat-related illnesses are increasing. Socio-economically, the level of disaster preparedness is low in low-income regions.

Adaptation Strategies:
· Climate-oriented health plans, early warning systems
· Community-based disaster training and solidarity networks
· Shaded public spaces for vulnerable groups

Disaster Risk Management
Analyses show that flooding, landslide, and storm events in Sakarya have increased by 60% in the 2010–2024 period.
Disaster management units operate in a fragmented manner, and data sharing is limited.

Adaptation Strategies:
· Establishment of a disaster information system under a single roof
· GIS-based integration of early warning systems
· Revision of post-disaster recovery plans according to climate sensitivity

Governance and Institutional Capacity
The lack of institutional coordination limits the impact of climate actions.
It is necessary to establish climate change units within local governments.

Adaptation Strategies:
· Inter-institutional data sharing protocol
· Climate adaptation action plans at the municipal level
· Coordination of national–local financial resources

5. Priority Climate Hazards and Risk Components

As part of the climate change adaptation efforts conducted for Adapazarı, six different potential climate hazards specific to the region (Extreme Precipitation/Flooding, Drought, Heatwaves, Cold Waves, Forest Fires, and Storms) were initially included in the analysis based on literature reviews and historical disaster data. However, considering the efficient management of resources and the prioritization of adaptation actions, these hazards were evaluated through stakeholder participation and the Analytical Hierarchy Process (AHP) method, leading to a strategic prioritization at the end of the process. As a result of the analyses, the critical climate hazards most threatening Adapazarı's resilience were ranked as follows:

· Extreme Precipitation and Floods: Identified by stakeholders as the "first priority threat" due to frequent flooding, the pressure on urban infrastructure, and the increase in impervious surfaces.
· Drought: Ranked second due to risks concerning the sustainability of water resources and agricultural production.
· Heatwaves: Defined as the third priority risk due to their increasing impacts on public health and energy demand.

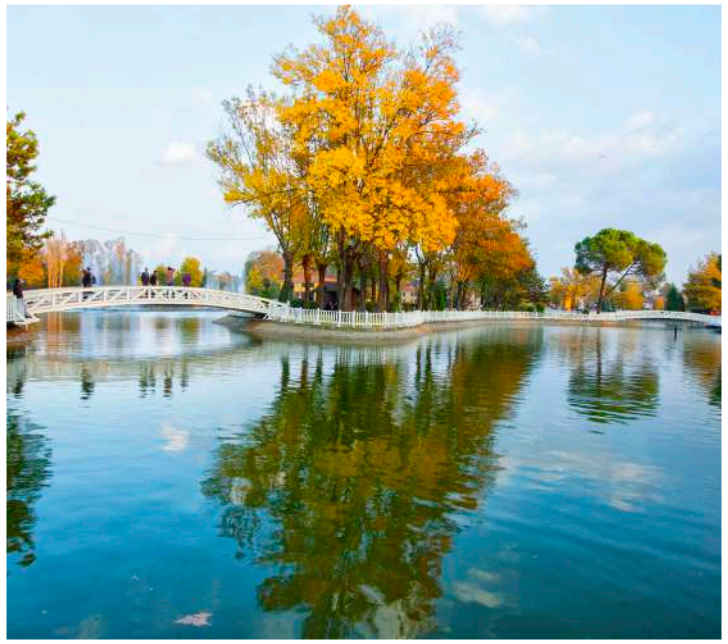
As a result of the analysis, the impacts of other climate hazards such as Storms, Cold Waves, and Forest Fires were excluded from the priority intervention areas for this planning period, as they were deemed relatively more limited or manageable. Accordingly, the Adaptation Plan has been structured to focus on the top three hazards carrying the highest risk factors.

The city's future vision in the face of climate change was established by evaluating different climate scenarios (RCP 4.5 and RCP 8.5) alongside long-term demographic trends. The analyses indicate that average temperatures will increase steadily under both emission scenarios, and specifically under the RCP 8.5 scenario, the precipitation regime will become more unstable with severe fluctuations and an increased frequency of anomalies. This picture of uncertainty in climatic data, combined with Adapazarı's continuously growing population, indicates that the pressure on urban infrastructure, public services, and ecological balances will increase exponentially in the future.

Sectoral impact analyses conducted under these changing conditions have clarified which of the city's "nerve endings" are touched by the three identified critical hazards. Extreme precipitation and floods, viewed by stakeholders as the greatest threat, primarily place water resources management, agriculture, urban settlements, and transportation infrastructure at risk. Drought, ranked second, directly targets food security and biodiversity; meanwhile, heatwaves emerge as a cross-cutting risk area that must be managed due to their cumulative effects on public health, energy, and social development. These prioritized risk areas and future projections have been detailed through an indicator-based vulnerability analysis based on the IPCC (Intergovernmental Panel on Climate Change) risk framework. These analyses, in which sectoral exposure, sensitivity, and adaptive capacity are evaluated integrally, reveal that climate hazards are not isolated events but rather exhibit a multidimensional structure that creates chain reactions across sectors.
The key findings and strategic orientations that must be focused on to increase Adapazarı's resilience are:
1. The Need for "Green Transformation" in Urban and Infrastructure Systems: In the city center, extreme precipitation stands out as the most critical threat due to increasing population density and impervious surfaces. While the capacity insufficiency of existing drainage infrastructure increases flood risk, analyses prove that the presence of urban green spaces is the most important "buffer mechanism" to reduce this risk.
Therefore, adaptation strategies focus on going beyond gray infrastructure investments and integrating Sustainable Urban Drainage Systems (SUDS) and nature-based solutions into zoning plans.
2. The Principle of "Efficiency" in Agriculture and Water Management: Drought, which is the dominant threat to the agricultural sector, creates a food security risk due to the region's high "blue water footprint" and irrigation-dependent monoculture farming patterns.
The primary strategy proposed against the pressure of decreasing water resources is the dissemination of water efficiency technologies, such as drip/sensor-based irrigation, and the promotion of a transition to drought-resistant crop patterns.
3. The "Critical Loop" Between Health and Energy: Heatwaves not only threaten public health but also create peak load pressure on the energy grid due to cooling demand.
To manage this cross-interaction, the establishment of early warning mechanisms in the health system and the enhancement of grid resilience through demand-side management in the energy sector have been identified as mandatory, complementary actions.

6. Conclusion

The plan has revealed that climate change adaptation specifically for the Adapazarı district must be addressed within a multidimensional framework. The findings indicate that the climate risks Adapazarı faces over the next 25 years are not merely environmental, but are also economic and social issues.
The outputs of the plan are supported by recommendations for nature-based solutions, green infrastructure investments, early warning systems, water management reforms, and institutional capacity building.
In this context, with proper planning and cooperation, Sakarya has the potential to become a model for climate resilience in the Black Sea Basin.



WHAT IS CLIMATE CHANGE?

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as follows:

"A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

Climate refers to the long-term average weather conditions over a specific region or a broad geographic area. The climate system is a complex and interactive structure consisting of the atmosphere, land surfaces, glaciers, oceans, seas, and living organisms. This system changes over time due to both its own internal dynamics and the influence of external factors (such as solar activity, volcanic eruptions, and greenhouse gas accumulation).

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as follows:

"A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variabi-

This definition treats climate change not merely as a natural process, but as a global phenomenon accelerated by human influence.

External forcing factors affecting the climate system can be both natural and human-induced. Natural forcings include volcanic activities, changes in the amount of solar radiation, and deviations in the Earth's orbit; human-induced forcings, on the other hand, result primarily from the increase in emissions of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

Solar energy is the primary power source of the climate system. The behavior of the global climate is determined by changes in solar radiation, the Earth's capacity to reflect sunlight (albedo), the balance of long-wave radiation trapped by greenhouse gases in the atmosphere, and ocean-atmosphere interactions (such as ocean currents and wind regimes).

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According to the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC), human activities are responsible for 95% of global climate change. In particular, the increase in fossil fuel use starting with the Industrial Revolution in the late 18th century, combined with urbanization, deforestation, and the rapid production-consumption cycle, has pushed atmospheric greenhouse gas concentrations to their highest historical levels.

This process has led to a rapid increase in energy demand and the use of natural resources; consequently, greenhouse gas emissions have accumulated in the atmosphere, and global average temperatures have risen. As of 2024, the world's average temperature is approximately 1.47 °C higher compared to the pre-industrial period (1850–1900) averages.

The consequences of climate change are not limited solely to temperature increases.

On a global scale, the frequency of droughts, floods, wildfires, storms, and extreme weather events is increasing; sea levels are rising, glaciers are melting, and ocean acidification is accelerating. These developments pose serious threats to biodiversity, water resources, ecosystem balance, and human health.

In summary:

Climate change is not merely a physical change in the atmosphere; it is a multidimensional crisis that profoundly affects economic systems, food security, and ecosystems. Therefore, the fight against climate change is more than a technical problem—it is a matter of existential transformation for humanity. At the center of this transformation lies the principle of "sustainability." Sustainability means meeting the needs of the present without depleting resources and being able to hand down a more resilient, greener, and more livable world to future generations.

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GLOBAL CLIMATE AGENDA AND TÜRKİYE'S ADAPTATION VISION

"We are on a highway to climate hell with our foot on the accelerator."
- ANTONIO GUTERRES

Following this warning, the United Nations drew a roadmap for humanity: the 2030 Sustainable Development Goals. A total of 17 universal targets aim to secure the future of our planet, reduce inequalities, and create a level of prosperity in harmony with nature.
These goals range from the eradication of poverty and hunger to quality education, gender equality, clean energy, and sustainable urban life.

Global Call and 2030 Targets

At the same time, the protection of water, soil, and ecosystems, the strengthening of climate action, and the building of peaceful, inclusive societies lie at the heart of this vision. According to the United Nations, each of these goals operates like interconnected links in a chain:
- Fighting poverty is, at the same time, fighting for the climate; providing education is creating sustainable production;
- Strengthening social equality is increasing environmental resilience.

The 2030 Agenda is a call for a global transformation in which not only states but also cities, institutions, and individuals take responsibility.

Achieving these goals means steering humanity's course away from the devastating impacts of the climate crisis and moving toward a more resilient and secure future centered on justice, solidarity, and sustainability.

Climate Change Scenarios

Climate change scenarios are scientific constructs that examine the effects of radiative forcing resulting from greenhouse gas emissions and the responses of the climate system to these effects. These scenarios form the foundation of global climate models and are used to evaluate future projections of temperature, precipitation, and atmospheric composition.

In its Fifth Assessment Report (AR5), the Intergovernmental Panel on Climate Change (IPCC) updated climate scenarios to create four new pathways called Representative Concentration Pathways (RCP). These scenarios are classified according to the levels of energy accumulation (W/m²) caused by greenhouse gases in the atmosphere:

- RCP2.6: The lowest emission scenario. It aims to keep the global temperature increase below 2 °C compared to the pre-industrial period.
- RCP4.5: An intermediate emission scenario. Global greenhouse gas concentrations are expected to reach approximately 540 ppm CO_2 equivalent by the end of the century.
- RCP6.0: A scenario where greenhouse gas intensity remains higher; warming is likely to exceed the 2 °C limit.
- RCP8.5: The highest emission scenario, defined as the "pessimistic scenario." By the end of the century, the CO_2 equivalent exceeds 900 ppm, and the global temperature increase approaches 4 °C.

These scenarios are used to model the effects of factors such as population growth, energy use, and land cover change on the climate system in the future. General trends reveal that the concentrations of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) show an increase across every scenario throughout the 21st century.

Climate Change Scenarios for Türkiye

Regional climate projections prepared for Türkiye are carried out by the General Directorate of Meteorology (MGM) and are based on the IPCC's RCP scenarios. Within the scope of MGM's studies, RCP4.5 (moderate scenario) and RCP8.5 (pessimistic scenario) have been taken as the basis.

In these projections, data obtained from global climate models (HadGEM2-ES, GFDL-ESM2M, MPI-ESM-MR) were downscaled to the scale of Türkiye at a 20 km resolution using the RegCM4 regional climate model.

Regarding precipitation regimes, no homogeneous trend is observed.
While precipitation is expected to increase in northern latitudes and around the Equator, a decrease is projected for the Mid-latitudes and semi-arid regions (for instance, Central Anatolia and Southeastern Anatolia). Throughout Türkiye, the frequency of short-duration but intense precipitation events and heatwaves is expected to increase.

Results indicate that in the near future (2016–2035), the global average surface temperature will increase by 0.3–0.7 °C compared to the 1986–2005 period. In the long term (2081–2100):

- Under RCP2.6: an increase of +0.3 °C to +1.7 °C,
- Under RCP4.5: an increase of +1.1 °C to +2.6 °C,
- Under RCP6.0: an increase of +1.4 °C to +3.1 °C,
- Under RCP8.5: an increase of +2.6 °C to +4.8 °C

is projected.

These findings reveal that Türkiye must strengthen its climate change adaptation policies, particularly in areas such as water resources management, agricultural production, energy demand, and public health.

"Development in harmony with nature, a just society, and resilient cities."

Turkey's Location

The United Nations' 2030 Sustainable Development Goals serve as a common compass for all countries in the world.
Türkiye, adopting this global vision, has entered a comprehensive transformation process that balances economic growth with environmental sustainability.
Within the framework of the **"Voluntary National Review (VNR) Report on the Sustainable Development Goals,"** which has been in effect since 2016, Türkiye has set concrete targets for priorities such as fighting climate change, energy transformation, preservation of natural resources, and social justice.

In this direction, with the ratification of the **Paris Climate Agreement** in 2021, Türkiye officially announced its **net-zero emission target by the year 2053.**
This target encompasses not only reducing carbon emissions but also increasing energy efficiency, expanding the share of renewable resources, strengthening sustainable transportation systems, and creating climate-friendly cities.

Türkiye's **Nationally Determined Contribution (NDC)** includes a commitment to reduce greenhouse gas emissions by "up to 41% compared to the business-as-usual scenario."
This commitment entails a transformation across all sectors, including industry, transport,

Furthermore, with the **Climate Law and the Green Deal Action Plan**, the aim is to integrate environmental policies with economic development strategies. Joint projects conducted with the United Nations—for example, UNDP Türkiye's "Green Economy" and "Climate Resilient Cities"—provide support to local governments, the private sector, and universities to accelerate this transition.
In this way, Türkiye is strengthening both its transition to a low-carbon economy on a national scale and a fair, green, and inclusive development model on a global scale.

The Context of Climate Adaptation Planning in Turkey

In line with its obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement, Türkiye is taking significant steps to strengthen climate change adaptation policies at the local level. National strategy documents developed over the last decade, particularly the National Climate Change Adaptation Strategy and Action Plan (UDEP), have identified increasing the adaptation capacity of provinces and municipalities as a priority goal.

In this regard, Local Climate Adaptation Plans (LAP) are being prepared or implemented across various provinces and metropolitan municipalities in Türkiye. These plans are the fundamental tools that ensure the implementation of national targets at the local scale.

These plans, generally developed under the coordination of the Ministry of Environment, Urbanization, and Climate Change through international cooperation projects and technical support mechanisms, consist of the following core components:

- Sectoral vulnerability analyses in areas such as water, agriculture, health, and infrastructure,
- Climate hazard maps and projection studies,
- Defining compliance objectives, indicators, and areas of action,
- Definition of adaptation targets, indicators, and action areas,

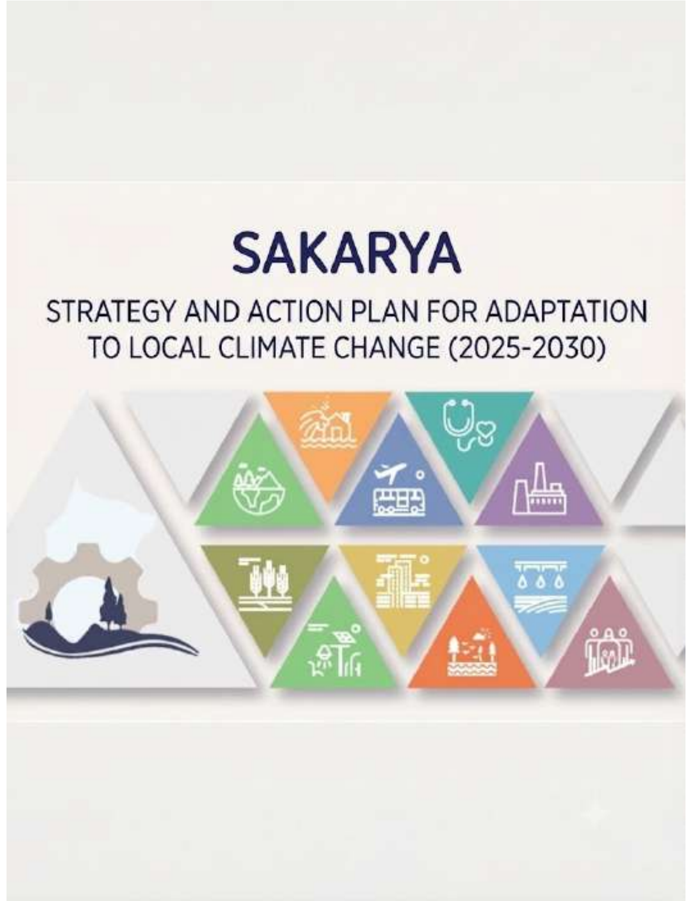
Today, many municipalities—especially metropolitan cities located in climate-sensitive regions—have prepared their own local adaptation plans or have moved into the implementation phase. These plans form the fundamental pillars that integrate the climate change adaptation perspective into spatial planning, investment strategies, and disaster preparedness efforts.

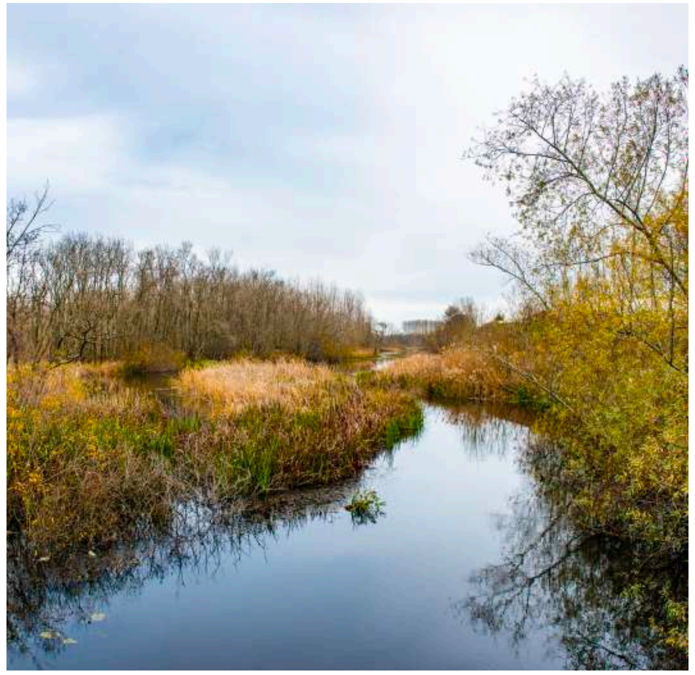
Sakarya Province Climate Adaptation Strategy and Action Plan (YUSEP)

Sakarya is among the pioneering provinces that have developed a Local Climate Adaptation Plan in response to observed and projected climate risks. The plan was prepared under the coordination of provincial-level public institutions, with the participation of academic organizations and civil society representatives.

Sakarya Local Climate Adaptation Strategy and Action Plan (YUSEP) covers the 2025–2030 period and aims to mitigate the impacts of climate change on urban systems, ecosystems, and society, while also strengthening local resilience and progressing in alignment with sustainable development goals.

This plan, developed in alignment with Türkiye's national climate strategies and international frameworks, adopts a proactive and preventive approach based on local realities, data-driven decision-making processes, and institutional coordination.





The plan identifies extreme precipitation and flooding, heatwaves, and drought as the most critical climate risks across the province. Particularly, Serdivan and Karasu districts stand out as regions with high exposure levels; in these areas, blue-green infrastructure investments and floodplain restoration have been prioritized. The frequency and intensity of these risks are expected to increase due to climate change, rapid urbanization, and the degradation of natural buffer zones.

The strategy is divided into thematic areas such as urban planning, transportation, water management, agriculture, industry, public health, and governance. Each area is supported by risk assessments and adaptation measures:

Sector / Theme	Proposed Core Actions
Urban Planning and Construction	· To increase surface permeability and expand green spaces. · To limit urban sprawl and encourage compact, climate-sensitive settlement forms. · To reopen covered streams and strengthen ecological corridors.
Transportation and Communication	· To reduce the ratio of asphalt surfaces and use permeable paving materials. · To prepare a Urban Transportation, Communication, and Climate Emergency Plan. · To establish early warning systems based on smart city infrastructure.
Water Management	· To prepare a comprehensive water efficiency strategy and reduce water losses. · To prioritize the protection of strategic water resources such as Lake Sapanca. · To monitor and regulate groundwater extraction.
Agriculture and Food Security	· To protect agricultural lands and encourage good agricultural practices. · To support organic and climate-resilient agricultural practices. · To develop a provincial-level Drought Action Plan.
Industry	· To evaluate climate-related technological risks, especially in SEVESO (BEKRA) facilities. · To increase the resilience of industrial infrastructure against climate change.
Public Health	· To establish early warning systems for heatwaves and extreme weather events. · To integrate health services into climate risk monitoring systems. · To ensure the monitoring of climate-health risks at the district level.
Governance and Institutional Framework	· To clearly define the roles and responsibilities of public institutions. · To strengthen coordination among municipalities, governorates, universities, and ministries. · To establish mechanisms for monitoring and updating the plan.
Horizontal Measures (Covering All Sectors)	· To appoint climate focal points within institutions. · To conduct personnel training and capacity-building activities. · To increase access to climate finance. · To create campaigns and support systems that will increase public awareness.

Additionally, the plan includes horizontal measures such as the appointment of climate focal points, personnel training and capacity building, access to climate finance, and increasing public awareness; thereby ensuring the long-term sustainability of the plan.

The Power of Civil Societies in Türkiye

Climate action in Türkiye is not limited solely to state policies; it is also supported by a strong and dynamic network of civil society. This network views the struggle for nature conservation not just as an environmental issue, but as a process of economic, social, and cultural transformation.

Civil society organizations operate across a wide spectrum, including energy transformation, agricultural sustainability, protection of water resources, ecosystem restoration, gender equality, and climate justice.

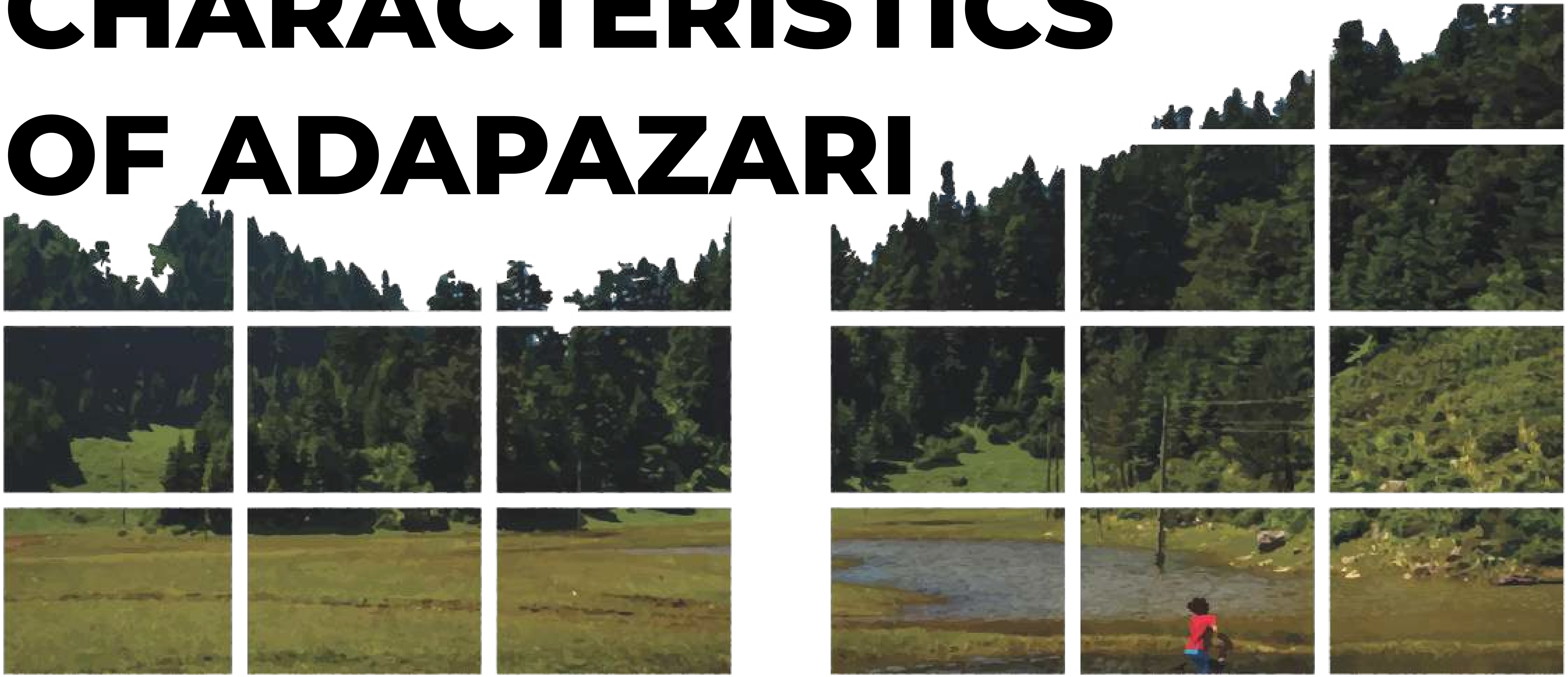
By working with local producers, youth, and women's communities, they involve diverse audiences as active participants in climate action.

These organizations raise awareness at the local level through both science-based data and participatory methods; they contribute to policy development in collaboration with decision-makers.

These organizations, which take an active role in national and international platforms, build bridges that bring all segments of society together in the fight against the climate crisis. By conducting joint projects with local governments, international organizations, and volunteer networks, they both build resilient communities and pave the way for social transformation for a fair and sustainable future.

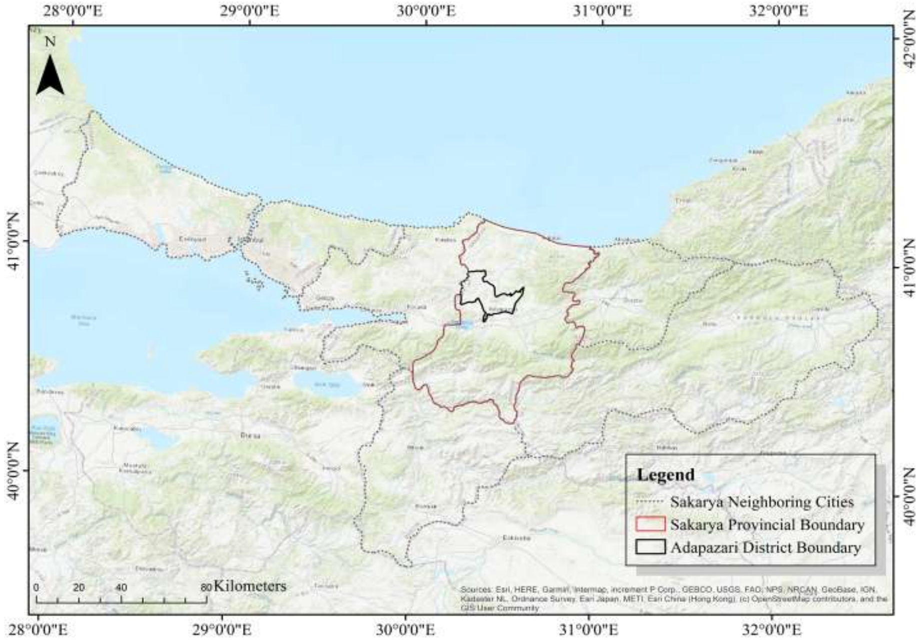
Today, climate action in Türkiye continues to grow not only at the governance level, but also at the heart of civil society—in the projects of youth, the initiatives of women, and the labor of local communities.

CHARACTERISTICS OF ADAPAZARI



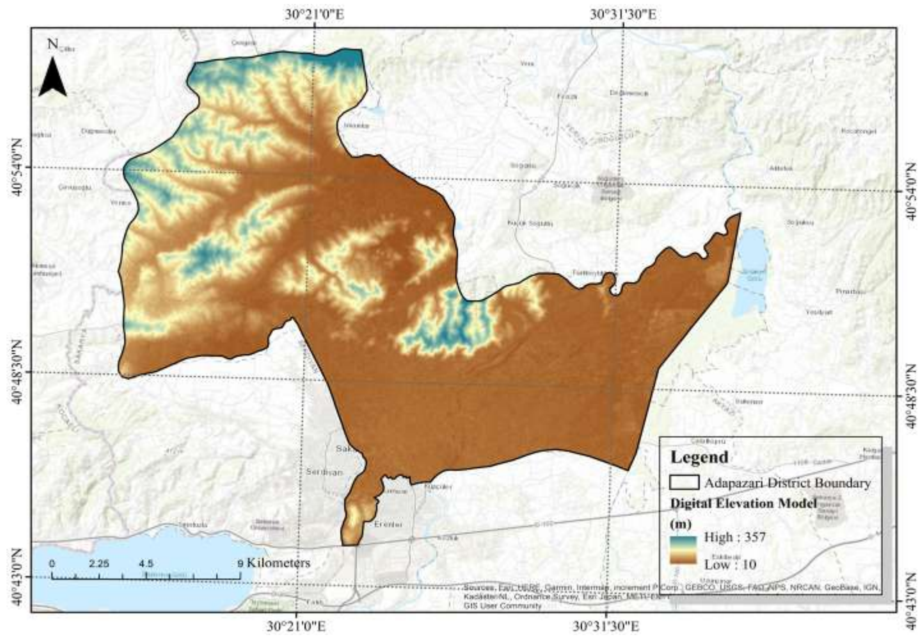
Morphological Characteristics

Adapazarı is located in northwestern Türkiye, at the center of the Sakarya province, and is positioned within the Lower Sakarya River Basin. The district possesses a morphological structure shaped by the interaction of the Sakarya River, alluvial plains, and the surrounding low hills. This structure represents a transition zone between the Marmara Region and the Black Sea basin.



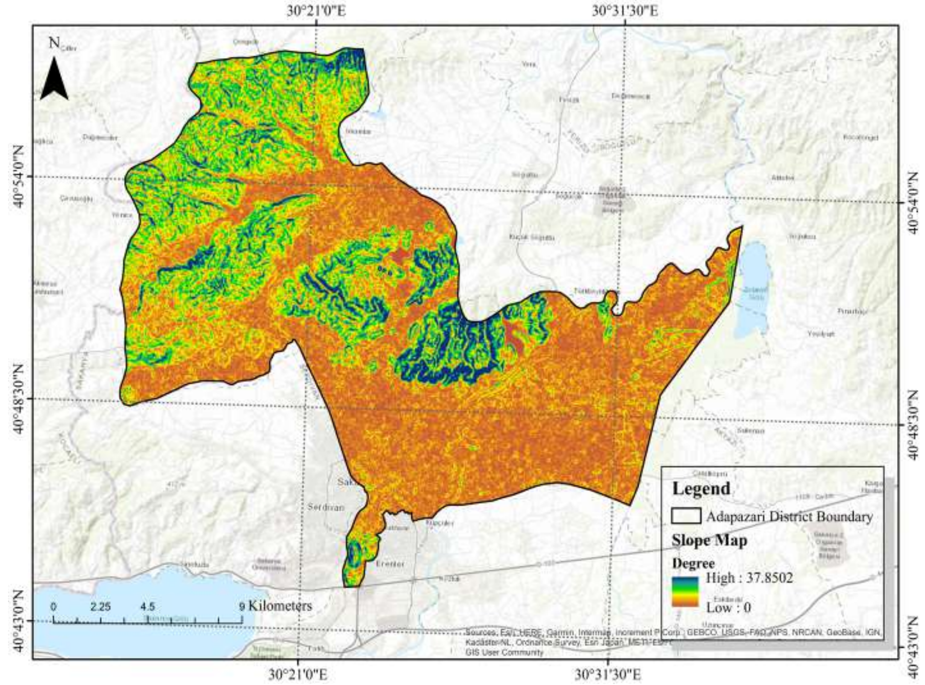
Geographical Location of Adapazarı

The city's central residential core is situated on a vast alluvial plain formed by the deposition processes of the Sakarya River and its tributaries. For this reason, although the soil exhibits high fertility, it is highly sensitive in terms of flood risk. The flat areas are intersected by a network of streams and drainage canals, carrying high vulnerability to surface water accumulation and flooding during periods of excessive precipitation.



Digital Elevation Model (DEM) of Adapazarı

In the southern and eastern parts of the district, the terrain rises toward the Samanlı Mountains, where slopes range from moderate to high levels. Erosion and slope instability (landslide) risks are observed in these regions, particularly in areas where vegetation has been degraded due to agricultural activities or urbanization.

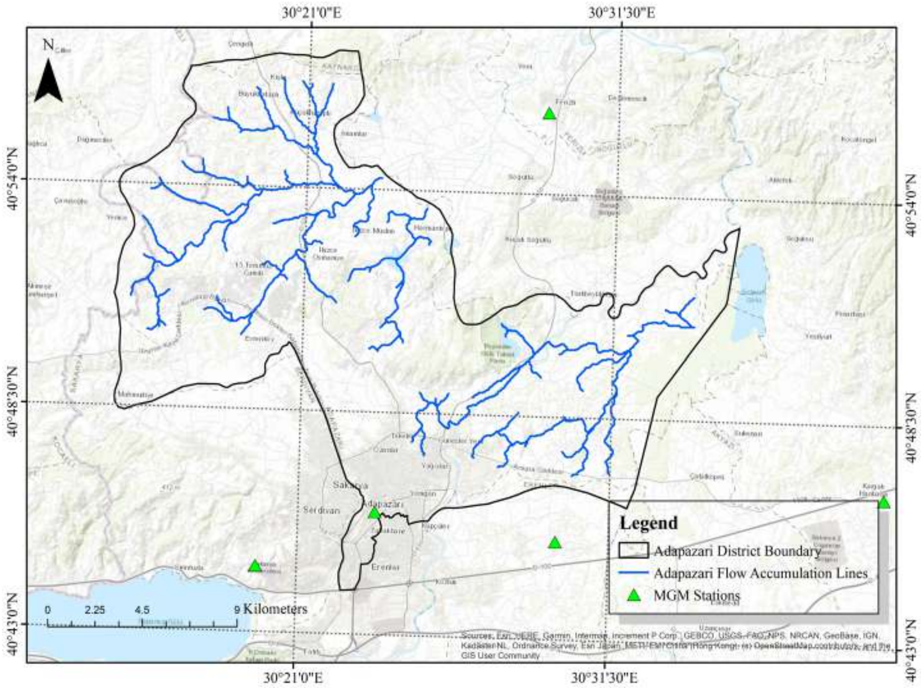


Slope Map of Adapazarı

Geologically, Adapazarı is situated on a sedimentary accumulation zone dominated by clay, silt, and sand layers. While these layers are permeable in certain areas, they carry potential for liquefaction and subsidence. The intersection of morphological structure with hydrological and tectonic dynamics directly influences the region's land use, infrastructure planning, and exposure to climate-induced risks.

Hydrological Characteristics

Adapazarı is situated within the Lower Sakarya River Basin, one of the most significant hydrological systems in Türkiye. The Sakarya River, flowing from east to west, serves as the primary surface water component of the district. In connection with this river, the Çark Stream, Mudurnu Creek, and numerous man-made irrigation and drainage canals create a dense hydrographic network throughout the district.



Adapazarı flow accumulation lines

The hydrological regime in Adapazarı is shaped by human interventions as much as by natural processes. The dominant alluvial plain of the district is a natural floodplain historically formed by the flood regime of the Sakarya River. During periods of snowmelt in the upper basins and intense precipitation, water accumulation occurs in these flat terrains; this situation can cause large-scale flooding, particularly in agricultural and residential areas.
The groundwater system is closely linked with surface waters. The high permeability of alluvial soils facilitates the natural recharge of aquifers. However, excessive extraction driven by agricultural and industrial water use leads to seasonal fluctuations and occasional groundwater stress.

In urbanized areas, the increase in impermeable surfaces restricts natural infiltration processes, increasing surface runoff and escalating flood risk. Human interventions, such as stream reclamation, canal excavation, and drainage basin modifications, have altered natural flow paths; this has increased risks for both flooding and the deterioration of water quality.

Meteorological Profile

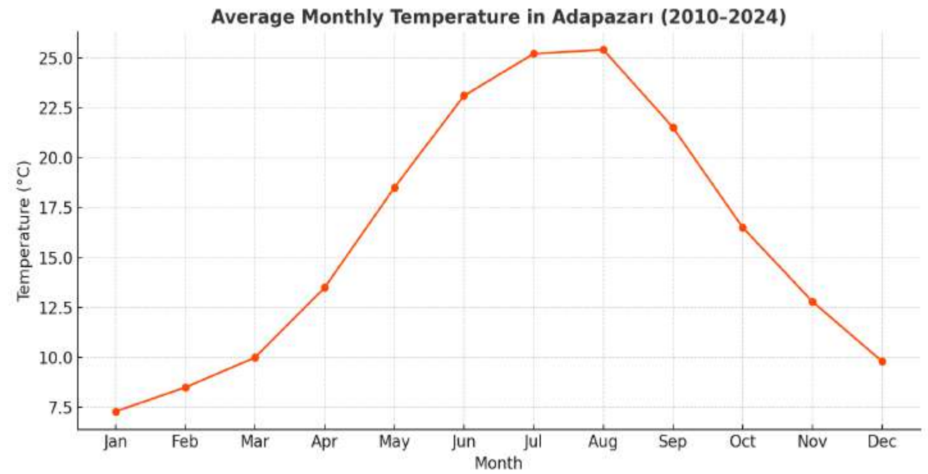
Adapazarı is under the transition effect of the Marmara and Black Sea macroclimatic zones and possesses a temperate and humid climate structure.

· Annual Average Temperature: 13–15 °C
(24–26 °C in July–August, 4–6 °C in January)
· Annual Average Precipitation: 900–1200 mm
(Wettest period: November–January, second peak: April–May)

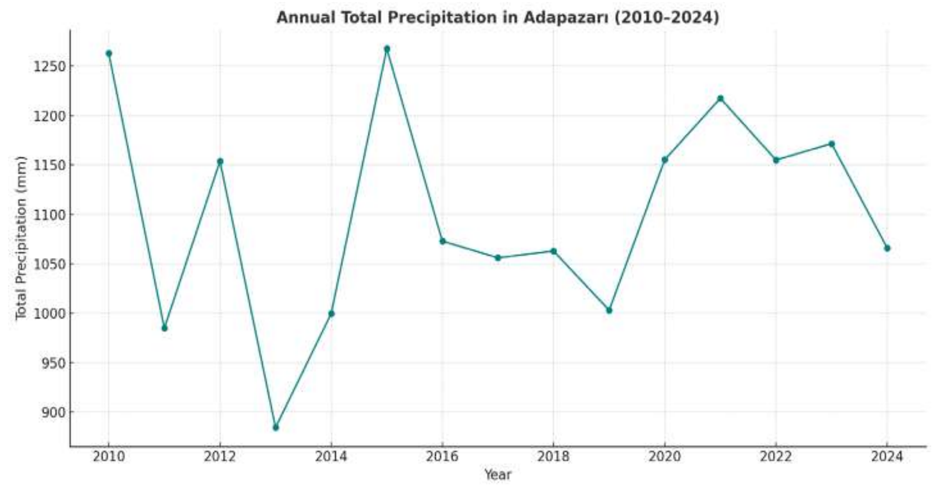
Observed Climate Trends:
· Significant increase in summer temperatures and a higher frequency of heatwaves,
· Increase in short-term but intense precipitation events, leading to urban flooding and landslides,
· Shifts in precipitation seasonality, specifically delayed autumn rains and prolonged dry spells during the growing season.

Projections:
· RCP4.5 Scenario: A temperature increase of $1.5–2.5 °C by 2050, accompanied by precipitation irregularities and increased intensity,
· RCP8.5 Scenario: Acceleration of warming in the second half of the century, prolonged heatwaves, and an increase in extreme precipitation events.

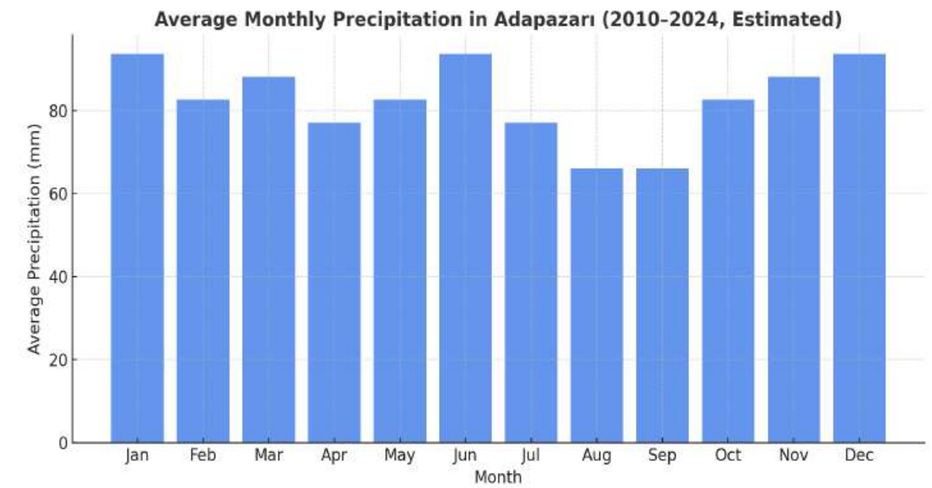
"These findings demonstrate that long-term adaptation measures are inevitable for Adapazarı in terms of water resources, agriculture, and infrastructure planning."



Average Monthly Temperature of Adapazarı 2010-2024 (MGM



Total Annual Rainfall Amount for Adapazarı 2010-2024 (MGM 2025)



Average Monthly Rainfall Distribution for Adapazarı (MGM 2025)

Land Use and Cover (LULC)

Adapazarı's land use exhibits a dynamic balance between natural areas, agricultural activities, and a rapidly growing urban fabric.

The main types of land cover are:

· Urban Areas: Concentrated in the north and center; covering industrial, residential, and commercial zones. In the last 20 years, the replacement of agricultural and wetlands with impermeable surfaces has led to decreased infiltration and increased surface runoff.

· Agricultural Areas: Concentrated in the southern and western parts; dominated by cereals, vegetables, and orchards. These areas are sensitive to hydrological variability and are of critical importance for food security.

· Forested Areas: Located in the southeastern and high-altitude sections; mixed deciduous forests regulate surface runoff, prevent erosion, and balance the microclimate.

· Wetlands and Water Bodies: Seasonal marshes, drainage canals, and aquatic ecosystems near the Sakarya River are important for the region's ecological diversity but are decreasing due to land conversion.

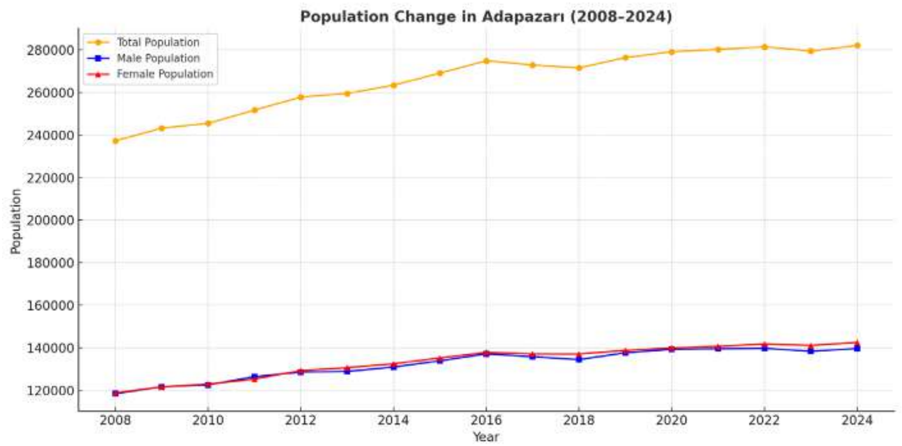
Satellite imagery shows an increase in artificial surfaces in recent years, contrasted by a decrease in natural vegetation and agricultural land. This change strengthens the urban heat island effect and increases the risks of flooding, soil sealing, and biodiversity loss.

Socio-Economic Profile

Adapazarı is the most densely populated residential center of Sakarya, with a population of approximately 290,000. The urban core density exceeds 1,100 people per km².

Population growth has been supported by rural-urban migration, restructuring after the 1999 Marmara Earthquake, and urbanization dynamics. Demographically, the majority of the population is young, but the ratio of the elderly population is increasing in rural surroundings.

Low-income households, seasonal agricultural workers, and groups living in informal settlements stand out as vulnerable groups in climate adaptation policies.



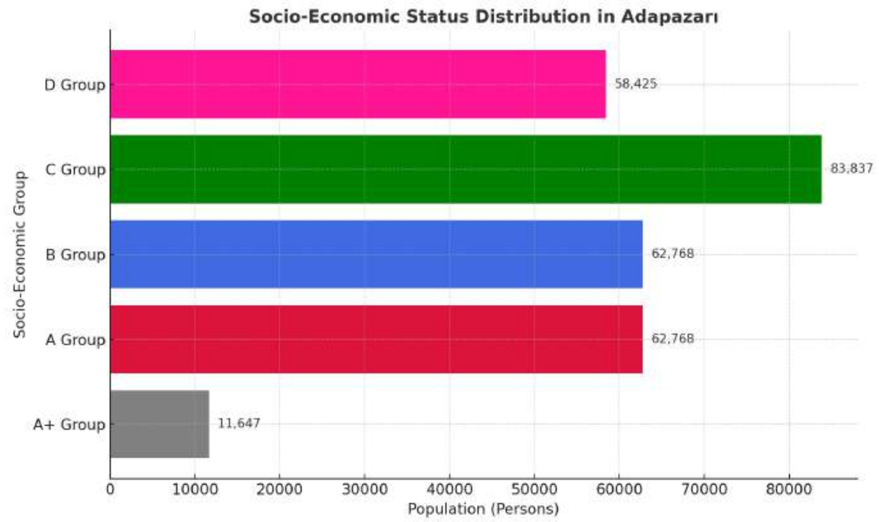
Population Change in Adapazarı 2008 2024 - TÜİK 2024

Socio-Economic Classes (SES)

· A+: High-income, executives, international lifestyle.
· A: Upper-middle class, academic/professional expertise, digital competency.
· B: Middle class, educated employees, teachers, civil servants.
· C: Lower-middle income, semi-skilled workforce, factory and service sector employees.
· D: Economically most vulnerable group; seasonal workers, unemployed, informal workers.

Economic Structure

· Industry and manufacturing: Automotive, textile, and machinery sectors are dominant; sensitive to climate risks due to high energy and water consumption.
· Agriculture: Despite the pressure of urbanization, it holds strategic importance; crop patterns are dependent on the seasonal climate and groundwater availability.
· Service sector: Education, health, and public administration are concentrated in the center.

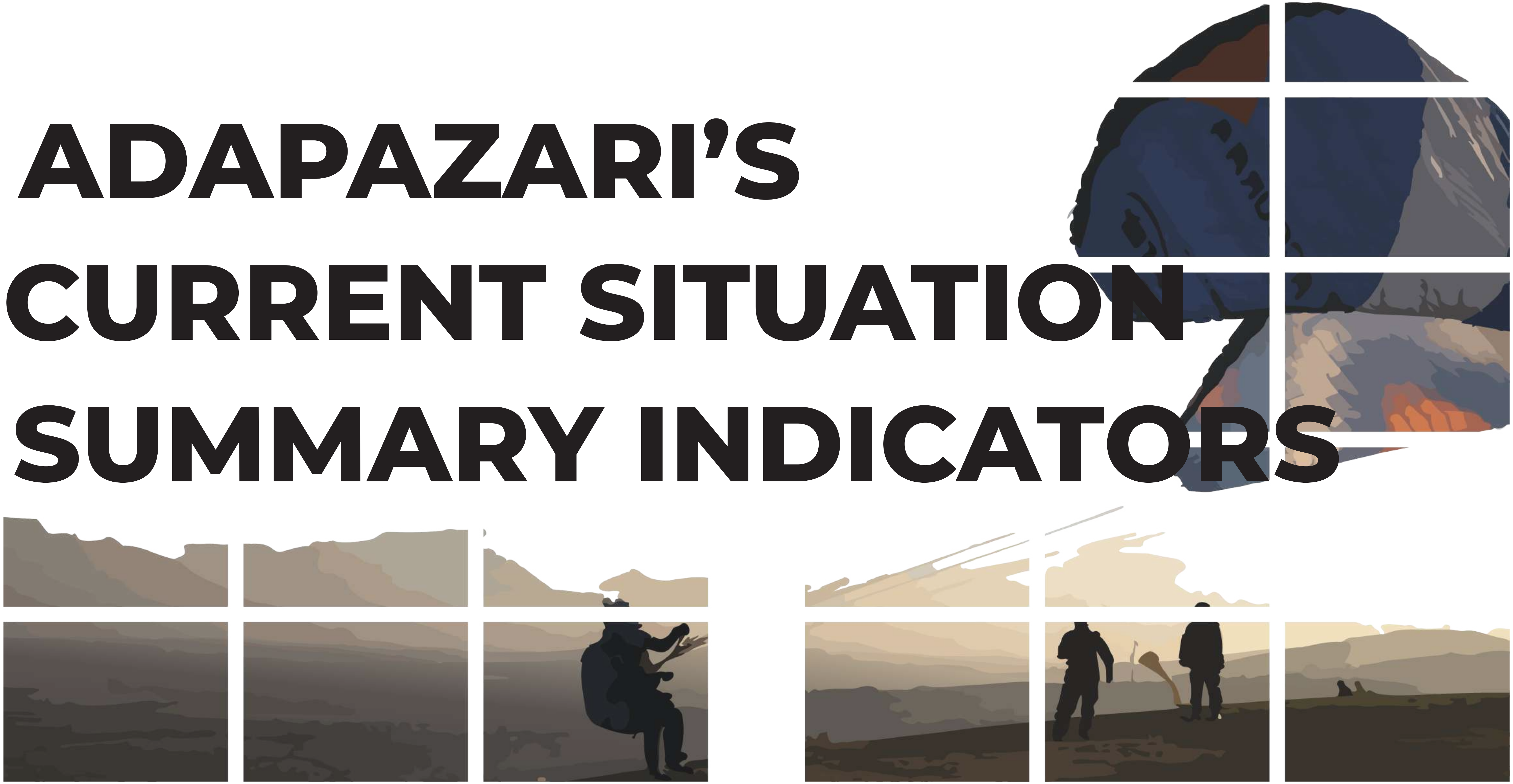


Socio-economic Status Distribution in Adapazarı (Endeksa 2025)

Urban and Infrastructural Conditions

Urban growth has exceeded infrastructure capacity in many neighborhoods.
Unplanned urbanization, outdated drainage systems, and lack of green spaces increase the risks of flash floods, heat islands, and air pollution.
Although highway, railway, and regional transportation networks are developed, their intersections with corridors under flood risk create systemic climate risks.
The active structure of civil society, the presence of local universities, and participatory municipal management are elements that increase Adapazarı's adaptation capacity. However, cross-sectoral coordination is still limited.
The plan aims to strengthen inter-institutional cooperation, increase community participation, and develop regional capacity through the LAP Team.

ADAPAZARI'S CURRENT SITUATION SUMMARY INDICATORS



Geographic and Morphological Data
· Location: Northwest Türkiye, Lower Sakarya Basin
· Total Area: ~278 km²
· Altitude: Average 31 m
· Terrain Structure: 65% flat plain, 25% gently sloping, 10% mountainous
· Geological Structure: Alluvium – layers of clay, silt, and sand
· High Flood Risk Areas: Surroundings of the Sakarya River, northern and western plains

Hydrological Indicators
· Main Watercourse: Sakarya River
· Primary Tributaries: Çark Stream, Mudurnu Creek
· Annual Average Precipitation: 900–1200 mm
· Groundwater Level: 8–12 m (shows seasonal variation)
· Flood-Prone Areas: City center and Serdivan sub-basins
· Water Stress: 15% reduction during the summer period due to agricultural extraction

Climate Data
· Annual average temperature: 14 °C
· Maximum temperature average: 26 °C (July–August)
· Minimum temperature average: 4 °C (January)
· Annual average precipitation: 1050 mm
· Wettest period: November–January
· Driest period: July–August
· In the last 20 years: Number of heavy precipitation days increased by 30%
· Projection (RCP4.5): +1.5–2.5 °C warming by 2050
· Projection (RCP8.5): Up to +3.5 °C increase by the end of the century

Demographic and Socio-Economic Data
· Population: 290,000 (2024 TÜİK)
· Population Density: 1,100 people/km²
· Average Age: 33.2
· Vulnerable Population Rate: 17% (low-income or seasonal workers)
· Service Sector Employment: 44%
· Industry Employment: 38%
· Agriculture Employment: 18%

Terrain Type	Ratio (%)	Explanation
Urban Areas	42	Industrial, residential, and commercial areas
Agricultural Areas	38	Grain, vegetable, and fruit production
Forest Areas	14	Mixed deciduous vegetation on the southeastern slopes
Wetlands / Water Surfaces	6	Sakarya River surroundings and seasonal marshes

Land Use (CORINE 2024)

Social Perception, Risk Awareness, and Participation Profile

Within the scope of the Adaptation Plan, a structured assessment process has been carried out to understand awareness, risk perception, institutional approaches, and participation expectations in the context of climate change in Adapazarı. In this process, complementary indicators aimed at revealing the current social and institutional capacity of the district were evaluated by handling the perceptions and assessments of individuals within a comprehensive framework.

Awareness
Current indicators show that general awareness regarding climate change in Adapazarı has reached a certain level of maturity. The perception that climate change is affecting the region is widespread, and the familiarity with basic concepts and climate-related impacts is remarkable. Nevertheless, making the link between climate change and individual life practices more visible stands out as a significant area of development in terms of reflecting the current awareness more strongly in daily behaviors and individual areas of responsibility.

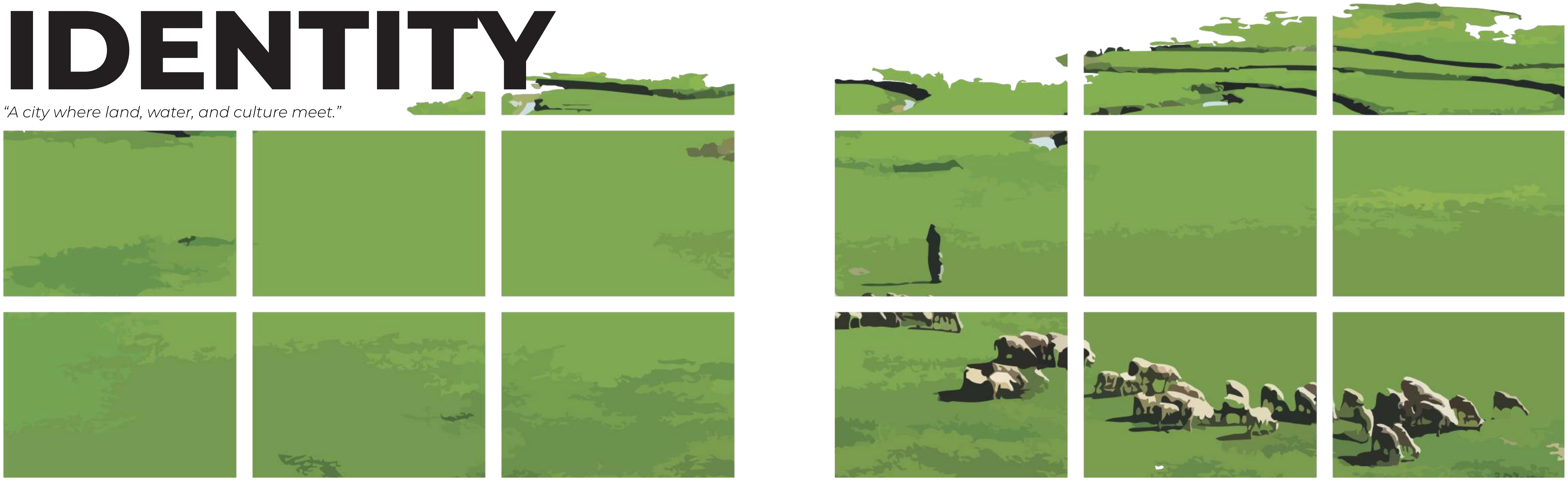
Risk Perception
Social evaluations point to a strong awareness that climate change creates concrete risks, particularly through extreme weather events, health impacts, and economic losses. The association of hazards such as extreme precipitation, heatwaves, and drought with daily life and livelihood conditions shows that climate risks are evaluated through concrete experiences at the local scale. The differentiation of perceptions regarding certain risk types is a natural situation reflecting the diversity of local experiences and the multi-layered structure of the region.

Corporate Perception and Trust
In the context of perceptions regarding institutional capacity, there is a framework indicating that different actors undertake complementary roles in the fight against climate change. While the work carried out by local governments is closely monitored, the contributions provided by civil society actors to the adaptation process create a visible area of influence in the eyes of the public. This picture indicates that there are significant opportunities to reinforce social trust in climate change adaptation processes, along with strengthening inter-institutional cooperation, transparency, and communication.

Participation and Ownership
Social indicators reveal that individual and collective participation is seen as an important and effective tool in the fight against climate change. This expectation provides a strong foundation for strengthening participatory processes at the local level and structuring communication channels in a more inclusive manner. Furthermore, the fact that trust in the ability of climate change adaptation plans to respond to local needs is largely maintained shows that social ownership can be further strengthened through correctly designed participation mechanisms.

ADAPAZARI'S NATURAL AND CULTURAL IDENTITY

"A city where land, water, and culture meet."



Geographic Identity

Located in the northwest of Türkiye, in the center of the Sakarya Plain, Adapazarı is a typical transition geography with its fertile lands, high humidity, and variable climate structure.
This plain, shaped by the floods of the Sakarya River over thousands of years, forms one of the youngest and most fertile alluvial systems in Türkiye.
This natural balance provides the city with both agricultural productivity and climate vulnerability.

Geomorphological studies show that the Adapazarı Plain has been filled with approximately 8 meters of fertile alluvium over the last 10,000 years.
(Source: MTA Geological Surveys, 2023)

Green Spaces and Ecological Balance

Adapazarı has been known for many years with the identity of a "green city"; however, in the last twenty years, rapid urbanization and construction have put pressure on the natural green belt.
The wetlands along the banks of the Sakarya River are a stopover route for hundreds of migratory birds and play a critical role in the continuity of the regional ecosystem.
The forest areas surrounding the city naturally lower the temperature by 2–3°C during the summer months; however, the increase in construction causes this "green armor" to weaken a little more each year.

In 2000, 46% of the city's surface was green space, whereas today this rate has declined to 34%.
(Source: Sakarya Metropolitan Municipality, 2024 Arazi Kullanım Verisi)

Connection with Nature: The Breathing Space of the Black Sea

Sakarya River does not only irrigate Adapazarı; it also forms the main artery of an ecological life line extending to the Black Sea. Every 1°C increase in sea temperatures leads to a decrease of up to 3% in the average agricultural humidity in the region.

This ecological chain makes Adapazarı a strategic "carbon sink" and a center of biodiversity for the northwestern ecosystem of Türkiye.

Social and Economic Fabric

Adapazarı is one of the rare cities in Türkiye that carries both agricultural and industrial identities together.
The automotive, food, and rubber sectors work in an integrated manner with agricultural production; this makes the city one of the important centers of a mixed economy in terms of both production and employment.
The district's population exceeds 350,000 in the morning hours due to the labor force coming from surrounding districts, which creates critical pressures on transportation, energy, and infrastructure planning.
The presence of communities of Balkan, Caucasian, and Black Sea origin in the social structure strengthens cultural diversity and social cohesion.

In Adapazarı, the industrial employment rate is 42%, and the agricultural employment rate is 18%.
(Source: TÜİK Regional Statistics, 2024)

Vulnerabilities and Opportunities

Adapazarı, due to its location on the North Anatolian Fault Line and its position within the Sakarya River floodplain, is at the intersection of both subterranean and atmospheric risks.
In the last 10 years, groundwater levels have decreased by 1.8 meters, and the temperature in the city center has been measured on average 4°C higher than in the rural surroundings.
In contrast, the district also possesses regional resilience and development opportunities through its renewable energy potential, agricultural production capacity, and industrial diversity.

Adapazarı is one of the rare cities in Türkiye where the risks of earthquakes, floods, and heatwaves are observed simultaneously.

The Value of Adapazarı

Adapazarı is a regionally prioritized district from both an economic and ecological perspective.
Besides being a pioneer in Türkiye's corn and rice production and one of the leading districts in the automotive and rubber industries, it is of vital importance for the country in terms of water resources management and biodiversity with its wetlands fed by the Sakarya River. [Image showing agricultural production areas, industrial zones, and the Sakarya River wetland ecosystem]
This multidimensional structure transforms the district into a priority study area for climate adaptation policies, disaster risk reduction, and sustainable production strategies.

METHODOLOGY

The methodology followed in the preparation of this plan is based on three complementary core principles:

"Multi-Criteria Decision Analysis (MCDA), participatory evaluation, and data-driven analysis"

This integrated approach ensures that the planning process is both scientifically rigorous and socially inclusive, as well as adaptable to local conditions.

Multi-Criteria Decision Analysis (MCDA)

The Analytic Hierarchy Process (AHP) method ensured the prioritization of climate hazards in line with stakeholder opinions and pre-determined evaluation criteria. In this way, a transparent and systematic decision-making mechanism was established under complex and uncertain conditions.

Participant Evaluation

Participation is one of the fundamental components of the methodology. Adaptation Teams, consisting of public institutions, non-governmental organizations, academic representatives, and local communities, have played an active role in the processes of defining vulnerabilities, verifying sectoral connections, and collectively determining adaptation priorities.

Data-Driven Analysis

The technical components developed in this plan are built upon the integration of Geographic Information Systems (GIS), climate projections, land use, and socio-economic indicators. This structure has enabled a quantitative evaluation of the region's exposure, sensitivity, and adaptation capacity components.

The set of indicators used in the analysis process was determined according to each sector and climate hazard matching.
The data were compiled through literature reviews, national statistical institutions (TÜİK, FAO, Copernicus), local government records, and expert opinions.
For example, for the agricultural sector, indicators such as product diversity and yield variability were used; for water resources, variables such as total consumption and blue water footprint were utilized.
Each indicator was evaluated in terms of both its current status and its impact on climate risk.
After selecting the indicators, the direction of each indicator's impact on the risk score was defined.

In this context, it has been determined that an increase in the value of some indicators leads to an increase in risk (e.g., high water consumption, low product diversity), while others lead to a strengthening of adaptation capacity (e.g., socio-economic development, green space ratio). This stage has ensured analytical consistency and transparency in the determination of risks.

Methodological Framework

For the geographical scope of the data, Türkiye's NUTS-2 level provinces were taken as a reference.
These provinces include: Denizli, Sakarya, Yalova, Bolu, Konya, Aydın, Isparta, Kayseri, Kırklareli, Bilecik, Çanakkale, Edirne, Karabük, Manisa, and Balıkesir.
This selection allowed for Adapazarı to be compared with provinces having similar socio-economic profiles and enabled the analyses to be conducted within a relative framework.

For example, the total water consumption value for Adapazarı was not evaluated as "high" or "low," but by being normalized within the minimum-maximum value range across these provinces.

At this stage, the risk of indicator redundancy and double counting was also prevented.
Indicators containing similar information (e.g., total agricultural area and ratio of agricultural area) were either merged or their weights were reduced.

In conclusion, this section has provided the database and methodological reliability that form the basis for the entire plan.
The justification for selection, the impact, and the comparison reference for each indicator have been clearly defined; thus, a solid scientific foundation has been established for the subsequent normalization and weighting stages.

In summary;
This methodological approach presents a multi-layered climate adaptation planning model developed specifically for Adapazarı.
This approach, which integrates local experiences with scientific analysis, offers a planning framework that can be taken as a reference not only on a regional scale but also on a national and international scale in the process of adaptation to climate change.

THREE CRITICAL CLIMATE RISKS FOR ADAPAZARI

Adapazarı is one of the regions that feels climatic changes most sensitively due to its geographical location and physical structure. Its low-altitude plain character and intense urbanization pressure cause the city to be directly affected by both regional and local atmospheric movements. The current situation places Adapazarı in a high-risk group against the most concrete outputs of the climate crisis: heavy precipitation, drought, and heatwaves.

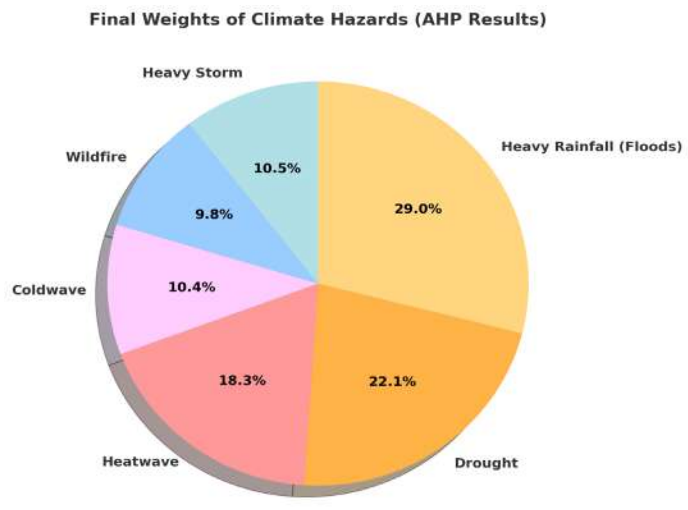
The results obtained show that three main climate risks stand out in Adapazarı:

· Heavy precipitation creates increasing pressure on urban infrastructure and drainage systems.
· Drought poses a serious threat to water resources, agricultural production, and ecosystem health.
· Heatwaves have significant impacts on public health, energy consumption, and quality of life.

These three climate hazards were determined as a result of the data-driven assessments conducted within the scope of the plan. Meteorological and socio-economic indicators used in the analyses were evaluated within the framework of exposure, sensitivity, and adaptive capacity components; vulnerability levels for each hazard were calculated through GIS-based spatial analyses.

Therefore, these three hazards are not merely meteorological events; they are holistic risks affecting every aspect of life, from agriculture to infrastructure, and from public health to economic stability. This plan aims to develop science-based, nature-oriented, and participatory adaptation strategies for Adapazarı against changing climatic conditions.

In 2000, green areas comprised 46% of the city's surface, while today this figure has dropped to 34%.
(Source: Sakarya Metropolitan Municipality, 2024 Land Use Data)



The Severity Levels of Climate Hazards Affecting Adapazarı

The plan does not merely measure risks; it aims to develop a sustainable adaptation model in which local governments, academia, and civil society act together. These three headings are of critical importance for protecting the future of Adapazarı; because each represents a threshold that can turn into a disaster if no action is taken, or into an opportunity when it is.

a. Heavy Rains

The Sakarya Plain carries the humid character of the Black Sea climate. The annual precipitation amount, ranging between 900–1200 mm, has become irregular in recent years, and heavy downpours concentrating in short periods lead to floods in the city According to the plan analyses, the frequency of heavy precipitation has increased by 45%.

The key priorities identified are:
Innovative irrigation methods to increase water efficiency, rainwater harvesting, and the establishment of groundwater monitoring networks.

With rapid urbanization, the covering of the natural soil surface with concrete and asphalt can prevent rainwater from infiltrating the soil, causing 70-80% of it to turn into direct surface runoff.

b. Drought

Although rainfall amounts have remained constant, the seasonal distribution has been disrupted, and prolonged drought periods and increased evaporation have led to a 1.5-meter drop in groundwater levels.
This poses a critical risk to agriculture, water resource management, and ecosystem health.

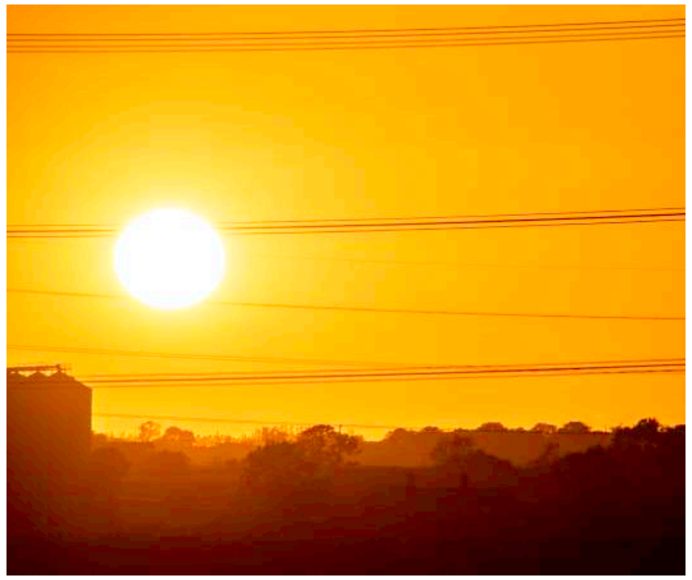
The key priorities identified are:
Implementing innovative irrigation methods to increase water efficiency, rainwater harvesting, and establishing groundwater monitoring networks.

In the Sakarya Plain, groundwater levels are decreasing by an average of 2 cm per year; at this rate, a decrease of approximately 60 cm is expected in 30 years.

c. Heatwaves

The average temperature in Adapazarı has risen by 1.3°C since the 2000s, with an additional increase of 1.5–2.5°C projected by 2050.
While the number of days above 35°C increases by 25% every decade, this situation carries serious risks in terms of both human health and energy consumption.
The key priorities identified are:
The expansion of green space networks, shading plans, and climate-sensitive urban designs that will reduce the urban heat island effect.

On a summer day with a perceived temperature of 40°C, this value can rise to 43–44°C in the center of Adapazarı due to the urban heat island effect.



CLIMATE RISK ANALYSIS
KEY COMPONENTS AND METHODOLOGICAL STEPS

The plan is built upon three fundamental components to measure Adapazarı's resilience against climate change:
Exposure, Sensitivity, and Adaptive Capacity.
Together, these three components reveal which hazards the region is open to, how sensitive it is to these hazards, and how strongly it can respond.

Project Research Stages

1. Data Collection and Mapping
Climate, hydrology, socio-economic and environmental indicators are collected and a GIS (Geographic Information Systems) based data infrastructure is created.
Objective: To determine Adapazarı's current climate structure, risk areas and natural resource capacity.

2. Risk Analysis (Exposure – Sensitivity – Adaptation Capacity)
A multi-criteria decision analysis (MCDA) approach is applied for each region based on these three factors.
Different indicators are normalized and weighted to create a climate risk index.
Objective: To determine the vulnerability level of the district.

3. Socio-Economic Assessment
The impacts of climate risks on public health, income, transportation, energy, and agriculture have been assessed.
Objective: To measure not only the physical

The Importance of Three Main Factors

Exposure:
It defines to what extent Adapazarı is "exposed" to climate impacts such as flooding, temperature increase, and drought. Here, natural conditions (topography, precipitation distribution, soil structure) and human influence (urbanization, infrastructure, population density) are evaluated together.

Sensitivity:
It shows to what extent ecosystems and sectors are affected when these impacts occur. Sensitivity levels in areas such as agriculture, water resources, transportation, and energy are analyzed.

Adaptability:
This assesses how quickly and effectively Adapazarı can adapt to changing conditions. Institutional capacity, infrastructure resilience, education level, and societal awareness are all included in this assessment.

4. Developing Adaptation Strategies
Nature-based solutions (green infrastructure, water harvesting, flood buffer zones) and community-based adaptation practices have been identified.
Objective: To produce concrete actions that will reduce risks.

5. Policy and Action Plan Development
The analysis results have been transformed into implementable policy recommendations for local governments.
Objective: To turn scientific outputs into a decision support tool.

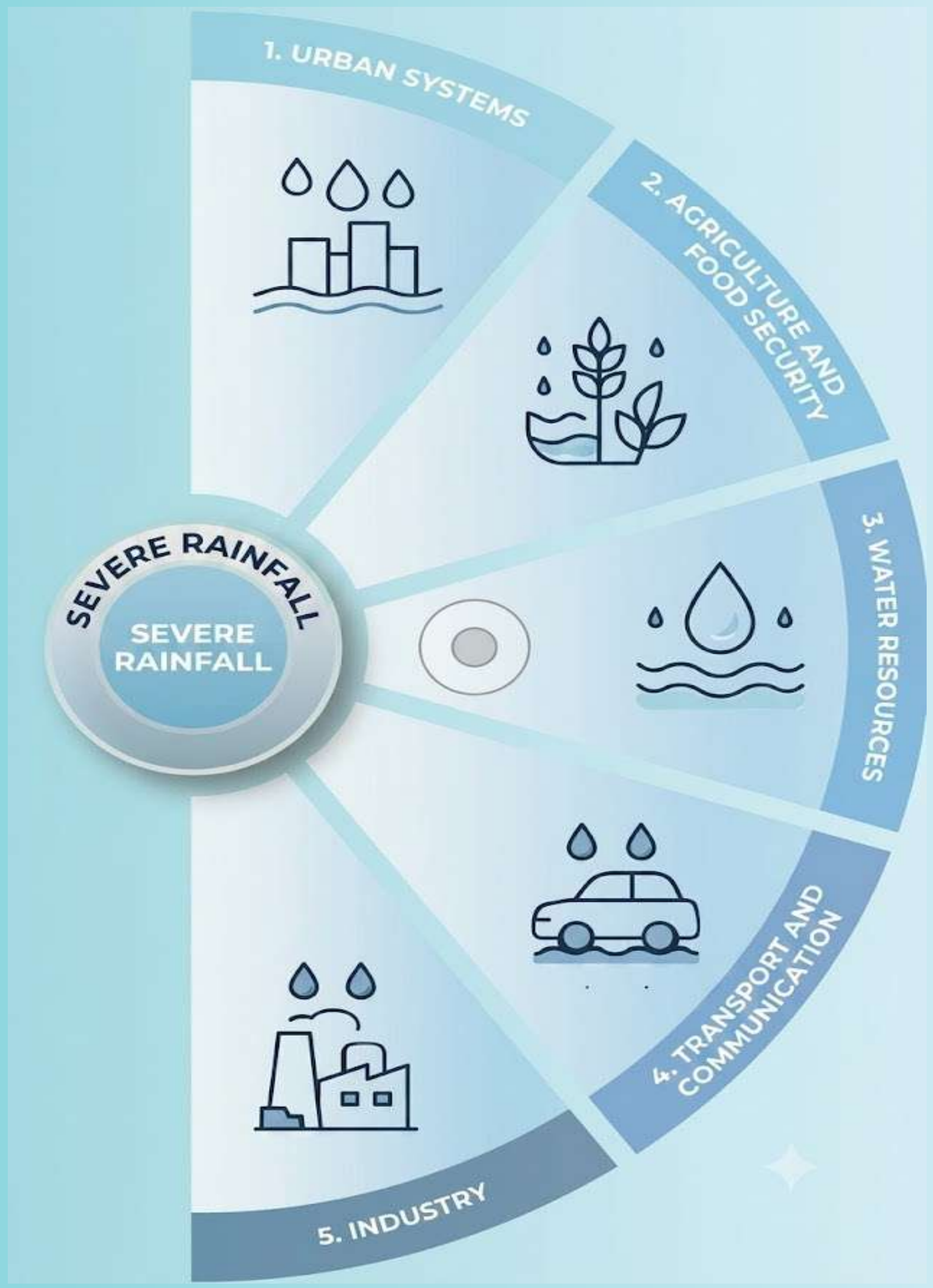
CATEGORIZATION OF FACTORS ACCORDING TO HAZARD-SECTOR MATCHING

Within the scope of the plan, in order to evaluate the direct and indirect effects of climate change on different sectors in Adapazarı district of Sakarya province, three main climate hazards were identified: heavy rainfall, heat waves, and drought.

In this context, risk-sector mappings were conducted to determine which sectors are affected by each risk, and sectoral vulnerability levels were analyzed through these mappings. This approach enabled a holistic assessment of risks and provided a basis for developing adaptation strategies.

Appropriate indicators have been identified for each hazard; these indicators have been categorized to assess the degree to which the relevant sectors are sensitive to climate risks.

This classification clearly identifies priority intervention areas and allows for a systematic analysis of climate risks in Adapazarı in areas such as urban systems, water resources, agriculture, energy, health, tourism, and biodiversity.



HEAVY RAINFALL INDICATORS RELATED TO THE HAZARD

The threat of heavy rainfall creates multifaceted impacts, including flooding, soil erosion, infrastructure damage, and economic losses.

This section summarizes the indicators identified for five key sectors (Urban Systems, Agriculture and Food Security, Water Resources, Transportation and Communication, Industry) evaluated specifically in Adapazarı.

1. Urban Systems Exposure-Sensitivity-Adaptability Analysis

A risk analysis was conducted to determine the potential impacts of heat waves on the public health sector and to provide a basis for developing adaptation strategies.

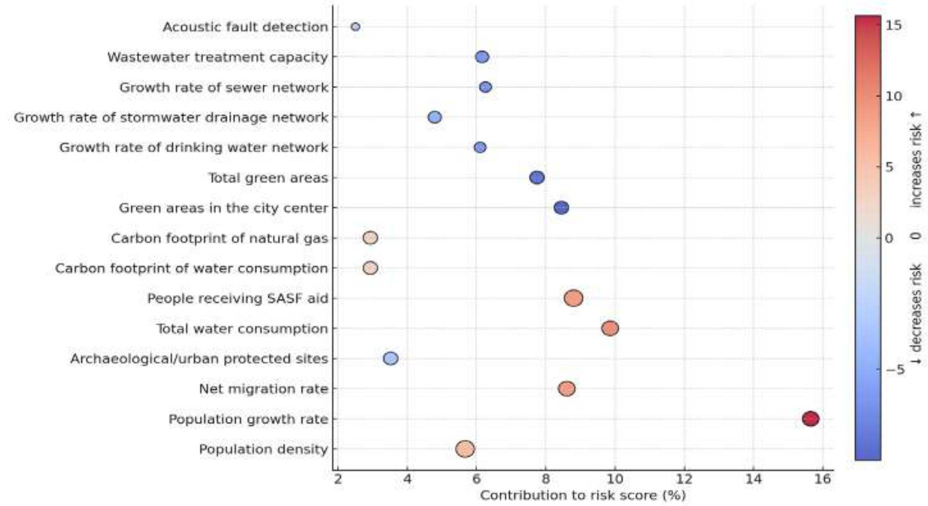


Figure 15. Contribution of indicators related to urban systems to the risk score within the scope of severe rainfall hazard.

Table 2. Indicators of exposure, sensitivity, and adaptation capacity for urban systems.

Exposure	Sensibility	Adaptability
Population Density	Number of Beneficiaries of the Social Assistance and Solidarity Foundation	Drinking Water Network Expansion Rate
Population Growth Rate	Carbon Footprint of Water Consumption	Rainwater Drainage Network Expansion Rate
Net Migration Rate	Carbon Footprint of Natural Gas Consumption	Sewerage Network Expansion Rate
Protected Area / Urban Site Area	City Center Green Area Ratio	Wastewater Treatment Capacity
Total Water Consumption	Total Green Area Percentage	Acoustic Fault Detection

These indicators were used to measure the impacts of heavy rainfall on urban areas and to create a basic dataset for subsequent risk analyses.
The data obtained reveal how urban density, migration, and infrastructure planning are related to flood risks.

These indicators reveal the degree of physical and socio-economic vulnerability to heavy rainfall in urban areas; they show that increasing green infrastructure plays a decisive role in reducing vulnerability.

These indicators form the basic data sets used to assess the resilience of urban systems to severe rainfall conditions.
Early warning and infrastructure modernization are the most important elements that increase the adaptability of cities to climatic risks.

2. Agriculture and Food Safety Sector Exposure-Sensitivity-Adaptability Analysis

A risk analysis has been conducted for the Adapazarı district, specifically focusing on the agriculture and food security sectors in the context of the threat of heavy rainfall.

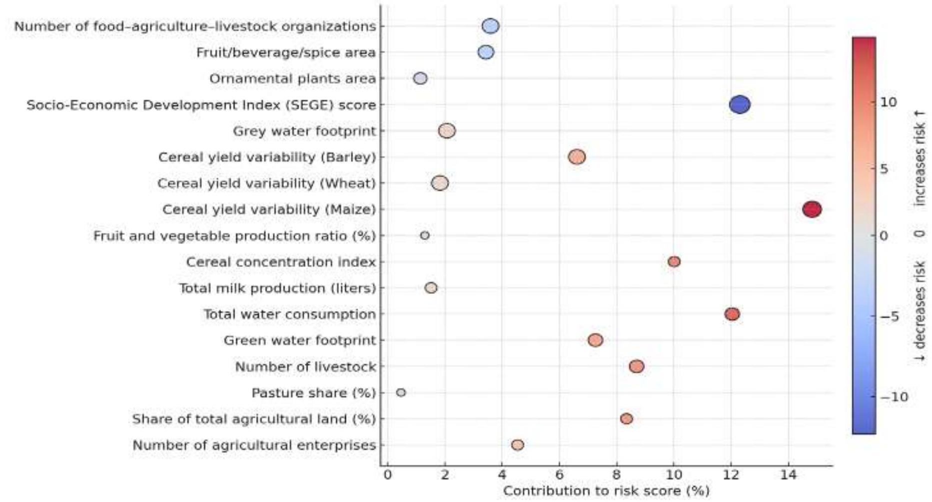


Figure 16. Contribution of indicators related to agriculture and food security to the risk score within the scope of severe rainfall risk.

Table 3. Indicators of exposure, sensitivity, and adaptation capacity for agriculture and food safety.

Exposure	Sensibility	Adaptability
Number of Agricultural Enterprises	Grain Yield Variability (Maize)	Süs Bitkileri Ekili Alanı (dekar)
Total Agricultural Land Percentage (%)	Grain Yield Variability (Wheat)	Meyve / İçecek / Baharat Bitkileri Ekili Alanı (dekar)
Pasture Area Percentage (%)	Grain Yield Variability (Barley)	Gıda–Tarım–Hayvancılık Alanında Faaliyet Gösteren Kuruluş Sayısı
Number of Animals	Gray Water Footprint (m^3/year)	
Green Water Footprint (m^3/year)	SEGE Score	
Total Water Consumption (m^3/year)		
Total Milk Production (liters)		
Grain Density Index (%)		

These indicators reveal the extent to which agricultural production systems are directly affected by heavy rainfall. Increasing production diversity and improving water use efficiency are key strategies to enhance the resilience of Adapazarı's agricultural sector to climate risks.

These indicators show the level of sensitivity in the agricultural sector, particularly regarding fluctuations in grain production and water use pressures. Ensuring yield stability and improving water management will increase the resilience of agricultural systems in Adapazarı to rainfall-related risks.

These indicators reflect the level of adaptation through agricultural production diversity and organizational capacity. Increased diversity and cooperation play a key role in making the agriculture and food security sector in Adapazarı more resilient to heavy rainfall. These indicators point to the sector's capacity and resilience potential.

3. Water Resources Exposure-Sensitivity-Adaptability Analysis

In Adapazarı district, within the scope of the threat of heavy rainfall, the effects of existing and potential future risks on urban settlements and water resources have been examined; accordingly, a detailed risk analysis has been carried out.

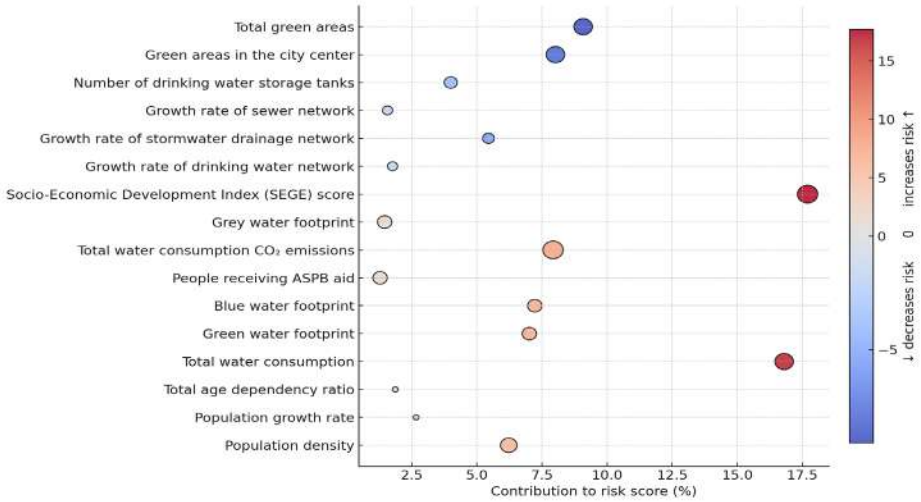


Figure 17. Contribution of water resource indicators to the risk score within the scope of severe rainfall hazard.

Table 4. Indicators of exposure, sensitivity, and adaptation capacity for water resources.

Exposure	Sensibility	Adaptability
Population Density	Number of Beneficiaries of the Social Assistance and Solidarity Foundation	Drinking Water Network Expansion Rate
Population Growth Rate	TOTAL CO_2 Emissions from Water Consumption (tons/year)	Rainwater Drainage Network Expansion Rate
Total Dependency Ratio (%)	Gray Water Footprint (m^3/year)	Sewerage Network Expansion Rate
Total Water Consumption	SEGE Score	Number of Drinking Water Reservoirs (units)
Green Water Footprint (m^3/year)		Green Areas in the City Center (m^2)
Blue Water Footprint (m^3/year)		Total Green Area (m^2)

These indicators reveal the extent and manner in which water resources are affected by heavy rainfall.
When water footprint components (blue and green) and population-based indicators are evaluated together, it is seen that water management in Adapazarı is at high risk in terms of both quantity and quality.

These indicators reveal how vulnerable the water resources system is currently to rainfall pressures. In particular, high CO_2 emissions and greywater footprint values show that environmental pressures pose significant risks to water quality.

These indicators allow us to assess the water resources sector's capacity for preventive measures and its existing institutional and technical resilience.
Green infrastructure investments and the expansion of water management systems are key factors in increasing Adapazarı's resilience to heavy rainfall.

4. Transportation and Communication Sector Exposure-Sensitivity-Adaptability Analysis

A risk analysis has been conducted in Adapazarı district regarding the transportation and communication sectors in the context of the threat of heavy rainfall. This analysis aims to assess the current and potential impacts of extreme rainfall on transportation infrastructure, communication networks, and service continuity.

Figure 18. Contribution of indicators related to the transportation and communication sector to the risk score within the scope of severe rainfall risk.

Table 5. Indicators of exposure, sensitivity, and adaptation capacity for the transportation and communication sectors.

Exposure	Sensibility	Adaptability
Population Growth Rate (%)	Number of Employees in the Transportation / Storage / Communication Sector (persons)	City Center Green Area (m^2)
Average Vehicle Distance (km/year)	Population Density (persons/km^2)	Total Green Area (m^2)
Total Number of Vehicles (units)	Road Network Length (meters)	

These indicators form the basic data set for assessing the direct impacts of heavy rainfall on transportation systems.
High population growth, heavy vehicle traffic, and long driving distances increase the pressure on infrastructure, raising the risk level.

These indicators reveal the fragility of the transportation and communication infrastructure. High population density, a long road network, and a large number of employees increase the system's vulnerability to precipitation and threaten service continuity.

Urban green spaces have been considered as natural buffer zones that reduce the risk of post-rainfall flooding and maintain the functionality of transportation networks. These indicators stand out as key elements strengthening the sector's climate adaptation capacity.

5. Industrial Sector
Exposure - Sensitivity - Adaptation Capacity Analysis

In order to anticipate the threats that heavy rainfall may pose to the industrial sector and to determine the necessary precautions, a risk analysis was carried out specifically for the

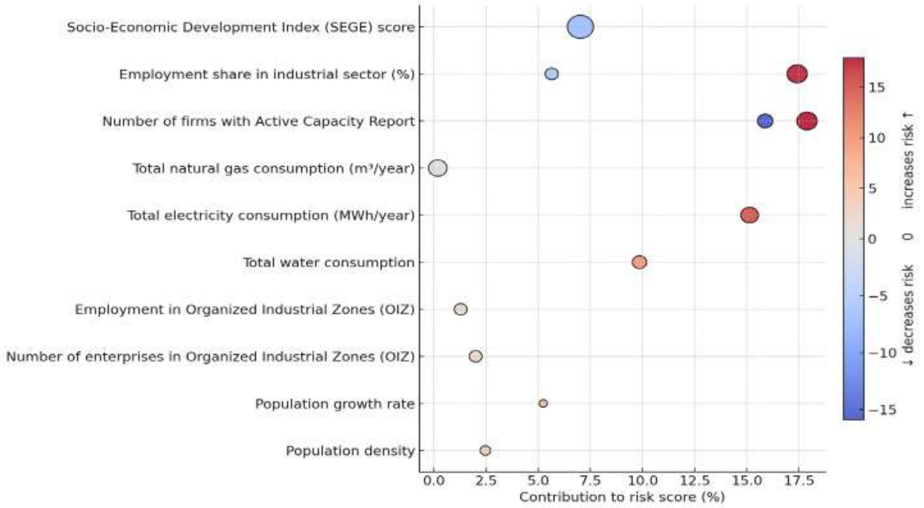


Figure 19. Contribution of indicators related to the industrial sector to the risk score within the scope of severe rainfall risk.

Table 6. Indicators of exposure, sensitivity, and adaptability for the industrial sector.

Exposure	Sensibility	Adaptability
Population Density	Number of Companies with Activity Reports	SEGE Score
Population Growth Rate	Percentage of Workforce Employed in Industry (%)	Number of Companies with Activity Reports
Number of Businesses in Organized Industrial Zones (OSB)	SEGE Score (Socio-Economic Development Index)	Percentage of Workforce Employed in Industry (%)
OSB Employment (Number of People)		
Total Water Consumption (m^3/year)		
Total Electricity Consumption (MWh/year)		
Total Natural Gas Consumption (m^3/year)		

These indicators reveal the extent to which industrial facilities are directly affected by heavy rainfall.
High dependence on energy and water, along with dense industrial infrastructure, indicates that the industrial sector in Adapazarı is highly exposed to flood risk.

"The Socio-Economic Development Index (SEGE) has been included in the analysis in a two-way manner, both in terms of 'vulnerability' by reducing structural resilience and in terms of 'adaptation capacity' by increasing institutional planning and intervention capabilities."

These indicators reflect the potential impact of heavy rainfall on production, employment, and economic activity in the industrial sector.
Regions with high industrial density and production capacity are more susceptible to rainfall-related disruptions.

These indicators reveal the crisis management, planning, and recovery capacity of the industrial sector. High level of development, established firms, and a strong workforce contribute to high adaptability in the sector.
Analyses conducted in Adapazarı show that heavy rainfall creates a multi-dimensional risk area encompassing not only the physical environment but also water, agriculture, industry, transportation, and urban systems.

Indicators defined for each sector have quantitatively and spatially described the levels of exposure, vulnerability, and adaptation capacity caused by climate-induced floods.

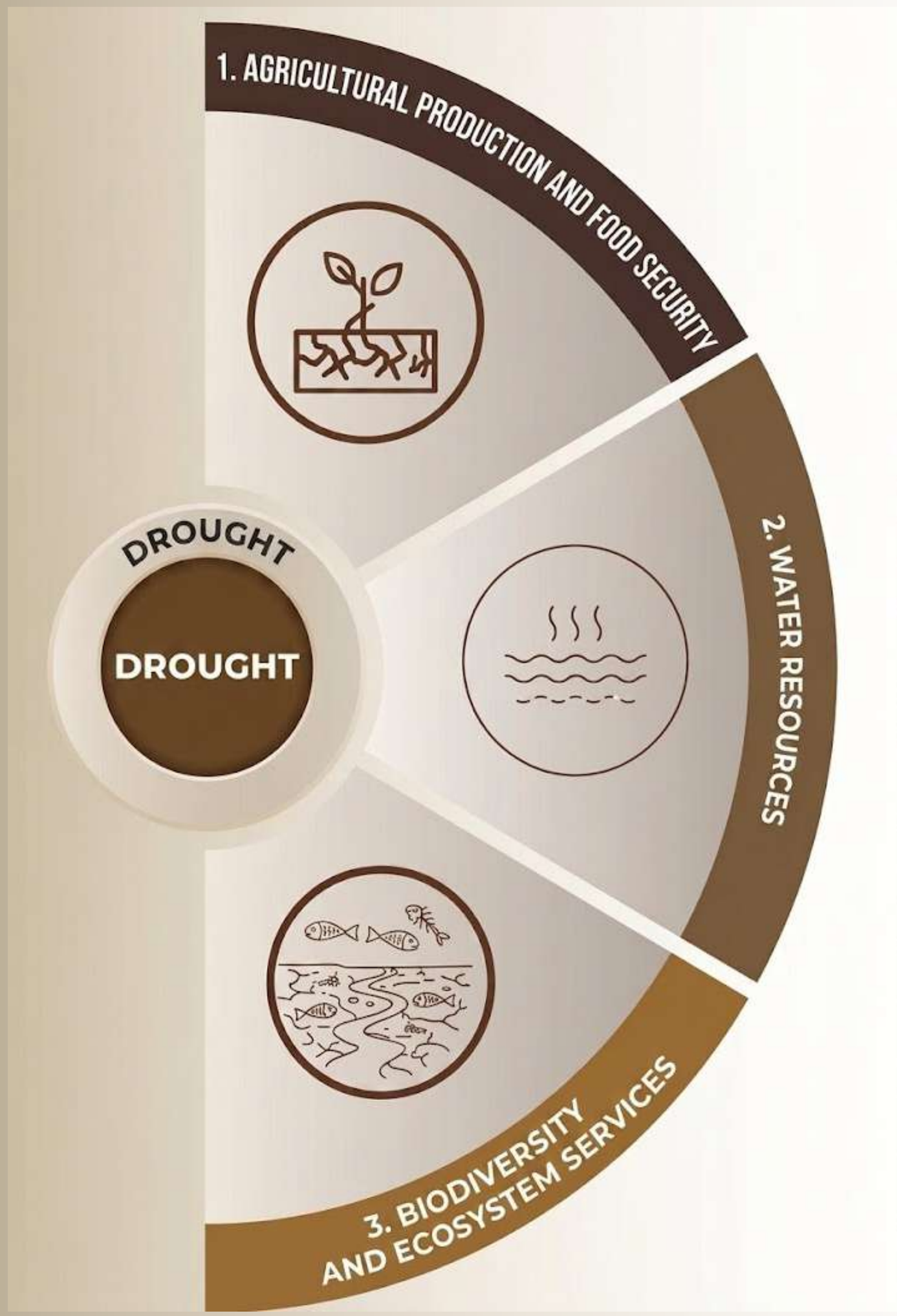
SUMMARY

· Urban systems are at high risk even from short periods of rainfall due to high population density and inadequate drainage infrastructure.
· Water resources are under pressure from excessive rainfall in terms of both quantity and quality; expanding infrastructure capacity and increasing green space ratios are critically important.
· The agricultural sector is directly affected due to the unidirectional nature of its production pattern and the intensity of its water consumption.
· The industrial sector is one of the areas most vulnerable to economic losses due to its high dependence on energy and water.
· Transportation and communication infrastructure struggles to maintain service continuity after rainfall due to intensive use and a low permeable surface area.

Exposure	**Maruziyet**	**Sensibility**	**Adaptability**
Urban Systems	High population density, rapid migration, limited drainage capacity	Socio-economically vulnerable groups, carbon-intensive consumption	Infrastructure modernization, early warning systems
Water Resources	Increasing water demand, high blue and green water footprint	Pollution burden, low SEGE regions	Reservoir expansion, drainage systems, green areas
Agriculture and Food Security	Large agricultural land, high water use, monoculture	Efficiency fluctuations, greywater load	Production diversification, cooperative organization
Industry	High dependence on energy and water	Production disruptions, employment risk	Planning and crisis management capacity
Transportation and Communication	High number of vehicles, intensive road use	Long road network, population density	Green infrastructure integration, drainage strengthening

Table 7. Qualitative assessment of exposure, sensitivity, and adaptation capacity components by sector.

When these indicators are considered together, nature-based solutions, infrastructure strengthening, and the integration of green spaces stand out as three key strategic priorities for Adapazarı.



DROUGHT THREAT INDICATORS

Drought, due to decreased rainfall, rising temperatures, and declining soil moisture, poses serious risks such as yield losses in agricultural production, disruptions in water supply, and ecosystem degradation.
These effects are felt in both the short and long term in the water resources, agriculture-food security, and biodiversity sectors.
Therefore, exposure, sensitivity, and adaptation capacity indicators have been determined for different sectors; the aim is to measure, prioritize, and manage risks.
Sector-based indicators are a fundamental tool for monitoring the impacts of drought, developing adaptation plans, and increasing resource efficiency.

1. Agriculture and Food Safety Sector Exposure-Sensitivity-Adaptability Analysis

Within the context of drought risk, the risks to agricultural and food resources in Adapazarı district have been assessed; vulnerability levels have been determined through exposure, sensitivity, and adaptation capacity indicators. This analysis aims to reveal potential pressures on agricultural production and food security and to provide a basis for developing adaptation strategies.

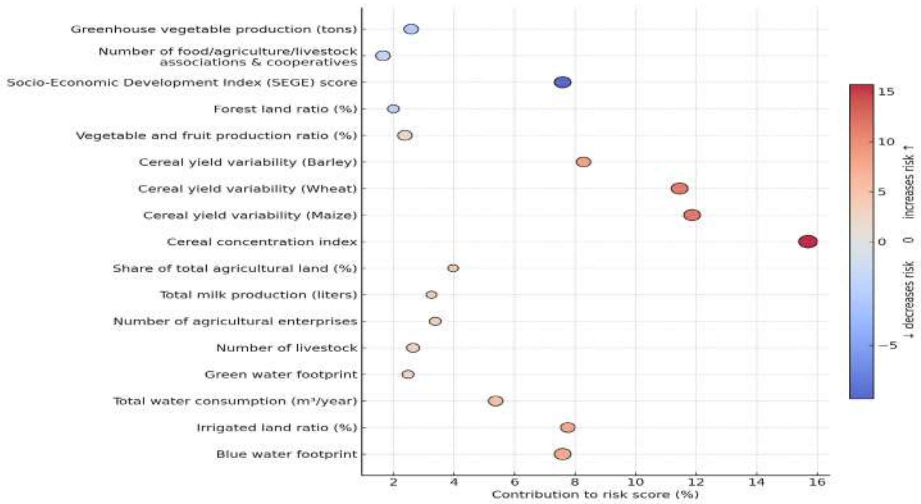


Figure 20. Contribution of indicators related to the agriculture and food security sector to the risk score within the scope of drought threat.

Table 8. Indicators of exposure, sensitivity, and adaptability for agriculture and food safety.

Exposure	Sensibility	Adaptability
Blue Water Footprint (m^3/year)	Grain Density Index (%)	SEGE Score
Irrigated Land Percentage (%)	Grain Yield Variability (Maize, kg)	Number of Food / Agriculture / Livestock Associations and Cooperatives
Total Water Consumption (m^3/year)	Grain Yield Variability (Wheat, kg)	Greenhouse Vegetable Production (tons)
Green Water Footprint (m^3/year)	Grain Yield Variability (Barley, kg)	
Number of Animals (units)	Fruit-Vegetable Production Rate (%)	
Number of Agricultural Enterprises (units)	Forest Area Rate (%)	
Total Milk Production (liters)		
Total Agricultural Land Percentage (%)		

These indicators reveal the level of exposure of the agriculture and food security sector to drought.
High water consumption, irrigation dependency, and livestock production intensity are the main factors increasing risks in the sector.
The results show that water efficiency practices and increased production diversification are critical in mitigating the effects of drought.

These indicators reveal the vulnerability and sensitivity level of the agriculture and food security sector to drought.
High grain density and yield variability threaten production stability, while the protection of forest areas and the increase in crop diversity are key factors that strengthen resilience in the sector.

These indicators reveal the resilience and adaptation capacity of the agriculture and food security sector to drought.
High institutional organization, advanced socio-economic structure, and controlled production techniques stand out as key elements in reducing the effects of drought in Adapazarı's agricultural systems.

2. Water Resources Sector Exposure-Sensitivity-Adaptability Analysis

Within the context of drought threat, risks to the water resources sector in Adapazarı district have been assessed; vulnerability levels have been determined through exposure, sensitivity, and adaptation capacity indicators. This analysis aims to reveal the potential pressures that water resources may face under drought conditions and to provide a basis for developing adaptation strategies.

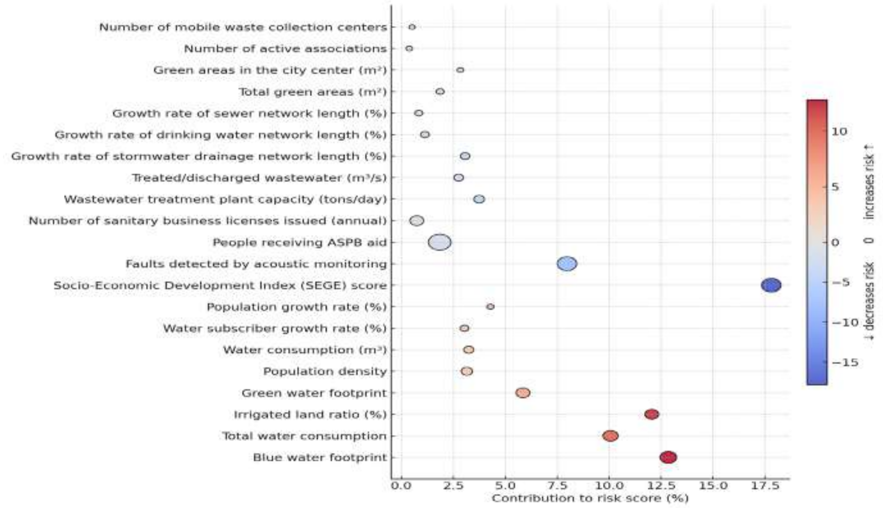


Figure 21. Contribution of water resource indicators to the risk score within the scope of drought threat.

Table 9. Indicators of exposure, sensitivity, and adaptability for water resources.

Exposure	Sensibility	Adaptability
Blue Water Footprint (m^3/year)	SEGE Score	Wastewater Treatment Plant Capacity (tons/day)
Total Water Consumption (m^3/year)	Number of Faults Detected by Acoustic Monitoring	Amount of Wastewater Treated/Discharged (m^3/s)
Irrigated Land Percentage (%)	Number of Beneficiaries of the Social Assistance and Solidarity Foundation	Rainwater Network Expansion Rate (%)
Green Water Footprint (m^3/year)		Drinking Water Network Expansion Rate (%)
Population Density		Sewerage Network Expansion Rate (%)
Water Consumption Volume (m^3)		Total Green Area (m^2)
Water Subscriber Growth Rate (%)		Green Areas in City Center (m^2)
		Number of Active Associations (units)
		Number of Mobile Waste Collection Centers (units)

These indicators show the high vulnerability of water resources to drought.
Increased water consumption, irrigation dependency, and population growth disrupt the supply-demand balance, increasing the risk of water scarcity.
The results indicate that sustainable water management and efficiency-based planning should be prioritized.

These indicators reveal the vulnerability of Adapazarı's water resources to drought.
High failure rates, economic fragility, and water demand from industrial activities show that existing water systems are under pressure.
The results point to the need to reduce infrastructure losses and strengthen economic resilience.

These indicators form the basic data set for evaluating the drought adaptation capacity of the water resources sector.
Wastewater recovery, infrastructure expansion, and the presence of green spaces are key elements supporting water supply security.
The results show that reuse and green infrastructure investments play a critical role in increasing the resilience of water management in Adapazarı.

3. Biodiversity and Ecosystem Services Sector Exposure-Sensitivity-Adaptability Analysis

Within the biodiversity and ecosystem services sector, the current and future impacts of drought risk have been assessed; and sectoral risk levels have been determined through indicators of exposure, vulnerability, and adaptation capacity.

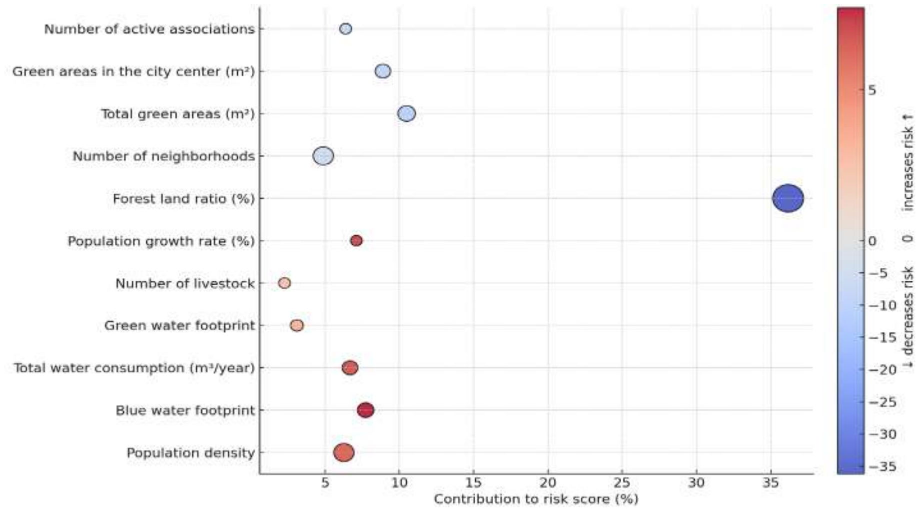


Figure 22. Contribution of indicators related to the biodiversity and ecosystem services sector to the risk score within the scope of drought threat.

Table 10. Indicators of exposure, sensitivity, and adaptation capacity for the biodiversity and ecosystem services sector.

Exposure	Sensibility	Adaptability
Population Density	Forest Area Percentage (%)	Total Green Area (m²)
Blue Water Footprint (m³/year)	Number of Neighborhoods (units)	Green Area in City Center (m²)
Total Water Consumption (m³/year)		Number of Active Associations (units)
Green Water Footprint (m³/year)		
Number of Animals (units)		
Population Growth Rate (%)		

These indicators reveal the level of exposure of the biodiversity and ecosystem services sector to drought and the regions where risk is concentrated. High population density, overreliance on water resources, and pressure from livestock production reduce the regeneration capacity of ecosystems, thus deepening the effects of

These indicators reveal the level of vulnerability of biodiversity and ecosystems to drought.
The decrease in forest cover and the increase in habitat fragmentation are reducing the ecological resilience capacity in Adapazarı and accelerating the spread of drought effects on ecosystems.

These indicators reveal the resilience and adaptation capacity of the biodiversity and ecosystem services sector in the face of drought.
Strengthening green infrastructure and increasing community participation are the main factors determining the ability of ecosystems in Adapazarı to regenerate and ensure service continuity against the effects of drought.

SUMMARY

• Water Resources Sector:
Increased water consumption, population growth, and irrigation dependence create high exposure to drought.
Network failures, economic fragility, and industrial activities increase vulnerability; while wastewater recycling, infrastructure expansion, and green space investments strengthen water supply security.

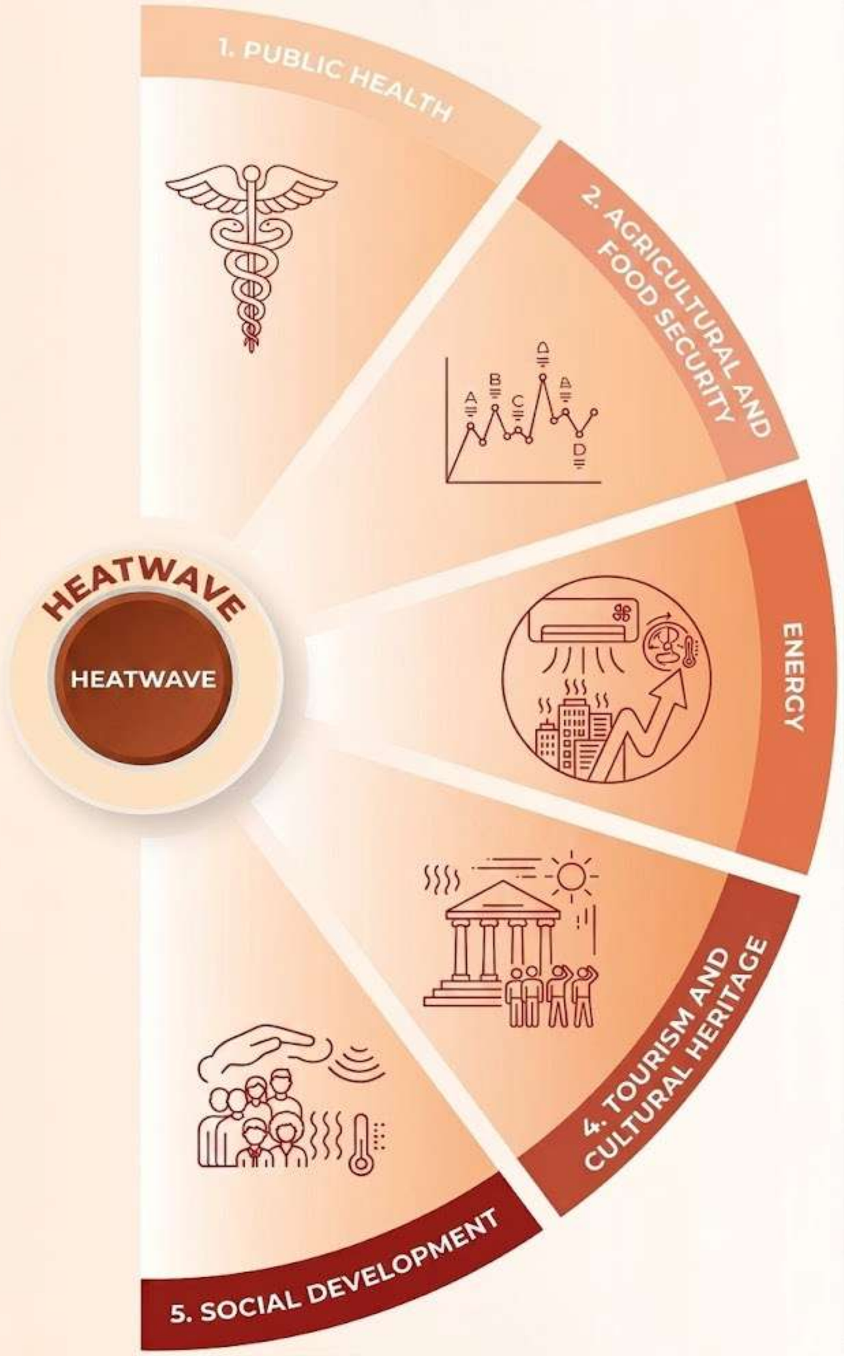
• Agriculture and Food Security Sector:
Irrigation-based production, high livestock activity, and low crop diversity make the sector vulnerable to drought risk.
Yield instability and monoculture tendencies increase production vulnerability; while cooperatives, greenhouse production, and socio-economic development levels support adaptation capacity.

• Biodiversity and Ecosystem Services Sector:
Increasing population and water use accelerate habitat loss, and the decrease and fragmentation of forest cover weaken ecological resilience.
In contrast, strengthening green infrastructure, protecting ecological corridors, and the active

Sector	Exposure	Sensibility	Adaptability
Water Resources	High water consumption, population growth, and reliance on irrigation increase the risk of drought.	Failure rates increase economic vulnerability and industrial demand sensitivity.	Wastewater recycling, infrastructure expansion, and green space investments strengthen adaptation.
Agriculture and Food Security	High irrigation requirements and the intensity of livestock production increase exposure.	Monopolies and yield fluctuations reduce stability.	Cooperation, greenhouse production, and socio-economic development increase adaptation.
Biodiversity and Ecosystem Services	Population growth and dependence on water resources increase environmental stress.	Forest loss and habitat fragmentation reduce ecological resilience.	Green infrastructure and civil society cooperation strengthen ecosystem resilience.

Table 11. Qualitative assessment of exposure, sensitivity, and adaptation capacity components by sector.

Drought is a multifaceted risk in Adapazarı, affecting the water, agriculture, and ecosystem sectors in an interconnected way. Integrated water management, green infrastructure strengthening, and community-based adaptation strategies should be key priorities in enhancing regional resilience.



HEATWAVE DANGER INDICATORS

Heat waves pose serious risks, including increased energy demand during prolonged periods of high temperatures, increased health problems, agricultural yield losses, and economic damage. This situation leads to production disruptions and demand pressure in the energy sector, a decrease in visitor numbers in the tourism sector, exposure of vulnerable groups to risks in the social development sector, crop and livestock losses in the agricultural sector, and an increase in heat-related illnesses in public health. Therefore, exposure, sensitivity, and adaptation capacity indicators have been determined for different sectors; the aim is to monitor the effects of heat waves, prioritize risks, and develop necessary adaptation strategies. Sector-based indicators play a critical role in increasing the resilience of energy and health systems, protecting agricultural production, and reducing societal risks.

1. Public Health Sector Exposure-Sensitivity-Adaptation Capacity Analysis

A risk analysis was conducted to determine the potential impacts of heat waves on the public health sector and to provide a basis for developing adaptation strategies.

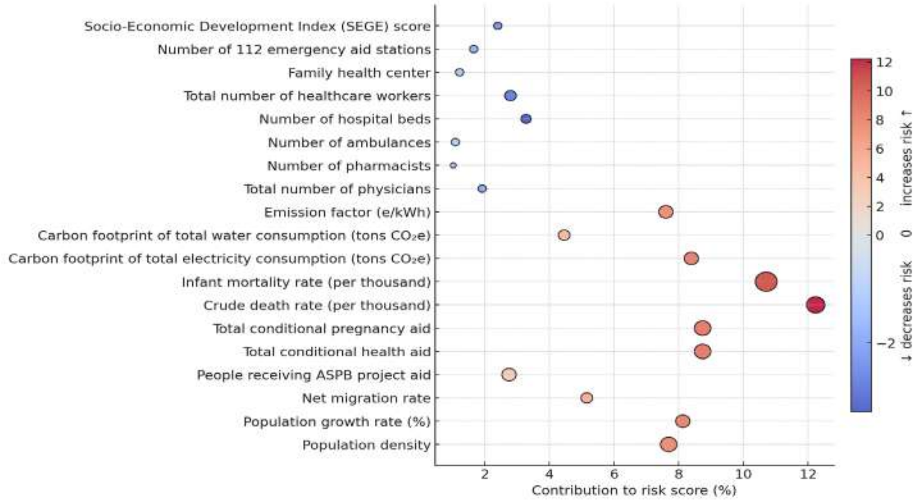


Figure 23. Contribution of indicators related to the public health sector to the risk score within the scope of heatwave risk.

Table 12. Indicators of exposure, sensitivity, and adaptation capacity for the public health sector.

Exposure	Sensibility	Adaptability
Population Density	Crude Death Rate (per thousand)	Total Number of Physicians
Net Migration Rate	Infant Mortality Rate (per thousand)	Number of Pharmacists
Population Growth Rate (%)	Total Electricity Consumption Carbon Footprint	Number of Ambulances
Number of Beneficiaries of Ministry of Family and Social Services (ASHB) Project Support	Total Water Consumption Carbon Footprint	Number of Available Hospital Beds
Number of Conditional Health Assistance Received	Emission Factor	Total Number of Healthcare Workers
Number of Conditional Pregnancy Assistance Received		Number of Family Health Centers
		Number of 112 Emergency Medical Service Stations

These indicators reveal the population groups and systemic pressures that determine the level of exposure in the public health sector during heatwaves.
Increased population density, rapid migration, and dependence on social assistance show that vulnerable groups are at risk; while health support programs strengthen adaptation capacity.

These indicators reveal the vulnerability of the public health sector to heatwaves.
Rising mortality rates, infant health risks, and high carbon emissions amplify the health impacts of heatwaves, while protecting air and water quality is critical to building societal resilience.

These indicators reveal the resilience and adaptability of the public health sector to heat waves.
High healthcare personnel and infrastructure capacity, emergency response systems, and a strong socio-economic structure form the basis of effective crisis management and preventive health services against heat waves in Adapazarı.

2. Agriculture and Food Safety Sector Exposure-Sensitivity-Adaptability Analysis

A risk analysis was conducted for Adapazarı district to anticipate the potential threats that heat waves may pose to the agriculture and food security sectors and to determine the necessary preventive measures. The analysis evaluated the following indicators, and vulnerability levels were determined based on these components, thus establishing the overall risk level.

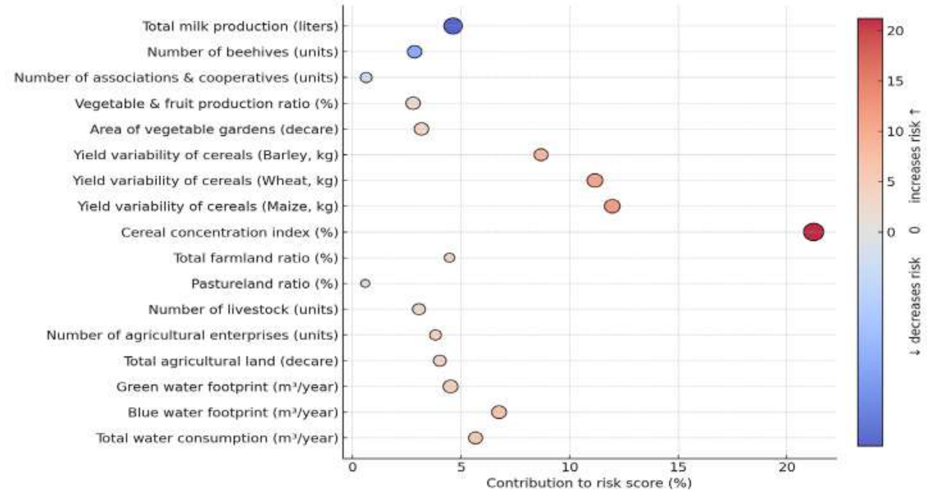


Figure 24. Contribution of indicators related to the agriculture and food sector to the risk score within the scope of heatwave threat.

Table 13. Indicators of exposure, sensitivity, and adaptability for the agriculture and food sector.

Exposure	Sensibility	Adaptability
Total Water Consumption (m^3/year)	Grain Density Index (%)	Number of Associations and Cooperatives (units)
Blue Water Footprint (m^3/year)	Grain Yield Variability – Maize (kg)	Number of Beehives (units)
Green Water Footprint (m^3/year)	Grain Yield Variability – Wheat (kg)	Total Milk Production (liters)
Total Agricultural Area (decar)	Grain Yield Variability – Barley (kg)	
Number of Animals (units)	Vegetable Garden Area (decar)	
Number of Agricultural Enterprises (units)	Vegetable and Fruit Production Rate (%)	
Pasture Area Percentage (%)		

These indicators reveal the high level of exposure of the agriculture and food security sector to heat waves.
Increased water demand, along with the pressure of extreme heat on livestock and production, are among the key factors threatening food supply security.

These indicators reveal the vulnerability of agricultural production and the food supply chain to heat waves. Reduced crop diversity and volatility in grain yields weaken food supply security; diversification strategies are crucial in reducing vulnerability.

These indicators reveal the adaptation capacity and resilience of the agriculture and food security sector to heat waves. Strong producer organizations, the protection of pollination ecosystems, and livestock production capacity are key elements that increase the resilience of food systems to rising temperatures.

3. Energy Sector Exposure-Sensitivity-Adaptability Analysis

Within the context of heatwave threats, a risk analysis was conducted to anticipate potential threats to the energy sector, both present and future, and to determine measures to address them. This analysis assessed the sector's exposure, sensitivity, and adaptation capacity levels; vulnerability levels were determined based on these components, and the overall risk level was established.

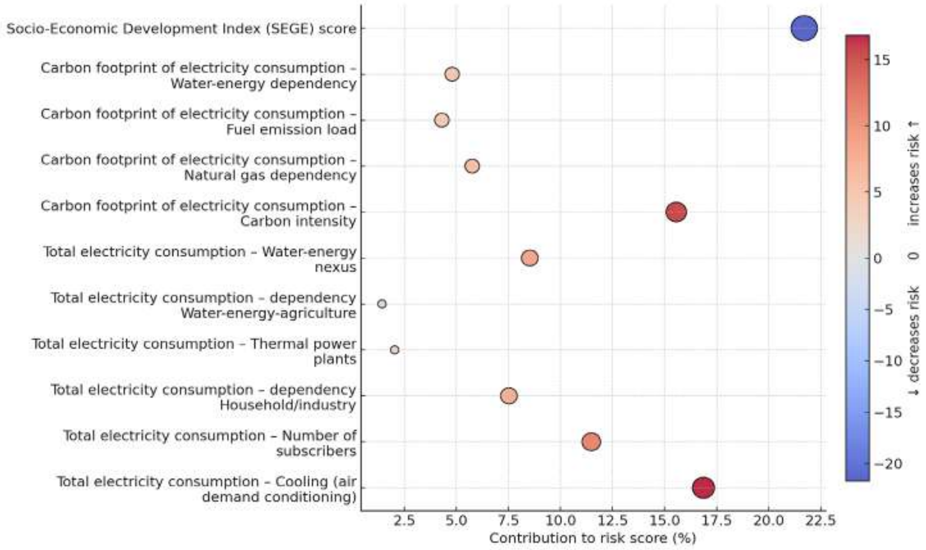


Figure 25. Contribution of indicators related to the energy sector to the risk score within the scope of heatwave threat.

Table 14. Indicators of exposure, sensibility, and adaptability for the energy sector.

Exposure	Sensibility	Adaptability
Total Electricity Consumption (MWh/year)	Carbon Footprint of Electricity Consumption (tons CO_2e/year)	SEGE Score
Number of Natural Gas Subscribers	Natural Gas Emission Factor (EF)	
These indicators show that the energy sector is highly vulnerable to heat waves, and increasing energy demand and grid load amplify the risks.	These indicators show that the energy sector is highly sensitive to heat waves, and that the carbon intensity of energy production, in particular, increases environmental vulnerability.	This indicator reflects the energy sector's resilience and adaptability to heat waves. An improved socio-economic structure, infrastructure security, and demand management capabilities contribute to risk mitigation.

4. Tourism and Cultural Heritage Sector Exposure-Sensitivity-Adaptability Analysis

A risk analysis was conducted in Adapazarı district for the tourism and cultural heritage sectors in the context of the heatwave threat.
This analysis assessed the sector's exposure, sensitivity, and adaptation capacity levels; vulnerability levels were determined based on these components, and the overall risk level was established.

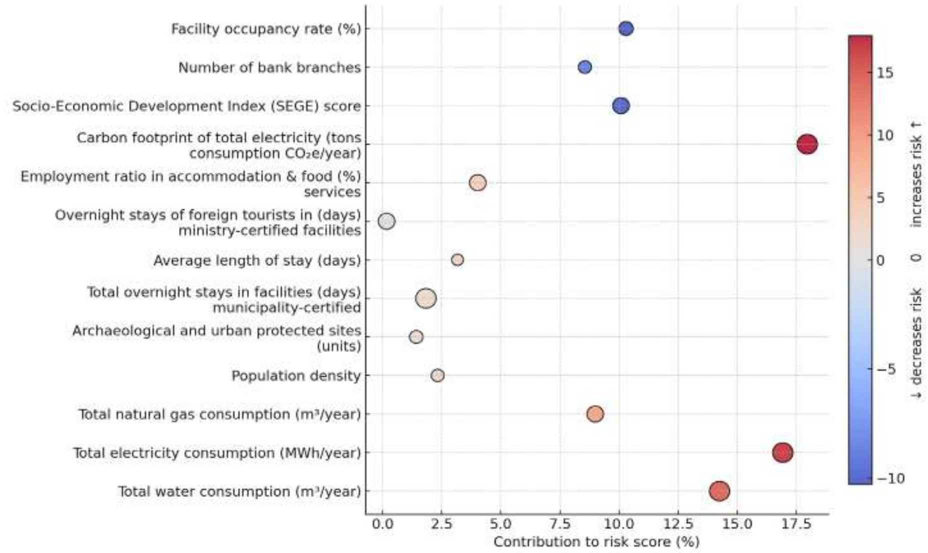


Figure 26. Contribution of indicators related to the tourism and cultural heritage sector to the risk score within the scope of heatwave risk.

Table 15. Indicators of exposure, sensitivity, and adaptation capacity for the tourism and cultural

Exposure	Sensibility	Adaptability
Total Water Consumption (m^3/year)	Total Number of Overnight Stays in Municipality-Certified Facilities (days)	SEGE Score
Total Electricity Consumption (MWh/year)	Average Length of Stay (days)	Number of Bank Branches (units)
Total Natural Gas Consumption (m^3/year)	Number of Overnight Stays by Foreign Tourists in Ministry-Certified Facilities (days)	Occupancy Rate of Tourism Facilities (%)
Population Density	Employment Rate in the Accommodation and Food Services Sector (%)	
Archaeological and Urban Sites	Carbon Footprint of Total Electricity Consumption (tons CO_2e/year)	
These indicators reveal that the tourism and cultural heritage sectors have a high level of exposure to heat waves. Increased water and energy demand and intense visitor pressure increase the burden on infrastructure, creating critical risks in terms of service quality and the preservation of cultural assets.	Heat waves risk reducing accommodation demand and length of stay by decreasing the thermal comfort of visitors, while simultaneously negatively impacting the health and productivity of service sector workers. This, combined with increased cooling needs in facilities, creates both operational challenges and additional energy and carbon costs for the sector.	These indicators reflect the resilience and adaptability of the tourism and cultural heritage sectors to heat waves. Developed infrastructure, financial access, and strong operational capacity are key elements that enhance the sector's ability to manage crises and adapt.

5. Social Development Sector Exposure-Sensitivity-Adaptability Analysis

Within the context of the heatwave threat, the risks that may arise now and in the future in urban residential areas and the social development sector in Adapazarı district have been examined, and a risk analysis has been carried out in light of these facts.

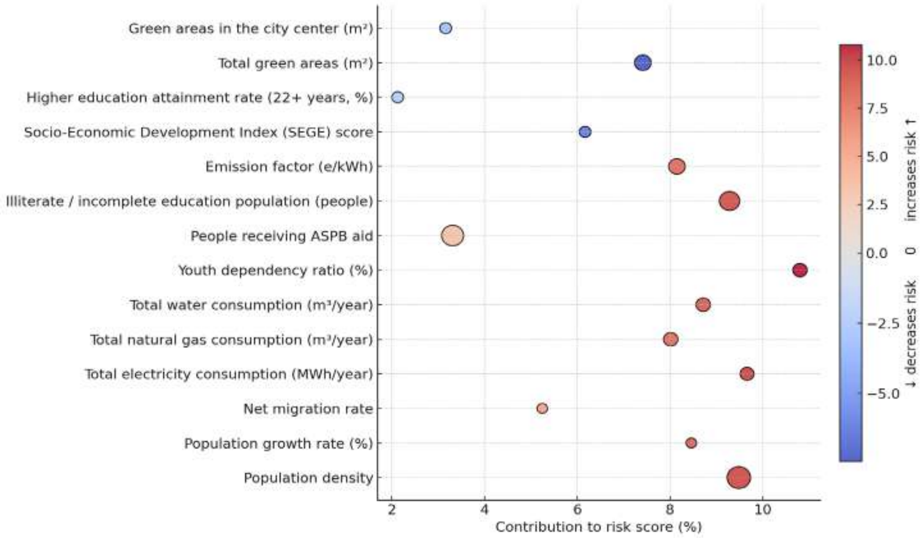


Figure 27. Contribution of indicators related to the social development sector to the risk score within the scope of heatwave risk.

Table 16. Indicators of exposure, sensitivity, and adaptability for the social development sector.

Exposure	Sensibility	Adaptability
Population Density	Youth Addiction Rate (%)	SEGE Score
Population Growth Rate (%)	Number of People Benefiting from the Social Assistance and Solidarity Foundation	Higher Education Rate (22+ years, %)
Net Migration Rate	Illiterate or Those Who Have Not Completed School Education (persons)	Total Green Area (m²)
Total Electricity Consumption (MWh/year)	Emission Factor (e/kWh)	City Center Green Area (m²)
Total Natural Gas Consumption (m^3/year)		
Total Water Consumption (m^3/year)		

These indicators show that the social development sector has a high level of exposure to heat waves.
Increased population density and energy-water demand place critical pressures on infrastructure and service systems, increasing social vulnerability.

These indicators reveal the social and environmental vulnerabilities of the social development sector to heat waves.
High youth dependency ratios, low education levels, and dependence on social assistance are key factors that weaken the resilience of society to extreme heat.

These indicators reveal the factors that strengthen social and ecological resilience against heat waves in Adapazarı.
High socio-economic development, education level, and the presence of green spaces are the main factors that form the basis of risk reduction strategies.

SUMMARY

- **Energy Sector:**
Increasing electricity and natural gas demand is creating significant pressure on energy infrastructure; carbon-intensive production increases vulnerability, while advanced infrastructure and management capacity strengthen adaptation.

- **Tourism and Cultural Heritage Sector:**
High energy and water consumption and intense tourist pressure increase infrastructure vulnerability; financial access and facility modernization support resilience.

- **Social Development Sector:**
Increasing population, migration, and low education levels increase social vulnerability; socio-economic development and the presence of green spaces strengthen adaptation capacity.

- **Agriculture and Food Security Sector:**
Excessive water demand, grain yield volatility, and monoculture production increase vulnerability; producer organizations and ecosystem services ensure resilience.

- **Public Health Sector:**
Increasing population density, migration, and emission pressures increase health risks; strong health infrastructure and personnel capacity enhance adaptation ability.

Sector	Exposure	Sensibility	Adaptability
Energy Sector	Increasing demand for electricity and natural gas is putting critical pressure on energy supply.	High carbon intensity increases environmental vulnerability.	An advanced socio-economic structure and modern infrastructure strengthen demand management capacity.
Tourism and Cultural Heritage Sector	Increased water and energy use and intense visitor pressure pose risks to infrastructure.	High tourist density and worker heat stress reduce service quality.	Access to finance and modern facility infrastructure enhance crisis management capacity.
Social Development Sector	Increased population density and energy and water demand are increasing pressure on infrastructure.	Reduced product diversity and volatility in grain yields weaken supply security.	Education level, socio-economic development, and the presence of green spaces strengthen societal resilience.
Agriculture and Food Security Sector	Increased water demand, production area pressure, and livestock heat stress threaten food security.	Increased mortality rates, infant health risks, and deteriorating air and water quality increase health vulnerability.	Strong cooperatives, pollination ecosystems, and production capacity increase sectoral resilience.
Public Health Sector	High population density, migration, and dependence on social assistance are increasing vulnerable groups.	Long road network, population density	Healthcare personnel, infrastructure capacity, and strong emergency response systems support crisis management.

Table 17. Qualitative assessment of exposure, sensitivity, and adaptation capacity components by sector.

Heat waves create vulnerability in Adapazarı through increased energy demand across all sectors, health risks, and socio-economic pressures. However, strong infrastructure, education, and organizational capacity form the cornerstones of regional resilience and sustainable adaptation strategies.

ADAPAZARI CLIMATE CHANGE VULNERABİLİTY AND RISK ASSESSMENT

The Black Sea Basin is one of the most sensitive geographical areas that will determine Turkey's climate future. Cities in alluvial plains, like Adapazarı, are complex systems that can simultaneously experience both water surplus and water scarcity risks. According to analyses, if current trends continue, disrupting this balance will create not only an environmental but also a socio-economic breakdown.

Rising Temperatures: A Silent Threat

According to RCP4.5 climate scenarios, the average annual temperature in Adapazarı will increase by 1.5–2.5°C by 2050.
This increase will lead to increased heat-related stress, especially during the summer months, loss of yield in agricultural products, and an intensification of the heat island effect in the city.
According to seasonal analyses, winters will become increasingly milder, while summers will become longer and drier, which could reduce soil moisture and groundwater levels in the Sakarya Plain, disrupting the ecosystem balance.
If no precautions are taken, the average annual temperature in the region could rise above 17°C by the 2080s, paving the way for a transition from the Marmara climate to subtropical conditions.

Imbalances in Precipitation and the Water Cycle

The data shows that there will be a change in the intensity and timing of rainfall, not a significant decrease in the total amount.
In other words, more intense rainfall over a shorter period: this means that the risk of flooding will increase exponentially.
At the same time, long dry periods in spring and summer will lower groundwater levels and increase the need for agricultural irrigation.
This imbalance will weaken Adapazarı's delicate relationship with the Sakarya River, potentially increasing sediment accumulation and flood frequency in the river.

Black Sea Ecosystem

The Black Sea is one of the fastest warming seas due to global climate change. Satellite observations show that sea surface temperatures have risen by 1.2°C in the last 50 years, and oxygen levels in deep waters have decreased by 40%. This directly affects both the marine ecosystem and coastal cities. The decline in economically important species such as anchovy and sprat is making fishing in the region difficult, while the disruption of the moisture balance transported from the sea to the land is triggering extreme rainfall and humidity fluctuations in transition zones like Adapazarı. In the long term, this process risks irreversibly altering the ecological balance of the Black Sea.

Socio-Economic Impacts: Silent Migrations and Economic Shifts

Climate risks will transform not only the environment but also human mobility and the economic structure.
After 2050, a new wave of internal migration from rural areas to the city center is expected in Adapazarı, due to the combination of rising temperatures, decreased agricultural production, and flood risks.
This will put pressure on infrastructure while increasing water and energy demand.
Furthermore, the increased energy demand (cooling, drinking water treatment, agricultural irrigation) will also increase carbon emissions, creating a vicious cycle.
If no precautions are taken, Adapazarı will:
- Experience a doubling of annual floods,
- A 15% decrease in groundwater reserves,
- A 30% increase in urban heat island effect,
- A 20% loss in agricultural yields,
- Exceed 40 days of extreme heat per year.

These indicators represent a chain reaction that will affect not only nature but also the economy and social structure.

This plan, developed for the Adapazarı district, offers a data, science, and participation-based roadmap to reverse this situation:
- Strengthening blue-green infrastructures,
- Water efficiency action plans,
- Smart early warning systems,
- Community-based disaster management,
- Sustainable agricultural practices and groundwater monitoring systems,

are vital to mitigating climate risks in the next 10 years.

CLIMATE CHANGE ADAPTATION STRATEGIES

Analyses have shown that drought, heavy rainfall, and heat waves are the three main climate hazards in Sakarya province. Each affects different sectors, infrastructures, and social groups in different ways.

Below, under these three hazard headings, sectoral impacts, risk analysis results, and strategic adaptation recommendations are presented in order.

DANGER OF HEAVY RAINFALL

Heavy rainfall poses multifaceted risks in urban areas, straining infrastructure capacity, deepening social vulnerabilities, and putting pressure on environmental systems. These effects, varying depending on the demographic, physical, and socio-economic structure of cities, **necessitate a holistic risk mitigation approach.** This section addresses strategic intervention areas in urban planning, resource management, and community resilience, exploring how to strengthen cities' capacity to adapt to heavy rainfall.

1. In the Urban Sector
Strategies for Mitigating the Effects of Heavy Rainfall

Urban floods, infrastructure disruptions, and social impacts are closely related to demographic pressures, spatial development patterns, and the limitations of existing service capacity. Accordingly, strategies to enhance urban resilience encompass infrastructure improvements as well as water management, reducing social vulnerabilities, and strengthening green infrastructure solutions.

Risk Sensitive Urban Planning and Infrastructure Strengthening

Rapid population growth and migration pressures place a significant burden on existing infrastructure. Therefore, adopting risk-sensitive planning approaches in urban development processes is a critical priority.

Planning new disaster-resistant settlements in areas with low flood risk, strengthening the existing building stock against disasters, and accelerating infrastructure investments in areas receiving migration constitute the fundamental elements of this goal. In addition, integrating risk maps into planning processes will enable decision-makers to direct spatial development in a way that reduces disaster risks.

Sustainable Resource Management and Environmental Resilience

High water consumption, while reflecting the economic and social vitality of the city, is also a factor that increases vulnerability to heavy rainfall. Therefore, developing sustainable resource management strategies is of great importance.

Promoting water conservation and efficiency practices, reusing greywater and rainwater, and supporting technologies that reduce water demand are prominent in this context. In addition, green infrastructure solutions that contribute to rainwater management, such as rain gardens, permeable surfaces, and green roofs, will strengthen urban ecosystem services and increase environmental resilience.

Strengthening Social Resilience

Socio-economic vulnerability is one of the determining factors in post-disaster recovery processes.

Groups benefiting from social assistance mechanisms are particularly vulnerable to the effects of heavy rainfall.

Therefore, integrating social support systems with disaster risk management is of great importance.

Developing post-disaster recovery programs that include vulnerable groups will reduce social inequalities and strengthen resilience.

2. In the Agriculture and Food Security Sector
Strategies for Mitigating the Effects of Heavy Rainfall

Yield fluctuations in agricultural production, dependence on water and natural resources, and monoculture production patterns are key factors that increase the sector's vulnerability under conditions of excessive rainfall. Conversely, product diversification, cooperative structures, and local knowledge offer significant advantages that strengthen adaptability. In this context, improving agricultural infrastructure and supporting diversification in production systems stand out as critical areas for intervention.

Sustainable Management of Water and Natural Resources

The vulnerability of the agriculture and food security sector to heavy rainfall stems largely from its high dependence on water and natural resources. The intensive water use in agricultural irrigation systems and livestock activities exacerbates the effects of climatic fluctuations. Therefore, increasing water use efficiency and integrating resource management into long-term planning is critically important. Widespread adoption of innovative and efficient irrigation technologies will not only ensure production continuity but also contribute to the conservation of water resources.

Diversity and Resilience in Production Systems

The concentration of agricultural production in certain crop groups (especially high dependence on cereals) increases the sector's vulnerability to climate events. Heavy rainfall can cause significant fluctuations in cereal yields, posing a risk to food security. Therefore, increasing crop diversity and promoting the use of climate-resistant seed varieties are among strategic priorities. Diversifying the crop pattern will not only distribute risks but also strengthen the resilience of rural economies.

Strengthening Agricultural Workforce and Social Resilience

Labor dynamics in agricultural production play a critical role in managing climate risks. High age dependency ratios increase pressure on human resources in production systems and can limit service capacity in disaster situations. In this context, implementing policies that support the participation of young people and women in the agricultural workforce will strengthen both production capacity and social resilience. Strengthening social support mechanisms in rural areas and developing training programs for producers will contribute to disaster preparedness and recovery processes.

Increasing Institutional and Organizational Capacity

Agricultural organizations and cooperatives are key actors in strengthening solidarity and adaptation capacity among producers. Through these structures, information sharing, the dissemination of early warning systems, and effective coordination of post-disaster processes become possible. Strengthening organizational capacity will increase the sector's resilience not only to heavy rainfall but also to other risks related to climate change. Therefore, supporting institutional cooperation mechanisms and strengthening producer organizations will form the basis of long-term adaptation strategies.

3. In the Water Resources Sector Strategies for Mitigating the Effects of Heavy Rainfall

Increasing consumer demand, limitations in infrastructure capacity, and demographic pressures can make water management systems more vulnerable during periods of extreme rainfall. However, treatment plants, drainage systems, and green spaces offer significant opportunities to mitigate the effects of flooding. In this context, sustainable water demand management, increased infrastructure resilience, and support for vulnerable groups are considered priority areas for intervention.

Managing Demographic Pressures

A significant portion of the pressure on water resources stems from demographic dynamics. High population growth rates and dependent population ratios increase demand on service infrastructure and can lead to resource shortages. Therefore, integrating demographic projections into water demand scenarios is critical. Risk-sensitive zoning and service planning should be prioritized to limit the impact of urban sprawl on water resources. Furthermore, aligning water infrastructure capacity investments with population growth rates will contribute to preventing potential crises.

Strengthening Infrastructure and Natural Systems

One of the most critical areas in mitigating the impact of heavy rainfall on water resources is strengthening infrastructure and natural systems. While existing rainwater and sewer systems contribute positively to risk reduction, it is necessary to increase their capacity and ensure their regular maintenance. Making the drinking water distribution network resilient to weather conditions will ensure service continuity after heavy rainfall. In addition, increasing urban green spaces and protecting natural buffer zones will not only reduce flood risks but also support the conservation of water resources through ecosystem services.

Sustainable Water Management

High total water consumption reflects the economic and social vitality of the city, but also increases resource vulnerability. Therefore, the development of sustainable water management policies is necessary. Expanding water efficiency programs, promoting rainwater harvesting and greywater reuse, directly contributes to reducing demand. Furthermore, monitoring water use, particularly in the industrial and agricultural sectors, and strengthening conservation mechanisms will increase resource efficiency and support the overall resilience of the region.

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4. Strategies for Mitigating the Effects of Heavy Rainfall in the Transportation and Communication Sector

Disruptions to transportation and communication networks caused by excessive rainfall can lead to significant problems in both economic activities and emergency management. The extent of these effects is closely related to population density, transportation demand, and the capacity of existing infrastructure. Therefore, strengthening critical lines, planning alternative routes, and developing supportive solutions with nature-based practices are among the priority strategic areas.

Demographic and Transportation Demand Management

One of the most significant factors increasing the vulnerability of the transportation and communication sector to heavy rainfall is rapid population growth and the resulting demand for transportation. The large vehicle fleet and the increasing total vehicle kilometers each year weaken traffic safety and complicate evacuation processes during disasters. Therefore, planning transportation demand in line with population projections is of strategic importance. Strengthening public transportation systems, reducing reliance on private vehicles, and implementing disaster-adapted traffic management systems will reduce pressure on infrastructure and enable safer and faster evacuations in emergencies.

Supporting Natural and Green InfrastructureNatural and green infrastructure plays a significant role in enhancing the resilience of transportation systems to heavy rainfall. Green spaces reduce surface runoff, preventing water from overloading drainage systems, mitigating floods, and supporting urban water management. Therefore, expanding green spaces and creating natural buffer zones will significantly contribute to risk reduction. Furthermore, the use of permeable surfaces and nature-based solutions will strengthen transportation infrastructure. This approach complements engineering solutions, offering a holistic framework for managing disaster risks.

Strengthening Critical Transportation and Communication Infrastructure

One of the most significant impacts of heavy rainfall is disruption to transportation and communication infrastructure. These disruptions negatively affect not only transportation services but also supply chains and economic activity. The high number of employees in these sectors exacerbates the social and economic consequences of these disruptions. Therefore, investing in flood protection measures at critical points and planning alternative routes are strategic priorities. These measures will ensure service continuity even in adverse weather conditions.

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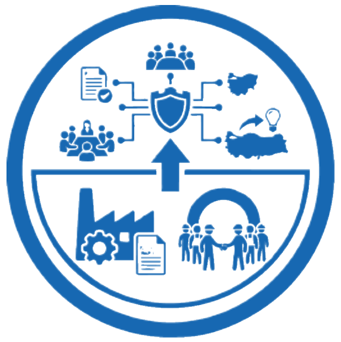
5. Strategies for Mitigating the Effects of Heavy Rainfall in the Industrial Sector

Flooding, power outages, and logistical problems in production areas can directly affect the operational continuity of industrial facilities. The sector's dependence on water and energy increases these vulnerabilities, while a strong institutional structure and technological infrastructure create significant adaptation advantages. In this context, increasing infrastructure resilience, improving resource efficiency, and strengthening sectoral cooperation are prominent areas for intervention.

Reducing Energy and Water Dependence

High water and energy consumption in the industrial sector directly impacts the sustainability of production capacity. Infrastructure failures or supply chain disruptions that may occur during heavy rainfall can increase the vulnerability of businesses and amplify economic losses. Therefore, promoting technologies that enable more efficient use of water and energy, supporting renewable energy investments, and implementing backup/diversification solutions in critical infrastructure are strategic necessities. These measures will not only reduce disaster risks but also contribute to the long-term competitiveness of the industrial sector.

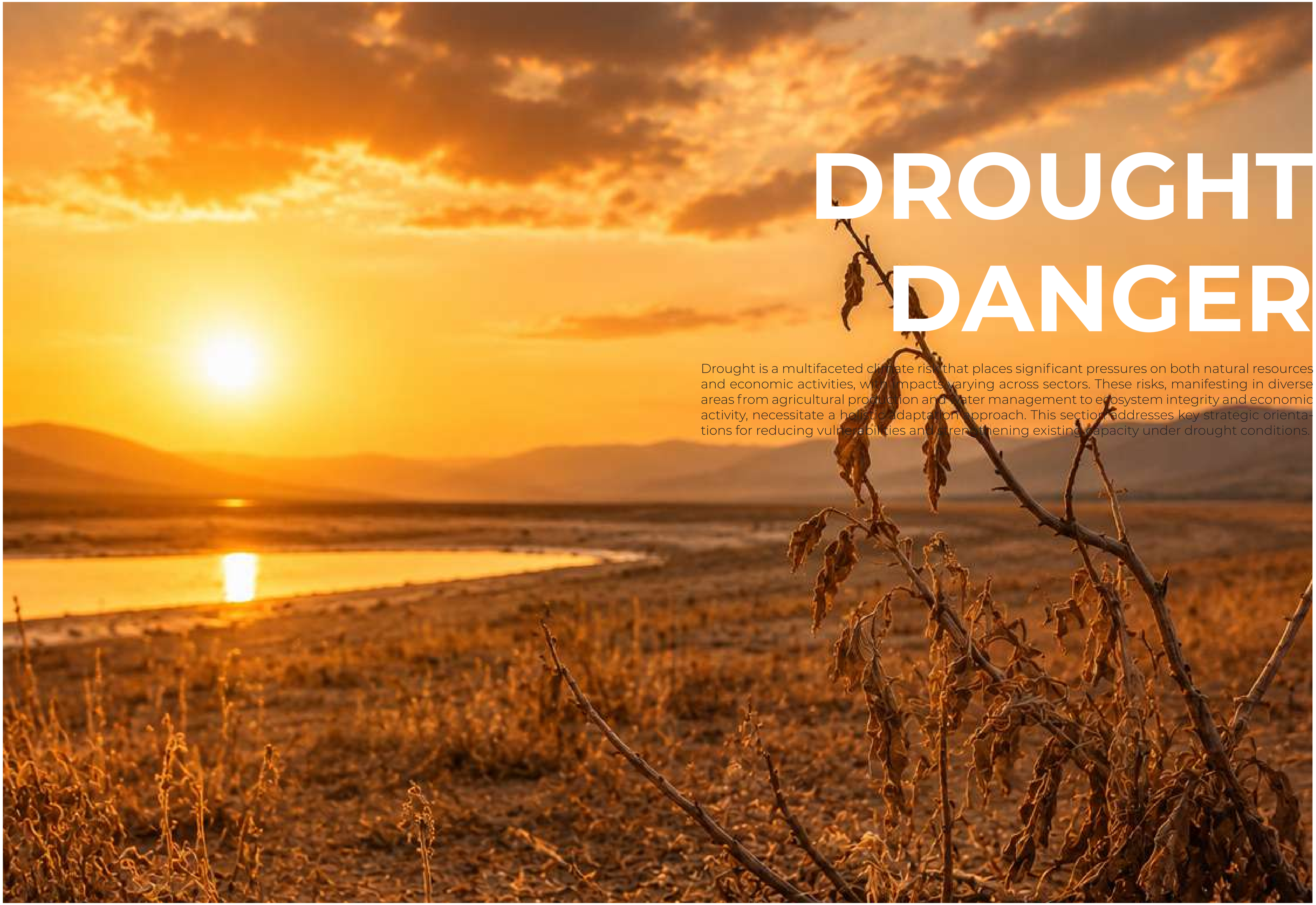
Strengthening Corporate and Organizational Resilience



One of the strongest aspects of the industrial sector is its institutional capacity and level of organization. Businesses with capacity reports, registered workforce, and industry associations provide critical mechanisms for coordination and resource mobilization during disasters. Through these structures, it becomes possible to standardize business continuity plans, ensure the active participation of employee organizations in crisis management, and transfer best practices from developed regions to other regions. These steps will enable the industrial sector to maintain its effectiveness and minimize economic losses even under disaster conditions.

Risk-Sensitive Planning in Industrial Zones

Organized Industrial Zones (OIZs) and areas with high employment density are among the regions most vulnerable to the potential impacts of heavy rainfall. Adopting risk-sensitive planning approaches in these areas is critical for both facility safety and employee protection. Integrating flood risk maps into OIZ planning, investing in protective infrastructure for critical production facilities, and preparing emergency plans that prioritize employee safety will strengthen sectoral resilience. This approach will enable industry not only to maintain its production capacity but also to contribute to public safety.



DROUGHT DANGER

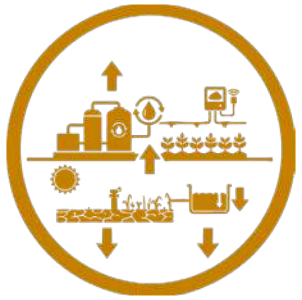
Drought is a multifaceted climate risk that places significant pressures on both natural resources and economic activities, with impacts varying across sectors. These risks, manifesting in diverse areas from agricultural production and water management to ecosystem integrity and economic activity, necessitate a holistic adaptation approach. This section addresses key strategic orientations for reducing vulnerabilities and strengthening existing capacity under drought conditions.

1. Strategies for Mitigating the Effects of Drought in the Agricultural Production and Food Security Sector

Analyses show that the agriculture and food security sector is particularly vulnerable to drought due to its high water dependence, the vastness of irrigated areas, and the concentration of grain production. These structural vulnerabilities can lead to production losses, income fluctuations, and disruptions in the supply chain. Conversely, the diversity in fruit and vegetable production and cooperative organization are strong points that support the sector's adaptability. Strategies developed in this direction should focus on key priorities such as increasing water use efficiency, diversifying production patterns, and strengthening producer resilience. This approach will not only limit losses during drought periods but also support the long-term sustainability of agricultural and food systems.

Reducing Dependence on Water

In drought conditions, the most critical vulnerability of the agriculture and food sector is its high water dependence in production processes. The vastness of irrigated areas, high total water consumption, and the size of the blue water footprint lead to a rapid increase in demand pressure during drought periods. This not only accelerates the depletion of existing water resources but also deepens supply-demand imbalances in both rural and urban areas. To reduce this dependence, the widespread adoption of modern irrigation technologies, the development of systems that enable water reuse, and the direct integration of water management into agricultural planning are strategic necessities.



Reducing Yield Fluctuations

Yield fluctuations in cereals under drought conditions constitute one of the most vulnerable points in terms of food security. Frequent yield losses in wheat, barley, and maize production lead to fluctuations in farmers' incomes and price instability for consumers.
To reduce this vulnerability, it is necessary to implement climate-adaptive agricultural techniques, promote the use of drought-resistant seed varieties, and develop early warning systems that can predict yield losses. These measures will strengthen agricultural supply security by increasing the resilience of production systems.

Increasing Diversity in Production Systems

Analyses show that agricultural production patterns are largely dependent on cereals. High cereal intensity index and limited fruit and vegetable production diversity further amplify the effects of drought shocks. Monoculture-focused systems deepen yield losses during periods of water scarcity, while diversified production systems reduce vulnerability by spreading risks. Therefore, increasing crop diversity, supporting climate-resistant seed varieties, and encouraging farmers to adopt alternative crops are of great importance. Increasing diversity in production not only reduces agricultural vulnerability but also strengthens the resilience of rural economies.

Strengthening Corporate and Controlled Production Capacity

Drought resilience is possible not only through technical measures but also through strengthening institutional and societal capacity. Expanding cooperative structures reduces vulnerability by facilitating farmers' access to information, finance, and markets.
Similarly, controlled production systems, such as greenhouse farming, support adaptation by providing efficiency in water use, but their current scale is limited and needs to be expanded.
Furthermore, translating socio-economic development into sectoral benefits creates a more robust foundation for drought adaptation. This objective aims to reduce vulnerabilities by strengthening institutional organization and controlled production practices within the sector.

2. Strategies for Mitigating the Effects of Drought in the Water Resources Sector

Analysis findings reveal that high water consumption, extensive irrigation areas, and increasing demand pressure weaken water supply security during drought periods. These vulnerabilities can pose serious risks to both agricultural and urban systems, especially during prolonged periods of insufficient rainfall. However, treatment infrastructure, green spaces, and existing institutional experience offer significant opportunities for adaptation. Strategies developed in this context should focus on priority areas such as sustainable water demand management, increasing irrigation efficiency, expanding water reuse systems, and strengthening public awareness.

Sustainable Management of Water Demand

The greatest vulnerability during drought periods arises when water demand exceeds available supply. A high blue water footprint and increased total water consumption indicate a deepening reliance on surface and groundwater. This reliance leads to rapid resource depletion, weakening supply security during prolonged periods of insufficient rainfall. Furthermore, a high population growth rate creates continuous demand pressure.

Therefore, managing water demand in a more sustainable way is a strategic priority. Implementing demand management programs, expanding water conservation practices at the household and industrial levels, and reducing infrastructure losses will directly contribute to mitigating these vulnerabilities.

Reuse and Strengthening Infrastructure Capacity

Analyses reveal that despite high water consumption, recovery and reuse rates are low. This indicates that the existing infrastructure has the capacity to manage water more efficiently, but this potential is not being fully utilized. This weakness becomes even more pronounced under drought conditions.

Increasing wastewater treatment capacity, strengthening stormwater and sewerage systems, and expanding projects that promote water reuse will transform infrastructure into a tool for reducing vulnerability. This strategy is considered not only a technical measure but also a mechanism that strengthens water supply security in the long term.

Reducing Dependence on Agricultural Irrigation

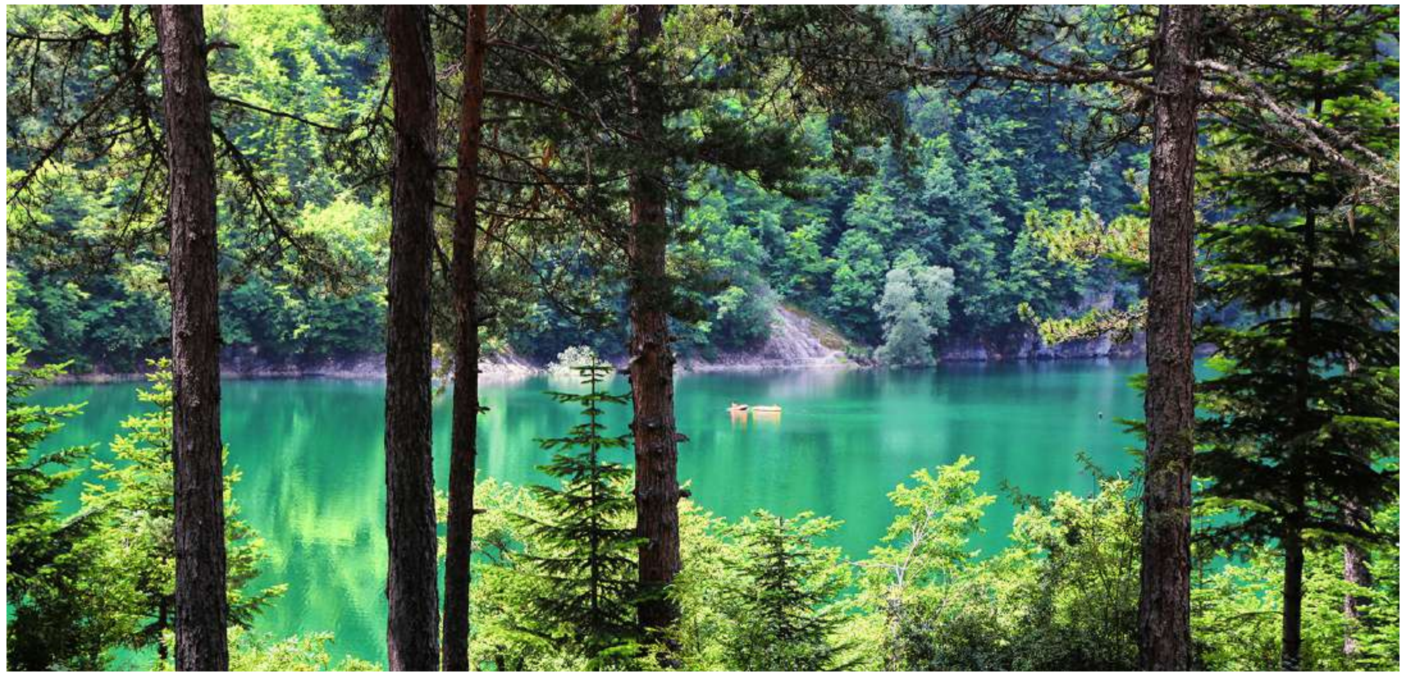
The high proportion of irrigated land and the heavy reliance on irrigation in agricultural production are among the most critical factors increasing the sector's vulnerability to drought. With the irregularity of rainfall patterns, agricultural water demand is increasing sharply, threatening both agricultural production and water supply security. To mitigate this vulnerability, increasing efficiency in irrigation technologies, supporting climate-resilient crop varieties, and promoting diversification in crop patterns are crucial. Such measures will reduce exposure by distributing the risks stemming from water-intensive and mono-crop-focused systems.

Supporting Ecosystem and Social Resilience

Drought affects not only technical infrastructure but also ecosystems and communities. The limited availability of green spaces reduces the capacity to benefit from ecosystem services and weakens the natural water retention potential within the hydrological cycle. This leads to the disruption of microclimates and further increases water demand in both urban and rural areas. At the same time, coping with drought becomes more difficult in regions with weak social organization capacity. Therefore, strengthening ecosystem services through nature-based solutions, protecting and expanding green spaces, and increasing community awareness and participation are of paramount importance.

3. Strategies for Mitigating the Impacts of Drought in the Biodiversity and Ecosystem Services Sector

Drought can have multifaceted impacts, including reduced biodiversity, weakened habitat integrity, and deterioration of ecosystem services, by limiting the regenerative capacity of ecosystems. Increased population, high water consumption, and habitat fragmentation exacerbate these vulnerabilities, while forest areas, green infrastructure, and civil society conservation activities offer significant adaptation advantages. Accordingly, priority strategies should focus on protecting natural habitats, strengthening ecological corridors, promoting nature-based solutions, and supporting community-based monitoring and conservation processes.



Reducing Human-Induced Pressures

In drought conditions, one of the most critical vulnerabilities of ecosystems stems from human-induced pressures. High population density, rapidly increasing water consumption, and the size of the blue water footprint weaken the regenerative capacity of natural systems. These pressures can lead to the drying up of aquatic ecosystems, a decrease in species diversity, and the unsustainable use of ecosystem services.

Therefore, implementing programs that increase water efficiency, developing land-use policies that prevent population growth from deepening habitat fragmentation, and adopting planning approaches that consider ecosystem services have become a strategic necessity.

Supporting Green Infrastructure and Community Participation

Another factor that reduces the vulnerability of biodiversity to drought is strengthening green infrastructure and community participation. Urban and rural green spaces contribute to water retention capacity, support the continuity of ecosystem services, and mitigate the negative effects of drought by reducing the urban heat island effect.

However, protecting and expanding these areas is crucial for reducing existing vulnerabilities. At the same time, more active participation of civil society organizations in monitoring, maintenance, and restoration activities will contribute to the protection of ecosystems while also increasing public awareness.

Preservation of Habitat Integrity

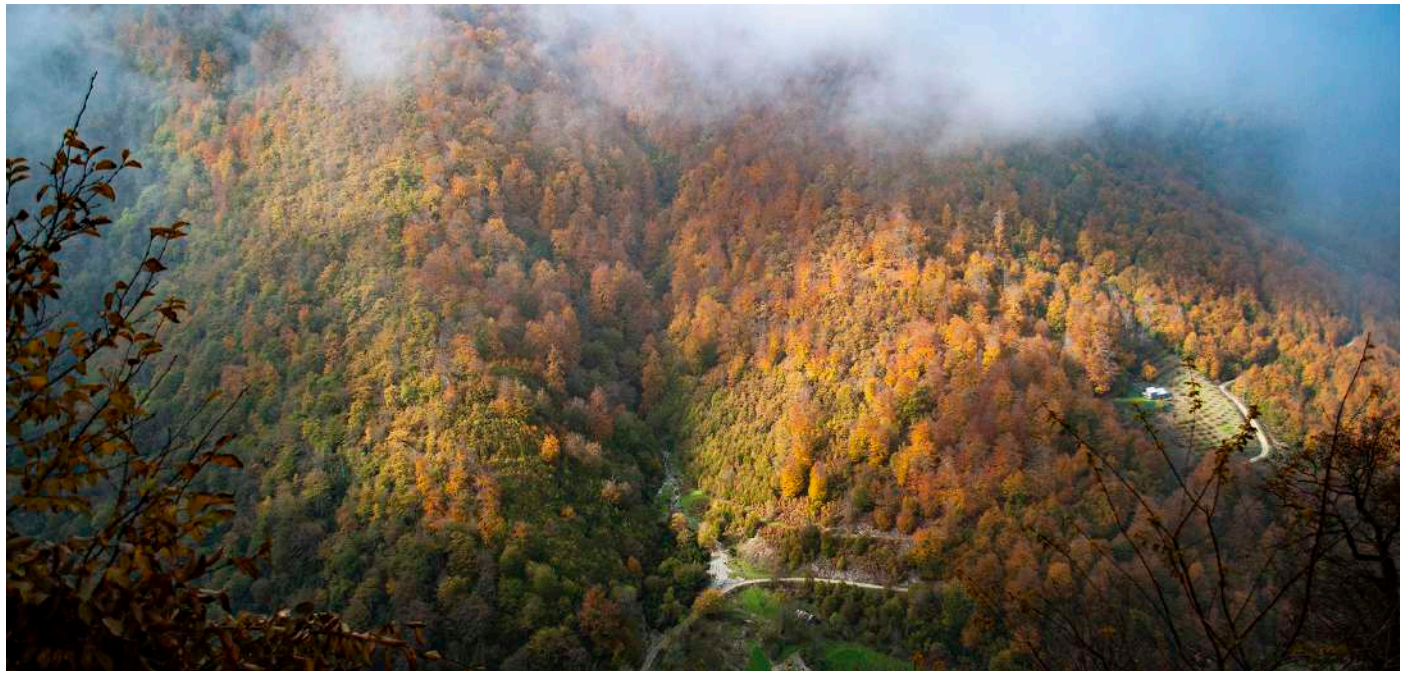
One of the most significant vulnerabilities facing biodiversity under drought conditions is habitat fragmentation. In particular, the expansion of settlements and the increase in the number of neighborhoods weaken ecosystem continuity and cause drought shocks to spread over wider areas. Loss of habitat integrity disrupts species migration routes and reduces ecosystem resilience.

Therefore, the creation of ecological corridors, limiting land-use changes that take drought impacts into account, and implementing spatial planning strategies that reduce fragmentation are critical. This goal not only protects natural habitats but also ensures the long-term sustainability of ecosystem services.

Strengthening Natural Tampons

Forest ecosystems play a vital role as natural buffer systems in combating drought. Through their microclimate regulation, moisture retention, and evaporation reduction capabilities, forests significantly mitigate the effects of drought. However, the shrinking of forest areas weakens these natural buffering mechanisms and increases vulnerability.

Therefore, the protection, expansion, and restoration of forest ecosystems not only reduce drought risks but also contribute to the conservation of biodiversity. In this context, ecosystem restoration projects and the integration of forests into climate adaptation policies should be among the strategic priorities.



HEATWAVE DANGER

Heat waves pose significant health risks, particularly to the elderly, infants, and vulnerable groups. Environmental stress and migration exacerbate this vulnerability, while existing health infrastructure proves inadequate. Therefore, the priority should be the protection of at-risk groups, strengthening health capacity, and reducing environmental risks.

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1. In the Public Health Sector
Strategies for Mitigating the Effects of Heat Waves

Analyses show that heat waves pose more significant health risks, particularly to the elderly, infants, and socioeconomically disadvantaged groups. While increasing environmental stressors and migration dynamics exacerbate these vulnerabilities, existing health infrastructure, although offering some adaptation capacity, is not entirely sufficient. Therefore, priority strategies should focus on protecting vulnerable groups, strengthening health response capacity, and mitigating environmental and infrastructural risks.

Protection of Vulnerable Groups

The greatest public health risk arises in vulnerable population groups most affected by heatwaves. Infants, the elderly, pregnant women, and individuals with chronic illnesses are at the forefront of these groups. Analysis results show that infant and crude mortality rates, in particular, reflect this vulnerability. Furthermore, the large size of the population benefiting from health and maternity assistance highlights the dependence of these groups on social support mechanisms.

Therefore, a strategic priority should be the development of targeted health and social policy tools for these groups. Activating early warning systems, expanding routine health checkups, and rapidly mobilizing social support networks during heatwaves are critically important.

Increasing Social Resilience

Mitigating the effects of heatwaves requires not only a strong healthcare system but also strong societal resilience. Population density and migration patterns can create inequalities in access to services. Individuals living in socioeconomically disadvantaged areas are at a disadvantage in accessing healthcare.

Therefore, strategies aimed at increasing societal resilience are vital. Establishing resilience networks at the neighborhood level, facilitating the integration of migrant populations into healthcare services, and implementing targeted support programs in disadvantaged areas are key elements of this goal.

Strengthening Healthcare Service Capacity

Heatwaves place a sudden and intense burden on the healthcare system. Increased emergency room visits, strain on hospital bed capacity, and increased workload for healthcare workers are direct consequences. Therefore, enhancing the resilience of the existing healthcare infrastructure is a strategic goal.

Increasing the number of physicians, nurses, pharmacists, and other healthcare workers, strengthening hospital bed capacity, and ensuring uninterrupted service in primary healthcare facilities (family health centers, 112 emergency stations) during crisis periods are key steps to increase adaptability. In addition, providing disaster-focused training to healthcare workers and developing emergency response protocols specific to heatwaves will strengthen the system's resilience.

Reducing Environmental and Infrastructural Risks

The effects of heat waves are not limited to the health sector; environmental and infrastructural factors also increase risk levels. Carbon emissions associated with high energy and water consumption are a significant determinant of heat stress. Furthermore, the emission intensity of electricity generation negatively impacts urban air quality during heat waves.

Therefore, the strategic objective should focus on reducing environmental and infrastructural risks. Implementing energy and water efficiency programs, installing backup energy and cooling systems in critical health facilities, and increasing green spaces to mitigate the urban heat island effect are key components of this objective. These measures will not only reduce the burden on the health system but also strengthen the overall adaptation capacity of the community.

2. In the Agriculture and Food Security Sector Strategies for Mitigating the Effects of Heat Waves

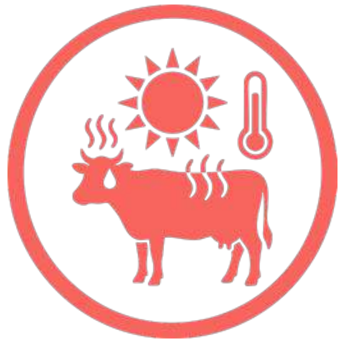
Heat waves can affect food security by causing losses in both yield and quality of agricultural production. High water consumption, blue water footprint, and the concentration of grain production increase this vulnerability, while crop diversification and ecosystem services offer certain advantages. In this context, adaptation strategies should focus on reducing water dependence, increasing production diversification, and protecting the food supply.

Reducing Instability in Grain Production

One of the most critical effects of heat waves is the increased volatility in grain yields. Variability in staple crops such as wheat, maize, and barley creates fragility in the food chain and leads to price instability. Furthermore, a high grain density index indicates that production is monoculture-based and that dietary diversity is limited.
This exposes producers to economic vulnerability and society to food security risks. Addressing these problems requires diversification of crop patterns, support for heat and drought-resistant seed varieties, and the implementation of alternative supply policies in the food chain.

Strengthening Food Security

Heatwaves affect not only production processes but also the quality of food available to the population. In livestock, heat stress leads to yield and quality losses and increases the risk of zoonotic diseases; fluctuations in milk production restrict access to protein and calcium, posing a serious health threat, especially for children, the elderly, and individuals with chronic diseases. Similarly, reductions in fruit and vegetable production weaken dietary diversity and deepen micronutrient deficiencies. To mitigate these risks, promoting controlled production practices, protecting the supply of milk and animal products, and supporting heat-tolerant fruit and vegetable varieties are critical for both public health and food security.



3. In the Energy Sector
Strategies for Mitigating the Effects of Heat Waves

Increased cooling demand during heatwaves can intensify energy demand pressure, leading to grid overload. The sector's dependence on fossil fuels increases both supply security and environmental vulnerabilities. However, technological advancements and investments in renewable energy offer significant opportunities. Accordingly, strategies should focus on demand management, diversification of production systems, and reduction of carbon intensity.

Strengthening Energy Demand Management

The energy sector's most critical vulnerability to heat waves stems from increased demand pressure. High reliance on air conditioning and refrigeration systems places a strain on grid capacity and threatens supply security. The increase in subscriber numbers and the sensitivity of electricity demand to seasonal fluctuations lead to a sharp increase in risks during heat waves. To mitigate these vulnerabilities, strengthening demand-side management, promoting high-efficiency technologies, and implementing mechanisms to encourage energy conservation have become a strategic necessity.

Increasing Socio-Economic Resilience

The impacts of heatwaves on energy demand and supply security are not limited to technical infrastructure but also extend to the societal dimension. Rising energy prices and supply disruptions make it more difficult for vulnerable groups to access energy, increasing social vulnerability. Therefore, it is necessary to reflect socio-economic development levels in the energy sector, accelerate infrastructure modernization investments, and strengthen the coordination capacity of local governments during crisis periods. In addition, activating social support mechanisms during energy crises will help protect the most vulnerable groups and strengthen societal resilience.

Diversification and Enhancement of the Resilience of Energy Production Systems

Heat waves also create vulnerabilities in energy production processes. In particular, the dependence of thermal power plants on cooling water places additional pressure on energy supply security under high temperature conditions. Similarly, the dependence of energy-intensive industrial processes on electricity increases production losses and deepens economic vulnerabilities. Therefore, increasing energy source diversification, developing technologies with low water dependence, and accelerating the transformation of energy-intensive industrial processes are critically important. These measures will make energy production and consumption systems more resilient to climate shocks.

Reducing Carbon Intensity

Another point of vulnerability in the energy sector is high carbon intensity. Fossil fuels used in electricity generation not only increase emissions but also complicate energy supply security in the context of climate risks. Droughts and heat waves exert dual pressure on fossil fuel-dependent energy systems, leading to supply disruptions on the one hand and increasing environmental vulnerabilities on the other. Therefore, promoting low-carbon energy sources, implementing carbon reduction mechanisms, and reducing reliance on fossil fuels such as natural gas are among strategic priorities. These measures will support both energy security and environmental sustainability.

4. Strategies to Mitigate the Effects of Heat Waves in the Tourism and Cultural Heritage Sector

Heat waves can increase energy and water demand in the tourism sector, negatively impacting service continuity and visitor experience. High tourist numbers, employee stress, and increased operating costs make vulnerability more apparent. However, access to financial resources and institutional capacity offer significant advantages. Adaptation strategies should focus on reducing resource consumption, effectively managing service demand, and strengthening workforce resilience.

Reducing Energy and Water Dependence

This stems from the heavy reliance on air conditioning and cooling systems, which leads to sudden increases in electricity demand during heat waves, pushing the limits of grid capacity. Similarly, increased use of pools and showers raises water demand, deepening the supply-demand imbalance and threatening service continuity. In addition, high natural gas consumption directly affects service continuity, increasing the vulnerability of the sector.

Therefore, the widespread adoption of energy and water-efficient technologies, the integration of renewable energy solutions, and the promotion of greywater utilization in hotels are strategic priorities to reduce these vulnerabilities.

Increasing Workforce Resilience

The continuity of tourism services largely depends on employee performance. However, heat waves have a direct impact on employees, especially in the hospitality and food and beverage sectors. Employees exposed to heat stress experience decreased productivity, reduced service quality, and increased occupational health risks. Therefore, implementing flexible working hours, taking occupational health measures against climate-related stresses, and providing regular rest breaks are important. In addition, educating employees on climate risks will contribute to maintaining service quality and reducing vulnerabilities.

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Managing Tourist Density and Service Demand

The impact of heat waves on tourism is particularly evident in terms of tourist density and average length of stay. High tourist density increases comfort and safety risks, while longer stays increase exposure to extreme heat. This can negatively affect tourism revenue by reducing visitor satisfaction. Furthermore, international tourist flows are highly sensitive to temperature conditions and can cause shifts in global demand.

Therefore, diversifying the tourism season, balancing spatial distribution, and implementing information and adaptation programs for heat-sensitive tourists are critical steps in managing this vulnerability.

Strengthening Institutional and Financial Capacity

Institutional and financial capacity are key determinants in tourism's adaptation to heatwaves. A high SEGE score facilitates infrastructure modernization, while access to banks makes crisis investments easier. Occupancy management also supports adaptation by providing flexibility. However, due to existing vulnerabilities, expanding financial incentives, investing in climate adaptation, and implementing crisis demand management mechanisms are fundamental strategies to increase the sector's resilience.

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SHORT - MEDIUM - LONG TERM APPLICABLES

Adapazarı Climate Change Adaptation Strategy

This section presents the prioritized implementation plan of climate adaptation measures identified within the scope of the plan, according to their time scale. The aim is to start with low-cost steps that can be implemented immediately, taking into account existing resources and institutional capacity, and to ensure structural transformation in the long term.

SHORT TERM (0-2 YEARS)

This phase encompasses actions that are low-cost and yield results quickly. The goal is to both raise public awareness and lay the foundations for a data-driven infrastructure.

Area of Action	Application Step	Expected Result
Urban Infrastructure	Permeable surface applications, rain garden pilot areas.	15% reduction in local floods
Water Management	Establishment of groundwater observation wells.	Creation of a hydrological database
Agriculture	Sensor-assisted irrigation pilot projects	10% savings in water usage
Energy	Energy efficiency audits in municipal buildings	Increased awareness of public consumption
Ecosystem	Cleaning and rehabilitation activities around Sapanca and Sakarya Rivers	Strengthening community participation
Social & Health	Awareness campaign for extreme heat periods	Reduction of public health risks
Governance	Establishment of a "Climate Adaptation Office" at the municipal level	Ensuring institutional coordination

Table 31. Steps that can be taken in the first 2 years.

MIDDLE TERM (3–5 YEARS)

This phase involves implementing the technical infrastructure to mitigate risks.
The goal is to increase resilience and make corporate practices permanent.

Area of Action	Application Step	Expected Result
Urban Infrastructure	Establishment of Sustainable Urban Drainage Systems (SUDS)	40% reduction in flood risk
Water Management	Expansion of rainwater harvesting infrastructure	On-site water management, increased reserves
Agriculture	Promotion of drought-resistant crops, training programs	20% reduction in yield loss
Energy and Industry	Incentive model for renewable energy power plants	10% reduction in carbon emissions
Ecosystem and Biodiversity	Wetland restoration, green corridor design	Habitat integrity is strengthened
Transportation	Rainwater drainage road infrastructure and bicycle paths	Reduction in greenhouse gas emissions
Governance	Climate data sharing protocol (municipality, DSI, AFAD, TMO)	Inter-institutional data integration is ensured

Table 32. Steps that can be taken in the medium term.

LONG TERM (5–10+ YEARS)

Long-term actions aim to make Sakarya's capacity to adapt to climate change permanent. This phase includes strategic investments, legislative changes, and green transformation policies.

Area of Action	Application Step	Expected Result
Urban Infrastructure	Fully integrated blue-green infrastructure network (river buffer zones, permeable surfaces)	60% reduction in flood risk
Water Management	Smart water management platform and sensor-based monitoring systems	25% reduction in water losses
Agriculture	Regional "Climate Resilient Agriculture Basin" plan	Long-term food security is ensured
Energy and Industry	Zero-carbon industrial zones	Emission intensity decreases, providing export advantages
Ecosystem	Restoration of carbon sink areas (forests, wetlands)	Regional carbon offsetting is achieved
Transportation	Electric public transport and carbon-neutral logistics systems	City emissions decrease by 30%
Community and Education	Climate literacy curriculum, university collaborations	Long-term behavioral transformation
Governance	Climate adaptation financing (green bonds, international funds)	Sustainable investment capacity is strengthened

Table 33. Long-term steps that can be taken.

General Prioritization Table

Duration	Top Priority	Main Objective	Expected Impact
0–2 years	Infrastructure pilot applications, database creation	Initial risk mitigation	Decrease in the number of disasters, increased awareness
3–5 years	Technological investments, institutional coordination	Strengthening adaptation capacity	Increased sectoral productivity
5–10+ years	Sustainable development and green transformation	Creating a resilient city model	Long-term climate resilience

Table 34. Time-based strategic priorities.

URB-01: Planning new settlements in areas with low flood risk and strengthening the existing building stock against disaster risks			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – Urban Planning and Development Dept., DSI	Adapazari Municipality (UDD, PWD), PDEUCC (PD), DSI-RD, AFAD-PD, OIZ Directorate, TOKI	Middle Term (3-5 Years)	Reduction in the size of urban areas at risk (ha/year); • Reduction in the number of flood and inundation events in urban areas (number/year)

URB-02: Accelerating infrastructure investments in areas receiving migration			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – Urban Planning and Development Dept., SASKI	Adapazari Municipality, Governorate / District Governorship, PDEUCC (PD), ILBANK	Middle Term (3-5 Years)	Size of areas lacking infrastructure (ha)

URB-03: Implementing risk-sensitive zoning and urban planning practices in areas under high urbanization pressure			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – Urban Planning and Development Dept.	Adapazari Municipality, (UDD), PDEUCC (PD), DSI-RD	Middle Term (3-5 Years)	Size of risk-based urban transformation area (ha);

URB-04: Promoting water-saving and efficiency practices and technologies that reduce water demand (rainwater harvesting, greywater reuse)			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SASKI	Adapazari Municipality (PWD), PDEUCC (PD), DSI-RD, Professional Chambers	Middle Term (3-5 Years)	Reduction rate of water losses and leakages (%)

URBAN SECTOR ADAPTATION STRATEGIES

URB-05: Implementing green infrastructure solutions to strengthen urban ecosystem services			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Adapazarı Municipality – Parks and Gardens Dept.	Adapazari Municipality (PGD), PDAF (RDF), PDEUCC (PD)	Middle Term (3-5 Years)	Decrease in active green space per capita (m^2/year);

URB-06: Integrating social support mechanisms with disaster risk management and developing post-disaster recovery programs for vulnerable groups			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Governorate / District Governorship	AFAD-PD, SMM (CCZWD), Adapazari Municipality, Provincial Health Directorate (MoH-PD), MoFSS-PD	Middle Term (3-5 Years)	Number of studies to identify vulnerable population broken down by elderly people, women, children, etc. (number);

URB-07: Expanding community-based awareness and volunteer programs			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Adapazarı Municipality	SMM – CCZWD, Governorate / District Governorship, NGOs, Sakarya University	Short Term (0-2 Years)	Number of local residents receiving disaster-preparedness training (people);

WRS-01: Integrating water-demand projections into population scenarios and continuously monitoring demand management and the supply–demand balance			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – SASKI	DSI-RD (ISK-TO-BPD), PDEUCC (PD, TSMS-RD), Sakarya University	Long Term (5-10 Years)	Provincial water-efficiency plan (yes/no); · Water footprint report (yes/no);

WRS-02: Implementing risk-sensitive zoning and service planning			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – Urban Planning and Development Dept.	Adapazari Municipality (UDD, PWD), DSI-RD, AFAD-PD, YIKOB	Middle Term (3-5 Years)	Number of plans revised according to climate risks (number);

WRS-03: Making infrastructure investments for water-supply capacity in line with population growth			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – SASKI	DSI-RD, PDEUCC (PD, ILBANK-RD), District Municipalities	Middle Term (3-5 Years)	Length of drinking and utility water network (piped system) (m);

WRS-04: Expanding and mainstreaming water-efficiency programs			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – SASKI	PDAF (DSI-RD), Adapazari Municipality, PDEUCC (PD, GDWM)	Middle Term (3-5 Years)	Number of active stations monitoring the quantity and quality of surface and groundwater at the provincial level (number);

WATER RESOURCES SECTOR ADAPTATION STRATEGIES

WRS-05: Promoting rainwater harvesting and greywater reuse practices			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – SASKI	Adapazari Municipality (PWD), PDEUCC (PD), Professional Chambers	Middle Term (3-5 Years)	Amount of rainwater use (m^3/year); · Implementation rate of actions for rainwater management (%)

WRS-06: Strengthening monitoring and protection mechanisms in sectoral water use			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
DSI – 54th Regional Directorate	SMM – SASKI, PDAF (GDWM), PDEUCC (PD), MoIT-PD	Short Term (0-2 Years)	Ratio of water saved under municipal water-efficiency strategies to water used (%);

WRS-07: Increasing the capacity of rainwater and sewerage systems			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – SASKI	Adapazari Municipality (PWD), DSI-RD, YIKOB, PDEUCC (PD)	Middle Term (3-5 Years)	Implementation rate of actions for rainwater management (%)

WRS-08: Making drinking-water and distribution infrastructure resilient to climate/drought conditions; strengthening storage capacity			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SASKI	DSI-RD, AFAD-PD, PDEUCC (PD, ILBANK-RD)	Middle Term (3-5 Years)	Increase rate in disruptions to water distribution services caused by extreme weather events (%)

WRS-09: Expanding green areas and protecting natural buffer zones

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
Adapazari Municipality – Parks and Gardens Dept.	PDAF (RDF, NCNP-BD), Adapazari Municipality (PGD), PDEUCC (PD)	Middle Term (3-5 Years)	Number of newly planted trees per year (number);

WRS-10: Increasing efficiency in water-saving and irrigation technologies in urban and rural areas (drip, sprinkler, etc.)

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
PDAF-SASKI	SMM – SASKI, DSI-RD, Municipality, Irrigation Unions, Cooperatives	Middle Term (3-5 Years)	Increase in the number of projects using water efficiently (number/year)

WRS-11: Supporting agricultural practices that are more resilient to drought and promoting diversity in agricultural production

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
PDAF	DSI-RD, SMM (ASD), Sakarya University, Irrigation Unions, NGOs	Middle Term (3-5 Years)	Implementation status of district-level agricultural land-use plans (%);

WRS-12: Increasing wastewater recovery and reuse projects; reducing network losses

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
SMM – SASKI	PDEUCC (PD, GDEM, ILBANK-RD), DSI-RD (GDWM), OIZ Directorate, Sakarya University	Middle Term (3-5 Years)	Number of facilities/ projects reusing used water (number)

WRS-13: Using nature-based solutions for water retention and conservation

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
DSI – 54th Regional Directorate	SMM (PGD, SASKI), PDAF (GDF-RD, NCNP-RD), PDEUCC (PD)	Middle Term (3-5 Years)	Number of enterprises with monitoring studies on surface and groundwater use at district level (number);

WRS-14: Increasing community-based awareness campaigns

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
Adapazarı Municipality	SMM – CCZWD, SMM – SASKI, NGOs, Neighborhood Headmen	Short Term (0-2 Years)	Type and number of awareness-raising activities (number);

WRS-15: Strengthening institutional–civil cooperation

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
SMM – CCZWDD Adapazari Municipality	Governorate, Adapazari Municipality, NGOs, Irrigation Unions, Sakarya University	Short Term (0-2 Years)	Number of municipalities, public institutions, professional chambers, and NGOs with projects or studies on climate change adaptation and risk management (number)

AFS-01: Promoting high water-efficiency irrigation technologies; supporting drip, sprinkler, and reuse systems

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
PDAF SASKI	DSI-RD (GDWM), SMM (ASD), Irrigation Unions, Cooperatives, Sakarya University	Middle Term (3-5 Years)	Increase in the number of projects using water efficiently (number/year)

AFS-02: Scaling good practices to reduce water use in livestock and safeguarding the security of supply for animal products

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
PDAF	Governorate / District Governorship, UCA, Cooperatives, Producer Unions	Middle Term (3-5 Years)	An inspection-related monitoring indicator could be added

TAG-03: Planning agricultural production and water management in an integrated manner

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
PDAF	DSI-RD (GDWM), SMM (ASD, SASKI), PDEUCC (PD), Sakarya University	Long Term (5-10 Years)	Increase in the area under good agricultural practices on agricultural lands near water basins (ha/year);

AFS-04: Increasing crop diversity and supporting non-cereal production areas

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
PDAF	Maize Research Institute, Sakarya University (Agriculture), UCA, Cooperatives, ARDSI	Middle Term (3-5 Years)	Inventory of traditional and natural methods that increase climate-adaptation capacity at district level (yes/no)

AGRICULTURE AND FOOD SECTOR ADAPTATION STRATEGIES

AFS-05: Expanding climate- and drought-resilient seed varieties and implementing climate-resilient agricultural techniques

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
PDAF	Maize Research Institute, TUBITAK, Sakarya University (Fac. of Agric. & Tech.), AFAD-PD, Cooperatives	Middle Term (3-5 Years)	

AFS-06: Implementing policies to increase the participation of young people and women in the agricultural workforce

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
Governorate / District Governorship, Adapazari Municipality, MARKA	PDAF, Adapazari Municipality, MoLSS-PD, ISKUR, NGOs	Long Term (5-10 Years)	Number of enterprises receiving technical and financial support (number);

AFS-07: Strengthening social support mechanisms in rural areas and increasing producers' disaster-preparedness capacity

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
Governorate / District Governorship, Adapazari Municipality, MARKA	PDAF, AFAD-PD, Sakarya University. (SUBU), NGOs, Cooperatives	Middle Term (3-5 Years)	Number of enterprises receiving technical and financial support (number);

AFS-08: Strengthening cooperatives, producer organizations, and solidarity networks

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
Governorate / District Governorship, Adapazari Municipality, MARKA	UCA, CAE, Cooperatives, Producer Unions, KOSGEB, ARDSI, Governorate	Middle Term (3-5 Years)	Number of enterprises receiving technical and financial support (number);

AFS-09: Developing agricultural R&D activities and early-warning and monitoring systems; expanding information sharing			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDAF	Maize Research Institute, TUBITAK, Sakarya University, (Agriculture/Technology Faculties), TSMS-RD (PDEUCC)	Long Term (5-10 Years)	Change in credit and grant amount used for new technologies (%)

AFS-10: Scaling controlled and local production systems; implementing diversified supply policies in the food chain			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDAF	Adapazari Municipality, Cooperatives, Governorate, UCA	Long Term (5-10 Years)	No-till farming practice (yes/no);

AFS-11: Developing policies to turn socio-economic development into producer benefits			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Governorate / District Governorship	PDAF, SMM (ASD), Cooperatives, MARKA, Sakarya CCI	Long Term (5-10 Years)	

AFS-12: Implementing policies that support pollination services			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDAF	UCA, Aricilik Cooperativesi, PDEUCC (PD), Sakarya University	Middle Term (3-5 Years)	Beekeeping Climate Change Adaptation Plan (yes/no)

AFS-13: Scaling water-saving and reuse practices in agricultural uses			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDAF	SMM – SASKI, DSI-RD, Irrigation Unions, Cooperatives	Middle Term (3-5 Years)	Increase in the number of farmers using new technology (%);

AFS-14: Promoting the transition from monoculture to multi-crop systems			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDAF	Maize Research Institute, Sakarya University, (Agriculture), Cooperatives, TUBITAK	Long Term (5-10 Years)	

TCS-01: Aligning transportation-demand projections with population scenarios

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
SMM – Transportation Dept.	SMM – Urban Planning Dept. (UDD), Adapazari Municipality (UDD), Sakarya Univ.	Middle Term (3-5 Years)	Planning study, Transportation Master Plan revision (yes/no) (prepared at the provincial level but also covers the district)

TCS-02: Developing public transport, bicycle routes, and vehicle-sharing systems to reduce private car dependence

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
SMM – Youth and Sports Dept.	Municipality (UDD, PWD), SMM – PWD	Middle Term (3-5 Years)	Increase in the number of bicycles offered in the bike-sharing system (number/year);

TCS-03: Adapting traffic management systems to disaster conditions

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
AFAD-PD	SMM – TD, SMM – DAD (Disaster Affairs DB), Governorate, Provincial Police Department (GDS-PD)	Middle Term (3-5 Years)	Decrease in the number of people affected by climate-change hazards (people/year)

TCS-04: Integrating climate-resilient planning into transportation and communication infrastructure

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
SMM – Transportation Dept.	SMM – CCZWD, AFAD-PD, PDEUCC (PD, TSMS-RD), MoTI (GDH, ICTA)	Middle Term (3-5 Years)	Decrease in the number of people affected by climate-change hazards (people/year)

TCS-05: Making protective investments against flooding at critical transportation points

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
DSI, Meteorology Directorate	DSI-RD, AFAD-PD, Highways (MoTI-GDH), District Municipalities (PWD)	Middle Term (3-5 Years)	Decrease in the number of main arteries, avenues, and streets affected by flood and inundation events (number/year);

TCS-06: Creating alternative routes and systems within supply chains

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
Governorate / District Governorship	SMM – TD, AFAD-PD, OIZ Directorate, MoTI (GDH), Sakarya CCI	Middle Term (3-5 Years)	

TCS-07: Expanding urban green areas; supporting transportation networks with permeable surfaces, rain gardens, and nature-based solutions

Responsible Institutions	Relevant Institutions	Implementation Period	Monitoring Indicator
SMM – Road Maintenance Dept.	District Municipalities (UDD, PGD, PWD), SMM – SASKI, PDAF (RDF)	Short Term (0-2 Years)	Decrease in urban asphalt and concrete surface area (ha/year%);

IND-01: Promoting water and energy efficiency practices in industry; supporting renewable-energy investments			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDEUCC	MoIT-PD, SMM (CC-ZWDD), OIZ Directorate, KOSGEB, MoENR (EIGM), MARKA	Middle Term (3-5 Years)	Increase in WWTP, adv. treatment, reuse, recovery & rainwater harvesting facilities (no./yr)

IND-02: Implementing redundancy and diversification solutions to reduce dependence on critical infrastructure			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
OIZ Directorate	AFAD-PD, Governorate, MoTI-RD (Highways), MoIT-PD	Middle Term (3-5 Years)	Status of completion of required infrastructure needs analysis (yes/no);

IND-03: Developing settlement plans in OIZs based on flood-risk maps and making protective infrastructure investments in critical facilities			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
OIZ Directorate	DSI-RD, AFAD-PD, SMM – Urban Planning Dept. (UDD), PDEUCC (PD), MoIT-PD	Middle Term (3-5 Years)	There is no OIZ in Adapazarı district.

IND-04: Preparing emergency response plans that prioritize workforce safety and standardizing disaster/business-continuity plans in industrial facilities			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDLSS	OIZ Directorate, AFAD-PD, Governorate, Sakarya PDO, Sakarya MO	Middle Term (3-5 Years)	Ratio of the number of facilities with risk assessments to the total number of BEKRA facilities (%)

IND-05: Encouraging unions and industry associations to take an active role in risk management			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDEUCC	OIZ Directorate, Sakarya CCI, Sector Associations, MoLSS-PD, Governorate	Short Term (0-2 Years)	

IND-06: Transferring good practices from regions with high SEGE scores to other regions			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – CCZWDD	OIZ Directorate, PDEUCC-PD, MARKA, Sakarya University, Sakarya CCI	Middle Term (3-5 Years)	

BIO-01: Developing land-use policies to reduce the ecological pressures of population growth; not allowing zoning on agricultural land			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – Urban Planning and Development Dept.	PDEUCC (PD, CETSMS, GDSP), PDAF (PD), Adapazari Municipality (UDD)	Long Term (5-10 Years)	Reduction in the amount of agricultural land used for urbanization purposes (ha/year);

BIO-02: Mainstreaming sustainable water-use programs			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – SASKI	DSI-RD (ISK-TOBPD), PDAF, PDEUCC (PD)	Middle Term (3-5 Years)	

BIO-03: Implementing spatial planning strategies that integrate ecosystem services and limit settlement fragmentation			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Adapazari Municipality	PDEUCC (PD, GDSP), PDAF, Adapazari Mun. (UDD), Sakarya University., SMB	Long Term (5-10 Years)	Reduction in the city's expansion radius (km/year

BIO-04: Creating ecological corridors and ensuring habitat continuity			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Adapazari Municipality	SMM – PGD, PDEUCC (PD), DSI-RD, Sakarya Universtiy	Middle Term (3-5 Years)	Annual change in total green area size (%);

BIODIVERSITY ADAPTATION SOLUTIONS

BIO-05: Evaluating land-use changes by considering drought impacts			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDEUCC	SMM – Urban Planning Dept. (UDD), PDAF, DSI-RD	Middle Term (3-5 Years)	Reduction in protected area size affected by climate change (ha/year)

BIO-06: Protecting and expanding forest ecosystems and strengthening their microclimate-regulation functions			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDAF, Forestry Administration (RDF)	SMM – PGD, PDEUCC (PD), SMM – Itfaiye DB, AFAD-PD	Long Term (5-10 Years)	Current forest fire hazard and risk maps (number);

BIO-07: Implementing ecosystem restoration projects within the framework of drought adaptation; preserving and expanding the integrity of green infrastructure			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDAF	SMM – PGD, DSI-RD (GDWM), PDEUCC (PD), NGOs	Long Term (5-10 Years)	

BIO-08: Supporting the active participation of civil society in community-based monitoring, maintenance, and ecosystem restoration processes			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Adapazari Municipality	SMM – PGD, PDAF (RDF), NGOs, Neighborhood Headmen	Short Term (0-2 Years)	Type and number of awareness-raising activities (number);

ENR-01: Implementing demand-side management programs (smart meters, dynamic tariffs) and expanding energy-efficiency practices			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SEDAS (Electricity Distribution Company)	SMM – CCZWD, EPCCD, Adapazari Municipality, Governorate/Sanayi Ticaret Odalari	Middle Term (3-5 Years)	Number of developed smart-grid projects (number)

ENR-02: Promoting high-efficiency cooling and air-conditioning technologies			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDEUCC	SMM – Urban Planning Dept. (UDD), Adapazari Municipality, OIZ Directorate, MoENR-EIGM	Middle Term (3-5 Years)	Number of implemented electricity-efficiency projects (number);

ENR-03: Increasing renewable-energy investments; encouraging low-carbon energy sources and the phase-out of fossil fuels			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Energy companies / Power plant operators	SMM – CCZWD, EPCCD, MoENR-TEIAS RD, Governorate, OIZ Directorate	Long Term (5-10 Years)	

ENR-04: Using technologies that reduce water dependency in energy production			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Energy companies / Power plant operators	DSI-RD, SMM – SASKI, OIZ Directorate, MoENR	Long Term (5-10 Years)	Number of projects supporting technologies that reduce water dependency in energy production (number)

ENERGY ADAPTATION SOLUTIONS

ENR-05: Transforming energy-intensive industrial processes and implementing carbon-pricing and emission-reduction mechanisms			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDEUCC	OIZ Directorate, MoIT-PD, MoENR (EIGM), KOSGEB	Long Term (5-10 Years)	A strategy to be ensured through sanctions under this law.

ENR-06: Accelerating investments in the modernization of energy infrastructure			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
MoENR – TEIAS Regional Directorate / SEDAS	SMM – Public Works Dept. (PWD), OIZ Directorate, MoENR	Middle Term (3-5 Years)	Number of new infrastructure projects established (number)

ENR-07: Securing vulnerable groups' access to energy through social support mechanisms			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Governorate / District Governorship	SMM – Social Services Dept., Adapazari Municipality, MoFSS-PD, SEDAS	Short Term (0-2 Years)	Number of electricity awareness campaigns (number);

ENR-08: Strengthening the coordination capacity of local governments during energy crises			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Governorate / District Governorship	AFAD-PD, SMM – DAD (Disaster Affairs), SEDAS, OIZ Directorate	Short Term (0-2 Years)	Spatial distribution analysis of vulnerable groups (yes/no)

PSH-01: Developing special health programs for infants, older adults, and pregnant women during heatwave periods			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Provincial Health Directorate – MoH (PD), Population Directorate	SMM – CCZWD, Adapazari Municipality, Governorate, FHCs	Short Term (0-2 Years)	Distribution by socio-demographic and case definitions (ratio)

PSH-02: Rapidly activating social assistance mechanisms during disaster periods			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Governorate / District Governorship	AFAD-PD, Provincial Health Directorate (MoH-PD), SMM, Social Services Dept., Adapazari Municipality, MoFSS-PD	Short Term (0-2 Years)	

PSH-03: Expanding community-based awareness campaigns			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Adapazari Municipality	Provincial Health Directorate (MoH-PD), SMM – CCZWDD, MEB-PD, NGOs	Short Term (0-2 Years)	Number of awareness-raising and training activities (number);

PSH-04: Strengthening health infrastructure and installing backup energy/cooling systems in critical facilities			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Provincial Health Directorate – MoH (PD)	Governorate, SMM – Public Works Dept. (PWD), MoENR/SEDAS, ILBANK	Middle Term (3-5 Years)	Number of cross-institutional and cross-sector cooperation protocols for implementation (number);

PUBLIC HEALTH ADAPTATION SOLUTIONS

PSH-05: Developing early-warning and emergency-response protocols for heatwaves			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Provincial Health Directorate – MoH (PD) + AFAD	AFAD-PD, Governorate, SMM, CCZWD, TSMS-RD (PDEUCC)	Short Term (0-2 Years)	Number of warning stations (number)

PSH-06: Expanding disaster-focused training for healthcare workers			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Provincial Health Directorate – MoH (PD)	AFAD-PD, Sakarya University. (Medicine/Health), SMM, CCZWD	Short Term (0-2 Years)	Number of awareness-raising and training activities (number);

PSH-07: Implementing energy and water efficiency programs in health facilities			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Provincial Health Directorate – MoH (PD)	SMM – SASKI, SEDAS, PDEUCC (PD)	Middle Term (3-5 Years)	

PSH-08: Increasing green areas and establishing neighborhood-level resilience networks to reduce the urban heat island effect			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – Parks and Gardens Dept.	Adapazari Municipality (PGD), Provincial Health Directorate (MoH-PD), SMM – CCZWD, NGOs	Middle Term (3-5 Years)	Number of local residents receiving disaster-preparedness training (people); amount of green area (m^2)

PUBLIC HEALTH ADAPTATION SOLUTIONS

PSH-09: Developing policies to improve migrant populations' access to healthcare and provide targeted support to low socio-economic areas			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Governorate / District Governorship	Provincial Health Directorate (MoH-PD), SMM – Social Services Dept., Adapazari Municipality, Provincial Migration Administration (MoI-PMMPD)	Middle Term (3-5 Years)	

TOURISM AND CULTURAL HERITAGE ADAPTATION SOLUTIONS

TCH-01: Standardizing energy and water efficiency measures in hotels; promoting renewable energy and greywater use			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDCT (CHPRBD)	SMM, SASKI (RDD, UDD), PDEUCC (PD), MoENR/SEDAS	Middle Term (3-5 Years)	Number of buildings with greywater installation (number);

TCH-02: Balancing spatial distribution through demand-management programs and diversification of the tourism season			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDCT	SMM – Urban Planning Dept. (CSAD, UDD), Adapazari Municipality, NGOs, MARKA	Long Term (5-10 Years)	

TCH-03: Integrating information, health/safety measures, and occupational health practices into service processes for tourists sensitive to heatwaves			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDCT	Provincial Health Directorate (MoH-PD), AFAD-PD, Governorate, MoLSS-PD	Short Term (0-2 Years)	Number of cultural heritage sites/assets with climate vulnerability analysis (number);

TCH-04: Introducing flexible working and rest arrangements			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDLSS	PDCT, Governorate	Short Term (0-2 Years)	

TOURISM AND CULTURAL HERITAGE ADAPTATION SOLUTIONS

TCH-05: Increasing adaptation capacity through training programs and supporting climate-adaptation investments with financial incentives			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDCT	SMM – CCZWD, MARKA, Sakarya University, NGOs, KOSGEB	Middle Term (3-5 Years)	Number of supported projects and amount of support (TL)

TCH-06: Accelerating infrastructure modernization			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – Public Works Dept.	PDCT (KVKBKM), Adapazari Municipality, ILBANK	Middle Term (3-5 Years)	No. of local coordination activities for climate-risk design & implementation guide (no.)

TCH-07: Strengthening institutional capacity to facilitate demand management during crisis periods			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Governorate / District Governorship	PDCT, AFAD-PD, SMM – CCZWD, MARKA	Short Term (0-2 Years)	

SOCIAL DEVELOPMENT ADAPTATION SOLUTIONS

SDV-01: Integrating social support mechanisms into climate risk management; sharing data in coordination with meteorology, district governorates, and district municipalities			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Governorate / District Governorship	SMM – Social Services Dept., Adapazari Municipality, AFAD-PD, Provincial Health Directorate (MoH-PD), MoF-SS-PD	Middle Term (3-5 Years)	

SDV-02: Developing targeted post-heatwave recovery programs and subsidies for disadvantaged and vulnerable groups			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Governorate / District Governorship	SMM, Social Services Dept., Adapazari Municipality, Provincial Health Directorate (MoH-PD), MoFSS-PD, Provincial/District SASF	Short Term (0-2 Years)	Number of social assistance/social service programs developed in line with climate change (number)

SDV-03: Expanding community-based awareness, volunteering, and heatwave-risk campaigns			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Adapazari Municipality	SMM – CCZWDD, Provincial Health Directorate (MoH-PD), NGOs, Neighborhood Headmen	Short Term (0-2 Years)	

SDV-04: Integrating climate change and risk management into the education curriculum; implementing training programs to strengthen community resilience			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
PDNE	SMM – CCZWDD, Sakarya Univ., Adapazari Mun., NGOs, AFAD-PD	Long Term (5-10 Years)	This coded activity appears as awareness across many sectors; instead of repeating it under each sector, it could be placed only under social development to cover all sectors.

SOCIAL DEVELOPMENT ADAPTATION SOLUTIONS

SDV-05: Expanding urban green areas, shaded zones, and nature-based cooling solutions			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
SMM – Parks and Gardens Dept.	Adapazari Municipality, (PGD), PDAF (RDF), PDEUCC (PD)	Middle Term (3-5 Years)	

SDV-06: Ensuring community participation in the maintenance and use of green infrastructure			
Responsible Institutions	**Relevant Institutions**	**Implementation Period**	**Monitoring Indicator**
Adapazari Municipality	SMM – PGD, NGOs, Neighborhood Headmen	Short Term (0-2 Years)	

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