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STRENGTHENING CLIMATE ADAPTATION IN TURKEY PROJECT

TR2017 ESOP MI A3 04

METHODOLOGY OF VULNERABILITY AND RISK ANALYSIS AND DETERMINATION OF THE SCOPE OF ANALYSIS OF PRIORITY SECTORS

T.C. ÇEVRE, ŞEHİRCİLİK VE İKLİM DEĞİŞİKLİĞİ BAKANLIĞI

Çevre ve İklim Eylemi Sektör Operasyonel Programı

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LIST OF ABBREVIATIONS

ABE	Acute Intestinal Infections
AR4	4. Evaluation Report
AR5	5. Evaluation Report
ASM	Family Health Center
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
EIA	Environmental Impact Assessment
CORINE	Coordination of Environmental Information
MOEU	Ministry of Environment and Urbanization
D	Sensitivity
DKMP	General Directorate of Nature Conservation and National Parks
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DSI	State Water Works
WHO	World Health Organization
E	Vulnerability
EMRA	Energy Market Regulatory Board
EUNIS	European Nature Information System
FAO	Food and Agriculture Organization
ICD	International Classification of Diseases (International Statistical Classification of Diseases and Related Health Problems)
ILO	International Labour Organization
HDI	Human Development Index
IOM	International Organization for Migration
IPCC	Intergovernmental Panel on Climate Change
IRE	Climate Risk Index
IUCN	International Union for Conservation of Nature
GNP	Gross National Product
GDP	Gross Domestic Product
HUSPAM	Hacettepe University Social Policies Research and Implementation Center
M	Exposure
MDB	Multilateral Development Bank
MDGF	Millennium Development Goals Fund
MEA	Millennium Ecosystem Assessment
MGM	General Directorate of Meteorology
MTA	Mineral Research and Exploration
MUSIAD	Independent Industrialists' and People's Association
NAPs	National Adaptation Plans
NDF	Nordic Development Fund
OGM	General Directorate of Forestry
OBA	Important Plant Area
SDA	Important Nature Area
ÖKA	Important Bird Areas

PVA	Participatory Vulnerability Assessment
R	Risk
RegCM	Regional Climate Model
SUEN	Turkey Water Institute
SYGM	General Directorate of Water Management
T	Danger
TARBIL	Agricultural Monitoring and Information System
TUIK	Turkish Statistical Institute
TUMSİAD	All Industrialists and People's Association
TUSIAD	Turkish Industry and Business Association
TVKGM	General Directorate for the Protection of Natural Assets
UK	Adaptive Capacity
UN	United Nations
UNDP	United Nations Development Program
UNDRR	United Nations Office for Disaster Risk Reduction Reduction)
UNFPA	United Nations Population Fund
UNFCCC	United Nations Framework Convention on Climate Change (United Nations Framework Convention on Climate Change)
WFP	World Food Programme
WHO	World Health Organization
YAS	Groundwater
YÜS	Surface Water

APPENDICES

Appendix 1	Indicator List

EXECUTIVE SUMMARY

The impacts of climate change vary from region to region, sector to sector and even within sectors. Understanding the vulnerability and risk level of the region is crucial for planning and implementing adaptation actions at the regional level. Climate change is the root cause of climate-related risks, but it is not the only factor. Regional impacts of climate change also depend on the development of environmentalpoliticaltechnological and socio-economic conditions at the regional scale. For example, urbanization of coastal plains, deforestation of hill slopes or construction of buildings in high-risk areas are among the factors that will increase risk. On the other hand, building institutional and technical capacity to address climate hazards is an approach that can reduce risk. The approaches to be developed for all sectors should be elaborated depending on their characteristics, geography and many other factors.

Vulnerability and risk assessment is essential for planning and implementing adaptation measures and prioritizing resources. This assessment is crucial to identify which regions, sectors or system components are particularly affected by climate change and where there is an urgent need for adaptation.

For this reason, consultation meetings with broad stakeholder participation were organized for priority sectors to get an idea of the exposure, sensitivity factors and adaptive capacity that will affect risk analyses. At the same time, sector experts shared their initial findings on the scope of the risk and vulnerability analysis and inter-sectoral vulnerability from the studies they have conducted or utilized so far on the subject. The following is an assessment that emphasizes the interrelationship of sectors as well as important exposure and sensitivity factors.

In the National Water Plan, which was developed by taking into account the current situation and future potential of Turkey's **water resources** and published in 2019, it is stated that many bottlenecks such as fragmented water legislation, overlapping authority and lack of coordination between institutions, mostly development-oriented priorities making it difficult to protect water resources, slow impacts on protection due to rapidly developing industry, agriculture sector and population growth have caused many problems even before climate change risks are taken into account. It is very important to determine the main indicators, especially sensitivity, that can be used in the vulnerability analysis regarding drought and water scarcity, floods and floods, which have emerged due to the negative impacts of climate change on water resources and are expected to increase further, in determining short-medium-long term actions. In order to determine the risk of drought and water scarcity hazards leading to loss of life and property, it is first necessary to identify the exposed elements (people, livelihoods, species or ecosystems, environmental functions, services and resources, infrastructure, economic, social and cultural assets). Vulnerability factors include soil moisture, sectoral surface and groundwater allocations, agricultural irrigation area and irrigation water, crop loss due to extreme weather events, network losses in the water distribution system, amount of water withdrawn in the manufacturing industry, amount of built-up area-covered surface, proportion of illegal construction, proportion of water bodies under diffuse pressure, etc. Water management is also one of the most important issues to be analyzed carefully as it affects many other priority sectors (agriculture, livestock, industry, energy, urban life, etc.).

Many processes such as life cycles, , physiology, photosynthesis and food chains of living organisms are closely related to climate. Therefore, climate change impacts that may affect **biodiversity and ecosystems** may be higher than other priority sectors. Turkey is a country rich in biodiversity. As a result of the high diversity of ecological characteristics such as climate, location, topography and bedrock/soil, many habitats and marinecoastalwetland, lake and river, forest, maquis and shrubland, steppe, pasture, mountain ecosystems cover large areas in our country. These ecosystems both provide a living and growing environment for species and produce various ecosystem services. Ecosystem services are provided by ecosystems to all living things.

products and services. These products and services are evaluated under four main headings: provisioning (food, clean water, fish, wood, etc.), supporting (biodiversity, photosynthesis, soil formation, habitat provision, etc.), regulating (pollination, climate regulation, disaster/erosion prevention, water purification, air quality regulation, disease and pest reduction, resistance to invasive species, etc.) and cultural ecosystem services (recreation and aesthetic values, educational and inspirational values, moral and spiritual values, science and education, etc.). **Biodiversity and ecosystems** are closely related to all 10 sectors identified as priority sectors that will be affected by climate change in our country. For example, some of these sectors (agriculture, animal husbandry, fisheries, water resources and tourism) are direct ecosystem services. Therefore, if ecosystems are affected by climate change, these sectors, which are important for the national economy, will also be negatively affected. Other sectors (disaster risk reduction, cities, industry, energy, transportation-communication and public health) are vulnerable to the impacts of extreme weather events (floods, floods, droughts, fires, etc.) that may be exacerbated by damage to ecosystems from climate change or other factors. In addition, the vulnerability of the biodiversity and ecosystems sector will increase if adaptation and mitigation measures in these sectors are insufficient and especially if investments in these sectors are made without considering ecosystems.

From a **public health** perspective, **the health sector** considered in terms of being affected by the results of other sectors and/or the pressure these effects create on society. As a result of the weakness and damage of other sectors in the face of climate change, the health sector will be burdened the most. This situation defined as "health burden" refers to years of life lost prematurely, years of poor quality and dependent life. Since there are different regions in Turkey according to geography, climate and demography, there is no health impact of climate change or priority of one of its health impacts. Risks associated heat and cold, food and water, vectors, infectious diseases, ultraviolet radiation effects, injury, disability, mental problems are risks that may be seen with climate change. There are not enough studies on most of these. It is important to complete the lack of relevant scientific knowledge, identify exposure and susceptibility factors in risky areas and develop actions in priority areas.

In parallel with population growth, the need for **urban infrastructure** inevitably grows. Cities and their inhabitants are expected to be directly affected by climate change due to their water, energy, sewerage, transportation, communication and service infrastructures. Land use changes, increasing impervious surfaces and decreasing green areas are the determinants of the level of impact. Climatic hazards such as heat stress, extreme precipitation, flooding, landslides, air pollution, drought, water scarcity, sea level rise, storms and hail have different impacts on the emerging urban structure. The impacts of climate change on urban systems is a topic that has not been sufficiently addressed in our country. The vulnerability of cities creates different consequences on different urban systems in relation to different climate hazards. Therefore, the vulnerability of urban infrastructure and superstructure systems to different climate hazards such as heavy rainfall events, droughts, high temperatures, sea water level increases and poor air quality should be addressed separately. The negative impacts of the effects of changing climate conditions on people living in cities, buildings, transportation systems (roads, airports, railways, ports, metro lines), public services, infrastructure networks such as sewerage, industrial facilities and commercial activities should be risk analyzed and necessary measures should be taken before they cause economic disruption, social and ecological damages.

In order to assess the impacts of climate change on Turkey's **energy** , it should be taken into account that energy is a vital input for both its own production and the production of other sectors atrates. Risks that the energy sector may be exposed to; thermal power plants, HEPPs, which are closely related to water, decrease in the productivity of plant production used for energy production may affect energy production and reduce yields. However, the increasing frequency of extreme weather events a risk to the infrastructure and superstructures of the energy sector. Different energy production facilities may be exposed to different climate hazards or

Risk assessments should be made against the impacts of the energy crisis and those under risk should be identified and monitored with the indicators specified in the relevant section. In addition to all these negative impacts, the increase in energy demand due to warmer temperatures may adversely affect the sector.

It is important for **the industrial sector** to understand the risks of climate changebe prepared for these risksmitigate them and to take advantage of the opportunities that may arise. At a large scale, sector's risks affect the entire economy and the sector's approach can increase or decrease vulnerability, including investment decisions. The scope of vulnerability and risk for the industrial sector should be defined to cover core operations, including physical assets, efficiency of production processes, cost of operation and maintenance activities, health and safety, labor and labor productivity; the value chain, including the ability to supply raw materials and services, customer demand for specific products and services; and public services such as infrastructure, electricity, water services, etc. needed to export or import.

The tourism sector consists of a value chain that includes various service lines. These services include transportation, transportation and accommodation, as well as food and beverage, shopping, entertainment, event organization and other hospitality services. Infrastructure, human resources, service quality and consequently tourism revenues in the sub-sectors in the tourism value chain for tourist satisfaction are subject to risks that may be exposed and sensitive to the impacts of climate change.

Since transportation-communication sectors have an impact on keeping the national economy alive, social activities and development processes, it is extremely important to improve adaptive capacity, be prepared and ensure resilience to the impacts of climate change. The possibility that climate change may affect roads, railways, maritime, airways and urban transportation in different ways in different regions reveals the importance of regional study. each sub-sector, it is necessary to identify risks, examine exposure factors and sensitivity levels, and make assessments to develop adaptive capacity. However, it is also necessary to evaluate the sub-sectors of the transportation sector in an integrated manner with a system approach. In this context, it may be possible to examine issues such as intermodal integration, multi-modal transportation, flexibilities and alternative possibilities in infrastructure and transportation, as well as possibilities such as emergency management and travel demand management at national and urban level.

In order to analyze how climate change affects society/individuals, it is important to consider all sectors that make up the development economics of countries together with their vulnerabilities. While climate change affects society and individuals in many dimensions, it also affects the social determinants required to ensure a full quality of life and welfare in society. these impacts vary across sectors (such as nutrition and agriculture), international literature has highlighted some common social determinants. These include livelihood stability, nutrition, shelter and health. In some cases, addressing **the social dimension of** climate change may be seen as a side benefit, but the consequences that create a social vulnerability gap are important to ensure that vulnerability and risk analyses in many sectors are addressed in a holistic manner. Therefore, no matter which sector is addressed, identifying the segments that will be more vulnerable to risks will be very important when prioritizing for adaptation action planning.

While there are many different factors affecting the exposure and vulnerability of priority sectors, throughout the report it is frequently emphasized how interrelated they are and how the social dimension should not be ignored when addressing physical and financial risks in each sector.

INTRODUCTION

Climate change is one of the greatest environmental and developmental challenges facing natural ecosystems and socio-economic systems. According to the Intergovernmental Panel on Climate Change (IPCC), climate change is happening today and negatively affecting natural ecosystems and societies (IPCC, 2014). However, by mid-century, these impacts are expected to intensify and thus negatively affect sectors such as food production, water resources, biodiversity and health. Therefore, it is crucial to strengthen climate change adaptation actions and increase resilience against its negative impacts.

Climate change adaptation is the actions and measures taken to help the systems and ecosystems that hold societies and living things together to cope with a changing and is a process, not an outcome. It is the process of strengthening, developing and implementing strategies to combat the impacts of climate events (risks), capitalize on opportunities and manage impacts.

There is no clear distinction between the actions (investment, improvement, support, incentives, etc.) that countries currently undertake in their development efforts and climate change adaptation efforts. Most adaptation measures have an explicit or implicit development component. Therefore, climate change adaptation efforts need to be included in development efforts.

In climate change adaptation studies, it is necessary to identify impacts, understand vulnerability and adaptation processes and make assessments for these, and in this context, adaptation needs should be determined first. Adaptation needs differ according to regions, people and sectors. In order to make effective and strategic adaptation planning, the systems (location, community, sector) that will be most affected by the negative impacts of climate change be targeted. The concepts of vulnerability and risk are important for adaptation to climate change. These concepts help to identify the most sensitive points against the regional risks and threats posed by climate change.

One of the methods of vulnerability and risk analysis is to determine the risk components to be used in the analysis at the indicator level by creating impact chains. According to the methodology described in detail in the first section, this is done by developing certain adaptation indicators at various spatial scales. Since vulnerability is not a directly measurable concept, it is necessary to use a combination of indicators. In the process that will continue with the collection of indicators to be determined by impact chains, determining the risk level of priority sectors related to hazards will be important for focusing on the right adaptation measures.

In the second part, climate hazards, exposure, sensitivity and adaptive capacity issues related to priority sectors were examined by sector experts. Sectors, sub-sectors, vulnerable groups were examined by sector experts regarding the potential of priority economic sectors and non-economic areas identified within the scope of the project to be affected by climate change and the determination of the scope of vulnerability and risk analysis, and the relations of the sectors with each other were emphasized. Priority sectors/areas were identified as water management, agriculture and animal husbandry, biodiversity and ecosystems, public health, urban planning/infrastructure, energy, industry, tourism, transportation-communication, social development. Prominent stakeholders related to these sectors and areas and indicators that can be used in risk analyses are also included in the relevant sections.

1. ANALYSIS

The nature and severity of impacts resulting from climate change depend not only on changes in climate, but also on the vulnerability of the people or system affected[1]. The consequences of these changes can cause changes in the normal functioning of communities and societies and, depending on their severity, can cause major damage or loss of function.

Vulnerability and risk are influenced by a wide range of factors, including anthropogenic climate change, natural climate variability and socio-economic development[2] (Figure 1). Climate change adaptation and disaster risk management focus on reducing sensitivity and exposure and increasing resilience to the potential adverse impacts of climate change, including climate extremes.

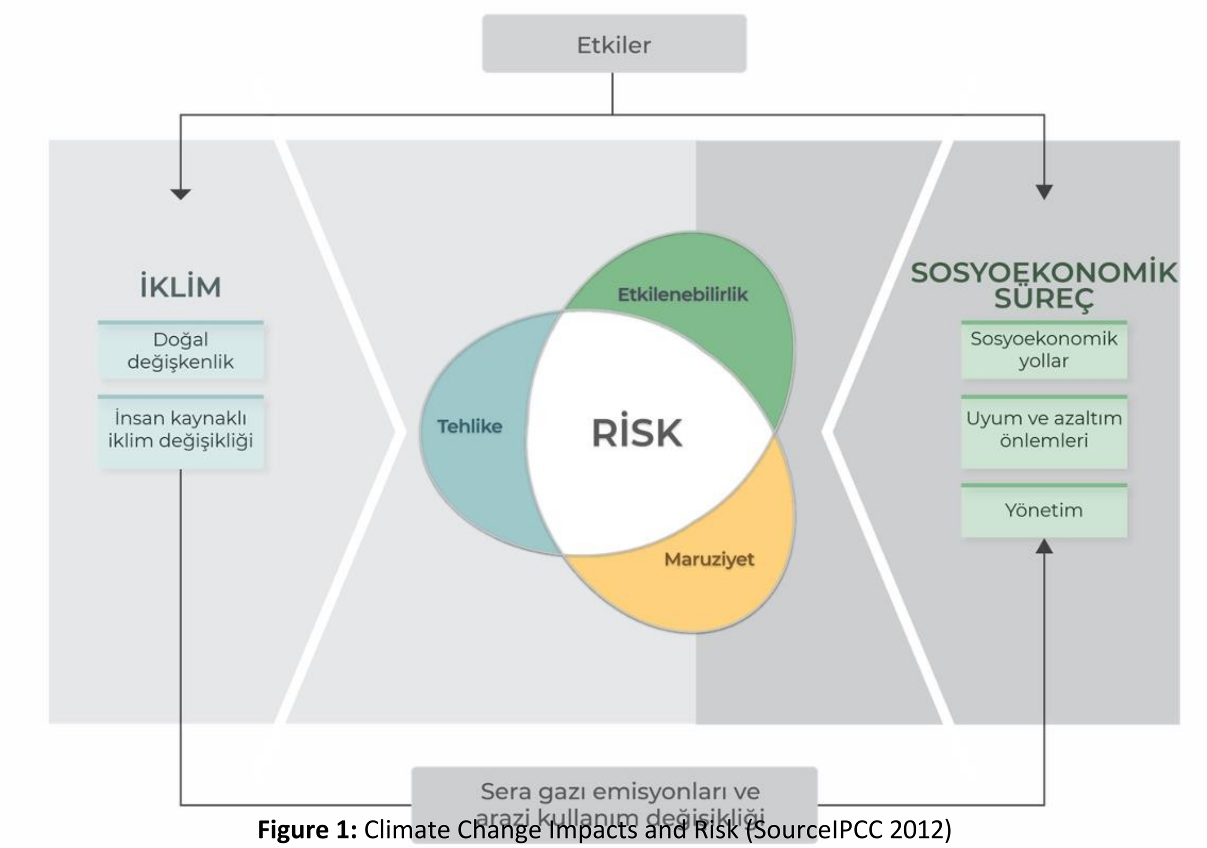


Figure 1: Climate Change Impacts and Risk (SourceIPCC 2012)

Although risk cannot be completely eliminated, it can be managed through various approaches such as reducing sensitivity and exposure, increasing adaptive capacity or sharing risk. There will be very different impacts for each country, as countries and sectors will have different exposures to climate change and different sensitivity and adaptive capacity. A solid foundation is needed to develop appropriate strategies and plans with political support at various levels of governance, from national to local, to deal with the challenges specific to these regions.

1 IPCC. (2007). IPCC Fourth Assessment Report: Climate Change 2007. Geneva: Intergovernmental Panel on Climate Change.

2 IPCC. (2012). Managing the Risk of Extreme Events and Disasters to Advance Climate Change Adaptation. Geneva: Intergovernmental Panel on Climate Change,

The impacts of climate change vary across regions, from sector to sector and even within sectors. Understanding the vulnerability and risk level of the region is crucial for planning and implementing adaptation actions at the regional level. Climate change is the root cause of climate-related risks, but it is not the only factor. Regional impacts of climate change also depend on the evolution of environmental, political, technological and socio-economic conditions at the regional scale. For example, urbanization of lowlands, deforestation of hill slopes, or construction of buildings in risk areas are among the factors that will increase risk. On the other hand, building institutional and technical capacity to address climatic hazards can reduce risk.

Vulnerability and risk assessment is essential for planning and implementing adaptation measures and prioritizing resources. This assessment is crucial to identify which regions, sectors or system components are particularly affected by climate change and where there is an urgent need for adaptation.

The Intergovernmental Panel on Climate Change (IPCC), in its Fourth Assessment Report (AR4), defines vulnerability as 'the degree to which geophysicalbiological and socio-economic systems are, and unable to cope with, the adverse impacts of climate change, including climate variability and extremes' (IPCC, 2007). The term 'vulnerability' in AR4 is used to refer to the vulnerable system itself (e.g. low-lying islands or coastal cities); and the impact on that system (e.g. flooding of coastal cities and agricultural land)[3]. According to IPCC AR4, vulnerability is a function of three factors: exposure, sensitivity and adaptive capacity[(4)] [(3)]. Exposure in AR4 relates to the magnitude and duration of climate-related stress, such as drought or changes in precipitation, while sensitivity is the degree to which the system is affected by climate-related stress or extreme events. Adaptive capacity in AR4 refers to the ability of the system to withstand or recover from extreme events/damages [3 4 6 5]. According to AR4, Effectiveness (E) is a function of Exposure (M), Sensitivity (D) and Adaptive Capacity (AC).

$$E = f(M, D, UK) \qquad (1)$$

The IPCC's Fifth Assessment Report (AR5) introduced a new approach and terminology. This approach is similar to the concept of disaster risk and differs from the current understanding of vulnerability outlined in IPCC AR4[6]. According to IPCC AR5, risk is defined as 'a potential for consequences' where something of value is at stake and the outcome is uncertain, recognizing the diversity of values. It is usually represented as the probability of hazardous events or trends occurring multiplied by the impacts if these events or trends occur (IPCC, 2014). The term 'risk' is primarily used to refer to the risks of climate change impacts [7]. According to AR5, Risk (R) is divided into Hazard (T), Exposure
(M) and is a function of Effectiveness (E).

$$R = f(T, M, E) \qquad (2)$$

[3] Schneider, SH et all, 2007, "Assessing key vulnerabilities and the risk from climate change", Cambridge University Press, Camridge
[4] Hahn, MB; Riederer, AM; Foster, SO, 2009, "The Livelihood Vulnerability Index: a pragmatic approach to assessing risks from climate variability and change - a case study in Mozambique.", Global Env. Change Journal [5] Ebi, K; Kovats, RS; Menne, B, 2006, "An approach for assessing human health vulnerability and public health interventions to adapt to climate change", Environ Health Perspect
[6] Fritzsche, K., Schneiderbauer, S., Bubeck, P., Kienberger, S., Buth, M., Zebisch, M., & et al. (2014). The vulnerability sourcebook: concept and guidelines for standardized vulnerability assessments
[7] Oppenhimer et all, 2014, "Emergent risks and key vulnerabilities. Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects", Cambridge University Press

The terms "vulnerability" and "exposure" are found in both IPCC AR4 and AR5, but they have different meanings. In the last two assessment reports prepared by the IPCC, the concept of vulnerability has been evaluated in different ways. While AR4 examines exposure, sensitivity and adaptive capacity to climate change under the vulnerability framework, in AR5, vulnerability is only one of the components of risk, encompassing only the components of sensitivity and adaptive capacity. Risk also includes hazard and exposure components (Figure 2).

In both the IPCC working definitions of AR4 and AR5, it is clear that vulnerability and risk involve an external element. This external element is climate-related stress (e.g. extreme weather events), represented by "exposure" in AR4 and "hazard" in AR5. The internal elements, on the other hand, are defined as "sensitivity" and "adaptive capacity" in AR4 and "exposure" and vulnerability" in AR5. element describes the controlling characteristics of the system (socio-economic, physical or environmental). It can be said that the terminology used in both IPCC assessment reports is different, but the basic assumptions follow a similar logic.

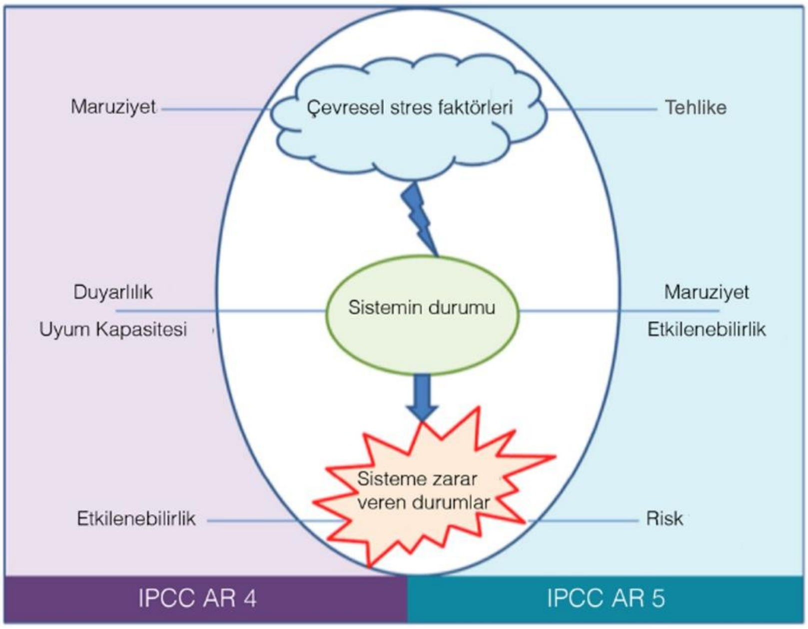


Figure 2: General logic of the two different approaches in IPCC AR4 and AR5[8].

1.1. Vulnerability and Risk Methodology

The construction of an index based on specific variables is widely used in quantitative approaches for vulnerability and risk assessment. The risk methodology focuses on assessing the risks facing key sectors in Turkey to the impacts of climate change, such as changes in temperature, precipitation and evaporation. Within the scope of the study, climate hazards were identified by examining disasters such as drought, heat waves, cold waves, heavy rainfall, forest fires and high winds that may occur due to extreme weather events caused by increasing temperatures and changing precipitation patterns and regimes.

The methodology to be used for risk analysis in this project is shared in Figure 3. In this context, as obtained in the Report on Analysis and Assessment of Climate Projections, MPI-ESM-MR global

[8] Das, S., Ghosh, A., Hazra, S., Ghosh, T., R, S. d., & S, &. S. (2020). Linking IPCC AR4 & AR5 frameworks for assessing vulnerability and risk to climate change in the Indian Bengal Delta. . Progress in Disaster Science, 7, 100110, https://doi.org/10.1016

The model results of RCP4.5 and RCP8.5 scenarios downscaled to 10 km resolution with RegCM, the regional climate model of the climate model, were used. The model results were first bias corrected and then extreme climate indices were calculated with the corrected results. Climate indices are indicators of the climate signal level of the hazard component. In the rest of the study, risk analysis will be performed by evaluating each component with the accepted formulas. After the risk analysis, risk maps will be produced.

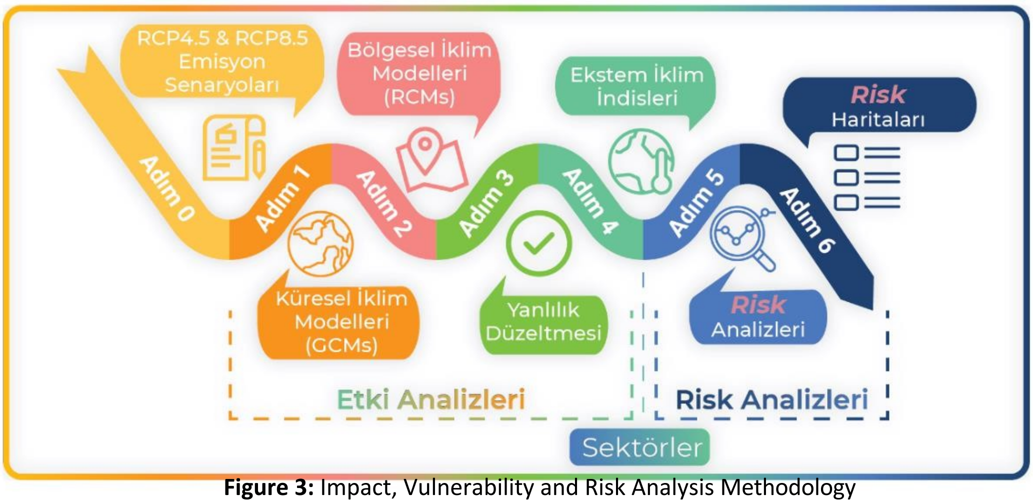


Figure 3: Impact, Vulnerability and Risk Analysis Methodology

Within the scope of risk analysis, the stages presented in Figure 4 will be followed. These stages can be corrected or added to during the study. In the first stage of the analysis, an impact chain will be created for each sector. While creating the impact chain, indicators will be determined according to the sectors and the data needed will be obtained from institutions and organizations. Since each of the indicators will be in different units and formats, the values will first be normalized to have a value between 0 and 1 and the normalized results will be classified from 1 to 5. The normalized indicators will then be weighted with the ratios determined by the experts and stakeholders and the risk calculation will be made in line with the accepted formulas.

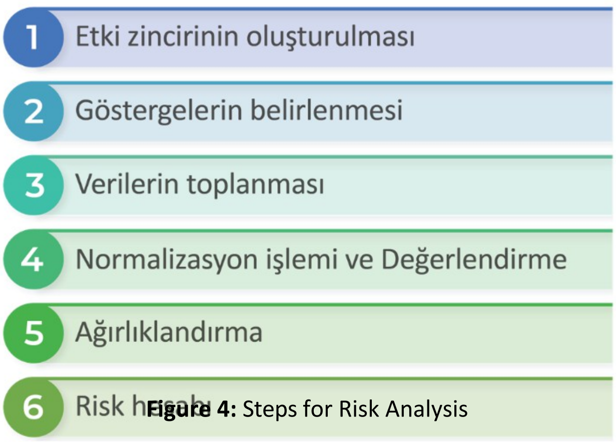


Figure 4: Steps for Risk Analysis

1.1.1. Creating the Chain of Influence

An impact chain is an analytical tool that helps to better understand, systematize and prioritize the factors driving risk in the system of interest. The structure of the impact chain, developed according to the IPCC AR5 approach, is based on an understanding of risk and its components. The impact chain consists of risk components (hazard, vulnerability, exposure) and underlying factors (Figure 5).

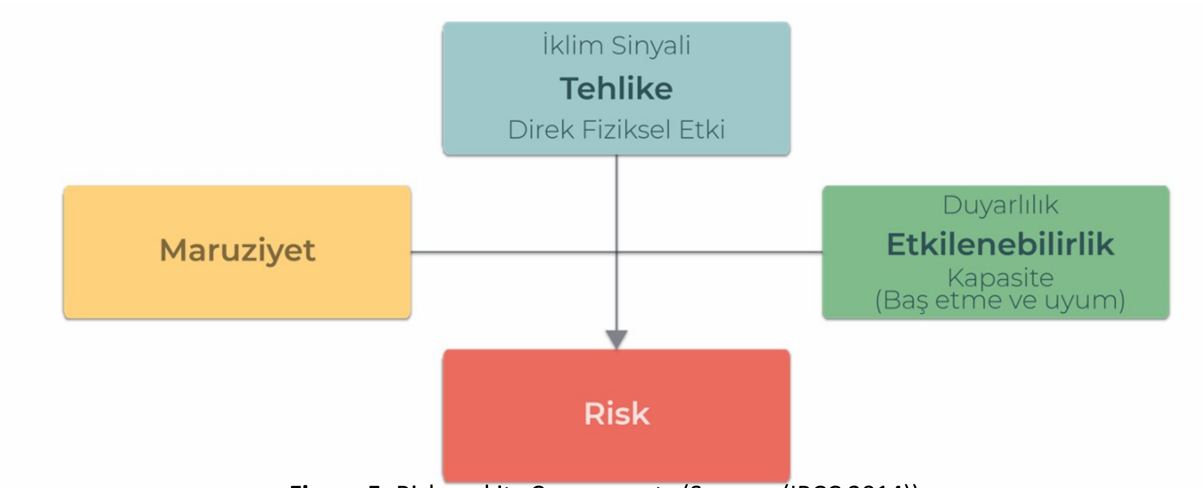


Figure 5: Risk and its Components (Source: (IPCC 2014))

1.1.1.1. Risk Component

The risk component is the potential for outcomes where the outcome is uncertain, where something of value is at stake. Risk is a combination of vulnerability, exposure and hazard (Figure 5). Climate risk is the potential climate-dependent consequences (climate impacts) to which something of value (assets, people, ecosystem, culture, etc.) is exposed. Often systems can be exposed to more than one climate risk (IPCC, 2014).

1.1.1.2. Hazard Component

The hazard component includes factors related to the climate signal and direct physical impact. It is the potential occurrence of a natural or human-induced physical event, trend, physical impact that could cause loss of life, injury, or other health problems, damage to or loss of property, damage to structures, livelihoods, service provision, ecosystems and natural resources.

The hazard can be a climatic event (e.g. heavy rainfall) or a direct physical impact (e.g. flooding). The hazard does not need to be an extreme weather event (e.g. tropical storm, flood), but also have a temporal slow-developing trend. Examples of slow-evolving trends include decreasing water from snowmelt, increasing average temperatures and sea level rise (IPCC 2014).

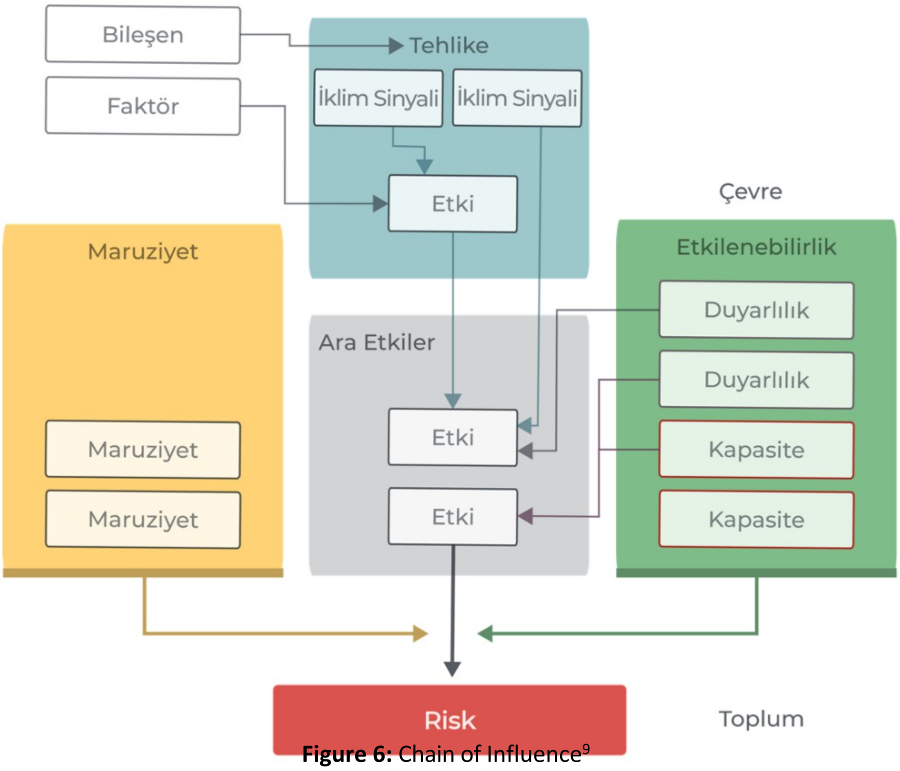


Figure 6: Chain of Influence[9]

1.1.1.3. Vulnerability Component

The vulnerability component can be defined as the susceptibility to adverse impacts. Vulnerability depends on sensitivity, susceptibility to harm, coping and adaptive capacity (IPCC, 2014).

- **Sensitivity:**

Susceptibility is determined by factors that directly influence the consequences of a hazard. Susceptibility can include physical characteristics of a system (e.g. building material of houses, type of soil in agricultural areas), social, economic and cultural characteristics (e.g. age structure, income structure).

- **Capacity:**

Capacity refers to the ability of societies to prepare for and respond to current and future climate impacts. It has two elements: coping and adaptive capacity.

Coping capacity can be defined as the ability of people, institutions, organizations and systems address, manage and overcome adverse conditions in the short to medium term using existing skills, values, beliefs, resources and opportunities (e.g. early warning systems).

Adaptive capacity is the ability of systems, institutions, people and other organisms to adjust to potential damage, take advantage of opportunities or respond to consequences (e.g. knowledge to introduce new farming methods). A wide range of factors determine adaptive capacity, such as wealth, social status, knowledge capital, etc.

[9] GIZ& EURAC, 2017, "Risk Supplement to the Vulnerability Sourcebook. Guidance on how to apply the Vulnerability Sourcebook's approach with the new IPCC AR5 concept of climate risk.", GIZ

The IPCC (2001) identifies eight broad classes of determinants of adaptive capacity:

i. Available technological options,
ii. Sources
iii. Structure of critical institutions and decision-making authorities,
iv. Stock of human capital,
v. Stock of social capital, including the definition of property rights,
vi. System access to risk-emitting processes,
vii. Knowledge management and the reliability of information provided by decision makers,
viii. Public perception of risk and exposure.

1.1.1.4. Exposure Component

The exposure component consists of one or more exposure factors. It is the presence of people, livelihoods, species or ecosystems, environmental functions, services and resources, infrastructure or economic, social and cultural assets in places and environments that may be adversely affected. Exposure elements that are exposed, vulnerable, exposed or exposed to risk. The degree of risk-related exposure is expressed in numbers, density, proportion, etc. (e.g. population density in a drought-affected area). For example, changing the number of people living in drought-prone areas can significantly reduce or increase risk (IPCC; 2014).

line with the IPCC AR5 approach, as the basic building blocks of cause-and-effect chains from hazard to risk "impacts" are shown.

1.1.1.5. Impacts

Unlike the hazard, vulnerability and exposure components, intermediate effects are not a risk component in their own right, but only an auxiliary tool to fully grasp the chain of cause and effect leading to risk. By definition, they are a function of both hazard and vulnerability factors. This means that all impacts identified that depend not only on the climate signal, but also on one or several vulnerability factors, should be placed here. In the IPCC report, the term impacts is primarily used to describe the impact of extreme weather events and climate change on natural and human systems. The term impacts generally refers to the effects on lives, health, ecosystems, economy, society, culture, services and structures due to climate change or extreme events over a given time period and the vulnerability of society and the system (IPCC, 2014).

In general, adaptation measures can reduce risk by reducing vulnerability and, in some cases, exposure (Figure 7). Vulnerability can be reduced by reducing sensitivity or increasing capacity. For example, capacity can be increased by training farmers on water-saving pressurized irrigation techniques, while sensitivity is reduced because pressurized systems reduce agricultural water use.

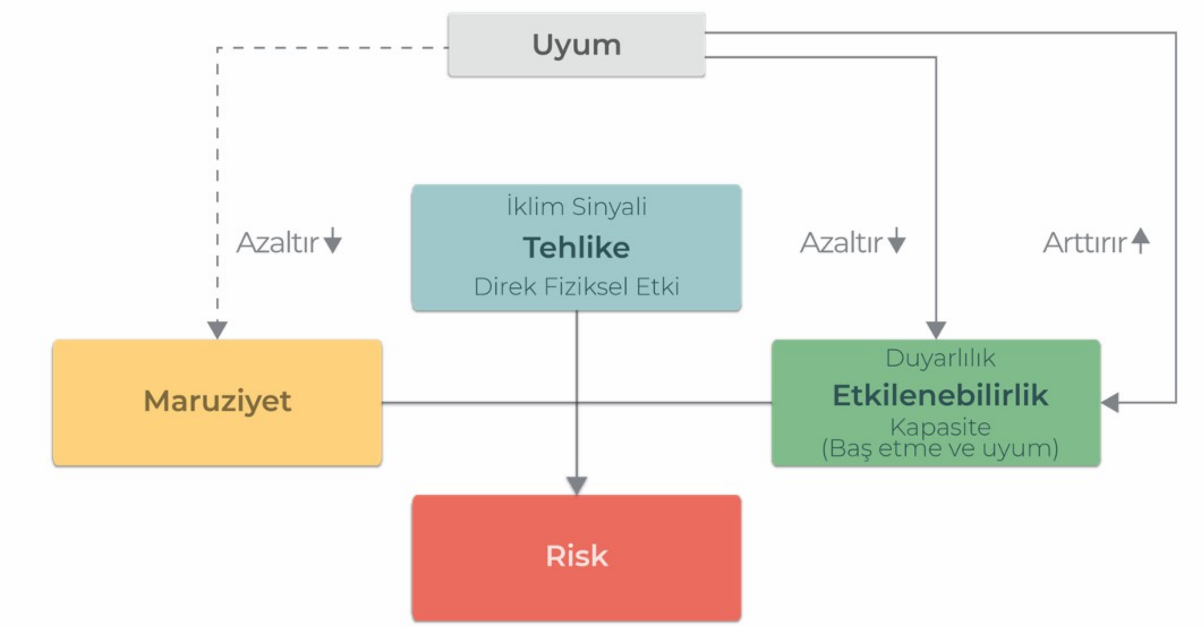


Figure 7: Risk and Compliance (Source: (GIZ and EURAC 2017))

1.1.2. Identification of Indicators

Vulnerability and Risk are measured through the development of specific adaptation indicators at various spatial scales [10]. As observed by Schauser, there is no agreed integrated measure of vulnerability to climate change, as vulnerability is a theoretical concept and cannot be directly measured. This also true for adaptation. The lack of a metric means that a combination or set of indicators is needed to provide an accurate picture of both adaptation and vulnerability. Therefore, indicators of risk and vulnerability tend to be used in combination with indicators of related terms such as impacts, exposure, susceptibility and adaptive and coping capacity. In some cases, risk and vulnerability are used as an overarching concept to be measured rather than being linked to adaptation. For example, the development of assessment criteria for adaptation[11] frames the effectiveness of adaptation measures as the vulnerability remaining after adaptation measures have been implemented, thus placing vulnerability at the center of assessment objectives.

Approaches measuring vulnerability and risk are as broad as the term itself. Indicators and measures can focus on a specific vulnerability topic (e.g. sector, group, theme) or cover multiple sectors and various scales (e.g. understanding the vulnerability of a habitat in a specific location or across an entire country). They can also form part of a broader monitoring or assessment effort, or be part of a separate index or system for a specific theme or objective. Vulnerability and risk indicators can also be combined with indicators of impact, adaptation and resilience and linked to inputs, outputs or outcomes. They can be positioned within a 'Theory of Change' (an approach that aims to provide a systematic explanation and example of how and why a desired change is expected to occur in a given context) or as part of a broader assessment process.

[10] Schauser, I., Otto, S., Schneiderbauer, S., Harvey, A., Hodgson, N., Robrecht, H., & et al. (2010). Urban regions: Vulnerabilities, vulnerability assessments by indicators and adaptation options for climate change indicators. [11] Weiland, S., & Tröltzsch, J. (2016). *BASE Evaluation criteria for Climate adaptation (BECCA).*

Indicators play an important role in monitoring, reporting and evaluating policies, programs and projects (EEA 2015) and 'provide clues and direction on how change is occurring and whether results are being achieved'.

Carter [12] emphasizes that stakeholder-driven approaches can be used as alternatives or complements quantitative indicator studies, where stakeholders agree on important issues and responses to assess vulnerability to climate change [13]. These stakeholders can be experts or vulnerable groups and can provide a valuable alternative perspective to quantitative indicators, as well as valuable sources of information where data limitations exist.

1.1.3. Data Collection

Collecting the data needed to conduct risk and vulnerability analyses according to the indicators identified is one of the most important steps in these analyses. All research projects use multiple methods to collect information. First, studies typically start with a literature review, followed by a series of data collection steps. These can be quantitative, qualitative or a combination of both. The information is then evaluated by experts (and sometimes stakeholders) and the final step is the development of frameworks or tools and the identification of knowledge gaps. Research projects are more homogeneous in terms of the steps involved than country assessment projects, which are more diverse in structure.

There is a wide range of methods used for data collection and analysis, such as climate projections, impact modeling, economic assessment, stakeholder workshops, surveys or panelssocial and institutional assessment, and expert inference. All projects use both quantitative and qualitative methods. Many of these projects mainly use quantitative methods (e.g. modeling) rather than qualitative methods (e.g. participatory). In some cases, stakeholders are a core part of the project and are part of the project on an equal footing with the researchers, producing outputs together. In other projects, stakeholders have an advisory role, providing top-down knowledge development followed by provision.

1.1.4. Normalization Process

Another step in risk analysis is the normalization of data. Data with different units collected by different institutions must be normalized in order to be comparable with each other. The term normalization refers to the process of extrapolating data with different scales and different units to a common scale without units [14]. All data should be standardized, not only to compare vulnerability or exposure indicators with indicators of hazard factors, but so that even hazard factor indicators are comparable with each other.

There is more than one normalization method. In sectoral risk and vulnerability analysis studies conducted around the world, the maximum-minimum normalization method, which is also used by the United Nations Development Program (UNDP) in the Human Development Index calculations, is commonly used to perform the normalization process. In this study

[12] Carter, T. &. (2011). MEDIATION D2.1 Review of existing methods and metrics for assessing and quantifying impacts and vulnerability identifying key shortcomings and suggesting improvements Status.
[13] Malone, E., & Engle, N. (2011). Evaluating regional vulnerability to climate change: purposes and methods. . Climate Change, 2(3), 462-474.
[14] OECD. (2008). Handbook on constructing composite indicators: methodology and user guide. Technical Report. Paris: OECD Publishing. http://www.oecd.org/std/42495745.pdfRetrieved from

The maximum-minimum normalization method will be used for normalization operations. According to this method, the available data is reevaluated between 0 and 1 in direct proportion to its previous values. The re-evaluation is done as follows:

$$Normalize\ edilmiş\ değer = \frac{Gerçek\ Değer - Minimum\ Değer}{Maksimum\ Değer - Minimum\ Değer} \times 100 \qquad (2)$$

$$Normalize\ edilmiş\ değer = 1 - \frac{Gerçek\ Değer - Minimum\ Değer}{Maksimum\ Değer - Minimum\ Değer} \times 100 \qquad (3)$$

Equation (2) and Equation (3) show the normalization methods used for parameters with positive and negative correlation with the risk value, respectively. As stated in the equations, the correlation of parameters with risk is important.

In this study, the normalization process described above is used to normalize the parameters and components from 0 - 1
values between 1 and 5, all indices will be scored between 1 and 5 in the risk calculation.

Table shows which scores correspond to the values obtained as a result of normalization.

Table 1: Class Values and Definitions (GIZ&EURAC, 2017)

Metric Risk Classes (0 to 1)	Risk Classes (1 to 5)	Description
0 - 0,20	1	Optimal (improvement required)
0,21 - 0,40	2	Very positive
0,41 - 0,60	3	Neutral
0,61 - 0,80	4	Quite negative
0,81 - 1,00	5	Critical (lead to serious problems can open)

1.1.5. Weighting

After the normalization of the parameters, the second step, weighting, needs to be performed in order to combine the parameters. In the literature, two main methods, weighted average and arithmetic average, stand out. Figure 8 shows these methods schematically.

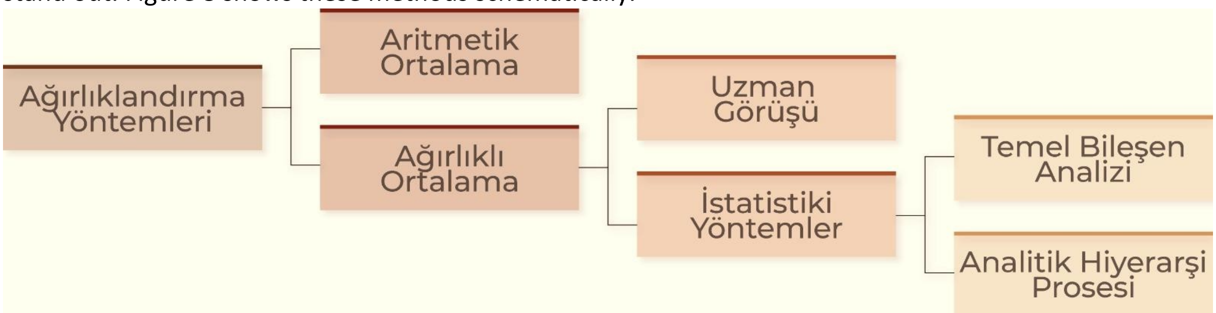


Figure 8: Weighting Methods

1.1.6. Arithmetic Mean

The arithmetic mean method that all indicators selected for vulnerability and risk analysis have equal weight. This method is very easy to use due to the difficulty of using statistical methods in cases such as data insufficiency and the difficulty of finding competent experts for each sector. In cases where expert opinion cannot be utilized, the arithmetic average method is seen as the most usable method.

1.1.7. Weighted Average

The weighted average method assumes that each indicator has different impact on sectoral vulnerability and risk. In order to calculate the weighted average, some statistical methods or expert opinions are utilized to determine the coefficients showing the impact ratios of the indicators.

Within the scope of this method, statistical methods are used to evaluate existing data sets and determine the coefficients weighting the indicators. Principal component analysis and uncertainty analysis are examples of these methods. However, such statistical methods large data sets to assess the overall behavior of the system. Therefore, in case of serious data gaps, they can lead to different interpretations of the system and give misleading results. As an alternative to statistical methods, there are also studies that utilize expert opinion to establish the importance ranking of parameters. However, in order to ensure consistency in such studies, experts familiar with each sector are needed. Within the scope of the project, the weighted average method will be used in vulnerability and risk calculations by coming together with sector experts. Thus, for each city and sector, risk levels and structures with high exposure and low vulnerability to climate risks will be determined. table provides examples of studies using different weighting methods.

Table 2: Studies Using Different Weighting Methods

Weighting Method	**Used for Determination of Weights Method**	**References**
Weighted Average	Expert Opinion	(Rao and others, 2016; Eriygama and others, 2010; Polsky, Neff and Yarnal, 2007; Schröter, Polsky and Patt, 2005; European Commission, 2014; Swain and Swain, 2011; Colorado Water Conservation Board, 2013; Stefano et al. 2015)
	Core Component Analysis	(Deressa, Hassan and Ringler, 2008; Liu et al. 2013; Nelson et al, 2010)
	Analytic Hierarchy Process	(Shukla, Sachdeva and Joshi, 2016)
	Logistics regression	(Shewmake, 2008)
Arithmetic Mean		(Swaroop, 2011; Chen et al, 2013; Deems, 2010; Nagarajan and Ganapuram, 2015; Chen et al, 2015)

1.1.8. Risk Account

In general, the vulnerability of a system to climate change is a result of the interactions between its main components. Any attempt to quantify social vulnerability and risk must demonstrate mathematically relative and causal relationships between these components. As illustrated the literature, there are multiple potential relationships for vulnerability analyses in the AR4 approach.

Table 3: Mathematical Relationships between Vulnerability and its Components[15]

Equation	Authors
E= f[M(UK); D(UK)]	Yohe and Tol (2002)
E= f(M, D, UK)	Adger (2003, p.32)
E= (M− UK)× S	Hahn et al. (2009), Shah et al. (2013)
E= -D− 0.5× UK	Yoo et al. (2011)
E= (M× D)/Dk	Balica et al. (2012)
E= (M+ D)− UK	Morzaria-Luna et al. (2014)
E= (M+ D+ UK)/3	Ahsan and Warner (2014)

E:Vulnerability, M:Exposure, D:Susceptibility, IC:Adaptive Capacity, Dk:Resilience

Some researchers propose relationships in the form of general equations, as indicated by [16], while others propose detailed formulas to express these relationships. The differences in these equations reflect differences in approach, scope, context and priorities. For example, while Hahn et al. and Shah et al. focus on livelihood vulnerability and propose the equation E = (M - UK) × D and the formula E = (M + D) - UK and E = (M + D + UK) / 3, Morzaria-Luna HN and Ahsan & Warner calculates social indicators of vulnerability for fishing communities (Hahn, Riederer and Foster 2009), (Shah, et al. 2013), (Morzaria-Luna HN 2014), (Ahsan and Warner 2014). In the context of vulnerability to flooding in coastal cities, the equation E = (M × D) / Dk, advocated by Balica et al. (Balica, Wright and Meulen 2012).

In contrast to IPCC's AR4 approach, which has been applied with different constructs for a long time, the risk calculation according to the IPCC AR5 approach, which is newer in the literature and developed to reduce the risk of disasters at the same time as adaptation to climate change, is made with different calculations as presented in the Table.

[15] Nguyen, C., Horne, R., Fien, J., & Cheong, F. (2017). Assessment of social vulnerability to climate change at the local scale: Development and application of a Social Vulnerability Index. Climatic Change, 143(3-4), 355- 370.
[16] Adger, W. (2003). Social aspects of adaptive capacity. In: Smith JB, Klein RJT, Huq S (eds) Climate change, adaptive capacity and development. London: Imperial College Press.
Yohe, G., & Tol, R. (2002). Indicators for social and economic coping capacity-moving toward a working definition of adaptive capacity. Glob Environ Chang 12(1), 25-40.

Table 4: Mathematical Relationships between Risk and its Components[17]

Equation	Authors
$E=M\times(D+K)$, $R=T\times E$	(Johnson, Depietri and Breil 2016)
$R={}_1\times T+W_2\times\times E$	(Sekhria, et al. 2020)
$E=\left(\frac{D}{n}\right)-\left(\frac{UK}{n}\right)$, $R=E\times\left(\frac{M}{n}\right)$	(Maragno, Fontana and Musco 2020)
$R=f(pT\times M\times E)$	(Connelly, et al. 2018)
$R=T\times M\times D(1-UK)$	(Das, Ghosh, et al, Linking IPCC AR4 & AR5 frameworks for assessing vulnerability and risk to climate change in the Indian Bengal Delta 2020)

Here, Risk (R) is given as a function of Hazard (T), Exposure (M) and Effectiveness (E), and Effectiveness corresponds to Sensitivity (D) and Adaptive Capacity (IC).

In another sectoral study, risk is calculated by multiplying and summing the weights of the components and dividing by the sum of these weights (GIZ & EURAC, 2017):

$$Risk=\frac{(Tehlike\times A_T)+(Etkilenebilirlik\times A_E)+(Maruziyet\times A_M)}{A_T+A_E+A_M} \quad (4)$$

When calculating risk values for each sector, the results will be evaluated according to the risk classes presented in the table below.

Table 5: Risk Classification (GIZ and EURAC 2017)

Metric Risk Classes (from 0 to 1)	Risk Classes (1 to)	Risk Rating
0 - 0,20	1	Very Low
0,21 - 0,40	2	Low
0,41 - 0,60	3	Middle
0,61 - 0,80	4	High
0,81 - 1,00	5	Very High

[17] Nguyen, C., Horne, R., Fien, J., & Cheong, F. (2017). Assessment of social vulnerability to climate change at the local scale: Development and application of a Social Vulnerability Index. Climatic Change, 143(3-4), 355- 370.

As a result, for each sector **Error! Reference source not found.** 6 As presented in **Table** 6, a result matrix for risk and its components will be made and risk levels for current and future periods will be determined. Radar charts and maps will also be prepared using this information.

Table 6: Example Results Matrix for Risk and its Components (GIZ & EURAC, 2017)

		Tehlike	Maruziyet	Etkilenebilirlik	Risk	Risk Seviyesi
Sektör 1	Mevcut Dönem	0,20	0,50	0,20	0,30	Düşük
	2041-2060	0,70	0,55	0,20	0,47	Orta
Sektör 2	Mevcut Dönem	0,65	0,40	0,80	0,62	Yüksek
	2041-2060	0,85	0,78	0,80	0,81	Çok Yüksek

However, these approaches are unlikely to clarify the causal relationships between the components of the Social Vulnerability Index (SVI).

Social vulnerability is often hidden and complex (Barnett et al. 2008; Fekete 2009). It is therefore not surprising that a variety of approaches are used to assess SEI (Yoon 2012). Table **7** provides a way of understanding this diversity by showing a range of elements and approaches in existing studies.

In the table, two main approaches to developing an SEI can be identified: (1) deductive ones based on existing theory and (2) inductive ones based on data. The limitation of a deductive approach is that theory-based factors may be inappropriate or inaccurate in describing dynamic systems of climate and community change. Moreover, this approach can only be used to select factors, not to aggregate them (Hinkel, 2011). The inductive approach should avoid problems arising from lack of data, especially in developing countries [18].

Table 7: Social Vulnerability Index Classifications (Nguyen et al2017).

Elements	Approaches	Authors
Components	Single component	Cutter et al. (2003)
	Multi-component	Hahn et al. (2009), Yoo et al. (2011), Heltberg and Bonch-Osmolovskiy (2011), Shah et al. (2013), Ahsan and Warner (2014)
Indicator selection and merger	Inductive	Cutter et al. (2003), Rygel et al. (2006), Boruff and Cutter (2007), Bjarnadottir et al. (2011)
	Deductive	Cutter et al. (2000), Wu et al. (2002), Heltberg and Bonch-Osmolovskiy (2011), Lixin et al. (2014), Zhou et al. (2014)
Indicator weights	Equal Weighting	Clark et al. (1998), Wu et al. (2002), Cutter et al. (2003),

[18] Hinkel, 2011

Elements	Approaches	Authors
	Unequal Weighting	Kleinosky et al. (2007), Bjarnadottir et al. (2011), Ahsan and Warner (2014), Lixin et al. (2014)
Spatial scales	International	Boruff and Cutter (2007)
	National	Cutter et al. (2003), Heltberg and Bonch-Osmolovskiy (2011)
	Local	Cutter et al. (2000), Wu et al. (2002), Bjarnadottir et al. (2011), Yoo et al. (2011)
Temporal scales	Today	Cutter et al. (2003), Boruff and Cutter (2007), Yoo et al. (2011), Ahsan and Warner (2014)
	Future	Wu et al. (2002), Rygel et al. (2006), Kleinosky et al. (2007), Yoo et al. (2011)
Data sources	Primary	Hahn et al. (2009), Shah et al. (2013), Ahsan and Warner (2014)
	Secondary	Cutter et al. (2003), Rygel et al. (2006), Boruff and Cutter (2007), Bjarnadottir et al. (2011), Lixin et al. (2014), Zhou et al. (2014)

Whichever approach is used, a number of conceptual and methodological factors need to be taken into account. Weighting schemes are always an important aspect of aggregation processes (Fekete et al. 2010; Yoon 2012). Most existing research does not specifically weight social vulnerability indicators. This that they weight each factor equally. However, since not all vulnerability indicators are equal, this methodology is unlikely to reflect reality. Some studies apply weighting methodology through 'expert judgment' (Vincent 2004); weights derived from principal component analysis (Crowards 1999); analytical hierarchy process (Bjarnadottir et al. 2011); and Pareto ranking (Kleinosky et al. 2007).

The spatial scale of assessment is also a crucial element to consider, as social vulnerability varies from place to place (Rygel and others 2006). SEI studies have been conducted at a variety of scales, ranging from country (Bjarnadottir et al. 2011; Cutter et al. 2000; Wu et al. 2002) to city (Yoo et al. 2011Batıbeniz et al2020)national (Cutter et al. 2003Heltberg and Bonch-Osmolovskiy 2011) to international (Boruff and Cutter 2007), including a group of Caribbean island countries. However, Hinkel (2011) argues that Social Vulnerability Indices are best studied at local scales where systems can be described in detail and, as a consequence, deductive arguments are available to allow for selecting and combining indicator variables and inductive variables.

Temporal scale is also important. Most research estimates SEI under present-day conditions, drawing on past and current socio-economic data and historical information on disasters. Only a few studies attempt to assess and compare different SEIs according to scenarios of future factors (Bjarnadottir et al. 2011; Kleinosky et al. 2007; Rygel et al. 2006; Wu et al. 2002).

Most approaches use secondary (census) data because this avoids the need to collect and source primary SEI-specific data. Others use primary data; for example, Hahn et al. (2009), Shah et al. (2013), and Ahsan and Warner (2014) use factors in the sensitivity and adaptive capacity components.

household surveys to collect data for estimation. Using primary data helps overcome the limitations of secondary data-driven methods, which often suffer from limited or no information on measurement error (Ahsan and Warner 2014; Hahn et al. 2009).

1.2. Vulnerability and Risk Analysis Preparation Process

Before starting the vulnerability and risk analysis, it is necessary to make a preliminary preparation by going through some stages. At this stage, firstly, the current situation is analyzed and the purpose is determined. The decisions to be taken at this stage determine the scope of the analysis in a sense. It is also an important stage for making a time plan by identifying different resources. Identifying the risks related to risk assessment helps to minimize the problems that may occur in the following stages.

There are three approaches to climate change impact and risk assessments. The methodology described in the previous section is suitable for situations where impact assessments can be carried out in all areas and the necessary indicators can be accessed without any problems. However, it may be difficult to find data as you go to the local level. In this case, different approaches can be developed based on quantitative data, expert opinions and meetings with citizens. Figure 9 visualizes this approach.

Climate Change Impact Assessments: Top-down approach and largely based on quantitative data. It mostly considers physical impacts.

Integrated vulnerability and risk analysis: A mix of top-down and bottom-up approaches, based on quantitative and qualitative data. It takes into account socio-economic impacts as well as physical impacts.

Community-based assessments: Bottom-up approach, mostly based on quantitative data. Largely location-oriented, based on social context and expert opinions. Can be objective up to a point.

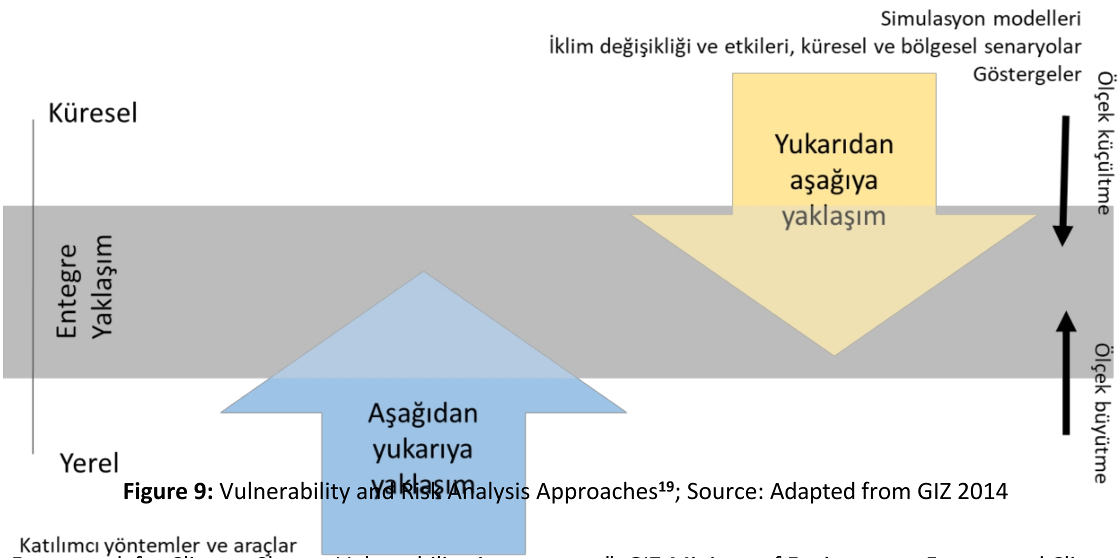


Figure 9: Vulnerability and Risk Analysis Approaches[19]; Source: Adapted from GIZ 2014

[19] "A Framework for Climate Change Vulnerability Assessments", GIZ-Ministry of Environment Forests and Climate Change, Government of India, 2014

The top-down approach relies more on quantitative data and is objective. It identifies existing policies and what is missing. It is based on statistical data and indicators.

The bottom-up approach is based more on qualitative data. It is developed through participatory methods based on data such as cognitive mapping, stakeholder analyses, focus group meetings, expert opinions and household surveys.

As **a first step**, it is necessary to thoroughly understand the content of the assessment. It is important to conduct the analysis process before planning climate change adaptation actions in order to find the right solutions to problems. Studies conducted in the relevant region or on the subject to be analyzed should be examined and analyzed. These studies are very helpful in determining priorities. If scientific studies have not been conducted, it may be necessary to ensure that these studies are conducted on critical issues.

In this first step, it also possible to determine from which institutions and how support can be obtained. Institutions and organizations that can be cooperated with can be stakeholders that can be used in scientific studies, in data collection related to indicators, and in different areas of expertise as people who know the region.

An important issue is to identify exogenous factors that may cause the impacts of climate change to be felt even more. The issue may be completely independent of climate change. The most common exogenous factors may include different issues such as population growth rates, development plans and distribution of sectors in the city, rural migration and level of awareness.

In the second step, it is necessary to determine what is expected from the analysis and what the purpose is. It is also determined which steps the analysis will provide data for in the following processes. This purpose may be the problems the city is currently experiencing or a specific need.

The main objectives of the Vulnerability and Risk Analyses are summarized below.

1) Past climate events, their consequences and how to address them are systematically assessed
2) Ensure a good understanding of current and future climate risks and hazards
3) Non-climate related factors are identified and taken into
4) Priority areas and issues requiring adaptation action are identified
5) Topics of interest in different fields are addressed
6) Information gaps and uncertainties are identified

The third step is to determine the scope of the assessment. The analysis should cover sectors and groups that may be affected. The key impacts that need to be assessed and the existence of vulnerable groups should be evaluated. The answers to the questions to be asked here are necessary to determine the methodology.

The impacts of climate change are being felt more and more every day, and adaptation to its consequences must be made more rapidly and comprehensively. In Turkey, which is located in the Mediterranean Region, one of the regions that will be most affected by climate change, impacts are expected to be felt at all levels of society and in all sectors of the economy. Therefore, adaptation actions should be systematic, covering both economic sectors and areas such as social development, biodiversity and ecosystems. Sectoral identification of actions will serve to actively mainstream climate resilience assessments in all relevant policy areas. The prominent economic sectors relevant to Turkey are agriculture and livestock, water management, urban infrastructure, energy, industry, tourism, transportation and communication. In addition to these, biodiversity-ecosystems, public health and social development issues will be studied separately and actions will be developed. Before identifying actions that can be included in policies for each sector, vulnerability and risk analyses need to be conducted. Disasters related to climate change will be included in each sector-specific study within the scope of the hazard component, which is the first component of the risk analysis.

2. SECTORS

2.1. Water Resources

2.1.1. Assessment of the Effects of Climate Change on Water Resources

The pressures on water resources are gradually increasing due to the increasing population in the world and the climate crisis. This pressure of climate change on water management constitutes one of the most important issues to be taken into consideration in terms of both human life and the healthy existence of nature.

Water, which is a basic resource for living life, is directly dependent on the precipitation regime, which varies depending on climatic characteristics. The shape, location, magnitude, frequency, duration and timing of precipitation affect the entire ecosystem and socio-economic structure. Changes in precipitation lead to changes in the time and severity of flood and drought events, surface runoff regime, the amount of water infiltrating underground, soil moisture, plant pattern and growth rates [20].

Global studies show that the relationship between the atmosphere, hydrosphere and biosphere will be affected by global warming in the coming period. As a result, there will be changes in the hydrological cycle and the precipitation regime will change. As a result of the increase in temperatures, there will likely be increases in global average precipitation and evaporation. Evaporation will increase with warming, and the warming atmosphere will hold more moisture as the temperature increase also increases the evaporation rate. In the long term, precipitation will increase with rising temperatures. Changes in average precipitation in a warmer world will exhibit significant regional variation. There will be regions with increased precipitation, regions with decreased precipitation and even regions with no change. As temperatures rise, the difference in average annual precipitation between dry and wet regions and the difference between wet and dry seasons is projected to increase globally. Although the frequency of precipitation will decrease, the intensity of precipitation will increase. As a result, the Mediterranean region, including Turkey, will be negatively affected by climate change. Significant decreases in flows will be seen especially after 2050s [21].

Climate change projections indicate an increase in the probability of drought and rainfall variability, which will directly affect the availability of water resources. The combination of long-term changes (e.g. higher average temperatures) and larger extremes (e.g. droughts) could have more decisive impacts on water demand and also on ecosystems. All climate projections covering the Mediterranean region show an increase in irrigation demand and a decrease in available water resources [22].

Turkey is divided into 25 hydrological basins and water, which constitutes the basis of these basins, is a vital and socially important resource. Located in a semi-arid region of the world in terms of water resources, Turkey's precipitation regime varies greatly according to seasons and regions, and in some river basinswater needs exceed the potential of the resources. In addition, effects such as increasing summer temperatures, decreasing winter precipitation, loss of surface water, frequent droughts, soil degradation, coastal erosion, floods and floods caused by climate change in Turkey directly threaten the existence of water resources [23].

In 2016, the General Directorate of Water Management launched the Climate Change Impact on Water Resources Project (İklimSU) to determine the impact of climate change on surface and groundwater.

[20] Ragab, R., & Prudhomme, C. (2002). Climate Change and Water Resources Management in Arid and Semi- arid Regions: Prospective and Challenges for the 21st Century. Biosystems Engineering, 81(1), 3-34.
[21] IPCC, 2013.The Climate Change 2013, Physical Science Basis.
[22] Iglesias, A., Garote, L., Flores, F., Moneo M. (2007). Challenges to manage the risk of water scarcity and climate change in the Mediterranean. Water Resources Management 21, 227-288.
[23] Republic of Turkey Ministry of Environment and Forestry, 2011. Turkey's Climate Change Adaptation Strategy and Action Plan.

was realized. Within the scope of the İklimSU project, three global models (HadGEM2-ES, MPI-ESM-MR, CNRM-CM5.1) have been reduced to regional scale and climate simulations with a resolution of 10x10 km have been obtained, and these climate simulations are also used within the scope of this project (Climate Adaptation) to analyze climate hazards. With the hydrological modeling used within the scope of the İklimSU project, the period 2015-2100 was studied in 3 periods and were compared with the reference period 1971-2000. As a result, according to the MPI-ESM-MR model selected for use in climate hazards, it is predicted that the gross water potential in the projection period will decrease by approximately 15-20% compared to the reference period. [24]

In many studies conducted at the scale of Turkey, it is expected that by 2100, winter precipitation will fall more in the form of rain and snow cover will melt more rapidly and join the surface runoff due to temperature increases. However, at the same time, the distribution of precipitation throughout the year, i.e. its intensity and frequency, is also expected to change or shift. As a result, precipitation is expected to fall more as rain rather than snow and the snowpack is expected to melt more rapidly, causing shortages at times when water is most needed, especially in regions where urban and agricultural water needs are regulated by snowpack at high altitudes throughout the year [25].

Climate change increases the vulnerability of water resources by reducing the availability of and accessibility to water resources and leads to negative impacts on water-dependent sectors. Since Turkey is located in a semi-arid climate zone, it is of great importance to improve water quality, increase the amount of usable water and ensure the sustainability of conservation and utilization balance [26].

Sector bottlenecks; fragmented water legislation, overlapping authority and lack of coordination among institutions, the fact that the development-oriented priority makes it difficult to protect water resources, and that the reflection of the positive effects of activities and planning for the protection of water resources in terms of quantity, quality and ecosystems remains slow due to the rapidly developing industry, agriculture sector and population growth, The inverse relationship between the distribution of water in the basins and the regional density of the population, investment needs in the water sector, environmental infrastructures, the need for financing for investments for the protection and improvement of water quality, the necessity of taking the necessary measures for the effective and efficient use of water primarily in the agriculture, industry and drinking-utility water sectors, water security problems especially in rural areas. In Turkey, water is mostly used in the agricultural sector (77%). Approximately 76% of the water used in agriculture is supplied from surface water and 24% from groundwater. This puts pressure on surface and groundwater. When State Hydraulic Works (DSİ) irrigations are analyzed, surface irrigation methods are used in about 60% of the irrigations and water loss is between 35% and 60%. However, irrigation efficiency is around 51%. The lack of precipitation that will occur due to climate change, especially in the Mediterranean Region, will affect agricultural areas, crop yields and livestock breedingdrought extreme weather events will cause a decrease in yields and affect food security. For this reason, within the scope of vulnerability and risk analysis studies regarding drought and water scarcity that will be experienced as a result of the negative impact of climate change on water resources, the agriculture sector has priority in adaptation studies in terms of its water saving potential.

Cities increase their attractiveness depending on their socio-economic development. In addition to increasing population and land use decisions, employment decisions are also important issues affecting urban water demand. In drought and water scarcity conditions, there are difficulties in meeting urban water demands and water shortages are experienced. The use of packaged water has become widespread in cities. People living in Istanbul

[24] General Directorate of Water Management, 2016. Impact of Climate Change on Water Resources Project.
[25] Republic of Turkey Ministry of Development, Eleventh Development Plan (2019-2023), Water Resources Management and Security Specialization Commission Report, Ankara, 2018.
[26] Republic of Turkey Ministry of Agriculture and Forestry, National Water Plan (2019-2023).

Approximately 75% and 30% of people living in Ankara consume carboy water (KB, 2019). As a result of unplanned construction, increase in impervious surface areas and interventions in stream beds, the impact of floods and inundations increases, resulting in loss of life and property. Especially the urban poor are more affected by this situation. **Water losses and leakages** in cities are higher than in developed countries and the rate of non-revenue water 40%. This brings vulnerability and risk analysis studies on drought, water scarcity and flooding in cities to the forefront, as well as adaptation studies for water conservation and flood protection.

Untreated water discharged into the receiving environment **causes pollution in water resources**. Decrease in river flows and decrease in water levels in lakes cause deterioration in water quality due to the presence of nutrients and pollutants in less volume of water. The increase in water temperatures decreases the amount of dissolved oxygen, which directly affects water quality. Prolonged drought causes pollutants to accumulate on the soil surface, which poses a risk to the quality of water resources when rainfall begins.

Another important factor is that **heavy rainfall** intensively carries sediments, point and diffuse pollutant sources into river beds. During floods, there is an increased risk of overflowing sewers and degradation of the quality of water resources through runoff from agricultural areas and urban runoff.

Droughts and floods make water storage difficult. Storage of water during dry periods and controlled release before floods to protect downstream communities is crucial. Since the design of water storages takes into account a lower amount of flow variability and uses relatively shorter historical data, the designed storage volume may be insufficient for flood protection if variability increases. In addition, early snowmelt flows in spring also cause difficulties in dam operation.

Groundwater will also be negatively affected by climate change due to changes in precipitation. In most regions, groundwater is used as the main source of water for irrigation, drinking and industrial water supply. Renewable groundwater is directly dependent on surface conditions and is affected by hydrological processes and thus by climate change. Most renewable groundwater aquifers are under pressure of overdraft at a rate faster than the recharge period.

Ecosystems and biodiversity are the most vulnerable systems to climate change. Wetlands fed by rainfall and rivers habitats for many species and to reducing flood damages. Decrease in precipitation and deterioration in water quality threaten wetlands.

The main impacts and risks of climate change on sectors such as water, water supply and water pollution, agriculture, ecosystems, health and socio-economic structure are given in the table below (**Error! Reference source not found.**).

Table 8: Major water-related sectoral impacts and risks [27].

Sectoral impacts and risks related to water				
Impact	Water Resources	Agriculture and Ecosystems	Health	Socio-economic Structure
Heavy rainfall	- Floods - Negative impacts on surface and groundwater quality due to sewage overflows - Contamination of the water supply - Water scarcity	- Crop damage - Soil erosion - No planting due to flooding	- Risk of physical injury and death increase in - Infectious respiratory and skin diseases increased risk of	- Flooding caused damage to settlements, commerce, transportation and

[27] United Nations Economic Commission for Europe, 2009. "Guidance on Water and Adaptation to Climate Change".

Sectoral impacts and risks related to water				
Impact	Water Resources	Agriculture and Ecosystems	Health	Socio-economic Structure
			- Risk of psychological disorders	damage to society - Migration - Urban and rural infrastructures pressure on - Loss of property
Including increased droughts high rainfall variability	- Changes in currents - More widespread water stress - Sediments, nutrients, dissolved organic carbon, increased water pollution and thermal pollution due to lower dissolution of pathogens, pesticides and salt - Salinization of coastal aquifers	- Land degradation - Lower yield / crop damage - Increase in livestock deaths - Increasing forest fire risk	- Increased risk of food and water shortages - Increased risk of malnutrition - Risk of water and foodborne diseases increase	- Water scarcity for settlements, industry and society - Decline in hydroelectric power generation potential - Population migration potential
Increase in temperatures	- Increase in water temperatures - Increase in evaporation - Earlier snowmelt - In the permafrost layer Melting - Long-term lake stratification with a decrease in nutrient concentration in the surface layer and long-term oxygen depletion in deeper layers - Increased algal growth, which reduces dissolved oxygen levels in the water body causing eutrophication and loss of fish - Interference pattern and own self-cleaning changes in capacity	- Reduced water available for agriculture, more irrigation water needed - Product changes in productivity - Changes in the growing season - Type changes in composition, organism abundance, productivity and phenological changes e.g. early fish migration	- Changes in vector-borne diseases - Heat waves due to increased deaths and personal decreased productivity - Increased risk of respiratory and skin diseases due to ozone and pollen	- In permafrost risks in fixed infrastructures - Deteriorati on of freshwate r quality

In order to see the impacts of climate change on the water sector in Turkey, assessments made on some indicators regarding the current situation are given below.

Turkey's long-term (1981-2010) average annual precipitation is 574 mm (1981-2010), which corresponds to an average annual precipitation volume of 450 billion m^3. The Eastern Black Sea Region receives the most precipitation (1,200-2,500 mm/year), while the Central Anatolia Region (around Salt Lake) receives the least precipitation (250-300 mm/year). Except for the coastal settlements in the Mediterranean and South Aegean regions, snowfall is observed in the winter months in other regions of Turkey [28]. Turkey's average annual runoff is 185.37 billion m^3. This amount corresponds to 41.2% of the average precipitation volume. Turkey's groundwater supply calculated and reported as a result of hydrogeological studies is 23.0 billion m^3 and the groundwater operating reserve is 17.8 billion m^3 [29].

[28] DSIhttps://www.dsi.gov.tr/Sayfa/Detay/754
[29] DSIOfficial Water Statistics for 2021, https://www.dsi.gov.tr/Sayfa/Detay/1344

Within the framework of today's technical and economic conditions, the surface water potential that can be consumed for various purposes is 94.0 billion m3 per year on average. Together with 18.0 billion m(3) of groundwater (YAS) potential, the consumable surface and groundwater potential of Turkey is 112.0 billion m3 on average per year.

Today, it is seen in the Annual Reports prepared by DSİ that water use is gradually increasing. Accordingly, in the DSİ 2020 Annual Report, it is stated that according to the realization of the total water potential in 2020, 57.44 billion m(3)water was used for various purposes [44.25 billion m(3) (77%) irrigation water, 13.19 billion m(3) (23%) drinking-use and industrial water] (30). In 2018, it is known that the amount of water use was 55.0 billion m3 and the increase in the last 2 years was approximately 2.4 billion m3. In addition, as of 2021, the water used constitutes 51.3% of the consumable surface and groundwater potential.

Water is a critical input for agricultural production and an important role in food security. Irrigated agriculture is more productive than rain-fed agriculture, allowing for more production and crop diversification. Approximately 35% of Turkey's 24 million ha of arable land is economically irrigated (8.5 million ha). By the end of 2019, approximately 78% of this area was under irrigated agriculture (6.65 million ha) [31]. Approximately 3.42 million hectares of this area has been constructed by DSİ (26). As of 2019, approximately 62% of the irrigation methods applied in irrigation systems larger than 1000 ha constructed by DSİ are irrigated by surface methods, 21% by sprinkler irrigation and 17% by drip irrigation [26] (Table 9).

Table 9: Irrigation Methods Applied in Irrigations Developed by DSİ (DSİ, 2021).

Years	Total Irrigated Area by Irrigation Methods*						
	Superficial Area Irrigated by Methods		Sprinkler Area Irrigated by Irrigation Method		Drip Irrigation Area Irrigated by Irrigation Method		Total Irrigated Area
	ha	%	ha	%	ha	%	ha
2018	945.412	61,7	320.623	20,9	266.410	17,4	1.532.445
2019	1.020.441	61,6	356.484	21,5	280.709	16,9	1.657.634

*Irrigations larger than 1000 and 1000 ha

According to TurkStat, in 2018, the amount of water withdrawn as potable water for municipalities and villages (WUS+WASwas approximately 6.6 billion m(3excluding seawater) ita water consumption (WUS+WASwas 236.4 liters/person-day on average. Considering 6.6 billion m3 as drinking-use water, industrial water consumption is 4.4 billion m(3).

[30] DSİ, 2021. DSİ 2020 Annual Report, Ankara, 2021. https://cdniys.tarimorman.gov.tr/api/File/GetFile/425/KonuIcerik/759/1107/DosyaGaleri/DS%C4%B0%202020-year-activity-report.pdf

[31] DSIhttps://www.dsi.gov.tr/Sayfa/Detay/754

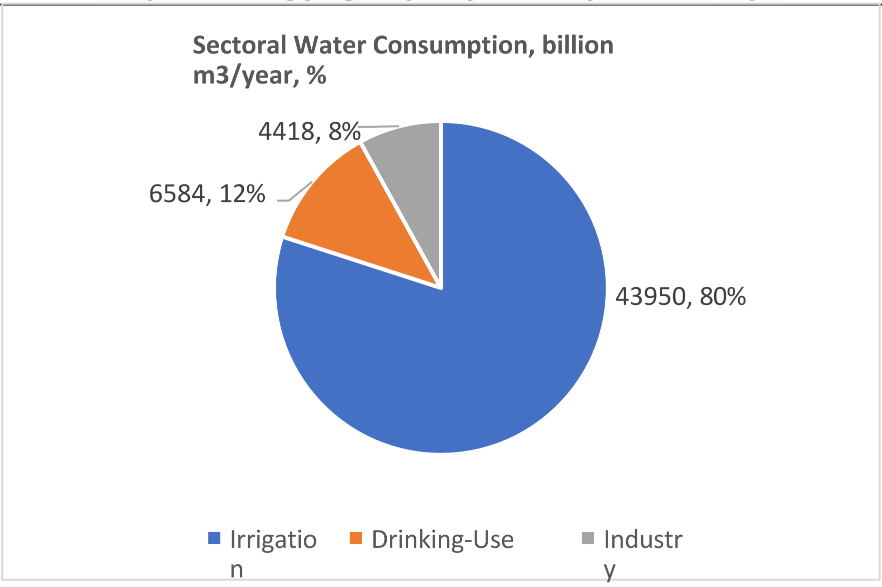


Figure 10: Sectoral water use as of 2018

Sectoral water use in the world 69% in the agricultural sector, 12% in the drinking water sector and 19% in the industrial sector. In Asia, these rates are 81%, 9% and 10%, respectively, while in Europe these rates are;

25%, 21% and 54%[32]. As can be seen from these values, water is used in agricultural irrigation at a higher rate than the world average[(33)] (Figure 11).

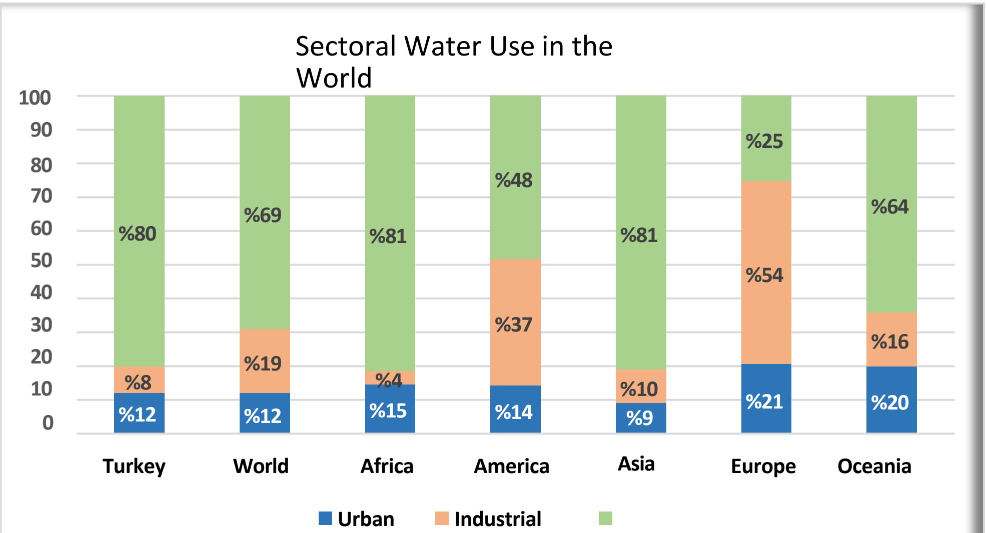


Figure 11: Sectoral distribution of water in the world (AQUASTAT, 2016)

Access to clean water and infrastructure services in cities are important for quality of life and public health. According to TurkStat data, as of 2018, 1,397 of 1,399 municipalities were served with drinking and potable water networks. Looking at urban water use, municipalities withdrew 6.2 billion m$^{(3)}$ of from water sources to drinking and potable water networks.

[32] FAO, 2021. Food and Agriculture Organization of the United Nations, https://firebasestorage.googleapis.com/v0/b/fao-aquastat.appspot.com/o/PDF%2FTABLES%2FWorldData-Withdrawal_eng.pdf?alt=media&token=02dec3dd-50fc-4d85-8ab7-521f376dedb0

[33] AQUASTAT, http://www.fao.org/nr/aquastat, Update: November 2016.

The amount of water distributed through the drinking and potable water network is approximately 4.4 billion m$^{(3)}$). is a difference of approximately 35.5% between water withdrawn and water distributed. Of the total 6.6 billion m$^{(3)}$ of water withdrawn from sources, 3.6 billion m^3 was treated in drinking and potable water treatment plants. municipal population served by drinking and potable water network to total municipal population was 98.6% and the ratio of municipal population served by drinking and potable water treatment plants to total municipal population was 60.1%.

Water losses in drinking and potable water transmission lines are divided into two groups: physical and administrative water losses; the sum of these two losses is referred to as total water In general, approximately 60% of total water losses physical water losses and approximately 40% are administrative water losses. In Turkey, physical water losses are generally higher than administrative water losses. For 2010, the Non-Revenue Generating Water levels in some countries are given in Figure 12. According to the figure, Turkey's non-revenue water rate is above 40% [34].

According to TurkStat data, as of 2018, 1,357 out of 1,399 municipalities were served by sewerage networks. Of the 4.8 billion m$^{(3)}$ of wastewater discharged from the sewerage network, 4.2 billion m^3 was treated in wastewater treatment plants. The average amount of wastewater discharged per capita 188.0 liters/person-day. Of the 4.8 billion m$^{(3)}$ of wastewater collected through sewerage network, 46.9% was discharged to rivers,
40.7% was discharged to sea, 3.1% to dam, 1.4% to lake-pond, 0.4% to land and 7.5% to other receiving environments. It was determined that 2.3% (96.6 million m^3) of treated wastewater was reused in industry, agricultural irrigation, etc. The share of municipal population served by sewerage network in total municipal population was 90.7%. The ratio of municipal population served by wastewater treatment plants to the total municipal population was determined as 78.7%.

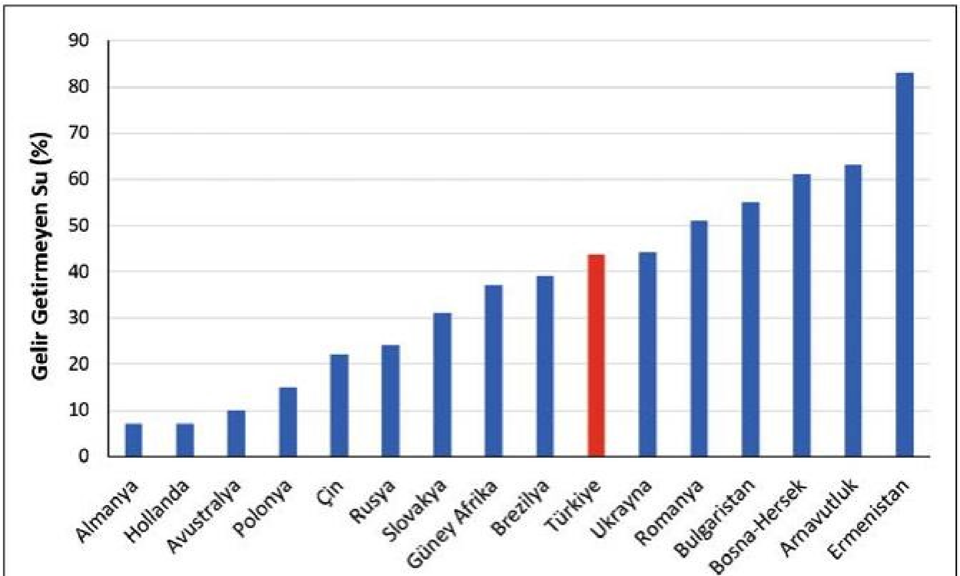


Figure 12: Non-revenue water levels in some countries for 2010 (H and A. Muhammetoğlu, 2017)

Seawater, surface and groundwater resources are used in the industrial sector. TurkStat provides statistical data on water withdrawals in manufacturing industry workplaces, thermal power plants, organized industrial zones and mining enterprises. Thermal power plants mainly use sea water. When the water consumption in the manufacturing industry is analyzed, it is seen that the highest water consumption is spent in the manufacture of chemicals and chemical productsmanufacture of textile products and the manufacture of food products [35]).

[34] H and A Muhammetoglu, 2017. Handbook on Control of Water Losses in Drinking Water Supply and Distribution Systems, SYGM, 2017.
[35] Çapar, G., & Yetiş, Ü. (2018). The Status of Water Efficiency in Industry in Turkey. Anahtar, 19-23.

Today, as a result of increasing pressures on water resources, the water used in **the production of goods and services** has also gained importance. The total amount of water used in all production and consumption processes is defined as the water footprint.

Hydroelectric power generation has a very important place in the evaluation of the water sector. In the period 1924-2019, 616 hydroelectric power plants (HPPs) with an installed capacity of 16,017.3 MW were built in Turkey and their average energy production was 54,304.2 GWh/year (DSİ2021). The share of hydroelectric energy in energy production in Turkey was 29.2% in 2019 [36].

One of the most common methods used to measure water scarcity is the "Falkenmark index" or "water stress index". This method was developed by Malin Falkenmark in 1989, taking into account the available water resource potential and population of countries. With this method, water scarcity is defined in terms of the total available water resources of a region, and the amount of renewable fresh water available each year per capita taken as the basis for determining water scarcity. Accordingly, if the amount of renewable water in a country is below 1,700 m^3 per capita per year, it is considered that the country is experiencing water stress; if it is below 1,000 m^3, it is considered to be experiencing water scarcity; and if it is below 500 m^3, it is considered to be experiencing absolute water scarcity [37].

While Turkey's average annual per capita consumable water amount was 1,652 m^3/year in 2000, this amount decreased to 1,519 m^3/year in 2010 and to 1,339 m^3/year in 2020 in parallel with the population increase. As of 2000, the decrease in the amount of consumable water 18.9% in 2020. According to TurkStat population projections (2018-2080), the amount of consumable water per capita is projected to decrease to 1,069 $m^{(3)}$/year in 2050 and to 1,046 $m^{(3)}$/year in 2080. In this assessment, the impact of climate change is not taken into account and it is seen that Turkey is a country experiencing water stress in terms of per capita water use according to the Falkenmark index (Figure 13).

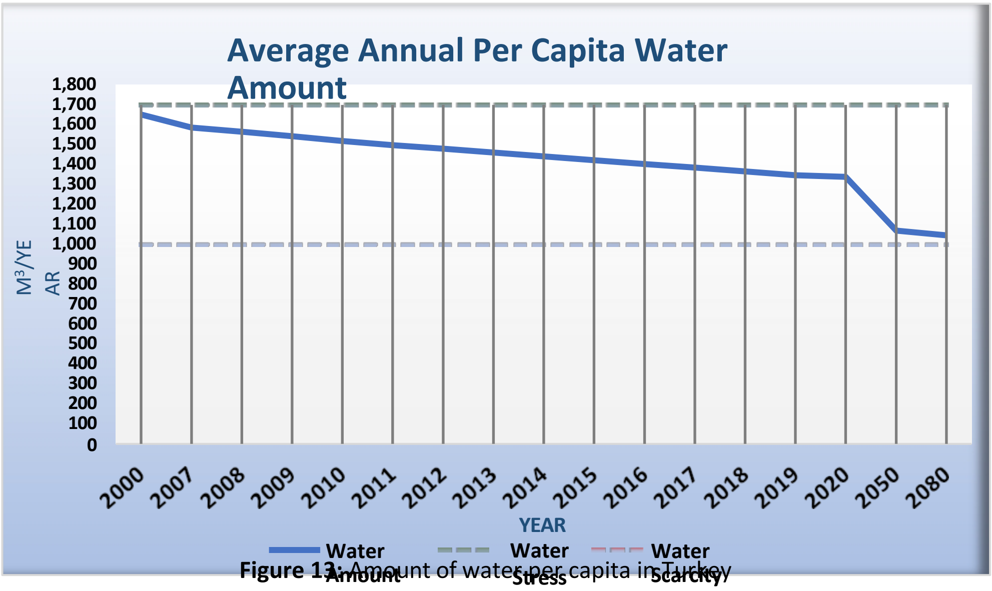


Figure 13: Amount of water per capita in Turkey

Another important water-related index is the Water exploitation index (WEI). The WEI is calculated as the average annual total amount of freshwater withdrawals divided by the average annual total renewable freshwater resources at the country level as a percentage of long-term freshwater resources. The WEI therefore shows the extent to which the current level of water use in a country puts pressure on available water resources. To assess water stress, the European Environment Agency (EEA)

[36] TEİAŞhttps://www.teias.gov.tr/tr-TR/turkiye-elektrik-uretim-iletim-istatistikleri

[37] Falkenmark, M. (1989) The Massive Water Scarcity Now Threatening Africa: Why Isn't It Being Addressed? Ambio, 18, 112-118.

categorizes the water stress status of countries by applying the following thresholds for water stress[38]:

- Values below 10% do not indicate stress,
- 10-20% low stress,
- 20-40% stress,
- Values above 40% indicate areas under severe stress.

Turkey's average annual runoff is 185.37 billion m^3, groundwater recharge calculated and reported as a result of hydrogeological surveys is 23.0 billion m^3 and total annual renewable freshwater resource is 208.37 billion m^3 excluding foreign contribution). As of 2018, when the total of 55.0 billion m$^{(3)}$ of water used by the sectors is calculated as the ratio of renewable freshwater resources to the WEI index, Turkey is a country experiencing water stress with a ratio of 26%.

The main disasters related to water resources floods triggered by heavy rainfall and drought and water scarcity disasters triggered by low rainfall and increasing temperatures. is a phenomenon in which water rises from where it is located or comes from elsewhere and covers surfaces that are usually dry. Floods are classified slow-developing, fast-developing and flash floods according to their rate of occurrence. Generally, floods that occur within a week or more are called slow floods, floods that occur within a day or two are called fast floods, and floods that occur within hours are called flash floods. In terms of the place of occurrence, floods are called coastal floods, urban floods, dry stream floods, dam/pond floods and river (stream and river) floods. In mountainous areas, as a result of rainfall and melting of snow on the hills, stream beds are filled with water that they cannot carry and flash floods occur. These floods, which also create the danger of landslides, are very dangerous, especially for settlements in the foothills [39].

Between 1950-2019, 6,833 floods/inundation events occurred and their distribution by province is shown in Figure 14.
is provided with.

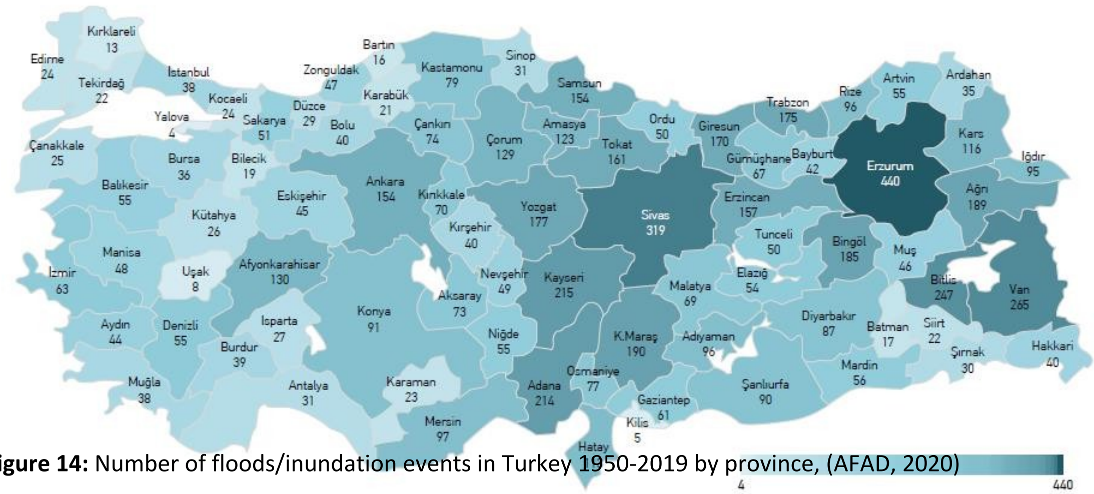


Figure 14: Number of floods/inundation events in Turkey 1950-2019 by province, (AFAD, 2020)

As can be seen on the map, when the distribution of floods/inundation events occurring since 1950 is analyzed Erzurum ranks first with 440 events. Sivas with 319 incidents, Van with 265 incidents and Bitlis with 247 incidents. On the other hand, in provinces such as Yalova, Kilis and Uşak

[38] EEA (2021), Indicator Fact Sheet, (WQ01c) Water exploitation index, https://www.eea.europa.eu/data-and-maps/indicators/water-exploitation-index/water-exploitation-index

[39] AFAD, 2020. Overview of 2019 in the Scope of Disaster Management and Nature-Borne Event StatisticsRepublic of Turkey Ministry of Interior, Disaster and Emergency Presidency, Ankara, 2020.

There were very few floods/inundation events. In 2019, a total of 499 floods/inundations (7.3% of the total between 1950 and 2019) occurred. Samsun ranked first with 81 floods/inundations. Samsun was followed by Trabzon with 37 incidents, Afyonkarahisar with 33 incidents, Zonguldak with 25 incidents and Aksaray with 22 incidents. On the other hand, in 19 provinces, no flood/inundation incidents were recorded in 2019 [40].

According to the analyzes made by MGM, 11 years of the 40 years in the 1981-2020 period were dry, among these years; 2008 was exceptionally dry, 1989 and 1990 were very severe dry, 2013 was severe dry, 1982, 1984, 1993, 1999, 2017 and 2020 were moderate dry and 2000 slightly dry.
[41].

With the melting of glaciers due to global warming, the sea level has started to rise. The rise in sea level poses a flood threat to the coasts with the waves formed during storms. It also causes salinization in fresh waters and aquifers with which it is associated during dry periods and periods of low flows.

2.1.2. Scope of Vulnerability and Risk Analysis

The vulnerability and risk analysis for water resources aims to provide a comprehensive picture of current and future risks, expected stressors and opportunities that may arise from climate change, and to provide information on how to assess adaptive capacity and deal with uncertainty.

Climate change in relation to water resourceswater quantitywater quality and hydromorphological characteristics
can have an impact on the economy. These impacts are

1) Due to the decrease in precipitation and increase in temperatures; water quantity decreases, evaporation losses increase, soil moisture decreases, water quality deteriorates with decreasing water volume and various hydromorphological effects such as land degradation occur. This situation creates the danger of drought and water scarcity.
2) Due to the increase in precipitation; the amount of surface water increases, river and lake levels rise, river flows increase and flood hazard arises. With the occurrence of floods, water quality deteriorates with the mixing of overflowing sewers, point or diffuse pollutants into water, and hydromorphological effects such as land degradation, landslides and erosion occur.

In order to identify the risks of drought and water scarcity, heavy rainfall and flooding that may lead to loss of life and property, it is first necessary to identify the elements of exposure (people, livelihoods, species or ecosystems, environmental functions, services and resources, infrastructure, economic, social and cultural assets). Exposure factors include areas at risk of drought, population density under flood hazard, areas of economic activity and public services, amount of damage due to natural disasters resulting from extreme weather events, etc.

Vulnerability is a combination of sensitivity and adaptive capacity. Sensitivity is the degree to which a system or species is negatively or positively affected by climate variability or change. As sensitivity factors; soil moisture, sectoral surface and groundwater allocations, agricultural irrigation area and irrigation water, network losses in the water distribution system, amount of water withdrawn in the manufacturing industry, amount of built-up area-covered surface, rate of illegal construction, proportion of water bodies under diffuse pressure, etc. can be counted.

Adaptive capacity is the ability of systems, institutions, people and other organisms to adapt to potential damage, take advantage of opportunities or respond to consequences. Elements of adaptive capacity

[40] AFAD, 2020. Overview of 2019 in the Scope of Disaster Management and Nature-Borne Event StatisticsRepublic of Turkey Ministry of Interior, Disaster and Emergency Presidency, Ankara, 2020.
[41] MGM 2021. http://kuraklikizle.mgm.gov.tr/

drought and flood management plans prepared within the scope of combating drought and flood, environmental protection expenditures, early warning systems, population served by drinking water and sewerage networks, closed system irrigation rate, areas protected from flooding, etc.

By evaluating the risk factors summarized above, a vulnerability and risk analysis study on water resources will be conducted with the help of the impact chain method.

2.1.3. Key Stakeholders

Turkey's water management system involves a large number of stakeholders, including government agencies at different levels, the private sector and civil society organizations, which are directly involved in or indirectly related to water management. The main public institutions are briefly summarized below.

Ministry of Agriculture and Forestry

- General Directorate of Water Management
- General Directorate of Nature Conservation and National Parks
- General Directorate for Combating Desertification and Erosion
- General Directorate of Food and Control
- General Directorate of Fisheries and Aquaculture
- General Directorate of Agricultural Reform
- General Directorate of Agricultural Research and Policies
- Department of Information Processing
- Research Institutes
- Organization under the Ministry: General Directorate of State Hydraulic WorksGeneral Directorate of Forestry, General Directorate of Meteorology, Water Institute

Ministry of Environment and Urbanization

- General Directorate of Environmental Management
- General Directorate of EIA, Permit and Inspection
- General Directorate of Infrastructure and Urban Transformation Services
- Directorate General for Spatial Planning Directorate General for the Protection of Natural Assets
- General Directorate of Geographic Information Systems
- Organization under the Ministry: ILBANK

Ministry of Energy and Natural Resources

- General Directorate of Renewable Energy
- General Directorate of Energy Affairs
- Department of Energy Efficiency and Environment
- Organization under the Ministry: MTA, EMRA

Ministry of Industry and Technology

- General Directorate of Industry
- General Directorate of Industrial Zones
- General Directorate General of Development Agencies is a subsidiary of the Ministry: TUBITAK

Ministry of

Health Ministry

of Interior

At the local level, metropolitan municipalities, municipalities, special provincial administrations, development agencies and OIZs are important stakeholders.

Other important stakeholders include Universities, Research Centers, the Union of Chambers of Architects and Engineers of Turkey, the Union of Municipalities of Turkey, Chambers of Commerce and Industry, Agricultural Insurance Pool Management Inc. (TARSİM), the Association of Insurance, Reinsurance and Pension Companies of Turkey (TSB), Professional Chambers, Irrigation Unions, Cooperatives, and National and Local NGOs.

2.1.4. Sectoral Indicators

With the indicator groups established for monitoring and evaluation of adaptation to climate change, it is aimed to determine the possible impacts of climate change on sectors evaluate the effectiveness of adaptation measures developed to mitigate these impacts.

The main indicators that can be used in vulnerability analysis regarding drought and water scarcity, floods and floods that occur due to the negative impacts of climate change on water resources are given below:

Hazard indicator: Heat waves indicator; drought indicator; heavy rainfall indicator; flooding, number of floods indicator; sea level indicator.

Exposure indicator: Indicator of disaster due to extreme weather events; indicator of area at risk of drought; indicator of number of population at risk of flooding; indicator of area where economic activity and public services are carried out in areas at risk of flooding.

Sensitivity indicator: Indicator for sectoral groundwater allocations; indicator for sectoral surface water allocations; indicator for groundwater level; indicator for crop loss due to extreme weather events; indicator for network losses in the water distribution system; indicator for soil moisture; indicator for illegal construction rate; indicator for built-up area - covered surface.

Adaptation capacity indicator: Indicator of number of river basin management plans prepared; indicator progress towards environmental objectives of river basin management plans; indicator of number of drought management plans prepared; indicator of provincial agricultural drought studies; indicator of closed system irrigation area ratio; indicator irrigation area with irrigation efficiency of 55% and above; indicator of number of flood management plans prepared; indicator of area protected from flooding; indicator of wastewater, storm water infrastructure strengthened within the scope of adaptation work; indicator of early warning systems; indicator of access to reliable drinking water; indicator of wastewater treatment rate; indicator of rainwater, gray water use.

Mixed vulnerability indicator: Number of dams indicator; urban blue infrastructure (water surface ratio) indicator; water use indicator.

2.2. Agriculture and Livestock

2.2.1. Assessment of the Impacts of Climate Change on Agriculture and Livestock

Agriculture and animal husbandry are among the socio-economic areas where the impacts of climate change are most visible. The direct relationship of human activities in this sector with ecosystems such as soil, water and forests reflects the effects of climate change on these natural systems on the human (human) systems that give rise to the effects of climate change on these natural systems. For this reason, both average changes in climate factors such as average temperature, precipitation, humidity and wind, and the increase in the frequency and intensity of extreme climate events such as droughts, floods and storms directly affect agriculture and animal husbandry.

The negative impacts of climate change are already being observed in this sector, which has high exposure and sensitivity. These impacts are expected to increase with significant repercussions in key areas such as sectoral production, consumption, international trade, employment, poverty, food security and social equity. Therefore, agriculture and livestock is one of the most prioritized sectors for increasing resilience and adaptation to the potential adverse impacts of climate change.

The impact chain in the agriculture and livestock sector (Figure 5 in the previous section) should be revealed through a systematic linking of climate-related risks and their components. This impact chain is built on the identification of sector-specific risk components (hazard, vulnerability, exposure) and underlying factors.

In the agriculture and livestock sector, the hazard component includes factors related to climate signaling and direct physical impact. It is the potential occurrence of climate-induced impacts (short and long term) that can damage production and supply chains, ecosystems and natural assets such as soil, water, forests and biodiversity. These hazard components include impacts on infrastructure and superstructures in agricultural areas, such as roads, irrigation, storage and energy. Also important are hazards to food chains and services provided to other sectors and settlements.

These hazards manifest themselves as decreasing precipitation, increasing average temperatures and sea level rise with slowly developing trends. Likewise, short-term extreme climate events such as heavy rainfall, floods, droughts and cyclones caused by climate change affect the agriculture and livestock sector.

2.2.1.1. Vulnerability Component

Vulnerability depends on susceptibility, susceptibility to harm (exposure), coping and adaptive capacity (IPCC, 2014).

- **Sensitivity:**

For the agriculture and livestock sector, sensitivity is the degree to which the sector is negatively (and sometimes positively) affected by climate change. The degree to which both the physical and biological structures of natural systems and socio-economic systems are affected is determined by the interaction of different factors.

Ecological and physical sensitivities:

- Yield sensitivity of agricultural crops
- Sensitivity to production areas of crops
- Product pattern sensitivity
- Climate sensitivity of animal species (ideal habitat and efficient production)
- Sensitivity of agricultural infrastructure (roads, irrigation, energy, etc.) to excessive rainfall and floods

Sensitivities of socio-economic systems:

- Agricultural income sensitivity of households
- Local and regional economic development and growth sensitivity (weight of agriculture)

- Macroeconomic sensitivities at country level (food prices, employment, trade, investments, etc.)
- Sensitization of other sectors linked to agriculture
- Social equity and justice sensitivity (climate change affects different social groups differently) via)
- Food security and poverty sensitization

As an example of sensitivity, studies based on plant models show that the impacts of temperature increases are gradually increasing in annual and perennial crops, despite regional differences. In cereal crops, which are crucial for global food security, studies have shown that for every one degree Celsius increase in global average temperature, global average land yields increase by 6% for wheat, 7.4% for maize, 7.4% for rice
3.2% for soybeans and 3.1% for soybeans. Evaluating around a thousand model results used in the literature published worldwide, IPCC predicts yield losses of 25-50% for temperature increases of 3℃ (around 2050) (Figure 15).

However, annual yield variability in cereals is also projected to increase (Figure 16). Since cereals are primary consumption products with low price elasticities, annual variability increases the perception of risk in international markets. World production of cereals is expanding towards regions with high annual yield variability, thus increasing supply risks. For example, wheat production is shifting from western Europe and the US, where yields are more stable, to the Russian Federation, Ukraine and Kazakhstan, where yield variability is higher.

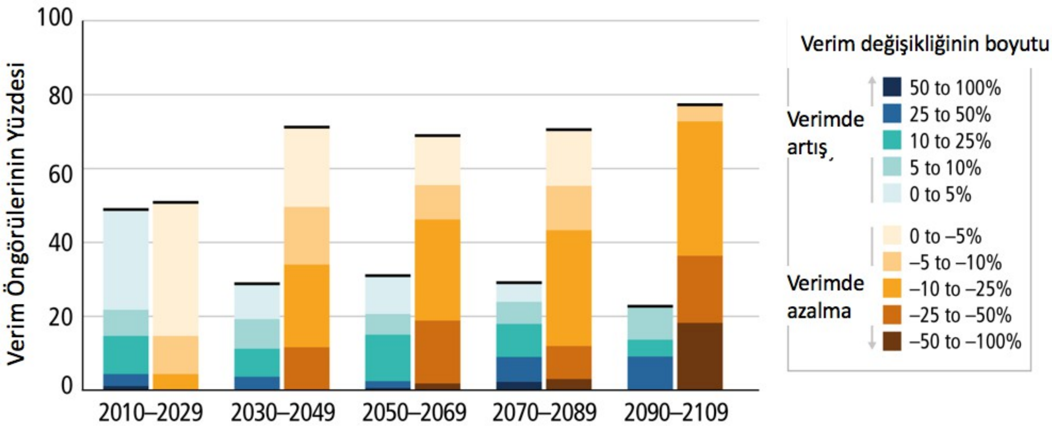


Figure 15: Yield impact of temperature increases on cereal production
Source: Intergovernmental Panel on Climate Change (IPCC), 2014

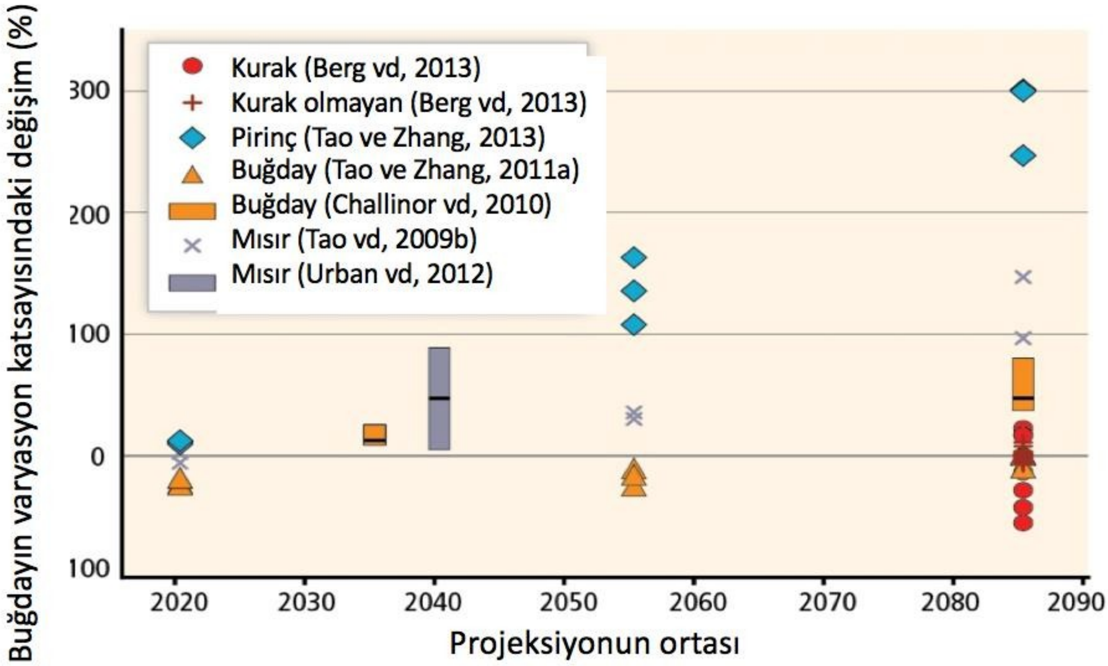


Figure 16: Impact of temperature increases on yield variability in cereal production
Source: Intergovernmental Panel on Climate Change (IPCC), 2014

As presented in the first part of this report, Turkey's geography is one of the most vulnerable regions of the world in terms of the impacts of climate change on agriculture and related food sectors, both due to the increase in average temperature and decrease in average rainfall in general, and the increase in extreme climate events such as droughts and heat waves. Climate change causes significant yield losses in the developmental evolution of agricultural crops with the change of phenological periods.

Scientific studies have shown that climate change has already caused shifts in the phenophases of agricultural crops in Turkey, resulting in yield losses. For example, it has been calculated that the spike and harvest phases of wheat change by four days per decade, and a 1°C increase in air temperature during the growth period results in an eight-day advance in the harvest date [42]. It has been reported that the main climatic factor affecting yield reductions is temperature increases that shorten the vegetation and grain filling period[43]. A study conducted in the Cilician Plain reported that the most important climatic factors affecting wheat yield deviations were maximum temperature at sowing and maximum rainfall at flowering[44].

As can be understood from this, in addition to the effects of general changes in climate factors, periodic variations create periodic sensitivities with their effects on plant development. These sensitivities are differentiated in plant and sub-climate breakdowns and thus the need for diversified adaptation approaches arises.

Similarly, in Turkey's agriculture and livestock sector, the sensitivity of farmers' incomes to climate change is high. The increasing impacts of climate change are increasing farmers' income sensitivity through crop losses and reduced sustainability of natural assets. Medium and

[42] Şensoy and Türkoğlu, N. , Çiçek, 2014; Türkoğlu et al. 2014
[43] Özdoğan, 2011
[44] Ozkan and Akcaoz, 2002

Long-term projections show that yield losses and related economic impacts will gradually increase on a crop and regional basis. This increases the sensitivity of the regional and national economy to climate change through the agriculture and livestock sector. For example, price increases caused by yield losses due to climate change inflation. According to IPCC projections, the price effect [45], which will gradually increase, will increase the climate sensitivity of inflation.

- **Capacity:**

Capacity in the agriculture and livestock sector is the ability of physical, ecological and human systems to prepare for and respond to observed and future climate impacts. It has two elements: capacity to cope with impacts and capacity to adapt to them.

In the sector, ***coping capacity can*** be defined as the capacity of farmers and agriculture-related institutions to manage and overcome adverse conditions created by drought, for example, in the event of a drought event, using their individual and institutional resources. Examples of coping capacity include the capacity of the individual farmer to take pre-drought measures (such as the to change seeds and cropping patterns, to take measures to increase the water-holding capacity of the soil), the early warning systems provided by government agencies, the capacity to provide financial assistance to affected farmers, the capacity to take measures to maintain food access, and the capacity to invest in increasing water productivity in the long term.

Adaptive capacity in the agriculture and livestock sector the ability of the sector, together with its components, to adapt to the potential damage caused by climate change, take advantage of opportunities or respond to consequences. A wide range of factors such as income, education, knowledge, financial resources, access to communication and information technologies determine adaptive capacity at the institutional and individual level. Academic studies in Turkey and around the world show that the main factors determining the adaptive capacity of farmers are income, education, age and exposure to climate impacts [46].

Reflections of the eight determinants of adaptive capacity defined by IPCC (2001) in the agriculture and livestock sector:

i. ***Available technological options*** (e.g. pressurized irrigation technologies, technologies for developing seed types with high adaptive capacity to climate change, new production techniques, satellite-based and sensor-based monitoring and agricultural application technologies, etc.)
ii. ***Resources*** (natural assets such as water, soil, biodiversity, economic resources, human resources, information and knowledge resources, corporate governance resources)
iii. ***Structure of critical institutions and decision-making authorities*** (prevalence and effectiveness of central and local institutions for agriculture and livestock, involvement and influence of other constituents in decision-making processes)
iv. **Human capital stock** (education, income, age, gender profiles of farmers, knowledge and education levels of employees of institutions in the agriculture and livestock sector, human capital of institutions at the decision-making point)
v. ***Social capital stock including the definition of property rights*** (sociological structure of agricultural and livestock societies, social and economic protection networks, legal infrastructure, protection and effectiveness of social and individual rights, social participation and equality structure)
vi. ***The system's access to risk-emitting processes*** (capacity to intervene in different links of risk chains within the sector, structure of production, processing, trade, consumption networks, capacity to measure and mitigate systematic interconnected risks)

[45] IPCC 2014
[46] Karapinar & Ozertan, 2020, "Sustainability of Agricultural Product Supply under the Impact of Climate ChangeTUSIAD, March 2020

vii. ***Knowledge management and reliability of information provided by decision makers*** (breadth and depth of research studies on climate change impacts and adaptation in the agriculture and livestock sector in universities, competence of public and private sector organizations in the agriculture sector to produce knowledge, competence of existing scientific research and data to be included in decision-making processes)

viii. ***Public perception of risk and exposure*** (perception of risk and exposure of those engaged in agriculture and animal husbandry, perception of risk and exposure of decision makers, perception of risk and exposure of components in other links of the chain (consumers, etc.).

Surveys conducted in the agricultural sector in Turkey show that farmers have a high perception of risk and exposure. According to a study conducted with a total of 700 farmers in 9 districts and 122 villages in Ankara, Kırklareli and Adana, 96% of the farmers answered "Yes" to the question "Do you know what climate change is?and 91% stated that they follow the news about climate change in newspapers and on television (Karapinar and Ozertan, 2020). To the question " you experienced sudden natural events related to climate such as heat, flood, drought, frost in the last 5 years?" 97% of the farmers yes, and 74.21%21 stated that drought started to occur more frequently.

2.2.1.2. Exposure Component

In agriculture and livestock, the exposure component is the presence of people, livelihoods, ecosystems such as soil, water, forests and the services they provide, irrigation, transportation and energy infrastructures, social and cultural assets associated with this sector in places and environments that may be adversely affected. The degree of risk-related exposure is expressed in numbers, density, proportion, etc. (density of agricultural land or producers in the drought-affected area). For example, a change in the amount of production living in drought-prone areas can significantly reduce or increase the risk (IPCC; 2014).

In Turkey, the share of agricultural land in total land area is quite large. This increases exposure through agricultural areas. The vast majority of the total agricultural land of approximately 40 million hectares is used for crop production and pastures (Figure 17). Regionally and locally, social structures that utilize more of their total land for agriculture and livestock breeding have higher agriculture-based climate exposure than others. Similarly, regional and local land use patterns in land sub-divisions differ in their exposure to climate conditions.

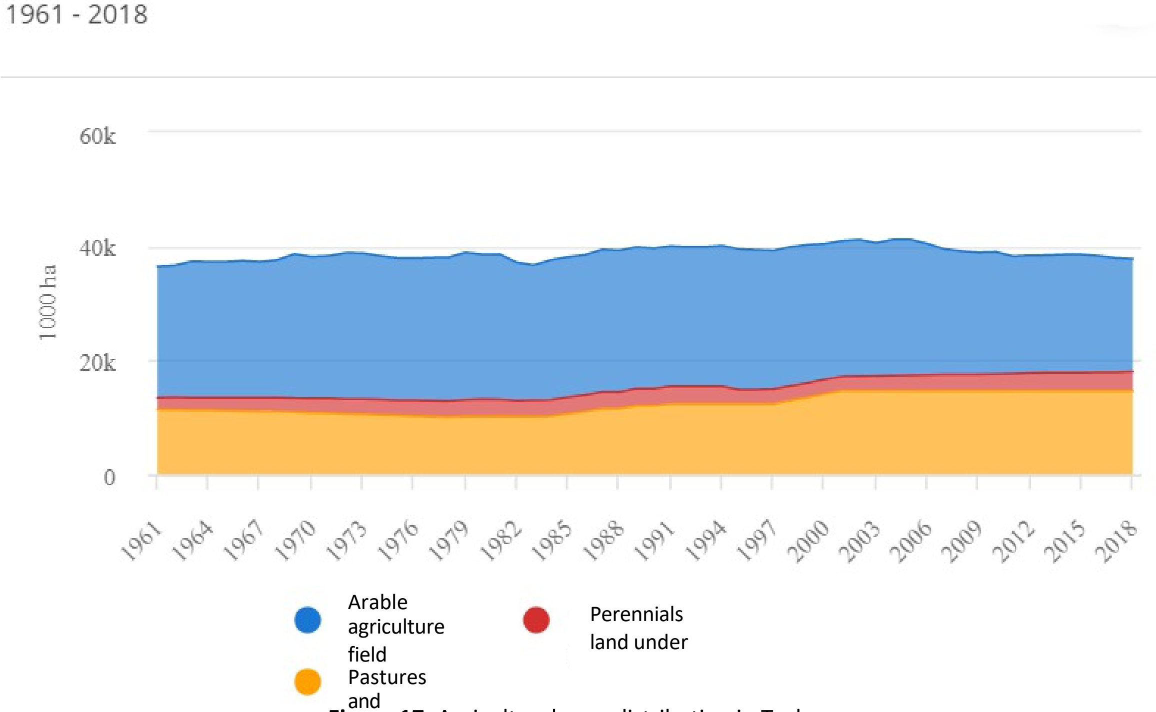


Figure 17: Agricultural area distribution in Turkey

The size and density of the population living in rural areas, the size and socio-economic profile of the agricultural labor force are important exposure factors. According to official figures used as a basis for international comparisons, the population living in rural areas about a quarter of Turkey's population. Considering the intensity of agricultural activities in rural areas, it can be said that societies living in rural areas are more exposed to climate change impacts. On the other hand, masses living in cities are exposed to impacts on food consumption, agricultural prices and macroeconomic factors.

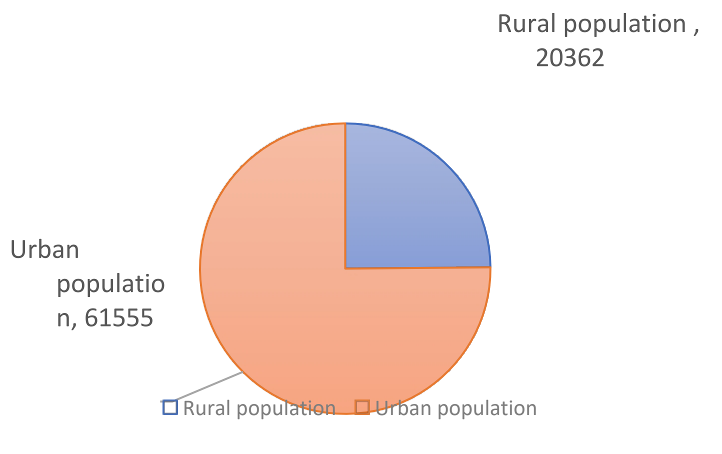


Figure 18: Rural urban population (thousand people), Turkey, *Source. FAO, 2021*

The size, socio-economic and demographic profile of the agricultural workforce is one of the key factors affecting exposure to climate change. The sector employs around 5 million people in Turkey (Figure 19). This workforce is exposed to climate change impacts through factors such as prices, costs, investments, international trade and availability of alternative employment opportunities.

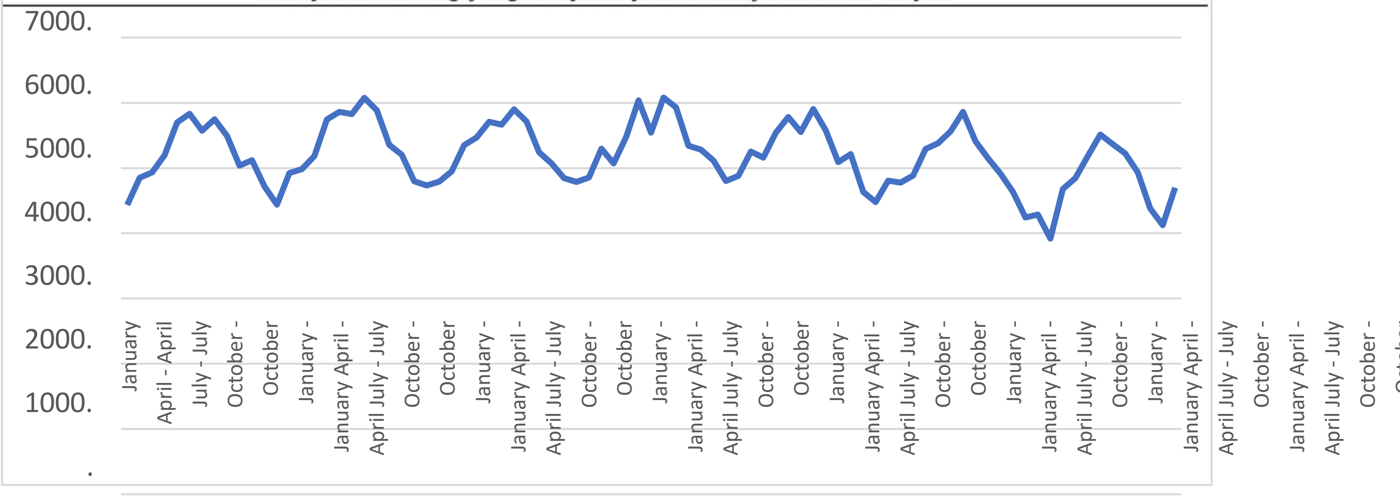


Figure 19: Agricultural labor force, Source: TURKSTAT2021

Local, regional and national economies are also to the impacts of climate change. At the regional level, this exposure is differentiated through the contribution of the agricultural sector to crop and livestock production. This exposure increases in regions with relatively more intensive agricultural production (Figure 20). For example, Konya Karaman region is the most intensive region in Turkey in terms of agricultural production value per capita, while Ağrı, Kars, Iğdır, Ardahan regions are the most intensive regions in terms of livestock production value. This is how the regions where the agricultural economy is exposed to climate change are differentiated within the country.

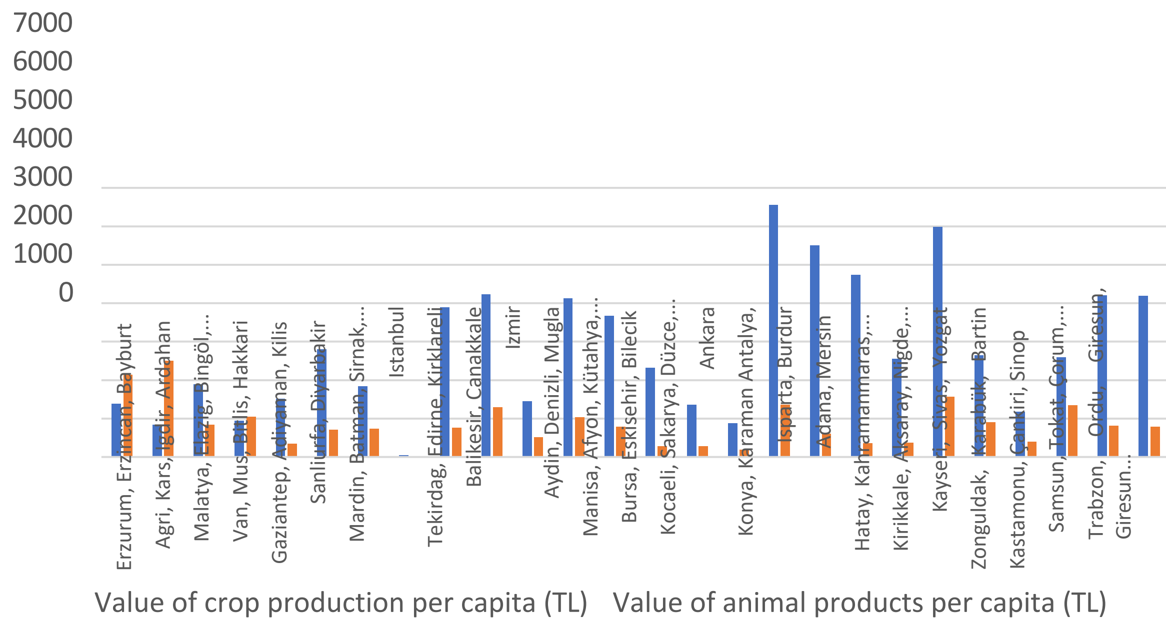


Figure 20: Crop and animal production value per capita by regions, TURKSTAT 2021

Different links of value chains in the agriculture, livestock and food sector exposed to the impacts of climate change (Figure 21). The chain starting from input production, producers, product buyers, agro-industry, logistics, retail, and foreign trade. Each link in the chain has different exposures. For example, the exposure in the logistics link is to the increased temperature conditions of the cold weather chain, while the exposure on the trade side is the exposure of the yields of different import/export product groups to climate impacts.

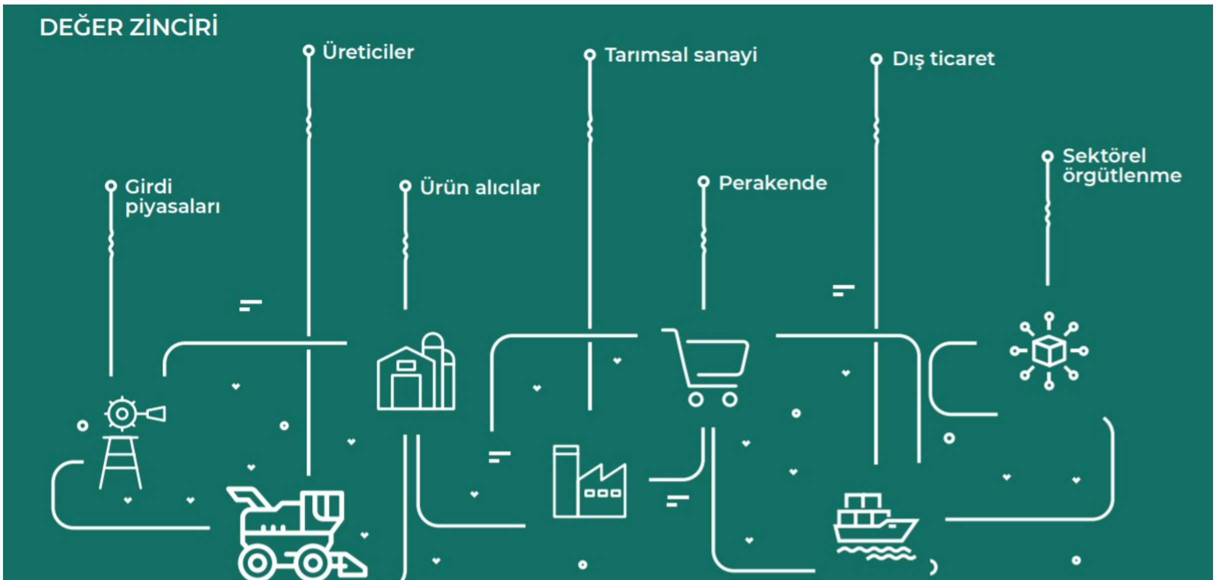


Figure 21: Agriculture and food value chain, Source: TUSIAD2020

2.2.1.3. Impacts

In the agriculture and livestock sector, "impacts" should be examined as the basic building blocks of cause-and-effect chains from hazard to risk. Impacts are a function of both hazard and vulnerability factors. In agriculture and livestock production, impacts are the effects on lives, ecosystems, agriculture and related economy, social relations, culture, services and structures in agricultural areas due to climate change or extreme events in a given time interval and indicate the vulnerability of society and the system (IPCC, 2014).

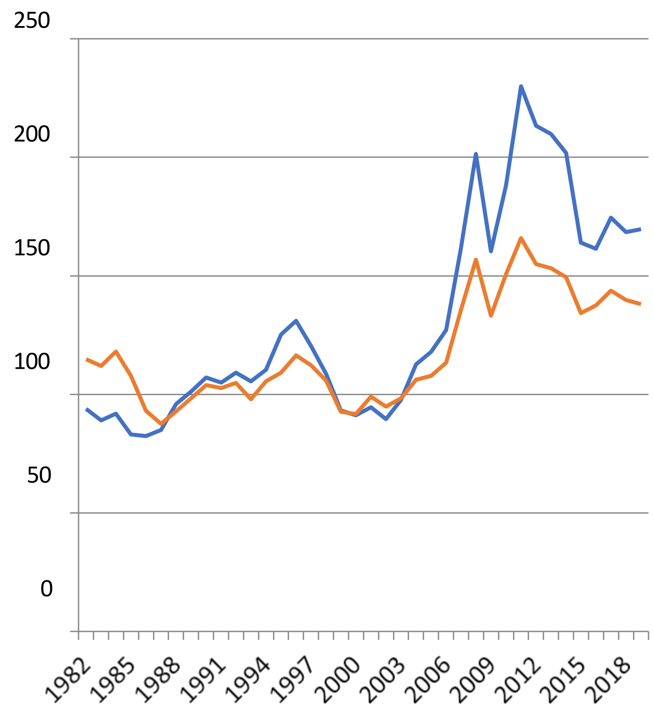
Adaptation measures in the sector can reduce risk by reducing vulnerability and, in some cases, exposure (Figure 7 in the previous section). Vulnerability can be reduced by reducing sensitivity or increasing capacity. For example, while reducing the climate sensitivity of agricultural yields by expanding water-saving pressurized irrigation practices, infrastructure strengthening will increase adaptive capacity in the sector.

One of the main impact channels of climate change at the sector level is the impact on production efficiency through changes in factors affecting plant phenology such as temperature, precipitation and humidity. Climate-related yield losses and fluctuations have the effect of increasing food prices. These effects add to the already elevated and volatile market trend after 2007 (Figure 22). While population growth and consumption growth and change triggered by economic growth (primary food sources to secondary and processed products) create relatively predictable increases on the demand side, increases on the food supply side are slowing down and risks are increasing.

Economic models based on the results of climate models estimate that price increases due to climate change will reach 84% on a crop-by-crop basis (Nelson et al.2011IPCC2014). Even in the absence of climate stress, increases in food prices have significant impoverishing impacts in both rural and urban areas and lead to food insecurity at the local level. Since food expenditures are the most important expenditure item for poor households, an increase in food prices further impoverishes poor households. Countries' access to food through trade is a key driver of food insecurity in some importing countries.

jeopardized by export restrictions on their own trade [47]. Wheat and
There were supply problems for basic products such as rice.

(a)



(b)

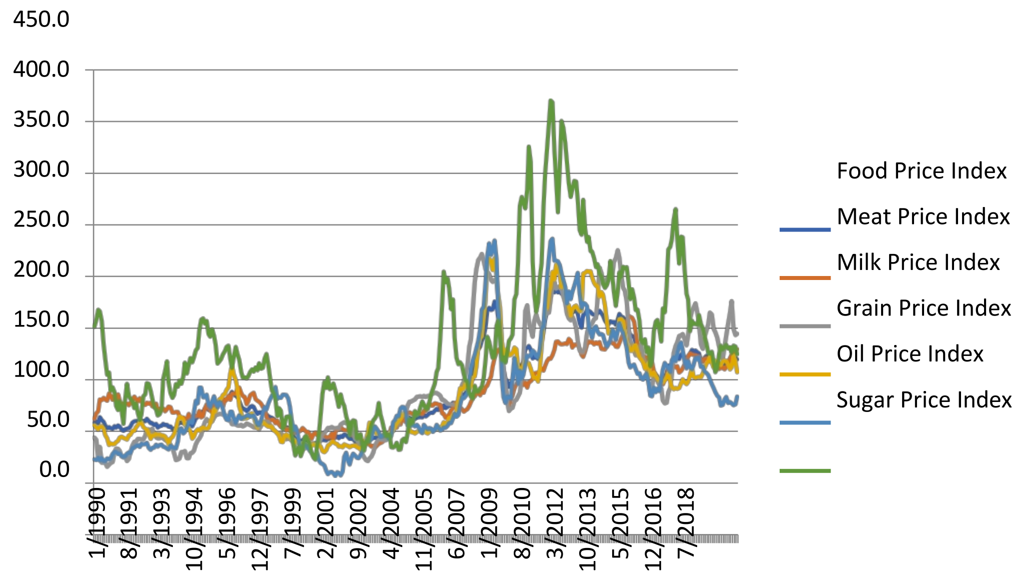


Figure 22: Nominal and real price trends in agricultural products, Source: FAO Food Price Index2019

[47] Karapinar, 2011

2.2.2. Scope of Vulnerability and Risk Analysis

The scope of vulnerability and risk analysis for the Agriculture and Livestock sector is a process that starts with impact chains. After analyzing the hazard components, other factors necessary for vulnerability and risk analysis should be determined. Exposure, sensitivity and adaptive capacity factors relevant to the agriculture and livestock sector are summarized below.

- Exposure factors
    - Soil and water ecosystems linked to agriculture and livestock production
    - Agricultural areas and pastures
    - Farmers, number, density - regional profiles
    - Regional economic linkages of the agricultural sector
    - Non-agricultural sector linkages
    - Food chains
- Sensitivity
    - Ecological and physical sensitivities
    - Yield sensitivity of agricultural crops
    - Sensitivity to production areas of crops
    - Product pattern sensitivity
    - Climate sensitivity of animal species (ideal habitat and efficient production)
    - Sensitivity of agricultural infrastructure (roads, irrigation, energy, etc.) to excessive rainfall and floods
    - Sensitivity of socio-economic systems
    - Agricultural income sensitivity of households
    - Local and regional economic development and growth sensitivity
    - Country-level macroeconomic sensitivities (food prices, employment, trade, investments)
    - Sensitization of other sectors linked to agriculture
    - Sensitivity to social equality and justice
    - Food security and poverty sensitization
- Capacity
    - Available technological options
    - Sources
    - Structure of critical institutions and decision-making authorities
    - Human capital stock
    - Stock of social capital, including the definition of property rights
    - System access to risk-emitting processes
    - Information management and reliability of information provided by decision makers
    - Public perception of risk and exposure
- Risks
    - Ecosystem impacts such as soil, water, forests
    - Impacts on crop and animal production yields
    - Impacts on production areas
    - Product pattern effects
    - Infrastructure impacts (irrigation, transportation and energy)
    - Agricultural income effects of households
    - Local and regional economic development and growth impacts
    - Macroeconomic impacts at country level (food prices, employment, trade, investments etc)
    - Impacts on other agriculture-related sectors (secondary impacts)
    - Social equity and justice impacts

- Poverty, food security impacts

2.2.3. Key Stakeholders

In general terms, the leading stakeholders in the agriculture and livestock sector are listed below.

- Ministries
- Development Agencies
- Governorships
- Metropolitan Municipalities
- Professional Organizations Qualified as Public Institutions
- Civil Society Organizations
- Professional Chambers
- International Organizations
- Universities
- Private sector

2.2.4. Sectoral Indicators

The main indicators that can be used in vulnerability analysis regarding the hazards and physical impacts arising due to the adverse effects of climate change on the agriculture and livestock sector are given below. Many of the indicators are also important for different sectors.

Hazard indicator: Heat waves indicator, temperature anomaly, drought indicator, heavy rainfall indicator, flooding indicator, flooding indicator, sea level indicator, number of frosty days indicator, number of stormy days indicator, change in precipitation, erosion risk indicator, number of days with snow cover.

Exposure indicator: Disaster indicator due to extreme weather events, indicator of area at risk of drought, indicator of number of population at risk of flooding, indicator of agricultural and livestock areas at risk of flooding, indicator of crop production in selected crops, indicator of number of floods and floods.

Sensitivity indicator: Indicator of agricultural area used for non-purpose, amount of damage due to natural disasters, crop loss due to extreme weather events, indicator of change in phenological growing season, indicator of agricultural area per winter, indicator of sectoral groundwater/ surface water allocations, indicator of sectoral groundwater/ surface water allocations, share in GDP, agricultural irrigation area, indicator of soil moisture, indicator of change in crop planting dates, indicator of change in yield, indicator of agricultural area due to rainfall.

Adaptation capacity indicator: Indicator for the rate of insurance coverage of damage due to natural disasters caused by extreme weather events, indicator for farmer training and extension activities, indicator for forest area under erosion control, indicator for the number of drought management plans prepared, indicator for the number of flood management plans prepared, indicator for the integration of climate change and adaptation into development planning, indicator for provincial agricultural drought studies, indicator for good agricultural practices, indicator for closed system irrigation area ratio, indicator for progress towards environmental objectives of river basin management plans, indicator for organic crop production, indicator for irrigation area with irrigation efficiency of 55% and above, indicator for the amount of support provided in agricultural basins, indicator for agricultural insurance, indicator for agricultural insurance damage payment, indicator for agricultural R&D expenditures, indicator for change in agricultural water consumption, indicator for change in crop yield after adaptation practices

Mixed vulnerability indicator: Number of dams indicator

2.3. Biodiversity and Ecosystem Services

Turkey is a country rich in biodiversity. The main reasons for this richness can be summarized as being on migration routes and the presence of a wide variety of climates, landforms and habitats. This is because during the ice ages of the past, species migrated southward from Europe and entered Anatolia through the Balkans and the Caucasus, and with the warming in the interglacial period, they moved northward again. Migrations were not only from Europe, but also from the south, especially with warming. During these migrations between northern and southern latitudes, various landforms and habitats such as valleys, mountains, plains, rocky plains, cliffs, dunes, etc. provided shelter for living creatures and allowed them to live without the need to migrate. On the other hand, new species have emerged due to geographical isolation, natural selection and evolution through mutations.

On the other hand, as a result of the high diversity of ecological characteristics such as climate, location, topography and bedrock/soil listed above, many habitats and ecosystems such as marine, coastal, wetland, lake and river, forest, maquis and scrub, steppe, pasture and mountain ecosystems cover large areas in our country. These ecosystems both provide living and growing environments for species and produce various ecosystem services. Ecosystem services are the products and services provided by ecosystems to all living things. These products and services are categorized under four main headings: provisioning (food, clean water, fish, wood, etc.), supporting (biodiversity, photosynthesis, soil formation, habitat provision, etc.), regulating (pollination, climate regulation, disaster/erosion prevention, water purification, air quality regulation, disease and pest reduction, resistance to invasive species, etc.) and cultural ecosystem services (recreation and aesthetic values, educational and inspirational values, moral and spiritual values, science and education, etc.). The status of biodiversity and ecosystems in Turkey, the ecosystem services they produce and their vulnerability to climate change are evaluated in the following section.

Biodiversity

Noah's Ark National Biodiversity Database prepared by the General Directorate of Nature Conservation and National Parks (DKMP), National Biodiversity Strategy and Action Plan (DKMP, 2008) and the number of taxa in Turkey compiled from various sources are given in Table 10. As can be seen from the table, the total number of taxa in our country is over 42 thousand, although there are not enough studies in some groups such as crustaceans, spiders and fungi.

Our country is also rich in endemic species. Of the 13,412 taxa recorded in the Noah's Ark database, 4,829 are endemic, representing an endemism rate of 36% [48]. However, the entry of all species in our country into the database has not yet been completed. According to the National Biodiversity Strategy and Action Plan, as of 2007, when the plan was prepared, 4,000 of the 19,000 invertebrate species were endemic. According to the International Union for Conservation of Nature (IUCN) criteria, 22% of the species entered into the Noah's Ark database are in the vulnerable (VU- Vulnerable), endangered (EN-Endangered) and critically endangered (CR- Critically endangered) categories (Figure 23). However, the threat categories of most of our species, especially endemic species, have not yet been evaluated by IUCN.

Table 10: Number of taxa in Turkey

Animals	Number of taxa	Plants and lichens	Number of taxa
Terrestrial mammals	173[1]	Vascular Plants	12.140[1]

[48] DKMP, 2021. Noah's Ark National Biodiversity Database. General Directorate of Nature Conservation and National Parks. http://www.nuhungemisi.gov.tr/ (Date of Access: 20.03.2021).

Animals	Number of taxa	Plants and lichens	Number of taxa
Cetacean	11[49]	Black mosses	910[5]
Birds	506[1]	Ferns	101[5]
Reptiles	147[1]	Green and red algae	2.150[5]
Bivalves	39[1]	Lichens	1.000[5]
Inland water fish	402[1]	Water algae	3.690[50]
Sea fish	512[51]		
Insects	20.114[52]		
Molluscs	522[5]		
Corals	24[53]		
Total	22.450	Total	19.991

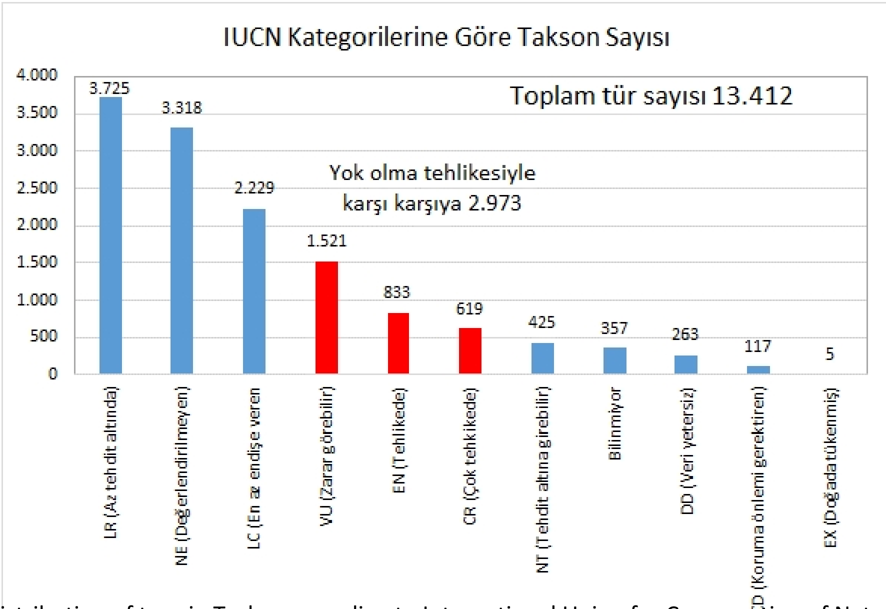


Figure 23: Distribution of taxa in Turkey according to International Union for Conservation of Nature (IUCN) categories (DKMP, 2021)

Habitat and Ecosystems

Turkey is rich in habitat and ecosystem diversity as well as species diversity. However, studies on the identification and mapping of habitats are quite insufficient and studies in this direction have started to be carried out in the last few years. EU member states determine the species and habitats that need to be protected by the EU Bird and Habitat Directives and the important ones are included in the Natura 2000 network. The identification and mapping of habitats in the EU carried out according to the European Nature Information System (EUNIS) classification. In our country, "Natura 2000 Requirements

49 Dede, A., Tonay, A.M., n.d. Marine mammals of Turkey. Turkish Marine Research Foundation. https://tudav.org/calismalar/denizel-biyocesitlilik/deniz-memelileri-calismalari/turkiyenin-deniz-mammals/ (Access Date: 20.03.2021).

50 Taşkın, E, 2019. Türkiye Bitkileri Listesi, Suyosunları. Ali Nihat Gökyiğit Foundation Publications, 804 p., Istanbul

51 Bilecenoğlu, M., Kaya, M., Cihangir, B., Çiçek, E., 2014. An updated checklist of the marine fishes of Turkey. Turkish Journal of Zoology, 38: 901-929.

52 DKMP 2008. National Biodiversity Strategy and Action Plan 2007. Ankara: National Biodiversity Strategy and Action Plan 2007. Republic of Turkey Ministry of Environment and Forestry, General Directorate of Nature Conservation and National Parks Publications.

53 Topçu, N.E., Öztürk, B., 2017. Mediterranean deep sea corals and their status in Turkish seas. Proceedings of the I. Turkey Deep Sea Ecosystem Workshop, June 19, 2017, Çanakkale, 139-152.

~~Technical Assistance Project for Strengthening the National Nature Conservation System for~~ Implementationand "Project on the Applicability of the EU Natura 2000 Concept in Turkey's Forest Areaswere completed. In the project carried out in Yenice and Karabük forests, it was revealed that 7 of the 12 habitat classes identified were unique to Turkey. This result is quite natural since the habitats included in the EU Habitat Directive belong only to continental Europe. As habitat classification and mapping studies increase in Turkey, it is obvious that many more new habitat classes will be identified. Within the scope of the "National Biodiversity Inventory and Monitoring Projectinitiated by DKMP in 2013, habitats in the provinces are identified according to the EUNIS habitat classification and the important ones are monitored.

There are two main sources of data on the area covered by ecosystems in Turkey. The first of these is TurkStat. However, only agricultural, forest and meadow/pasture areas can be accessed from TurkStat data. According to TurkStat, the area of cultivated agricultural land decreased from 27.9 million ha in 1990 to 23.1 million ha in 2020. On the other hand, it is stated that forest areas increased from 21.2 million ha to 22.7 million ha in the same period. Meadow and pasture areas 14.2 million ha in 1990, 12.4 million ha between 1991 and 2000, and 14.6 million ha in the following years. The other data source is the CORINE (Coordination of Environmental Information) classification, where satellite images are processed to determine land cover/use. CORINE land cover classification is done at different levels. For example, at level 1, there are 5 basic land covers (agriculture, artificial regions, forest and semi-natural areas, wetlands, water bodies). At other levels, land cover classifications are more detailed. In our country, land cover distributions in 1990, 2000, 2006, 2012 and 2018 were determined using CORINE classification. These land covers can also be considered to correspond to ecosystems. However, the 1st level classification is quite general and the area of most ecosystems and the change of these areas over the years cannot be determined. **Error! Reference source not found.**1, unlike CORINE level 1, meadow/pasture/grassland and dunes, bare rocks and glaciers, which are called other, are classified as a separate land cover and the change of land cover over the years is given. Accordingly, settlements, water surfaces and agricultural areas increased while other land cover decreased. The highest decrease is in meadow/pasture/grazing land (**Error! Reference source not found.**1). Since the 1st level CORINE classification does not cover all ecosystems, the 2nd and 3rd level classifications are shown in **Error! Reference source not found.**2. When CORINE and TurkStat data are compared, there is a discrepancy. The main reason for this discrepancy is that agricultural data are mostly obtained from the farmer registration system and parcel-based records, while forest data show areas that have been burned, cut for rejuvenation or allocated for non-forestry practices as legally forests even though they are not actually forests. Pasture data is also obtained from the Pasture

Table 11: Changes in various land covers over the years [54]

	1990	2000	2006	2012	2018	2018-1990 difference
Agriculture	31.850.445	31.559.667	32.022.421	32.095.951	32.070.262	219.818
Grassland	21.051.041	20.750.318	20.188.469	20.321.146	20.233.532	-817.509
Forest	20.431.435	20.587.505	20.283.540	20.378.501	20.355.101	-76.334
Settlement (artificial zones)	962.767	1.221.003	1.300.589	1.456.765	1.565.407	602.640
Other (dunes and cliffs)	2.265.283	2.339.384	2.489.127	1.985.718	1.984.763	-280.520
Wetland	273.792	283.557	417.588	412.519	413.787	139.995
waters	1.166.958	1.261.007	1.293.774	1.345.770	1.374.373	207.415

[54] http://corinecbs.tarimorman.gov.tr/corine

Table 12: Change in land cover over the years according to 2nd and 3rd level CORINE classification (CORINE database)

Land use/land cover	Main land Usage class	1990	2000	2006	2012	2018	2018-1990 Difference
1.1. City Structure	Settlement	768.243	903.074	877.874	957.287	984.199	215.955
1.2. Industrial Commercial and Transport Units	Settlement	86.185	167.323	226.745	265.603	303.141	216.956
1.3. Mining, Extraction and Construction Fields	Settlement	76.554	102.927	149.279	181.720	223.254	146.700
1.4. Non-Agricultural Artificial Green Fields	Settlement	31.785	47.678	46.691	52.155	54.813	23.028
2.1. Areas Suitable for Agriculture	Agriculture	18.170.405	18.121.802	18.564.389	18.673.788	18.660.824	490.420
2.2. Continuous Products	Agriculture	1.056.016	1.052.646	1.883.726	2.028.351	2.034.575	978.559
2.3. Pastures	Grassland	1.632.869	1.491.343	1.975.568	2.041.781	2.009.093	376.223
2.4. Heterogeneous Agricultural Areas	Agriculture	12.624.024	12.385.219	11.574.306	11.393.812	11.374.863	1.249.161
3.1.1. Broadleaf Forests	Forest	3.630.473	3.911.029	3.666.122	3.639.428	3.627.578	-2.896
3.1.2. Coniferous Forests	Forest	4.796.163	4.715.909	5.426.360	5.444.424	5.371.548	575.386
3.1.3. Mixed Forests	Forest	3.286.418	3.573.435	2.545.964	2.537.596	2.526.662	-759.756
3.2.1. Natural Grasslands	Grassland	9.153.101	8.996.130	8.931.250	8.907.984	8.877.571	-275.530
3.2.2. Heaths	Grassland				164	164	164
3.2.3. Sclerophyll Vegetation	Forest	915.271	922.111	863.072	1.065.700	1.061.214	145.943
3.2.4. Intermittent Forest - Scrubland	Forest	7.783.000	7.455.919	7.771.647	7.689.049	7.764.016	-18.984
3.3.1. Coasts, Beaches and Sand Flats	Other	124.061	132.237	98.309	92.540	91.898	-32.162
3.3.2. Bare Rocks	Other	2.140.572	2.206.557	2.390.228	1.892.552	1.892.238	-248.334
3.3.3. Sparsely Planted Areas	Grassland	10.265.070	10.262.846	9.281.651	9.371.380	9.346.868	-918.201
3.3.4. Burnt Areas	Forest	20.109	9.102	10.375	2.141	3.919	-16.191
3.3.5. Glaciers and Permanent Snow	Other	651	590	590	627	627	-24
4.1. Swamps	Wetland Fields	226.539	250.859	213.215	208.612	207.571	-18.968
4.2. Salt marshes and salt pans	Wetland Fields	29.769	32.698	204.373	203.907	206.216	176.447
5.1. Water bodies and watercourses	waters	1.166.958	1.261.007	1.293.774	1.345.770	1.374.373	207.415
5.2. Coastal lagoons/river mouths/deltas	Wetland Fields	17.484	18.093	15.752	17.272	17.211	-272
TOTAL AREA (ha)		79.572.011	79.588.626	80.640.028	80.636.521	80.636.521	1.064.510

The areal information of steppe ecosystems, which are rich in biodiversity and contain endemic species, is not available from CORINE land cover classification. Steppe ecosystems are mostly used as grasslands and pastures, and a significant portion of them are converted into agricultural areas. With the "Project on Agricultural Practices for Ecosystem-Based Adaptation to Climate Change in Steppe Ecosystems" carried out by the General Directorate of Agricultural Reform, a steppe map of our country was prepared and this map was uploaded to the Agricultural Monitoring and Information System (TARBIL), but it is not accessible. According to this project, steppe areas are 32 million ha.

Protected areas are of great importance for the conservation of biodiversity. Responsibility for protected areas in terrestrial ecosystems, wetlands, coastal and marine protected areas lies with the Directorate General for Nature Conservation and National Parks (DKMP), the General Directorate of Forestry (OGM) and the General Directorate for the Protection of Natural Assets.

(TVK) is undertaken by the Ministry of Environment and Urbanization. According to the Environmental Indicators Report published by the Ministry of Environment and Urbanization, the amount of protected areas decreased from 7.9 million ha in 2013 to 7.0 million ha as of 2018 [55]. When compared to the country's surface area, these values correspond to 10.1% and 8.9% respectively (**Error! Reference source not found.**3). The most important reason for the decrease in the amount of protected areas is the introduction of a registration process for wetlands with an amendment to the Wetlands Regulation in 2014 (MoEU, 2020). As of 2018, the length of protected coasts is 1957 km, which is 23% of the total coasts.

Table 13: Status and areal distribution of protected areas in 2013 and 2018[10]

Protected areas*	2013		2018		Responsible organization
	Quantity	Total area (ha)	Quantity	Total area (ha)	
Ministry of Agriculture and Forestry Protected Areas					
National Park	40	848.203	44	866.684	DKMP
Nature Park	192	90.218	243	106.453	DKMP
Nature reserve	31	64.243	30	46.794	DKMP
Natural monument	112	6.684	112	7.488	DKMP
Wildlife development area	80	1.191.340	81	1.172.421	DKMP
Wetlands (of international importance)	135	3.215.500			DKMP
Wetlands of local importance			9	10.289	DKMP
Ramsar site			14	184.487	DKMP
Wetland of national importance			48	714.133	DKMP
Conservation forests	55	320.451	55	251.519	OGM
Honey forest	200	24.861			OGM
Urban forest	128	11.722	137	10.363	OGM
Gene conservation forests	257	47.978	312	42.329	OGM
Seed stands	351	47.063	317	41.992	OGM
Seed gardens	179	1.414	197	1.457	OGM
Single surface total	1.760	5.869.677	1.599	3.384.717	
Ministry of Environment and Urbanization Protected Areas					
Special environmental protection zone	16	2.459.116	16	2.459.749	TVK
Natural site	1.273	1.322.749	2.450	2.017.549	TVK
Single surface total	3.049	7.883.511	4.065	6.961.046	TVK
Ratio to country area (%)		%10,1		%8,9	

* Camili Biosphere Reserve with an area of 25,258 ha is not included in the protected area statistics.

Non-governmental organizations (NGOs) working on nature conservation in Turkey have also carried out various studies. One of the oldest of these is the Important Bird Areas (IBAs) identified by the Wildlife Conservation Society. In this study, 97 IBAs [56] were identified. Later, 122 Important Plant Areas (IPAs) were identified by WWF Turkey[57]. With the ongoing studies, the number of IBAs was increased to 144[58]. Finally, 305 Important Nature Areas (KBAs) were established by Doğa Derneği[59]. Both protected areas and important areas identified by NGOs are important for the protection of biodiversity, habitats and ecosystems in Turkey and are considered as an integral part of the adaptive capacity of the sector.

[55] MoEU, 2020. Environmental indicators. Ministry of Environment and Urbanization, General Directorate of Environmental Impact Assessment, Permit and Inspection, Ankara, 198 pp.
[56] Yarar, M., Magnin, G., 1997. Important bird areas of Turkey. Association for the Protection of Natural Life, Istanbul.
[57] Özhatay, N., Byfield, A., Atay, S., 2005. Turkey's 122 Important Plant Areas. WWF Turkey, Istanbul.
[58] Özhatay, N., 2006. Important Plant Areas of Turkey along the BTC Pipeline, BTC Company, Istanbul
[59] Eken, G., Bozdoğan, M., İsfendiyaroğluS.KılıçD.T.LiseY.(editors) 2006. Important Natural Areas of Turkey. Nature Association, Ankara.

Ecosystem Services

The issue of ecosystem services is a fairly new topic for our country and it is seen that studies have started to increase in the last 10 years. Despite this, it can be said that society still benefits from many ecosystem services, but is not aware that these are ecosystem services. For example, food produced from agricultural areas, marine and inland fisheries, beekeeping, ecotourism, non-wood forest products and firewood, drinking and potable water, recreational use, ecological effects of green areas in cities are various products and services provided by ecosystems. According to the 2018 National Greenhouse Gas Inventory, the 84.9 million $_{CO2}$ equivalent greenhouse gas that forests take back from the atmosphere is an ecosystem service provided by forests [60]. In a study conducted by the General Directorate for Combating Desertification and Erosion, the organic carbon stock in Turkish soil was found to be 3.5 billion tons[61]. Therefore, ecosystem services should be considered as a cross-cutting issue for the priority sectors that will be affected by climate change in our country.

In some studies on ecosystem services, the pricing of these services has also been realized. For example, the total economic value generated by the forests in the Bolu Regional Directorate of Forestry is estimated to be 716 million dollars per year, 90% of which is not included in the calculation of GNP[62]. The only measurable part of the ecosystem services produced by Kayseri Sultansazlığı National Park was estimated to be 1.4 billion TL[63].

Apart from these studies, there are graduate thesis studies on the use of ecosystem services in areas such as landscape planning, hydrological planning and protected area planning. In terms of mapping ecosystem services in cities, studies have been carried out for İzmir Balçova([64]) and Ankara Çankaya([65]), albeit at the district level.

Factors Threatening Biodiversity and Ecosystems

The Millennium Ecosystem Assessment (MEA) states that habitat change, climate change, overuse, pollution and invasive species directly threaten biodiversity and ecosystems, while demographic, economic, socio-political, cultural and technological factors are indirectly effective[66]. As a matter of fact, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) announced that approximately 1 million species will face extinction in 2019 due to factors directly affecting them [67]. In our country, 22% of the taxa currently studied are threatened

[60] TurkStat2020Turkish greenhouse gas inventory 1990-2018National Inventory Report for submission under the United Nations Framework Convention on Climate Change. https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas- inventories-annex-i-parties/national-inventory-submissions-2020

[61] ÇEM. 2018. "Soil Organic Carbon Project, Technical Summary", General Directorate of Combating Desertification and Erosion,
Ankara, Turkey, 32 pp.

[62] Çelikkol Erbaş, B., 2015. Economic valuation of forest goods and services: The pilot study in Bolu Region. Natural Capital Accounting Regional Workshop for Europe and Central Asia (ECA) Region Organized by The World Bank and Turkish Ministry of Development, March 9-11, 2015, Pera Palace Hotel, Istanbul.

[63] Bilgin, A., Doğan, M., (Ed.) 2012. Draft Guidance on Integration of Nature Conservation into the Economic System 2 Biomonitoring Technical Practitioners: Sultan Sazlığı National Park Pilot Application. Ministry of Forestry and Water Affairs, Ankara.

[64] Berberoğlu, S., Çilek, A., Ünlükaplan, Y., (Ed.). 2019. A Framework for Resilient Cities: Green Oriented Adaptation Project. İzmir Buyukşehir Municipality and Landscape Research Association168 pp.

[65] Çağlayan, S.D., Balkız, Ö., Arslantaş, F., Sanalan, K.C., Lise, Y., Zeydanlı, U. 2020. Ecosystem Services as an Urban Planning Tool: The Case of Çankaya District. Ankara, Nature Conservation Center, 236 pp.

[66] MEA, 2005. Ecosystems and Human Well-being: Biodiversity Synthesis. Millennium Ecosystem Assessment, World Resources Institute, Washington, DC.

[67] https://ipbes.net/news/Media-Release-Global-Assessment#_ftn1

(Figure 24). Various pressure factors, including habitat changes and fragmentation, are also increasing day by day. For example, between 1989 and 2018, a total of 2.6 million ha of agricultural land was converted to non-agricultural use (MoEU, 2020). Between 2012-2019, the amount of forest area permitted for energy, mining and other uses was 294 thousand ha[68]. It is also stated in the Sustainable Forest Management Criteria and Indicators Reports prepared by OGM for the years 2009[69] and 2019[(70) that] the number of pieces smaller than 10 ha in forests is gradually increasing ().

Table 14: Changes in forest fragment sizes in Turkey (OGM 2009 and 2020b)

Fragmentation	2008	2019	2008-2019	
	Number of Parts	Number of Parts	Change	
	Quantity	Quantity	Quantity	Percentage (%)
smaller than 10 ha	55484	120789	65305	118
10 ha-99 ha	33829	30116	-3713	-11
100 ha-999 ha	11163	6427	-4736	-42
Larger than 1000 ha	1414	1187	-227	-16
Total	101890	158519	56629	56

The factors threatening taxa in Turkey were also analyzed in the DKMP Noah's Ark Database (Figure 24). Accordingly, human activities, agricultural practices and climate change come to the fore.

On the other hand, there is also an increase in the number of invasive alien species. For example, in the Environmental Indicators book published by the Ministry of Environment and Urbanization, it is reported that the number of alien species in the seas increased from 263 in 2005 to 500 in 2018, and that about 50 of them invasive, 25 alien species were identified in inland waters[71]. The number of invasive alien plants has also increased significantly and is reported to be 174[(72)]. Although there is no exact number of invasive insects, species such as Anoplophora chinensis, Cydalima perspectalis, Ricania japonica, Halyomorpha halys, Leptoglossus occidentalis are known to exist.

[68] OGM, 2020a. Forestry Statistics 2019. https://www.ogm.gov.tr/tr/ormanlarimiz/resmi-istatistikler

[69] OGM, 2009. Sustainable Forest Management Criteria and Indicators Report 2008. General Directorate of Forestry Publication. 142 p. Ankara

[70] OGM, 2020b. Sustainable Forest Management Criteria and Indicators 2019 Turkey Report. General Directorate of Forestry
Directorate of Publication. 215 S. Ankara

[71] MoEU, 2020. Environmental indicators. Ministry of Environment and Urbanization, General Directorate of Environmental Impact Assessment, Permit and Inspection, Ankara,

[72] Guner, A., Aslan, S., Ekim, T., Vural, M., Babac, M.T. (Eds.)., 2012. List of Plants of Turkey (Vascular Plants), Publication of NGBB and Flora Research Association, Istanbul.

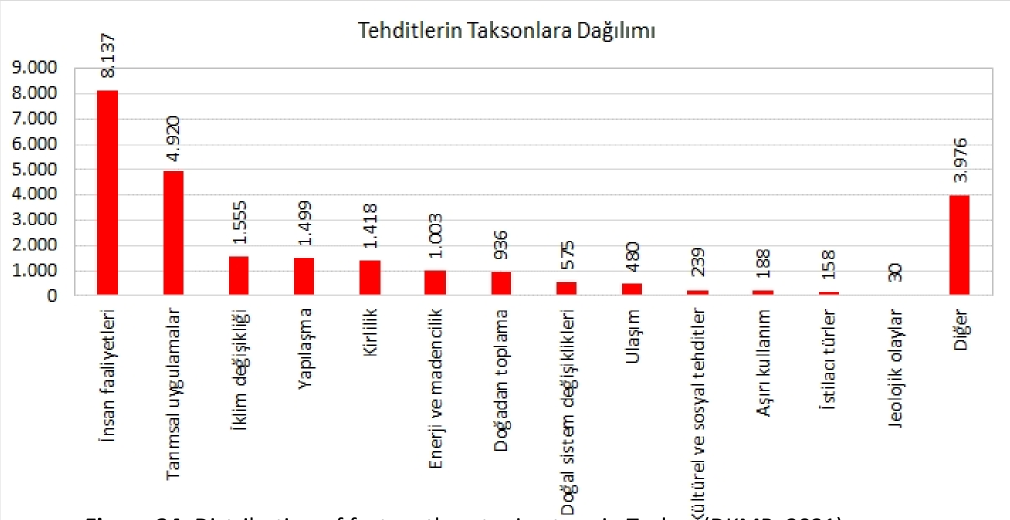


Figure 24: Distribution of factors threatening taxa in Turkey (DKMP, 2021)

Under the heading of over-utilization, over-hunting of fish and wild animals, collection of plants called non-wood forest products, increase in wood production in forests, consumption of underground and surface water resources as drinking and utility water can be listed. Increases are also observed in these examples of overuse in our country. For example, wood production has increased 2-fold compared to 2000[73].

In addition to these threats, a large part of our country is under the risk of desertification and is already experiencing intense erosion. While wind erosion is prominent in semi-arid regions such as Central Anatolia and Igdir, water erosion is quite intense in other regions. For these two threats, various monitoring systems [74, 75] and maps [76] have been created by ÇEM.

The factors that threaten biodiversity and ecosystems listed in summary can be considered as factors that are not related to climate change but affect climate adaptation (**Error! Reference source not found.**).

[73] OGM, 2020a. Forestry Statistics 2019. https://www.ogm.gov.tr/tr/ormanlarimiz/resmi-istatistikler

[74] ÇEM. 2018. DEMIS Turkey Water Erosion Statistics, Technical Summary. General Directorate for Combating Desertification and Erosion Publications, Ankara, Türkiye. https://www.tarimorman.gov.tr/CEM/Belgeler/yay%C4%B1nlar/yay%C4%B1nlar%202018/Dinamik%20Erozyon%20Modeli%20ve%20%C4%B0zleme%20Sistemi%20(DEM%C4%B0S)-%20Teknik%20%C3%96zet.pdf

[75] Erpul, G., İnce, K., Demirhan, A., Küçümen, A., Akdağ, M.A., Demirtaş, İ., Sarıhan B., Çetin, E., Şahin, S., 2020. Water Erosion Provincial Statistics - Soil Erosion Control Strategies (Sustainable Land/Soil Management Practices and Approaches) General Directorate of Desertification and Erosion Control Publications. Ankara

[76] ÇEM. 2017. "Turkey Desertification Model, Technical Summary", General Directorate of Desertification and Erosion Control, Ankara, Turkey.

Table 15: Direct or indirect damage to ecosystems and loss of biodiversity factors[77]

Direct Factors		Indirect Factors	
Factor	**Scope**	**Factor**	**Scope**
Habitat Change (Land use/land cover change)	- Urbanization/industrialization - Expansion of agricultural areas - Energy production (HEPP, WPP and electricity transmission lines) - Mining - Transportation - Deforestation - Afforestation - Dams and ponds - Drying up wetlands - Filling of coasts - Tourism - Fires - Illegal wood production - Erosion - Drying up wetlands - Transhumance	Socio-political	- Lack of management and control - Weak interaction between stakeholders - Inadequacies in nature protection and environmental legislation (EIAs etc.) - Economic growth policies based on industrialization - Lack of ecological standards - Low awareness - Low participation in decision-making processes - Insufficient capacity in education, training and research - Property issues - Biological Diversity hot points are left unprotected - Energy policies - Agriculture, Mining and Tourism policies
Overuse	- Hunting and fishing - Excessive use of groundwater and surface water consumption - Overgrazing - Excessive wood production - Intensive agriculture - Intensive recreation	Economic	- Globalization - Trade - Markets - Economic policies - Poverty - Development status of countries - Investments Decision giving ecosystem services are not taken into account at the ecosystem services stage - Consumption preferences
Pollution	- Eutrophication - Nitrogen storage - Pesticides/herbicides - Air pollution - Water pollution - Soil pollution - Light pollution - Urban/industrial waste	Demographic	- Population growth - Population density - Migrations
Invasive Species		Science an d Technology	- Technological waste - Newly discovered chemicals - Microplastics

2.3.1. Climate Amendment Biological Diversity and Ecosystem Services Impacts of Evaluation of

The life cycles and behaviors of living organisms and even their physiology are closely related to climate. On the other hand, processes such as matter and energy exchange transformations, water and matter (C, N, K, etc.) cycles, photosynthesis, food chain in ecosystems are also shaped by climate elements such as temperature and precipitation. Therefore, climate change impacts that may affect biodiversity and ecosystems may be higher than other priority sectors (**Error! Reference source not found.**). For example, temperature and precipitation variability may pose less risk to the industrial or energy sectors, while agriculture and forestry sectors

[77] Tolunay D., 2018. Pressures on ecosystems and solution proposals. Nature Rights Workshop December 8-9, 2018, Muğla, Muğla Metropolitan Municipality.

can create significant problems in ecosystems. Similarly, for example, increasing acidity in the seas can be considered as a factor that cannot be taken into account except for the fisheries sector. At the same time, many marine species, such as fisheries, which are a product of aquatic ecosystems, are also negatively affected by acidification.

Table 16: Climate change impacts that may affect biodiversity and ecosystems and the services they provide

Temperature	Increase in average temperatures
	Increase in sea water temperature
	Heat/cold waves
	Temperature variability
Precipitation	Heavy rains
	Precipitation variability
	Decrease in snowfall
Extreme weather events	Floods and floods
	Drought
	Increased humid conditions
	Storms
	Fires (Forest, reeds, etc.)
CO_2 concentration	Increasing acidity in the seas

Error! Reference source not found.6 The impacts of climate change on biodiversity and ecosystems and the products and services produced by them are evaluated in the following sections.

Genetic Diversity

Genetic diversity is about whether species can adapt to changing climatic conditions. Living things adapt to changing conditions through mutation. However, if the change is rapid, adaptation becomes difficult. In species with shrinking population sizes, the gene pool also shrinks, thus increasing the vulnerability of species. In our country, studies on the genetic diversity of species are very few. However, it can be accepted that the genetic diversity of species with local distribution, species in disconnected habitats and ecosystems, and species threatened by IUCN categories are also low. Temperature increases and extreme weather events expected to further reduce the number of individuals of species with shrinking gene pools, thus further decreasing genetic diversity. Species with low genetic diversity may face extinction risk due to factors other than climate change (habitat changes and fragmentation, overuse, invasive species and pollution).

Species

Temperature increase and variability and droughts are expected to cause changes in the phenology of species. For example, the prolonged growth period of plants, flowering and leafing due to the increase in temperatures during the winter months are still being experienced. As a result of such events, frost damage may be encountered as a result of sudden increases in temperatures. Droughts cause plants to shed their leaves prematurely to reduce water loss. It is also observed that animals that hibernate due to the increase in temperature cannot go to sleep, have to hunt, but as a result of not finding prey, hunger problems arise. In our country, there are incidents where bears cannot hibernate and human-bear conflicts have occurred while searching for food. Similarly, bees are known to leave their hives in winter months when temperatures rise. Temperature increases can affect the migration times, egg laying times and incubation periods of some species such as migratory birds. In some species whose sex is dependent on temperature, even the sex of the hatched individuals may change. The tadpole sea turtle (*Caretta caretta*) an example these species.

In this species, the number of females increased from 60% to 90% when the nest temperature increased from 29.7 °C to 31.5 °C[78].

With the increase in temperature, species predicted to migrate. These migrations are predicted to be to more northern latitudes and to higher elevations in mountainous areas. In our country, species distribution modeling of forest trees and bird species has been carried out based on climate change scenarios. For example, in a study conducted in the Seyhan basin, it was revealed that the areas where red pine, larch and fir species spread will decrease significantly[79]. Similarly, it was determined that the eastern beech species will be drawn to the cold and rainy Caucasus region in the future[80]. In the mountainous areas of the Eastern Black Sea Region, it is reported that be shifts of 200-400 m in the plant belts, and that the tree line has been moved up even today[81].

Similar studies have also been conducted for fauna elements. For example, it is predicted that especially migratory birds will be negatively affected by temperature increases, the number of individuals in populations will decrease, their distribution will shrink, species whose breeding areas are limited to the northern and western parts of our country will lose their breeding areas, whereas the breeding areas of species breeding in the south may have the potential to expand [82].

Climate change should not be expected to have a similar impact for every species. For example, it is stated that the stork (*Ciconia ciconia*) will not be affected much by temperature increases [83].

Climate change can have a negative impact not only on species but also on the relationships between species (competitionmutualismparasitism, prey/predator). For example, there is a high probability that flowers will bloom earlier, but bees will not be able to keep up and will have difficulties in finding food. Indeed, pollinator species are known to be highly vulnerable to climate change [84].

In a study on bats, it was determined that climatic variability between years resulted in a later emergence from hibernation and a decreasing number of insects, resulting in a decrease in the number of individuals in bat populations [85].

[78] Sezgin, Ç., 2016. Investigation of the effect of temperature on tadpole sea turtle (*Caretta caretta* L.) juvenile sex ratio and adult migration. Pamukkale University Graduate School of Natural and Applied Sciences Department of Biology Master's Thesis, 93 pp.

[79] Zeydanlı, U., Turak, A., Bilgin, C., Kınıkoğlu, Y., Yalçın, S., Doğan, H. 2010. Climate Change and Forestry: From Models to Practice. Ankara. Nature Conservation Center.

[80] Dağtekin, A.D., 2018. Modeling Spatial Distribution of Oriental Beech (*Fagus Orientalis)*: Past, Present And Future. Istanbul Technical University Institute of Graduate Studies Department of Climate and Marine Sciences Master's Thesis, 39 pp.

[81] Terzioglu S., Tufekcioglu A., Kucuk M. (2015) Vegetation and Plant Diversity of High-Altitude Mountains in Eastern Black Sea Region of Turkey and Climate Change Interactions. In: Öztürk M., Hakeem K., Faridah-Hanum I., Efe R. (eds) Climate Change Impacts on High-Altitude Ecosystems. Springer, Cham.

[82] Abolafya, M., 2011. Environmental distribution modeling of resident and migratory passerine birds from Turkey in a climate change perspective. Boğaziçi University / Institute of Environmental Sciences / Department of Environmental Sciences Master's Thesis

[83] Süel, H., 2019. Prediction of stork (*Ciconia ciconia* Linnaeus, 1758) distribution in Turkey according to climate change. Turkish Journal of Forestry, 20 (3): 243-249.

[84] Topal, E., Özsoy, N., Şahinler, N., 2016. Global warming and the future of beekeeping. Mustafa Kemal University Journal of Faculty of Agriculture 21: 122-120.

[85] Aşan Baydemir, N., 2017. Climate change and bats: Hibernation in a small mousecapped bat species in Central Anatolia. Human Engagement with Nature-International Symposium from the Poles to the Equator in the Natural Habitat in the City. June 8-9, 2017 Ankara.

Temperature increases affect the wintering and migration of not only terrestrial organisms but also aquatic organisms
is expected[86].

Impacts other than temperature increases are more likely to result in habitat destruction and mortality of individuals and shrinking population sizes. For example, rising sea levels will cause damage to dune vegetation or species that nest in dunes. Droughts a similar effect. In particular, the migration of species that migrate between inland waters, such as the pearl mullet, or between sea and inland waters, such as eels, may be prevented. If aquatic ecosystems dry up completely, the lives of aquatic creatures and bivalves to an end. Droughts will also prevent other terrestrial species from accessing water, and species whose water sources dry up may die or be forced to migrate. Even if aquatic ecosystems do not dry up completely, the water will become warmer due to decreasing water levels and physicochemical water quality (turbidity, salinity, nutrient content, etc.) will deteriorate. Trout species are particularly sensitive to temperature changes. Floods can also affect aquatic life by changing water quality. Material carried by floods can also have a negative impact by covering bottom meadows and nests.

Living species also provide ecosystem services. These services are mostly in the supply category. For example, 2,933 of the species registered in the Noah's Ark database of DKMP are used in medicine and herbal medicine production, 2,006 are used as meadow and pasture plants, and 1,606 are used for food [87].

Habitats

Habitats are the living/growing environments of species. They are sub-parts of ecosystems and also as refugia for species. According to the EU Habitats Directive, natural habitats and flora and fauna must be protected. Annex 1 of the Directive lists 231 habitat types, 71 of which are priority natural habitats in 9 different habitat types. However, habitat classification studies are very limited in Turkey. As mentioned before, habitats have been identified in a few projects and habitats have started to be identified within the scope of the National Biodiversity Inventory and Monitoring Project initiated by DKMP after 2013. For this reason, it is not publicly available how many different habitat types there are in Turkey within the scope of the EU directive and how many of them are prioritized. There are also very few scientific studies on the classification and mapping of habitats. However, for example, in one study, 16 habitat types endangered by the Bern Convention, another international convention, were identified in the important plant area of Terkos Lake and its surroundings (Özhatay, 2005). It is very difficult to evaluate how climate change will affect habitats in our country without knowing the existing habitat types, locations and endangered status. However, in general, it is possible to say that freshwater habitats, marshes will be affected by droughts, seagrass meadows and coral reefs may be affected by acidification due to sea level rise. There is also the possibility that habitats that are home to narrowly distributed species and endemic and threatened species, which act as refuges in a sense, may shrink or even disappear as a result of climate change.

Urban Ecosystems

Cities are among the sectors that will be most affected by climate change. Since cities are considered among priority sectors, they will not be analyzed in this section. However, urban ecosystems, especially green areas and groves within the city, create habitats for flora and fauna within the city, reduce the urban heat island effect and urban floods. With climate change, these ecosystem services will also be negatively affected. On the other hand, if urban ecosystems are damaged by climate change, access to drinking water and recreation areas may decrease. In addition, vulnerability to disasters such as floods and overflows will increase.

[86] Diken, G., 2020. Impact of anthropogenic climate change on fisheries and aquaculture and an overview of management strategies. Journal of Anatolian Environmental and Animal Sciences 5 (3): 295-303.

[87] DKMP, Noah's Ark Database 2021

Agriculture Ecosystems

Like urban ecosystems, agricultural ecosystems are also a priority sector. Agricultural biodiversity is expected to decrease due to climate change and other factors. The most important ecosystem service provided by agricultural ecosystems is food production, and agricultural productivity is still exposed to direct climate change-induced impacts such as temperature increase, floods, storms and hailstorms, and droughts. On the other hand, if other ecosystems are damaged, the degree to which agricultural ecosystems are affected will increase. For these reasons, in recent years, practices to reduce the vulnerability of both cities and agricultural areas through practices called nature-based solutions or ecosystem-based adaptation have become increasingly common.

Forest Ecosystems

As mentioned before, temperature increases are expected to cause shifts in forest areas as forest tree species are expected to migrate to northern latitudes and higher elevations in mountainous areas. However, the migration rate of forest trees is quite slow. Therefore, the accuracy of the results obtained with species distribution models is questionable. Again, since these models do not take into account, for example, soil factors or human impacts, it is difficult to comment on the future state of forests. For example, in mountainous areas, forests move towards subalpine and alpine meadows. However, in cases where soil depth is insufficient or stoniness is high, this progress will be very slow. In mountains with limited elevation, the area covered by forests will decrease. In mountainous areas, due to the increase in precipitation and decrease in temperatures with altitude, zones consisting of different tree species and called altitude climate zones are observed. One of the most typical examples of this is in Uludağ National Park. Climate change will cause these belts to shift towards higher elevations.

It is expected that the frequency, severity and area affected by forest fires will increase with the increase in temperature and evaporation due to drought and the decrease in air humidity. It is also possible that the so-called fire season, which covers the period between May 1 and November 30, will be extended. With the increase in defoliation and even death of trees due to drought, the combustible material load increases and thus the risk of fire increases. Although the amount of forest area burned seems to have decreased in recent years, the number of fires has increased from an annual average of 2000 in the 1990s and 2000s to more than 2500 in the last 10 years. This is due to the increase in forest-human interaction rather than climate change. Red pine forests in the Aegean and Mediterranean regions particularly vulnerable to forest fires. However, in the Black Sea region, increases outside the fire season have also been noteworthy in recent years.

Another expected effect of temperature increases on forests is an increase in diseases and pests. This is because the increase in temperature changes the life cycles of insects and other pests, causing them to reproduce more. For the last 20 years, insect damage has been increasing in fir, spruce and red pine forests. Insect damage is called smokeless fire in forestry. The introduction of invasive alien species due to climate change or other reasons is also already affecting forests. For example, the deaths observed in boxwood forests in the Eastern Black Sea region in the last few years are estimated to be caused by the fungus *Cylindrocladium buxicola* and *Volutella buxi*, which are thought to have come from neighboring countries [88]. The seed-sucking beetle (*Leptoglassus occidentalis*), which is also an invasive alien species, has damaged pine cones and caused economic loss to villagers living from pine nut production. The beetle has also spread to forests of other conifer species such as larch and red pine. As this insect eats seeds, it has an impact on the natural rejuvenation of forests.

[88] Tolunay, D., Öztürk, S., Gürlevik, N., Karakaş, A., Akkaş, M. E., Adıgüzel, U., Taşdemir, C., Aytar, F. 2014. Health Status of Turkey's Forests (2008-2012). Ministry of Forestry and Water Affairs, General Directorate of Forestry, Department of Forest Pest Control, ISBN No: 978-605-4610-44-0p. 71

pose risks. Today, an annual average of 40 thousand ha of forest area is affected by biotic pests.
is affected[89].

Another effect of temperature increase is the prolongation of the growth period of trees. This is because, in general, tree species continue to grow when monthly average temperatures are above 10 ºC. Therefore, the vegetation period may start earlier in the spring and end later in the fall. In fact, if the monthly average temperatures do not fall below 10 ºC, growth will continue. However, the variability in temperatures may cause an increase in frost damage.

The increase in CO_2 concentration in the atmosphere with temperature increases could theoretically cause trees to grow more and produce more vegetative mass. Thus, it can be evaluated that climate change will have a positive effect on forests. However, this is only with rainfall or the presence of water stored in the soil. Since drought effect is predicted to be intense in our country, this positive effect, called CO_2 fertilizer effect, should not be expected. On the contrary, since plant respiration will increase with the increase in temperature, the organic matter produced by photosynthesis will be lost through respiration and growth may slow down. This could result in a reduction in the amount of carbon stored in forests, for example.

With the impact of climate change, it is likely that the competitive relationships of tree species will be disrupted and especially fast-growing species and species with high adaptive capacity dominant. Thus, the species composition of forests will also change.

Extreme weather events (storms, lightning, heavy snowfall, etc.) can cause forest collapses or fractures. Between 2015 and 2017, an annual average of 148 thousand ha of forest area was destroyed due to these so-called abiotic damages (TOD, 2019). Although it cannot be interpreted as an effect of climate change, in October 2011, trees in forests in Kırklareli and Edirne provinces were felled due to the snow that fell while the trees were still leafless and the storm that followed. It is possible that similar events may occur in the future with the prolongation of the vegetation period and cold waves.

Drought may have negative impacts on some narrowly distributed forest types such as floodplain forests. Floodplain forests generally develop on alluvial soils in areas where rivers flow into the sea, and are special forests because they are subject to high ground water and occasional flooding. These forests, such as the İğneada and Acarlar Floodplain forests, which are reported to cover 11,000 ha across the country, are expected to be affected by decreasing groundwater levels and reductions in river flows. A similar effect may also be observed for sweetgum forests, an endemic species.

On the other hand, special conditions may be required for the seeds of forest trees to germinate. Humidity is the most important of these. However, the seeds of some species such as Taurus cedar cold temperatures. In the absence of germination due to insufficient soil moisture or lack of cold, problems should be expected in the natural rejuvenation of forests.

If forests are damaged due to climate change impacts, their ecosystem services such as carbon storage, water production, erosion and flood prevention will be reduced.

Steppe, Grassland and Pasture Ecosystems

There are natural and anthropogenic steppes in our country. While natural steppes are mostly spread in Central Anatolia and Southeastern Anatolia, anthropogenic steppes are formed by the destruction of forests around natural steppes. The plains in Central Thrace are also of anthropogenic character. A significant portion of these steppe areas are used as pastures and rangelands and are therefore important for animal husbandry. Steppe and grassland ecosystems in Central Anatolia and Southeastern Anatolia

[89] TOD, 2019. Forestry of Turkey: 2019, ISBN: 978-975-93478-4-0, 164+20 pages, Ankara

The most important pending climate change impact is an increase in the risk of desertification as a result of droughts due to temperature increase and decrease in precipitation. Currently, summer droughts[90] are the most important factors limiting plant life in the steppes, and these droughts will intensify in the future. These impacts may also lead to a change in species composition, reducing the degree of soil cover of herbaceous species. Due to reduced vegetation cover and droughts, wind erosion and dust storms can be expected to intensify in these regions. The most important ecosystem service provided by steppe and grassland ecosystems is food production due to animal husbandry. Thus, negative impacts on grasslands and steppes due to climate change will also affect livestock. On the other hand, steppe ecosystems are very rich in terms of species diversity and endemic species, and this diversity will also be damaged by climate change. In fact, it is stated that about half of Turkey's endemic plant species are found in steppes (Vural, 2006). Steppes are rich not only in plant diversity but also in fauna diversity. For example, the Anatolian wild sheep (*Ovis gmelini anatolica*), an endemic mammal, the Hatay mountain gazelle (*Gazella gazella*), which is in the vulnerable (VU) category according to IUCN, and the gazelle species in Urfa (*Gazella subgutturosa*) are species specific to the steppes [91]. Another mammal, the gelengi (*Spermophilus xanthoprymnus*), which is considered to be an indicator species for steppes, lives in steppes and pastures[92]. The biodiversity of steppes, which are under intense pressure due to agriculture and other human activities, is also very sensitive to climate change.

Scrub, Scrubland and Other Shrublands

Maquis ecosystems are dense in the Aegean and Mediterranean regions. Around the Sea of Marmara, there are thickets with maquis elements, albeit quite destroyed. In the Black Sea coastal regions, vegetation called false maquis is found. There are also remnant maquis communities in the regions beyond the Black Sea [93]. There are no studies on the effects of climate change on maquis in our country. However, these ecosystems are already highly affected by fires. Therefore, it can be said that the most important climate change effect in the future will be fires. Most of the plant species found in maquis ecosystems are adapted to the hot and arid Mediterranean climate. It is necessary to investigate how these plant species will respond to more severe temperatures and droughts in the future. Maquis, which are rich in species diversity, provide very important ecosystem services. These habitat creation, soil conservation and erosion prevention. On the other hand, most of the maquis plant species can be collected and used for various purposes. They are also important ecosystems for beekeeping. Climate change can be expected to affect these ecosystem services.

Mountain Ecosystems

Mountain ecosystems vary from bottom to top depending on the region and include steppe/maci, forest subalpine and alpine shrublands, subalpine and alpine meadows, rocky terrain and glaciers in high mountains. As mentioned earlier, these belts are expected to shift towards higher elevations in the mountains. In other words, forests will cause the forest boundary, which is around 2000 m, to move upwards with the increase in temperature. Even if the expansion of forest areas is considered a positive effect, it will result in the shrinkage of subalpine and alpine meadows. These meadows, which are important for animal husbandry and transhumance in mountains that are not very high, may disappear over time. In our country, Mount Ararat, Kaçkars, Cilo Mountain, Munzur Mountains, Süphan Mountain, Erciyes Mountain

[90] Vural, M., Adıgüzel, N., 2006. Natural habitats of Turkey: Steppes. In: Eken G, Bozdoğan M, İsfendiyaroğlu S, Kılıç DT, Lise Y (eds) Important Natural Areas of Turkey. Doğa Derneği, Ankara, pp. 28-30.

91 Ambarlı, D., Zeydanlı, U.S., Balkız, Ö., et al., 2016. An overview of biodiversity and conservation status of steppes of the anatolian biogeographical region. Biodiversity and Conservation 25: 2491-2519.

[92] https://www.dogavesehirler.org/tum-sergiler/turkiye-nin-memeli-hayvanlari

93 Aksoy, N., 2006. Maki. In: Eken G, Bozdogan M, Isfendiyaroglu SDTLise Y (edsImportant Natural Areas of Turkey. Doğa Derneği, Ankara, pp. 40-42.

There are glaciers in the mountains[94]. These glaciers are currently melting and shrinking due to temperature increase[95]. The most important ecosystem service of land glaciers is water production. Especially in the Eastern Anatolia Region, water resources should be expected to shrink with the decrease in snowfall and melting of glaciers. In addition, in mountain ecosystems where snowfall is high, there may be an increase in avalanches.

Stream Ecosystems

Together with other inland waters, river ecosystems provide habitat for a large number of aquatic species are a source of water for other living things. They are also utilized by humans for drinking/utilization and agricultural purposes. The climate change effect that will affect river ecosystems the most is the increase in temperature and consequently the increase in evaporation. Today, flow regimes are changing, flow rates are decreasing, and even drying up completely in dry periods due to both temperature increase and the use of their waters and the construction of dams and ponds. The ecological characteristics of rivers where they are born and where they flow through plains and flow into lakes or seas. They are cold as they originate mostly in mountainous areas and warm up as they flow through plains. These temperature differences and changes in water quality parameters cause different aquatic organisms to be found in different parts of the same river. Therefore, the effects of temperature increase on the creatures in the rivers also different. While trout species are mostly found in cold waters, species such as carp and catfish live in warmer and oxygen-poor turbid parts. Species such as trout are more sensitive to temperature changes, while carp and catfish are more resilient. If water levels decrease due to temperature and evaporation, the water temperature will increase further. At the same time, the physicochemical properties of the water will change. Species sensitive to temperature and water quality changes are expected to be negatively affected by these changes. Fish mortality may occur if the amount of dissolved oxygen in the water decreases. In the event of complete drying of rivers, if there are no more small puddles of water called refugia, fish, amphibians such as salamanders and some frog species, and invertebrates such as dragonflies and damselflies die out completely or their numbers may decrease significantly. The drying up of rivers will also damage riparian (riperian) systems. Another impact of drying up rivers due to increased temperature and evaporation is the disruption of the migration of fish migrating to spawn. Water quality may deteriorate as eroded materials from heavy downpours and floods may reach streams. In deltas and estuaries, salinization problems may be encountered due to both the decrease in the amount of water carried by rivers and the rise in sea levels. Similarly, storm surges due to increased storms may cause seawater intrusion into estuaries.

Lake Ecosystems and Wetlands

Lake ecosystems are currently experiencing level decreases and drying out due to the increase in temperature and evaporation, and this effect is expected to intensify in the future. Especially shallow lakes and wetlands can be considered quite vulnerable in this respect. Even if lakes and wetlands do not dry up completely, aquatic life will be adversely affected as water parameters will change as explained in river ecosystems. It has also been reported that these effects will cause eutrophication and algal blooms in lakes [96]. On the other hand, wetlands are important habitats for birds. If these dry up, birds be forced to migrate to other wetlands. In addition, lakes and wetlands

[94] Sarıkaya, M.A., Tekeli, A.E., 2014. Satellite inventory of glaciers in Turkey. In: Global land ice measurements from space (Kargel, J.S., Leonard, G.J., Bishp, M.P., Kääb, A., Raup, B.H. (Eds). 465-480. Springer Verlag, Berlin. [95] Sarıkaya, M.A., 2012. Recession of the ice cap on mount Ararat, Turkey, from 1976 to 2011 and its climatic significance. Journal of Asian Earth Science 46:190-194.

[96] Kuzkaya,E., 2015. Modeling impacts of eutrophication and climate change in Lake Eymir using clake model. Middle East Technical University Graduate School Of Natural And Applied Sciences, Thesis of Master of Science.

If these ecosystems dry up completely, the reeds around these ecosystems will also be damaged. There may even be reed fires.

Both rivers, lakes and wetlands provide ecosystem services such as drinking and potable water supply and fisheries. Even reeds can be a source of livelihood for rural people. However, the most important ecosystem service provided by these ecosystems, although not well known, water purification, also known as waste treatment. Because a significant portion of wastewater in our country and in the world is discharged into aquatic ecosystems, including the seas. Again, the few peatlands and wetlands in Yeniçağa and some other provinces in our country are important carbon sinks. Depending on climate change, these products and services they provide will also be disrupted. There is even a possibility that they will become a source of emissions.

Coasts

The main ecosystems of the coasts are dunes, dykes, estuaries, river mouths, deltas and estuaries. There are also marine influenced coastal cliffs. The most important expected climate change impact on coasts is rising sea levels. Even flat dunes and large parts of beaches without much elevation may be inundated. However, sea level rise is expected to have the greatest impact on lagoons. These lagoons include Yumurtalık, Akyatan, Köyceğiz Lake and Dalyan, Enez Dalyan Lake. There is also the possibility of salinization of the Kızılırmak, Yeşilırmak, Meriç River and Gediz River deltas as a result of rising sea levels and a decrease in the river flows of salt water. Sea swells caused by increasing storms on the coasts will also increase the risk. Another expected impact on coasts is coastal erosion. The rise in sea levels may also harm species that live and nest in the dunes on the coasts. Finally, climate change may also affect the tourism activities provided by the coasts.

Marine Ecosystems

Seawater temperatures and marine acidification are predicted to be effective in marine ecosystems. In addition, it is evaluated that the introduction of invasive alien species has increased even today, some of which, especially in the Mediterranean, due to the effect of climate change, and that the introduction of invasive alien species may continue in the future. It is stated that the distribution of many benthic and pelagic marine species will be narrowed, migrations will be forced, reproduction problems may occur due to the warming of sea waters, and especially species that prefer cold waters are more sensitive [97]. In addition, it is stated that it will change the physicochemical properties of the seas (less dissolved $_{O2}$), sex ratios, diseases, physiology of algae and plankton composition[98]. There may also be changes in the relationships between species (prey-predator). Increasing the acidity of seawater has different effects depending on the species, but species that use calcium carbonate in their skeletons and shells (crustaceans, coral reefs, benthic molluscs, etc.) have relatively higher fragility. The skeletal and shell forms of these species are damaged and their growth may stop [50].

It is inevitable that marine, coastal, river and terrestrial ecosystems affected by climate change will also affect other neighboring ecosystems. For example, soils carried from terrestrial ecosystems into rivers by heavy downpours first reach river mouths, from where they spread inland and then settle on the seabed. These sediments seagrass meadows, fish nests and eggs to be covered with mud. Prolonged sediment transport degrades water quality and can clog fish gills. As evaporation increases with increasing seawater temperatures, water vapor in the atmosphere also increases.

[97] Kayhan, F.E, Kaymak, G., Tartar, Ş., Akbulut Ş., Esmer, H.E., Yön Ertuğ, N.D., 2015. Global warming on fish and effects on marine ecosystems. Erciyes University Journal of Institute of Science and Technology, 31(3):128-134.

[98] Katar, H.H., Kızılgök, A.B., 2018. Effects of global warming on fisheries. Third Sector Social Economy,2018,53 (3) :1102-1125.

will increase. This lead to heavy downpours in the Mediterranean and Black Sea regions where mountains run parallel to the coast. Warming differences between land and sea will also have an impact on the intensity and direction of winds [99].

Climate change will disrupt the services provided by marine ecosystemsespecially fisheries, waste processingtourism and habitat creation.

Determinants of Biodiversity and Adaptive Capacity of Ecosystems

Some socio-political and ecological issues that may affect the adaptive capacity of biodiversity and ecosystems elements **Error! Reference source not found.**7

Table 17: Socio-political and ecological determinants of biodiversity and adaptive capacity of ecosystems

Socio-political	Ecological
- Existence of basic underlying data - Land use policies - Research and development - Inter-institutional cooperation and coordination - Awareness - Levels of participation and decision-making processes quality - Education and income level - Technological infrastructure (TV, internet, cell phone) - In cost-benefit analyses, ecosystems are also to be taken into account - Effective nature protection laws - Presence of NGOs - Financial resources - Diversification of economic activities - Gender equality - Public perception of risk and exposure - Diversification of economic activities - Presence of early warning systems - Generating data for monitoring - Local income/poverty data	- Knowledge of ecosystem destruction - Dependence on ecosystem services - Pollution prevention efforts - Ecological knowledge and awareness - Existence of good practice examples - Size of protected areas - Local ecological knowledge assets - Genetic diversity - Species diversity - Habitat/ecosystem diversity - Ecological characteristics of species (breeding time, fecundity, etc.) - Behavior change (e.g., prey switching) and learning - Habitat/ecosystem integrity and extent - Migration capacity - Rate and magnitude of habitat degradation - Habitat/ecosystem connectivity

Cross-cutting issues with other priority sectors

Biodiversity and ecosystems are closely related to all of the sectors identified as priority sectors that will be affected by climate change in our country. For example, some of these sectors (agriculture, animal husbandry, fisheries, water resources and tourism) are direct ecosystem services. Therefore, if ecosystems are affected by climate change, these sectors, which are important for the national economy, will also be negatively affected. Other sectors (disaster risk reduction, cities, industry, energy, transport-communications and public health) are vulnerable to the impacts of extreme weather events (floods, floods, droughts, fires, etc.) that can be exacerbated by damage to ecosystems from climate change or other factors. They are also vulnerable to

[99] Doğan, O.H., 2018. Investigation of the sensitivity of heavy rainfall to Black Sea sea surface temperature by generating ensemble simulations for Artvin/Hopa flood. Istanbul Technical University of Science and Technology Meteorological Engineering Department Atmospheric Sciences Program

The vulnerability of the biodiversity and ecosystems sector will increase if adaptation and mitigation measures in these sectors are insufficient and especially if investments in these sectors are made without taking ecosystems into account. For these reasons, the biodiversity and ecosystem services sector should be considered as a cross-cutting issue for all other priority sectors.

2.3.2. Scope of Vulnerability and Risk Analysis

Studies planned to be carried out within the scope of Vulnerability and Risk Analysis:

- Prioritize climate change hazards, exposure, sensitivity factors and adaptive capacity elements and create impact chains,
- Identify susceptible and vulnerable groups
- Identify measurable, verifiable and reportable indicators for climate change hazards, exposure, sensitivity factors and adaptive capacity elements, examine the data quality of the identified indicators and collect data,
- Creating simulations, models, approaches for future situations of climate change hazards,
- with horizontal cutting sectors,
- Investigate the possibilities of mapping baseline, simulation and indicators related to climate change hazards, exposure, sensitivity factors and adaptive capacity (for spatial representation),
- Identify areas where risks are concentrated.

2.3.3. Key Stakeholders

The stakeholders who will be responsible for the effectiveness of the adaptation measures developed to mitigate the impacts of climate change on the sectors determining the possible impacts of climate change on the sectors with the indicator groups established for monitoring and evaluation of adaptation to climate change are stated below.

Key Public Institutions:

- General Directorate of Nature Conservation and National Parks
- General Directorate for the Protection of Natural Assets
- General Directorate of Forestry
- General Directorate of Fisheries and Aquaculture
- General Directorate for Combating Desertification and Erosion
- General Directorate of Spatial Planning
- General Directorate of Water Management
- General Directorate of State Hydraulic Works
- General Directorate of Infrastructure and Urban Transformation Services
- General Directorate of Environmental Impact Assessment, Permitting and Inspection
- Central Hunting Commission
- National Wetland Commission
- General Directorate of Crop Production
- Turkish Water Institute
- General Directorate of Agricultural Reform
- General Directorate of Agricultural Research and Policies
- General Directorate of Meteorology
- General Directorate of Energy Affairs
- General Directorate of Renewable Energy
- General Directorate of Mining and Petroleum Affairs
- General Directorate of Mineral Research and Exploration
- Agricultural Research Directorates

- Directorates of Fisheries Research Institute
- Forestry Research Institute Directorates

Civil Society Organizations:
- WWF Turkey
- TEMA
- Nature Conservation Center
- Nature Association
- Turkish Marine Research Foundation
- Turkish Foresters Association
- Turkish Soil Science Association
- Water Research Association
- Marine Clean Association (Turmepa)
- Landscape Research Association
- Rural Environment and Forestry Problems Research Association
- Climate Action Network-Turkey
- Wheat Association
- ÇEKÜL
- TMMOB and affiliated chambers
- ORKOOP
- Fishing cooperatives
- Agricultural cooperatives
- Trade Unions
- Chambers of Agriculture
- Irrigation unions

Universities
- HIGHER EDUCATION
- Faculties of Agriculture
- Faculties of Forestry
- Faculties of Fisheries
- Faculties of Aquatic Sciences
- Veterinary Medicine
- Biology Departments
- Geography Departments
- City and Regional Planning Departments
- Landscape Architecture Departments
- Research and Application Centers

Public and municipalities to cooperate with
- Chief of General Staff
- General Directorate of Security
- Coast Guard Command
- General Directorate of Lifelong Learning
- Municipalities

2.3.4. Sectoral Indicators

Failure to prioritize the identification of indicators based on whether they are available or not; danger, focus on indicators to accurately measure exposure, sensitivity and adaptive capacity need to be identified. After identifying potential indicators in this way, it should be examined whether there are data that can measure the indicators identified, and if not, whether such data can be produced. Indicators created using existing data should be evaluated in terms of data coverage, quality and suitability for the purpose. For example, the forest area data produced by OGM shows forest areas according to the legal definition and does not reflect the actual forest areas. In other words, areas that have been burned or on which mining, energy or other facilities have been built are also shown as forests. A similar situation applies to the agricultural and pasture areas given by TurkStat. In addition, the data on agricultural, forest and pasture areas provided by OGM and TurkStat do not reflect spatial and temporal changes. However, indicators are expected to reflect these changes as well. For these reasonsit is considered that CORINE data is more useful for monitoring the state of ecosystems in Turkey and should be used.

Indicators that have emerged due to the negative impacts of climate change on biodiversity and ecosystem services and that can be used in vulnerability and risk analysis are given below.

Indicator of hazard and physical impact: Heat waves, drought, heavy rainfall, floods and overflows, number of frosty days, number of stormy days, number of storm disasters, number of forest fires, temperature anomaly, rainfall anomaly, sea water temperatures and sea level indicators.

Exposure indicator: CORINE Land cover changes indicator, aquaculture production, biodiversity indicator, changes in fish numbers and species indicator, forest fragmentation indicator, non-wood forest products indicator, forest ecosystem monitoring indicator

Sensitivity indicator: Number of species indicator based on endemism and conservation status, invasive alien species indicator, mid-winter waterfowl number indicator, area at risk of drought indicator, forest ecosystem monitoring indicator, population potentially affected by forest fire risk indicator, area of forest fires indicator, places where forest fires occur indicator, recreation areas indicator, agricultural irrigation water indicator, threatened habitats indicator, lake depth indicator, pollution indicator in rivers and lakes indicator, desertification risk indicator, soil erosion risk indicator

Adaptive capacity indicator: Indicator of forested area, indicator of forest area under erosion control, indicator protected areas, indicator of support to forest villagers,
indicators for wildlife protection activities, indicator for combating forest pests and diseases, indicator for forest area under rehabilitation, indicators that can be used in risk analyses related to biodiversity and ecosystem services

2.4. Public Health

2.4.1. Assessment of the Impacts of Climate Change on Public

Health is generally considered as a social sector. The main reason for this is that health is defined as a state of complete physical, mental and social well-being [100]. From a public health perspective, the health sector is considered in two aspects in terms of being affected by the results of other sectoral activities and/or the pressure these effects create on society. From an economic point of view, the health sector is a sector with high expenditures and returns in terms of social capital and is evaluated differently in financial dimensions. In climate discussions, the health sector is a sector that needs to addressed in a special way. If other sectors are weak and damaged in the face of climate change, the health sector will be the most burdened. It will even be locked and will not be able to provide adequate service. This situation, which is defined as "health burden", refers to years of life lost prematurely, years of poor quality and dependent life. For service continuity, the health sector should be included in the policies of other sectors as a separate item and should receive a share from budget items.

Published on 27 January 2015, the Ministry of Health's "National Program and Action Plan for Mitigating the Adverse Effects of Climate Change on Health" represents the beginning of national policies on the impacts of climate change on the health sector in Turkey[(101)].

It is seen that the impacts of climate change on the health sector in Turkey impose a great burden on the social determinants of health (economic stability, education, social and community structure, health and health services, neighborhoods and built environments) in terms of people, society and systems, and that the current situation, changes before and after COVID-19, and projections for the future are not different from the global framework. In general terms, the findings in the health special report prepared by WHO for COP24 and the Health and Climate Change Research Report are valid [(102103)]. Accordingly, while the health sector progresses in mitigation efforts for climate change only within the scope of reducing emissions of sectoral structures, green buildings, etc.[104105], there is little orientation towards climate-resilient health systems and the realization of climate-oriented health facilities. In the design of economic and financial policies for climate change, it is seen that no main sections on the assessment of health impacts are included in mitigation and adaptation measures. There is a need to update data systems that will help to reveal the impacts of climate change in the health sector. Current disease coding systems (ICD-10/11) do not meet the needs. Studies on the awareness of those who enter data, collect data, conduct research, academics, diagnose, and those in charge of protection, prevention and monitoring on the health impacts of climate change are limited. The importance of early warning and rapid response mechanisms to protect health from the impacts of climate change

[100] WHO (2020). Basic documents: forty-ninth edition (including amendments adopted up to 31 May 2019). Geneva: ~~World Health Organization. License: C~~C BY-NC-SA 3.0 IGO.

[101] National and Action Plan for Mitigating the Adverse Effects of Climate Change on HealthMinistry Publication No: 998, ISBN: 978-975-590-602-7, 1st Edition, Anıl Matbbacılık Ltd., Ankara 2015, https://hsgm.saglik.gov.tr/depo/birimler/cevre-sagligi/2-ced/iklim-degisikligi/Iklim_Degisikligi_Eylem_Plani.pdf [102] COP24 Special Report: Health&Climate Change, https://www.who.int/globalchange/publications/COP24- report-health-climate-change/en/, available in Turkish at https://www.skb.gov.tr/saglik-iklim-degisikligi-cop24-ozel- report-s35975k/

[103] WHO country survey: Tracking progress on Health and Climate Change, https://www.who.int/globalchange/resources/2017_2018-WHO-health-and-climate-change-country-survey-28may2018_final.pdf?ua=1, accessed on 12.02.2021

[104] Terekli G., Özkan O., Bayın G., Environmentally Friendly Hospitals: From Hospital to Green Hospital, Ankara Health Services
Journal, 2013; 12(2): 37-54

[105] Kılıç C.H., Güdük Ö., Green Hospital Concept and a Hospital on the Expectations of End Users in Turkey Example, GOSBD 2018; 7(1): 164-174

Although it is known, there are urgent calls for it to become a part of normal life [106107108]. Although climate and health are included as two different goals (3 and 13) in the sustainable development goals to be achieved by 2030, the remaining 15 goals guide the fine line between death and healthy, quality, long life [11]. It is necessary to ensure systematic follow-up of the data and evidence obtained on climate change mitigation and adaptationintegrate them with sustainable development goals and to use all this information for the protection of health.

Health Sector in National Documents on Climate Change in Turkey

In the National Climate Change Strategy (2010-2020and Climate Change Action Plan (2011-2023) published by the Ministry of Environment and Urbanization, it is aimed to investigate the effects of extreme weather events on human health and to investigate the interaction between infectious diseases and health risks ([109110]). There capacity building targets such as strengthening the infrastructure in risky areas and strengthening the capacities of health institutions. In the health section of Turkey's Climate Change Adaptation Strategy and Action Plan (2011-2023), published by the same Ministry, two priority targets were set([111]):

- Current and future impacts and risks of climate change on human
  Determination of
- Improving the capacity of the national health system to combat climate change-related risks

The health section of the 2019 "Seventh National Communication of Turkey" includes the impact of extreme climate events, current situation assessments on diseases transmitted by vectors and rodents, and the content of the national health impact report [112].

In Turkey, there is a national strategy and plan on the impacts of climate change on the health sector. In the baseline section, the results of a national survey on health impacts are of evidential value for the relationship between climate and health. *Studies are planned in cooperation with the Ministry of Health, WHO and the Union of Healthy Cities of Turkey to address the impacts of climate change on human health*. In Turkey, assessments on the impacts of climate change on the health sector are being addressed by the Ministry of Environment and Urbanization in intersectoral cooperation. In 2020, the Turkish Academy of Sciences published a report [113].

Turkey does not have a "National Health and Climate Change ProfileThe WHO Profile framework includes whether health is addressed as a priority sector in national climate change strategies and whether there are national health and climate change strategies and action plans, their commitment, monitoring and evaluation, early warning, financing, integration with other plans and sectors integration and international relations

[106] Evci Kiraz E.D. (2019), Climate Change Education Modules Series-14, The effects of climate change on human health. Ankara: IKLIM-IN Project Publication

[107] Lancet Countdown, About Us, https://www.lancetcountdown.org/about-us/, accessed 02.02.2021

[108] Sustainable Development Goals, https://sdgs.un.org/goals, accessed on 18.03.2021

[109] https://www.trakyaka.org.tr/upload/Node/33132/xfiles/Turkiye_Iklim_Degisikligi_Stratejisi_2010-2020_.pdf, accessed on 18.03.2021

([110])https://webdosya.csb.gov.tr/db/iklim/editordosya/file/eylem%20planlari/Iklim%20Degisikligi%20Eylem%20Plani_TR.pdf, 18.03.2021

[111] https://webdosya.csb.gov.tr/db/iklim/editordosya/uyum_stratejisi_eylem_plani_TR.pdf, date of access 18.03.2021

[112] Preparation of Turkey's 7th National Communication and 3rd Biennial Report Project publicationMinistry of Environment and Urbanization,
2018, Ankara, https://iklim.csb.gov.tr/ulusal-bildirimler-i-307, accessed 24.02.2021

[113] Eker H.H. et ., Ed.Şeker M. et al. (2020), Climate Change and Public Report in Turkey ,Turkey Academy of Sciences, Ankara

[114]. The 2015 MoH strategy and action plan largely addresses current and future climate risks for the climate-related events questioned in the profile (reflected in the targets: heat and cold waves, floods, wildfires, drought, air quality; storms are partially addressed, while sand/dust storms are not). According to a 2013 climate risk study, health is addressed as one of the risk categories in private sector adaptation to climate change[115].

For Turkey, the importance of field research for vulnerability and risk analysis is emerging. Collecting live data, epidemiological analyses, geographic information systems and other multidisciplinary analyses will be able to reveal the current situation, cumulative impact assessment and future projections.

Health Impacts of Climate Change

According to WHO projections, in about a decade's time, more deaths are expected to occur as a result of the expected hazards of climate change than the expected number of deaths per year. These "excess" deaths

38% due to malnutrition, 24% due to malaria, 19.2% due to diarrhea and 15.2% due to heat stress. The demographic profile and public health profile altered by the COVID-19 pandemic may face the dangers of climate change differently.

Since there are different regions in Turkey according to geography, climate and demography, there is no single health effect of climate change or priority of one of the health effects[4]. In international publications, studies conducted until 2021 addressed the relationship between extreme heat and/or heat waves and mortality[116][117]. As of 2021, there has been a rapid increase in international scientific study reviews addressing the relationship between climate change and health[118]. In Turkey, the most recent publications are the book "The Effects of Climate Change on Human " prepared within the scope of the "Supporting Joint Efforts in the Field of Climate Change Project funded by the European Union in 2019 and whose beneficiary institution is the Ministry of Environment and Urbanization, and the "Report on Climate Change and Public Health in Turkey" published by the Turkish Academy of Sciences in 2020. In addition to these two publications, the health impacts of climate change in Turkey were assessed through Turkey's 7th National Communication and the National Program and Action Plan for Mitigating the Adverse Effects of Climate Change on Health.

For guidance in vulnerability and risk analysis, the health hazards and impacts of climate change are classified under general headings in Table 18. Evidence on Turkey, which may be an example of these headings, has been reviewed in the four national documents mentioned above and in the sources of these documents.

[114] WHO country survey: Tracking progress on Health and Climate Change, https://www.who.int/globalchange/resources/2017_2018-WHO-health-and-climate-change-country-survey-28may2018_final.pdf?ua=1, accessed on 12.02.2021

[115] Baglee et al, Climate Risk Case Study, Pilot Climate Change Adaptation Market Study: Turkey" 2013, https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/climate+business/resources/publication_adaptationmarketstudy_turkey, accessed 03.02.2021

[116] Álvarez-Miño L, Taboada-Montoya R. Efectos del cambio climático en la Salud Pública, 2015-2020. Una revisión sistemática [Effects of climate change on Public Health 2015-2020. A systematic review.]. Rev Esp Salud Publica. 2021 Mar 17;95:e202103042. Spanish. PMID: 33729215 (English abtract is available).

[117] Can G. et.al., Excess Mortality in Istanbul during Extreme Heat Waves between 2013 and 2017, Int. J. Environ. Res. Public Health 2019, 16, 4348; doi:10.3390/ijerph16224348

[118] https://pubmed.ncbi.nlm.nih.gov/?term=climate+and+health&filter=years.1996-2021, accessed date:18.03.2021

Table 18: Health impacts of climate changeProf.E.Didem Evci Kiraz2021

Health Hazards	Health Effects
Heat/cold waves	Heat and cold related diseases
Sea level rise	Food and Water related diseases
Changes in water resources	Changing infectious disease agents
Increased ultraviolet radiation	Vector-borne diseases
Unusual weather patterns	Side effects of ultraviolet radiation
	Injury, loss of function and disability
	Spiritual Problems
	Re-emerging and new diseases

Heat and Cold Related Diseases

By the end of the 21st century, Turkey is projected to be the third country in Eastern Europe, the Balkans, Eurasia and the Turkic States to be most affected by extreme weather conditions. [119] [120]

Although there have been some studies on the relationship between heat waves and health in Turkey [121, 122, (123)], there is no representative evidence for Turkey on the relationship between hospital admissions due to extreme heat and mortality[15] and insufficient data on cold-related diseases.

Food and Water Related Diseases

Drought-induced water scarcity can cause the following health-related knock-on effects.

- pollution of small water sources, canals, lakes, dams, etc.
- salinization of agricultural land
- diminishing clean water resources
- reduction/differentiation in nutrients
- nutritional deficiency
- the movement of people towards food and water sources
- rapid population growth
- impoverishment
- infrastructure problems
- food and waterborne diseases
- diarrheal and other infectious diseases
- respiratory diseases caused by sandstorms
- for all these reasons, problems in health service delivery
- spread/outbreaks
- increased mortality rates

In 2012, when the results of daily Acute Intestinal Infections (ABI) surveillance covering 81 provinces were evaluated according to months, it was observed most frequently in July, August and September and least frequently in February.

[119] Baettig, M. B., M. Wild, and D. M. Imboden (2007), A climate change index: Where climate change may be most prominent in the 21st century, Geophys. Res. Lett., 34, L01705, doi:10.1029/2006GL028159.
[120] Eker H.H. et ., Ed.Şeker M. et al. (2020), Climate Change and Public Report in Turkey ,Turkey Academy of Sciences, Ankara
[121] Oktay C, Luk JH, Allegra JR, Kusoglu L. The effect of temperature on illness severity in emergency department congestive heart failure patients. Ann Acad Med Singap. 2009 Dec;38(12):1081-4. PMID: 20052444.
[122] Metintas S, Kurt E; PARFAIT Study Group. Geo-climate effects on asthma and allergic diseases in adults in Turkey: results of PARFAIT study. Int J Environ Health Res. 2010 Jun;20(3):189-99. doi: 10.1080/09603120903456828. PMID: 20191419.
[123] Meterology and Health, General Directorate of Meteorology, https://www.mgm.gov.tr/genel/saglik.aspx?s=123, accessed date: 19.03.2021

In August, the number of cases increased by 100% and one in every 19 people had ABE during the year.

Vector-borne Diseases

With climate change, the pattern of disease will change. Classic endemic disease bands will move northwards (**Error! Reference source not found.**25). The main reason for the movement is the change in the location, shape and resistance of the vectors that transmit diseases to humans and animals in parallel with ecological and biodiversity changes.

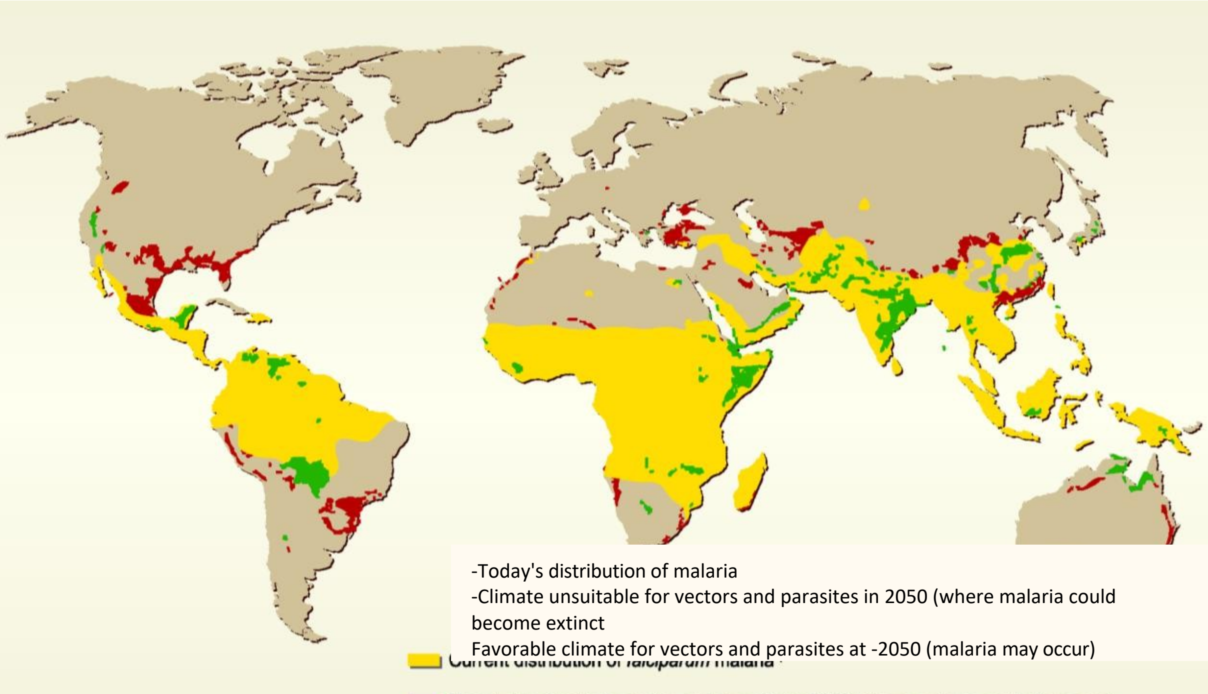


Figure 25: Climate change and malaria2050 scenario

Of the 1441 cases diagnosed with tularemia (a disease characterized by high fever and lymphadenopathy that is transmitted to humans by consuming water and food contaminated with rodent urine and other excretions) between 1936 and 2011 in Turkey, 866 (60%) cases occurred in the last 10 years, and the majority were detected in the southeast of the Marmara Region and the northern parts of the Central Anatolia Region, where a temperature increase trend was observed([124]). The increase in tularemia cases in Turkey has been attributed to contaminated drinking water[125]. While it was prevalent in the Marmara and Western Black Sea regions in 2005, new cases were reported in 2009-2010, especially in Central Anatolia and the Black Sea regions.

In Turkey, the number of malaria cases has significantly decreased in the last 10 years [126]. According to official records, 8742 people became ill and 409 people lost their lives due to Crimean Congo Hemorrhagic Fever between 2008-2017. Çorum, Kastamonu, Tokat, Yozgat, Yozgat, Karabük, Samsun and Sivas are the provinces where the disease is most . More than 80% of the cases in Turkey have been reported from Central and Northern Anatolia regions.

[124] Gürcan, Ş. (2014). Epidemiology of Tularemia, Balkan Med J, 31:3-10.
[125] TSHGM (2011) General Directorate of Primary Health Care Services Field Guide for the Control of Tularemia Disease, February 2011.
[126] Turkey 7th National Communication

Side Effects of Ultraviolet Radiation

It is known that there are case studies, experimental studies and community-based studies of the relevant clinical branches in terms of skin cancers and eye effects, but there is no monitoring and warning system at the national, regional, local, city, neighborhood, individual level of the sun's ultraviolet radiation level. There is no representative evidence for Turkey regarding the change in ultraviolet radiation in relation to climate change, health effects and the change in these effects.

The thesis titled "Early Warning Model for Weather Variables in Primary Prevention (Researcher: Dr. Burcu Diliüz Doğan, Supervisor: Prof. Dr. E. Didem Evci Kiraz)" is a climate and health study that draws attention to this field[127]. In the study, it was observed that in cases where the threshold values of the ultraviolet index monitored in a city exceeded the threshold values, alerting the society via digital media such as sms, e-mail, etc. created awareness in the participants and positively affected their attitudes and behaviors. Based on the results obtained, a local early warning system proposal was created.

Injury, Loss of Function and Disability

According to the international disaster database (EM-DAT), 1350 people lost their lives and nearly 2 million people were affected by floods between 1970 and 2014 [128]. The causes of deaths in the floods that occurred in Turkey between 1995 and 2004, in which at least 10 people died, were identified as drowning, injury and hypothermia.

Spiritual Problems

In a study conducted in Bartın province, the seasonality of depression was examined, and while 33 cases were seen in the summer and fall months in 2009, 24 cases of depression were seen in the spring and fall months in 2010.

In 2019, a study conducted with high school students and teachers in Şanlıurfa province investigated the effect of air temperature on teaching and learning. It was found that the most favorable study time for students and teachers was "sunny weather in winter". In the summer months, 80.7% of students thought that dusty weather negatively affected their desire to study, while 95.05% of teachers thought that hot weather negatively affected their desire to teach.

Re-emerging and New Diseases

There were no studies representing Turkey that examined the relationship between climate change and climate change and presented at the level of evidence.

2.4.2. Scope of Vulnerability and Risk Analysis

The studies on the relationship between climate change and the health problems experienced in Turkey in the previous section need to be further deepened. These areas, also mentioned in the previous section, are as follows.

- Heat and Cold Related Diseases
- Food and Water Related Diseases

[127] Diliüz Doğan & Evci Kiraz, 2016, https://tezarsivi.com/birincil-korunmada-hava-degiskenlerine-yonelik-erken-warning-model
[128] https://www.emdat.be/

- Changing Infectious Disease Agents
- Vector-borne Diseases
- Side Effects of Ultraviolet Radiation
- Injury, Loss of Function and Disability
- Spiritual Problems
- Re-emerging and New Diseases

2.4.3. Key Stakeholders

The Ministry of Health is a key stakeholder. The Ministry of Health's General Directorate of Public Health, Department of Environmental Health, Department of Early Warning and Response to Health Threats, and the Istanbul Office, which opened in September 2020 to operate in the field of "Preparedness for Humanitarian and Health Emergencies under the agreement between the Republic of Turkey and WHO, should be the triggering administrative structures for harmonization efforts.

Other key stakeholders; Ministry of Environment and Urbanization, Ministry of Family, Labor and Social Services, Ministry of Energy and Natural Resources, Ministry of Foreign Affairs (Directorate for EU Affairs), Ministry of Agriculture and Forestry, General Directorate of Meteorology, Ministry of National Education, Disaster and Emergency Management Authority (AFAD), TurkStat, RTÜK, local governments, municipalities, governorships, regional development agencies, chambers of commerce, industry, stock exchanges, universities, national/international organizations, disease-specialty associations, non-governmental organizations, media outlets, private sector, private hospitals, university hospitals, institutes and research centers.

2.4.4. Sectoral Indicators

Considering health hazards and eight health impacts of climate change, the most important indicator is population density. The group that has a low health sensitivity index and may be moderately affected is the group aged 65 and over [129]. In the vulnerability and risk assessment of the health sector, the proportion of the population aged 65 and over and dependency rates should be addressed.

The Index of Climate Risk (IRE) indicates the level of exposure and vulnerability to extreme events([130]). It is a warning for countries to be prepared to face more frequent and/or more severe events in the future. For IRE calculation, deaths per 100,000 inhabitants, purchasing parity and gross domestic product should be known. For Turkey, it is 115.17.

For **hazard** analysis for the health sector; heat waves, frosty days, consecutive dry days, drought risk, number of days with heavy rainfall can be used.

Population can be used as an **exposure** indicator and environmental impacts as a **sensitivity** indicator (road density, number of registered vehicles, air pollution), access to resources and services (waste, proportion of population served by wastewater, proportion of population using safe drinking water services, access to sewerage and municipal water), demographic factors (dependent population, proportion of female population aged 15-49, fertility rate, crude birth rate, proportion of children under 5, net migration rate), health status (infant mortality rate, life expectancy at birth, disability rate, crude death rate).

Socioeconomic factors (socioeconomic, financial development, GDP, unemployment rate, municipal environmental expenditures), health services capacity (number of people per physician, number of hospital beds per 10000 people, population per ASM, 112

[129] Yuksel, U. D. (2014). Analyzing vulnerability and resilience of Turkey to climate change. Scientific Research and Essays, 9(11), 503 - 515.
[130] Global Climate Risk Index 2021, https://germanwatch.org/sites/germanwatch.org/files/Global%20Climate%20Risk%20Index%202021_1.pdf

population per station), social capacity (number of people per social worker), educational capacity (proportion of college or faculty graduates), environmental impacts (proportion of natural areas), management capacity (presence of climate change projects, network membership, mayor commitments). These were selected because, as seen in the assessments in the previous sections, open, usable and continuous data sources are limited.

Infant mortality rate and maternal mortality rate are the main health indicators that can be used to compare one country with another in terms of public health. Regions that provide a healthy and high quality life for the mothers and babies who make up the future are defined as having a high level of health. Infant mortality rate for 2019 is 9.2 per 1000 live births and maternal mortality rate for 2019 is 13.1 per 100,000 live births [131,132]. Turkey's average is 11.3 per 1000 live births according to 2018 data. To monitor mortality due to childhood malnutrition, children under five years of age should be considered.

The following indicators should be included in the vulnerability and risk analysis of the health sector:

- Manpower on the effects of climate change on human health (trained health personnel, trained/specialized manpower in the field of surveillance, epidemiology, geographic information systems, sensors)
- Standardized data collection tools, systems and sharing platforms
- Climate/health literacy
- Technology adaptation, integration
- Social networks
- Technological infrastructure in the field of surveillance, epidemiology, geographic information systems, sensors
- Continuous, uninterrupted energy supply
- Continuous and increasing budget support
- Organizations that produce and share data and evidence
- The academic community the health impacts of climate change
- Rapid response and early warning systems that provide data and play a role in prevention and protection (localized (city) and location (neighborhood, dwelling, household))
- Models that best manage the health impacts of climate change
- Scenarios of interventions that enable the community to get back on its feet as as possible after the incident and return to a healthy, safe and quality life
- Structure of health organizations climate health risks
- Diseases seen and/or increasing in Turkey as a result of climate change
- Extreme weather events and the resulting natural disasters (floods, fires, etc.) can have a negative impact on human health.
  the impact of
- The link between climate changeinfectious diseases and health risks
- The relationship between climate change and water and foodborne diseases
- Vulnerable groups, their level of vulnerability to climate change and preparedness
- Impact of emergency response action plans in high-risk areas
- Awareness, education and behavioral patterns of relevant disciplines and sectors about the negative impacts of climate change on health
- Continuity of vulnerability and risk analysis, visualization, transfer to information platforms

[131] Health Statistics Yearbook 2018Ministry of Health, https://www.saglik.gov.tr/TR,2018-yayinlanlanmistir.html
[132] Health Statistics Yearbook 2019 News BulletinHealth, 73329/saglik- istatistikleri-yilligi-2019-haber-bulteni-yayimlanmistir.html

2.5. Urban Planning/Infrastructure

2.5.1. Assessing the Impacts of Climate Change on Urban Planning and Infrastructure

From the years of the industrial revolution to the present day, the continuous and rapid urbanization process has led an increase in greenhouse gas concentrations. Today, this process, which is accepted as one of the main reasons for global average temperature increases and changes in precipitation patterns, is expected to continue in the coming years. More than 54% of the world's population now resides in cities and more than 90% of the global economy is derived from cities. On the other hand, more than 65% of the world's energy is consumed in cities and 70% of global greenhouse gases are emitted from cities. In this regard, it is stated that cities have a share of 40-70% in UN-Habitat's production-based calculations and 60-70% in consumption-based calculations [133] (UN-Habitat, 2011: p.IV). Cities create negative impacts on the climate not only with the amount of greenhouse gases released into the atmosphere as a result of the activities carried out on them, but also with the increase in the rate of covered surfaces (impermeable surfaces). These rates are projected to increase even more when the global urban population is estimated to reach 6.5 billion in 2050. In the environments formed as a result of urban sprawl, the surface heat balance is disrupted and the urban heat island effect is created. Due to their socio-economic and environmental conditions, cities are the places that feel the effects of climate change the most and suffer the most [134]. In parallel with population growth, the need for urban infrastructure will inevitably grow. Subsequently, cities and their inhabitants; water, energy, sewerage, transportation, communication and service infrastructures will be directly affected by climate change. Land use changes, increasing impervious surfaces and decreasing green areas will determine the level of impact. Climatic hazards such as heat stress, extreme precipitation, flooding, landslides, air pollution, drought, water scarcity, sea level rise, storms and hail different impacts on the emerging urban structure. Therefore, the characteristics of cities play an important role in climate change vulnerability analysis and determination of adaptation measures [135].

In the IPCC 1.5 °C Special Report, cities are considered as places at high risk due to climate change-induced extreme heat events, variability in rainfall and sea level rise. The report predicts that a global average temperature increase of 1.5 °C will double the number of cities that will be exposed to high heat stress and that 350 million people will be affected by heat waves in 2050. Another important issue emphasized in the report is that more than 90 percent of the coasts face a sea level rise of more than 0.2 meters when a 2 °C warming occurs. According to the 2 °C increase scenario, a two-meter sea level rise is expected on the coasts by 2300.

Considering that 90% of our country's population lives in cities, the importance of risk and loss amounts increases. Both population increases and the urban land needed by this population will undoubtedly expose the population and urban areas to higher levels of risk in the face of climate change. At the same time, serious losses occur in green infrastructure, which is an important adaptation tool against climate change in the urban areas of our country. As built environments increase and the amount of land that can act as a buffer, such as ecosystems and food production areas, decreases, the ability of our cities to adapt and cope will decrease. Studies have shown that climate change will lead to hazards in our cities such as temperature increase, heat waves, floods, water scarcity, drought and sea level rise.

[133] UN-Habitat (2011). "Cities and Climate Change: Policy Directions". Global Report on Human Settlements 2011, London, Washington, DC: Earthscan

[134] Kaya, Y., (2018). "Urban Vulnerability Climate Change: An Evaluation for Istanbul". International Journal of Social Inquiry, Volume 11, Issue 2, pp.219-257

[135] Krellenberg, K., Turhan, E. (2017). How to respond to climate change at the local level? Cities of Turkey A Guide for

[136]. Although the severity, impact and nature of these hazards vary across cities, the consequences are vital.

The current state of cities and the way in which the activities carried out in them function both produce different patterns of energy use, increase the amount of greenhouse gases emitted into the atmosphere depending on the amount of fossil fuels used during energy production, and determine the level of vulnerability to the consequences of climate change. Many sub-issues such as cities' green infrastructure, built environment (main-form, neighborhood textures, street/street patterns, building typologies), economic-social structure (production activities, income groups, age groups) and technical infrastructure (transportation, transmission, sewerage, water infrastructures) positive and negative contributions to this process. In the face of emerging climate change and hazards, serious impacts arise on each sub-topic, and the vulnerability of cities to these processes should be addressed through each sub-topic.

The Mediterranean basin is considered to be one of the regions in the world that will feel the effects of climate change the most. The fact that our country, which continues its industrialization process and has a development problem, is located in the Mediterranean basin shows that it is highly vulnerable to climate change. Studies conducted by the IPCC indicate that the general temperature increase in the Mediterranean Basin will reach 1 to 2 °C and this increase will cause drought, heat waves and an increase in the number of extremely hot days. According to the pessimistic scenario for Turkey, the average annual temperature is expected to increase by 4.5 to 6°C towards the end of the century, reaching 6°C in the Southeastern Anatolia and Eastern Anatolia regions, and 4.5-5°C in other regions. In 2013, data on this situation was shared in the report submitted to the United Nations Framework Convention on Climate Change Secretariat as the Fifth National Communication Report. The impacts of climate change in our country were analyzed and modeling studies were conducted. In this context, information on warming and cooling trends, precipitation changes and seasonal temperature changes were expressed geographically in the report. Turkey's meteorological data between 1950 and 2010 were analyzed and it was stated that warming trends are generally in the Mediterranean Region, while cooling trends are in the Black Sea Region and in the interior and western regions. It was emphasized that spring average air temperatures showed an increasing trend throughout the country, and that the Mediterranean precipitation regime was dominant in winter and spring precipitation totals. The most noteworthy issue regarding precipitation is that there is a significant decreasing trend in precipitation (aridification) in the Marmara, Aegean, Mediterranean and Southeastern Anatolia regions and in the inner and southern parts of the Central and Eastern Anatolia Regions. Likewise, it is stated that the tendency of aridification continues in the winter season, especially in the western, southern and continental inner-southern regions. It has been predicted that the cities of our country will be significantly affected by the negative effects of climate change, especially the decrease in water resources, forest fires, drought and desertification, and related ecological degradation [137].

The cities of our country, which are located in four different climate zones (continental, Mediterranean, Marmara and Black Sea), face different challenges according to the zones they are located in and their own internal characteristics. For example, the city of Rize, located in the Black Sea climate zone, faces climate change in terms of increased rainfall and urban flooding, while the city of Mardin, located in the continental climate zone, faces problems such as increasing temperatures and drought. Warming trends are naturally observed in large cities where urbanization is rapid and widespread. Istanbul and its surroundings stand out as the places where the urban heat island effect is the strongest. Developing climate change vulnerability and adaptation capacity for the cities of our country

[136] Balaban, O. (2012). "Climate Change and Cities: A Review on The Impacts and Policy Responses". METU JFA, 29(1), 22-44.

[137] Tuğan, K. (2014). Climate Change and Cities, https://www.mta.gov.tr/v3.0/sayfalar/hizmetler/kutuphane/ekonomi-bultenleri/2014_18/b18_35-42.pdf

future planning needs to address the situation of different urban components in the face of different climatic hazards.

TableThe adversities that will arise with climate change will undoubtedly have devastating effects on cities. In the context of the emerging dangers, we see that there are serious increases in our country and that they have very serious effects on our cities. As a result of the expected increase of 4.5 to 6°C in average temperatures in our country in the long term and the expected decrease of up to 25% in total precipitation, some additional negative effects will be observed in cities. These impacts be manifested in the form of rising sea levels, storms, heavy rainfall and floods, landslides, drought, forest fires, heat waves, increased thirst and water scarcity due climate change. In addition, there may be risks such as damage to urban water resources and water infrastructure, to urban infrastructure, extreme cold, hurricanes and endangerment of public health [138-139]. Today, many of our cities are experiencing heavy rainfall, drought, hailstorms, storms and similar weather events that were not common in the past. The effects of these hazards and risks may vary depending on the characteristics of the cities. Complex and extensive transportation networks, economic activities, infrastructure density, green areas, informal settlements and poor groups living in these areas are factors that determine the unique conditions of cities.

The most important developments that are thought to harm urban life in Turkey are radical increases and decreases in the number of hot or cold days, droughts and heat waves [140]. These developments are expected to have impacts on different components of cities such as buildings, transportation, energy, ecosystem, water resources, health, agriculture and tourism. In addition, floods are also expected to become more frequent. It is recognized that heat waves and floods will pose more risks to urban quality of life, comfort and health in the future.

On the other hand, changes in sea level, which is one of the threats to be exposed to due to climate change, is thought to threaten our coastal cities and infrastructures. While the 20th century saw a global sea level rise of about 19 cm, model studies for the 21st century predict that this rise will be around 26 to 82 cm. When the studies conducted in Turkey on this subject are examined, it is found that the measurements made between 1972 and 2009 show an annual increase of 0.16 cm on the Mediterranean and Aegean coasts. In addition, in the calculations made, the vulnerability of the coastal cities of our country to the 1m sea level rise scenario was calculated to be low. In the 10m rise scenario, the Kızılırmak, Yeşilırmak, Gediz, Büyük Menderes, Seyhan and Ceyhan deltas are under serious threat[141]. In Turkey, the cities with high vulnerability in terms of this risk are Kocaeli and Çanakkale, while those with moderate vulnerability are Antalya, Samsun and İzmir, and those with low vulnerability are Mersin, Yalova, Ordu, İstanbul, Giresun, Tekirdağ, Zonguldak, Rize, Sinop and Trabzon([142]).

There is no doubt that the increased risks and climatic hazards associated with climate change have severe impacts on the built environment and ecosystem services, including infrastructure systems (water and energy supply, sanitation and sewerage, transport and telecommunications), services (including health care and emergency servicesand superstructure. In , climate change have serious socio-economic impacts. Population mobility is one of them, and climate change is expected to increase by 200 million to 1.1 million people by 2050.

[138] İPA(2017). Climate resilient citieshttp://www.ipa.gov.tr/assets/uploads/files/climate_change_261217.pdf
[139] Çobanyılmaz, P., Yüksel, Ü.D. (2013). Determination of the Vulnerability of Cities to Climate Change: Ankara Case, Journal of Süleyman Demirel University Graduate School of Natural and Applied Sciences
[140] Krellenberg, K., Turhan, E. (2017). How to respond to climate change at the local level? A Guide for Turkish Cities
[141] Şen, Ö.L., (2013). A Holistic View of Climate Change and Its Impacts in Turkey, IPM
[142] Kahraman, E.D., Aydın, B., (2016). Determination of Morphologically Fragility Levels of Coastal Cities Against the Threat of Sea Level Rise, TÜCAUM International Geography Symposium

billion people are to migrate. In the case of our countryit can be stated that the drought in Syria between 2006 and is related to climate change and that this drought is also an important multiplier in the refugee crisis in the region. The population migrating due to drought also increases problems such as infrastructure, health, water and employment in the areas where they settle.

Another issue that needs to be addressed is the pressures that climate change puts on food security. Climate change is expected to affect all processes of food from farm to table and increase food prices. These developments will certainly have negative social and economic consequences in cities. While there will be problems of access to food for urban dwellers, food processing, packaging and storage processes will be affected due to temperature increases [143].

The hazards that expected climate change-induced climate events will create in urban areas can be very diversified (Table 19). The severity of impacts and damage will also vary in relation to the characteristics of cities.

Table 19: Expected Climate Events Due to Climate Change and Their Impacts on Cities[144]

Climate event	Probability of Realization	Expected impacts in urban areas
***Warmer and cold days and nights *Warmer and numerous hot days and nights**	Very high probability	*Reduced energy demand for heating *Increase in energy demand for cooling purposes *Decline in air quality *Reduced transportation interruptions due to snow and icing *Impacts on winter tourism
More frequent heat waves	Very high probability	*Reduced quality of life for people without access to air conditioning *On the elderly, infants, children and the poor negative effects
Heavy rains are more frequent to be seen	Very high probability	*Negative impacts on settlements, trade, transportation and society affected by *Intense pressure on urban infrastructure *Increase in property loss
Increase in the amount of area affected by drought	Possible	*Water scarcity for households, industry and the service sector *Decline in hydropower generation capacity *Potential for mass migration
Severe storms are becoming more frequent to be seen	Possible	*Damage due to strong winds *Damage to water supply infrastructure *Potential for mass migration *Insurance companies not insuring risky areas
Sea level rise	Possible	*Flooding in coastal areas *Freshwater resources are endangered due to sea water to enter *Potential for mass migration

The expected impacts on cities may vary in relation to the economic, social and physical characteristics of the cities and some strategic issues mentioned in the table for each city come to the forefront. These issues are decisive in the adaptation actions of our cities to climate change. Elements of the infrastructure and superstructure of cities have different characteristics in the impacts of climate change.

[143] Bahçeci, D. (2019). Community-Based Change in Urban Areas: The City as a Method Bahçeleri, MA thesis, Istanbul Uni.
[144] Peker, E., Aydın, İ,C(2019). Cities in a Changing Climate: Mitigation and Adaptation Policies for Local Governments, IPM-Mercator policy note

Therefore, these are the two main topics that need to be addressed. The characteristics of this dual structure are decisive in the vulnerability of cities. For example, in the superstructure, the density of buildings and roads, the amount and distribution of green areas, the way in which blue infrastructure is utilized and settlements in risky areas constitute these characteristics, while the capacity and technological level offered in the infrastructure are decisive. As seen in Figure ***2626***, with respect to superstructure, energy production sites, urban built environment and urban form, building layouts, green areas, health infrastructure and transportation system are affected by climate change at various levels. In infrastructurewater infrastructure, energy transmission infrastructure, transportation and communication infrastructures are the prominent topics.

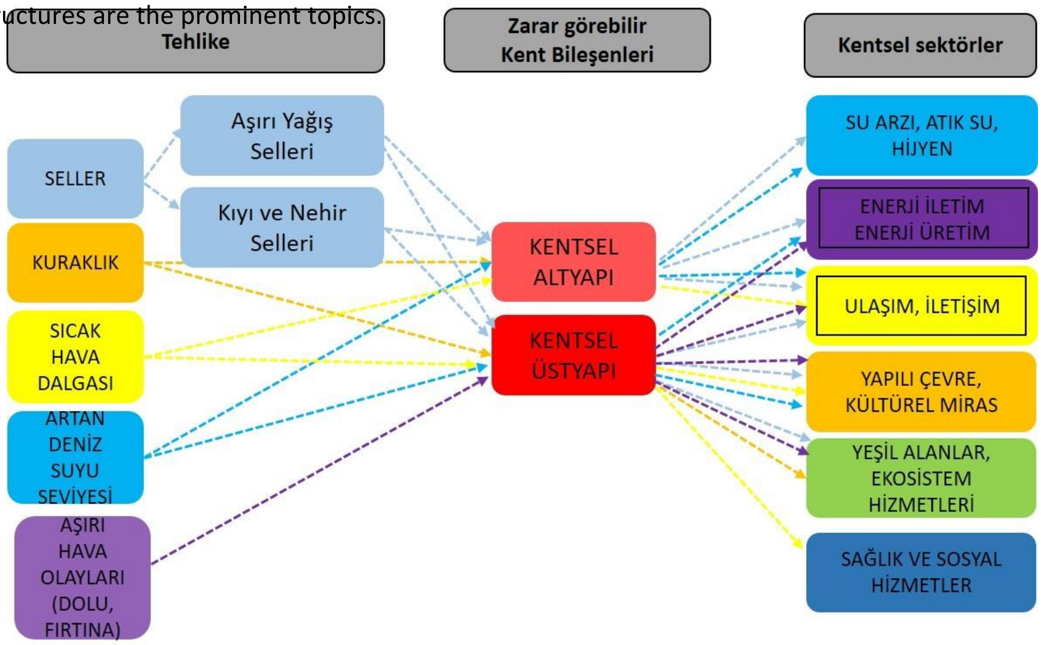


Figure 26: Urban Components in Vulnerability to Climate Change

The most comprehensive issue related to superstructure is urban form. Urban form affects the degree of utilization of local climatic conditions (prevailing wind direction, solar radiation), urban transportation network and infrastructure networks. For example, a sprawling and fringed urban form increases transportation distances within the city, to an increase in energy consumption and carbon emissions. In addition to the form of the city, building layouts reflecting neighborhood patterns also reveal the energy consumption pattern. For example, the use of contiguous or separate building layouts in cities with cold or hot climates creates different effects. They determine the amount of energy consumed for heating and cooling. The fringing urban forms and split-layout multi-storey building blocks that we have observed in our country's cities in recent years support vehicle-dependent lifestyles and increase vulnerability. Another important element of the built environment related to vulnerability is the density of buildings and population living in those parts of the city. Dense urban areas are likely to be affected by climatic hazards. Another factor related to the built environment is the building materials used. At the building scale, the choice of materials that will increase the surface reflectivity of the building, the materials used in roofs and facades a major contribution to the heat generation in urban areas in a positive or negative way. Building-based applications such as breathing facades, green facades and green roofs, which are prominent in the world, are solutions that reduce the amount of energy to be consumed, increase the amount of green space and reduce vulnerability. However, not every solution will be suitable everywhere and local conditions should be taken into consideration.

should be known. For example, it will be very difficult to ensure the sustainability of green covers in the hot and arid climate conditions prevailing in our cities in the South-Eastern Anatolia Region [145].

The transportation system, which includes elements of both urban infrastructure and superstructure, is another urban topic with high vulnerability to climate change. Urban transportation networks, which are motorized vehicle-oriented and encourage long-distance journeys, increase carbon emissions on the one hand, and are damaged by climate hazards such as floods, droughts and heat waves on the other. In addition to material damages such as deterioration, collapse and disruption of transportation infrastructure, the economic losses of transportation sector employees reach serious dimensions and negative social consequences arise. Infrastructures of our cities related to transportation such as airports, highway lines, railway lines and ports are affected by different climate hazards at different levels. Risks that may be experienced in the form of sea level rise will cause significant losses in our cities (such as Mersin, Samsun, Trabzon, Kocaeli, İzmir) whose economies depend on ports and related activities. Transportation infrastructures that will need to be constantly renewed in the face of climate hazards will also impose a serious economic burden on our cities. Increases in the areas allocated for the highway network due to the widespread and automobile-oriented urban development model will increase negative impacts. More compact urban forms that combine land use decisions and mass transportation forms will have an important role in reducing these negative impacts. Setting and implementing climate-sensitive standards in the construction of transportation infrastructures are practices that will reduce vulnerability [146-147-148-149-150].

The amount, layout and design of blue and green infrastructure in urban areas is another determining factor in the level of vulnerability. Green spaces in cities provide cooling through shading and enhanced evapotranspiration and a mitigating effect on the heat island effect experienced in many cities. However, current urban development trends in our country green areas to be generally fragmented, creating small green areas between buildings and roads. This process negatively affects the ability of tree, plant and animal species in green areas to disperse or move. Connections between ecological corridors, urban woodlands, gardens and other green spaces are recognized as a way to limit the negative effects of fragmentation. The vulnerability of urban green spaces to climate change is high in situations of water scarcity and drought. The scarcity of green spaces also increases the urban heat island effect and threatens quality of life. Regarding blue infrastructure, the method followed in Turkish cities is to close urban stream lines and build transportation systems on them. This situation causes the heat wave and heat island effect, which are among the dangers caused by climate change, to intensify in urban areas. In the face of this situation, rehabilitation and regulation of stream lines in urban areas gain importance as adaptation actions. In addition, climate change affects water resources in terms of both water quality and water quantity. In many cities, the water-related impacts of climate change are the result of exposure to extreme drought or excessive rainfall.

145 Peker, E., Aydın, İ,C(2019). Cities in a Changing Climate: Mitigation and Adaptation Policies for Local Governments, IPM-Mercator policy brief

146 Çolakoğlu, E., 2019, Climate ChangeSustainable Cities and Urban Planning InteractionClimate Change Training Modules Series 11

147 Moretti, L., Loprencipe, G., 2018, Climate Change and Transport Infrastructures: State of the Art, Sustainability, Vol:10

148 UN, 2020, Climate Change Impacts and Adaptation for Transport Networks and Nodes

149 DOT Center for Climate Change and Environmental Forecasting, 2002, The Potential Impacts of Climate Change on Transportation, Federal Research Partnership Workshop, Summary and Discussion Papers

150 Christodoulou A., Demirel H., 2018, Impacts of climate change on transport, A focus on airports, seaports and inland waterways, EUR 28896 EN, Publications Office of the European Union, Luxembourg, doi:10.2760/378464, JRC108865.

in urban areas. In the face of these impacts, there is a need for different water management strategies in urban areas for groundwater, artificial or natural reservoirs [151-152].

Urban infrastructure for health and social services is important factor that determines the level of vulnerability of cities with high vulnerability to climate change. The risks posed by climate change on urban areas may cause health problems on a social scale. Studies indicate that public health may be jeopardized and health infrastructures may be caught unprepared in terms of capacity due to changes in infectious disease types, water and food insecurity, extreme climate events such as heat waves and sudden heavy rainfall, and decreasing air quality [153-154-155-156-157]. On the other hand, in the face of this situation, children, the elderly and the sick living in the city will determine the vulnerability of our cities as groups that may be primarily affected by extreme climate events. Another dimension of this social impact is related to health workers. Climate change and related risks will put intense on those working in the health sector. Therefore, it is possible to construct adaptation strategies in the health sector in two categories. These will be those that need to be implemented under changing climate conditions and those that need to be implemented after climate-related disasters. While designing strategies, it is necessary to determine the vulnerability of cities in terms of health infrastructure and to realize technical and social infrastructure investments for areas that need to be strengthened. Vulnerability in terms of health varies depending on local characteristics.

When the expected impacts of climate change on the cities of our country are summarized, the picture that emerges is as follows:

- Increase in floods and inundation of infrastructure (tunnels, subways, underpasses, etc.) and residential areas,
- Increase in the need for cooling and indirectly electricity consumption due to the increase in temperature and the frequency of heat waves,
- Increased incidence of hailstorms, thunderstorms and tornadoes and associated damage to infrastructure such as power lines, vehicles and houses,
- Coastal erosion and to infrastructure due to rising sea levels in coastal cities,
- Drought-induced depletion of water resources and difficulty in accessing clean drinking and potable water,
  reduction in hydroelectric power generation
- Deterioration of air quality,
- Increasing health problems,
- Risk to food security and rising food prices,
- Increase in fires in forest areas around the city,
- Drying out of wetlands due to increased evaporation and water use,
- Migration of flora and fauna to more suitable habitats,
- in climate migration (from within or outside the country),

151 Brown, K., Mijic, A., 2019, Integrating green and blue spaces into our cities: Making it happen, Grantham Institute Briefing paper No 30, Imperial College London

152 Hu, L., Li, Q., 2020, Greenspace, Bluespace, And Their Interactive Influence On Urban Thermal Environments, Environmental Research Letter

153 Kiraz, E., D., 2019, Effects of climate change on human healthİklimin Climate Change Training Modules Series 14

154 Ministry of Health Public Health General Directorate, EIA Unit, 2020, Climate Change and Health, https://hsgm.saglik.gov.tr/tr/cevresagligi-ced/ced-birimi/iklim-de%C4%9Fi%C5%9Fikli%C4%9Fi.html

155 Çelik, S., Bacanlı, H., Görgeç, H., 2008, Global Climate Change and Its Effects on Human Health, MGM, Telecommunication Branch Directorate

156 Eker, E., Kantarlı, S., 2020, The Effects of Climate Change on HealthVoice of NatureIssue:5

157 Union of Healthy Cities of Turkey, 2005, Health and Climate ChangeCOP24 SPECIAL REPORT

- Economic losses in some sectors such as Urban, Coastal and Winter Tourism [158].

The vulnerability of a city to climate change is defined as the relationship between the degree to which it is affected or vulnerable to climate change stress, the level of meeting or responding to this stress (sensitivity) and the level of adaptation to climate changes (adaptive capacity). In the interaction between cities and climate change, the vulnerability and risks of cities and urban peripheral systems should be determined first.

2.5.2. Scope of Vulnerability and Risk Analysis

The rapid urbanization process in our country is a factor that determines exposure and vulnerability to climate hazards. As accepted all over the world, rapid and unplanned urbanization processes increase vulnerability to climatic hazards. For example, increasing population densities both increase the population exposed to hazards and disrupt the functionality of the urban infrastructure system with the additional burdens they bring to the infrastructure. The factors observed in Turkish cities that increase vulnerability can be categorized under eight different headings: The form of the city and its interdependence between its different parts; low capacity in infrastructures such as transportation, energy and water; high population and building density in certain regions; wrong location choices; socio-spatial segregation; environmental degradation; lack of institutional coordination and cooperation; and the existence of multiple institutions with authority over the city and its urban components. The current state of all these factors and the changes they will undergo are determinative in terms of the vulnerability of our cities to climate change and their adaptation actions against the change as enhancers, mitigators and facilitators.

The vulnerability of cities has different consequences on different urban systems in relation to different climate hazards. Therefore, the vulnerability of urban infrastructure and superstructure systems to different climate hazards such as heavy rainfall events, droughts, high temperatures, sea water level increases and poor air quality should be addressed separately. The negative impacts of changing climate conditions on people living in cities, buildings, transportation systems (roads, airports, railways, ports, metro lines), public services, infrastructure networks such as sewers, industrial facilities and commercial activities will create economic disruption, social and ecological damages.

Urban systems can actually be considered in three layers (physical structure, infrastructure, urban functions), but within the scope of this project, they will be reduced to two categories that can measure the impacts of different climatic hazards and will be considered as infrastructure and superstructure. The superstructure category covers both the activities in the urban area (different functions) and the economic and social relations that exist with these functions. The framework of vulnerability and risk analysis of cities in the face of climate change is determined according to the context in the IPCC, AR5 report. In this framework, hazard, exposure and vulnerability indicators (sensitivity and adaptive capacity) will be identified and analyzed for risk analyses. In this process, assessing the vulnerability of urban components for each climate hazard is the appropriate way to determine adaptation actions.

In order to analyze the interaction between climatic hazards and urban components through indicators within the AR5 framework, it is necessary to make a separate assessment for each hazard. In this context, floods are an important hazard that increases in frequency and severity due to climate change and urban areas. In international studies, floods are as coastal and river floods, rainfall floods and groundwater-induced floods. It is important to determine the vulnerability of urban systems to each flood risk. Sea level rise will create coastal flooding, destroying coastal areas traditionally favored by people for work, recreation and living space, and making it difficult to sustain these activities, in economic and social losses. For floods due to precipitation

[158] Tolunay, D. (2018). The Impact of Climate Change on Cities and Adaptation Studies on Climate Change in Cities, International City and Health Congress

The built environment in cities is the main determinant. Impervious surfaces are naturally abundant in urban areas and limit the surfaces that allow water to meet the soil. Apart from surface materials, the quality and capacity of stormwater drainage systems related to rainfall determine the impact and exposure to hazards. Therefore, the proportion of paved surfaces in cities, morphological structure (building layouts including heights), soil structure and slope status and drainage systems will be indicators of vulnerability. Although floods resulting from changes in groundwater levels are not a serious threat to cities in the case of our country, they are a danger that may arise due to climate change. Groundwater moving to regions with lower slopes can rise to the surface in these regions, causing floods and creating negative consequences if there is urban settlement and life in these regions. Another threat to urban systems is drought. Drought, which has impacts on the built environment and urban green areas, has negative effects on drinking water supply, water supply for industry and water supply for green areas. Drought, which causes decreases in groundwater levels, also causes subsidence on the land surface and results in road collapses and building slides in urban areas. Likewise, as drought reduces precipitation in urban areas, it will lead to an increase in airborne particles and a decrease in air quality. Heat waves pose a threat in urban areas as another hazard category [159]. IPCC reports indicate that heat waves will become more frequent and more severe by 2050. In order to determine the vulnerability of our cities in the face of this hazard, which has negative consequences on human health, especially for vulnerable groups (the elderly, children, those with chronic diseases), indicators regarding population and income groups and their distribution in urban areas must be determined and analyzed.

2.5.3. Key Stakeholders

In Turkey, there are stakeholders who can take part in and contribute to the process of determining the vulnerability of cities to climate change and strengthening adaptation actions to be carried out in cities. These stakeholders can be categorized under three main groups: public, private sector and civil society organizations. However, when stakeholders are considered in terms of their different roles, they can be categorized in a broader grouping. Public institutions, private sector, international organizations, civil society, academia and media are important actors (Figure ***2727***). However, the most important issue is the extent to which the parties can interact and work together in this process of multilateral climate change vulnerability analysis and identification of adaptation actions for cities. For this project, it is of great importance who the stakeholders gathered in the main groups are in relation to climate change and what their roles and positions might be.

[159] Stone, K., Duinen, R.V., Veerbeek, W., Dopp, S., (2011). Sensitivity and vulnerability of urban systems, Assessment of climate change impact to urban systems, Deltares

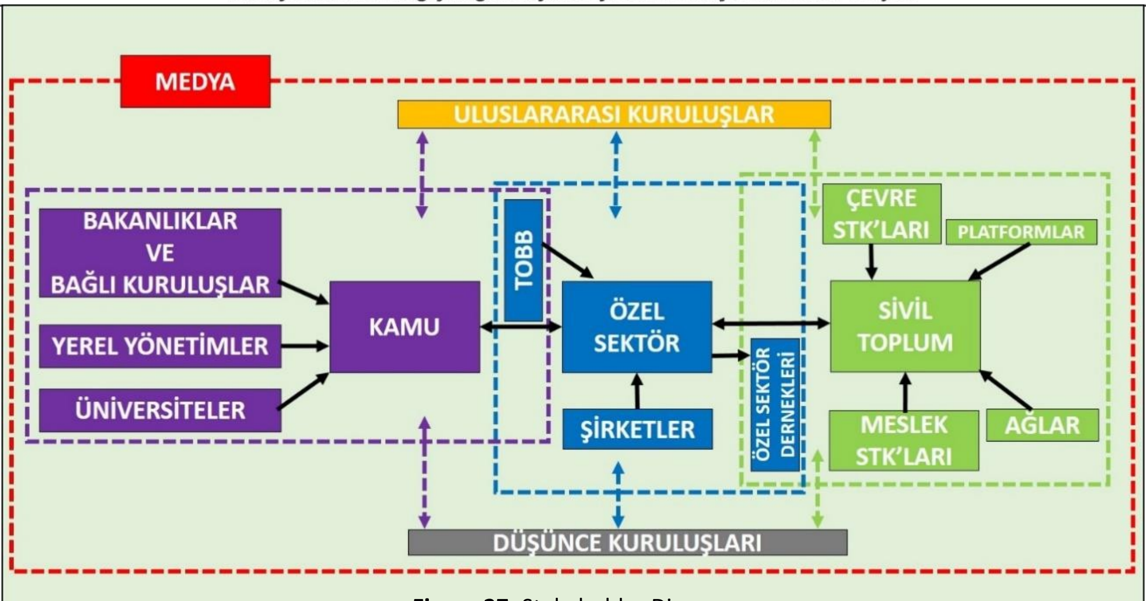


Figure 27: Stakeholder Diagram

When the stakeholder lists within the identified clusters are detailed, it is thought that municipalities, regional directorates of central institutions, local-national-international associations, individual experts and companies serving in different sectors can play an active role in the face of climate change in relation to cities. In addition to these groups, professional chambers and international organizations can also participate in the process as mentioned below.

Central Government and Provincial Organizations, Public Institutions

- Presidency
- Ministry of Environment and Urbanization
- Ministry of Foreign Affairs
- Ministry of Energy and Natural Resources
- Ministry of Interior
- Ministry of Culture and Tourism
- Ministry of National Education
- Ministry of Industry and Technology
- Ministry of Agriculture and Forestry
- Ministry of Transportation and Infrastructure, Regional Directorates
- TCDD Regional Directorates
- Regional Directorates of Highways
- Local Governments, Unions
- Development Agencies

Private Sector

- Electricity and natural gas distribution companies
- FigureRES, SPP Companies
- Industrial organizations
- Tourism sector
- Transportation sector
- Construction sector

Associations and Professional Chambers

- TUSIADMUSSAID
- Professional chambers affiliated to TMMOB
- WWF Turkey World Wildlife Fund
- Nature Conservation Center
- Nature Research Association
- TEMA Foundation
- Global Balance Association
- Energy and Climate Change Foundation
- Economic Policy Research Foundation of Turkey (TEPAV)
- Entrepreneur Women Association
- Turkish Women's Union
- Consumer Rights Association
- Green Thought Association
- Association for Local MonitoringResearch and Practices
- Regional Environmental Center - REC Turkey
- Habitat Association
- Turkey Environment Platform
- Turkish Nature Conservation Society
- Nature Association
- TÜRÇEK (Turkish Environmental Protection and Greening Agency

International Organizations

- Delegation of the European Union to Turkey
- United Nations Educational, Scientific and Cultural Organization National Commission for Turkey (UNESCO)
- United Nations Development Program (UNDP)
- World Health Organization Representative Office in Turkey (WHO)
- World Resource Institute Turkey Office (WRI Turkey)
- World Bank Turkey Office (WB)
- French Development Agency (AFD)
- German Society for International Cooperation (GIZ)
- Japan International Cooperation Agency (JICA)

Along with all these stakeholders, research centers, different faculties and Urban Regional Planning Departments of universities and experts in transportation planning can be among the important stakeholders.

For climate change adaptation actions, it is important to consider which activities the identified stakeholders can contribute to and what their roles can be. Different stakeholders can contribute at different levels in awareness raising, risk assessment, adaptation of urban infrastructure and superstructure components, data provision and data generation.

2.5.4. Sectoral Indicators

In the process of determining the vulnerability of cities to climate change, indicators of hazard, exposure, sensitivity and adaptive capacity are decisive. These indicators, which can be handled separately for urban infrastructure and superstructure components, are related to social and economic structure in addition to physical and environmental structure.

related indicators can also be grouped as related indicators. In line with AR5, the fifth report of the IPCC, risk assessments can be made by identifying hazard, exposure, sensitivity and adaptation indicators. While information on extreme temperatures, droughts, stormy days and floods can be listed as prominent **hazard indicators**, we can refer to the population, economic activities and settlements at risk of floods and other hazards as **exposure indicators**. **Vulnerability indicators** include income inequality, vulnerable groups (children and the elderly), disruptions due to extreme weather events and damage to infrastructure. Indicators to consider in relation to **adaptive capacity** are the existence of management plans focusing on different issues such as drought, water and flooding, data on reinforced infrastructures and services provided in relation to different issues such as health, drinking water and transportation.

In addition to the prominent indicators mentioned here, there are data and sensitivity indicators that can be obtained through separate local studies. These are: urban sprawl rate; size and percentage of urban transformation area; loss of agricultural land due to urbanization; loss of forest area around the city; population density and rate of change; building density distribution; number of vehicles in urban area; road density-surface amount; percentage of population living more than 500 meters from bus/metro stops; size of industrial areas and percentage in urban area; amount of public space and percentage in urban area; Percentage of population within 500 meters of primary education areas; Percentage of population living closer than 1km to the city center; Percentage of population living further than 3km from the city center; Percentage of population within 500 meters of commercial areas; Average building block size; Percentage of building blocks smaller than 1 hectare; Average parcel size of residential areas; Day and night surface temperature map of urban area; Slope condition; and Distance to seaside or river lines.

2.6. Energy

To date, research and studies on vulnerability to climate change and its potential impacts have the energy sector or system less comprehensively than many climate-sensitive natural systems and economic sectors such as ecosystems, agriculture, water resources, health and tourism. However, most of the climate impact assessments in the energy sector have focused on energy demand. However, the impact of climate change on the energy sector can mostly be seen on the input resources of renewable energy systems such as changes in hydroelectric water level, wind speed, insolation and cloudiness. Infrastructure for the extraction, transportation and storage of fossil-based exhaustible energy resources, as well as for the distribution and transmission of electricity, are relatively less affected by gradual changes in climate characteristics. The current and future impacts of extreme weather events can be more severe, and reducing vulnerability to them can be much more costly and threaten energy security. In line with the scope of the project, the vulnerability of climate change on the fossil and renewable energy supply sources in the Turkish energy system and the infrastructures used for their extraction, production and transportation, as well as on the electricity demand of the final consumer are discussed in the sub-section respectively.

2.6.1. Assessment of the Impacts of Climate Change on the Energy Sector

In order to assess the impacts of climate change on Turkey's energy , it should be taken into account that energy is a vital input both for its own production and, todegrees, for the production of other sectors. To see this clearly, it is enough to look at the Input-Output Table, which shows the interrelationships between sectors in an economy. The figure shows the energy input requirements of all economic sectors in percentage terms using the latest Input-Output Table published by TurkStat (base year 2012). It is clear from the figure that, except for the energy sector itself [(160),] between 1% and 25% of other sectors are used as inputs in the production of all goods and services. For this input to be continuous, the need for an energy system that is resilient to extreme weather events can be clearly seen.

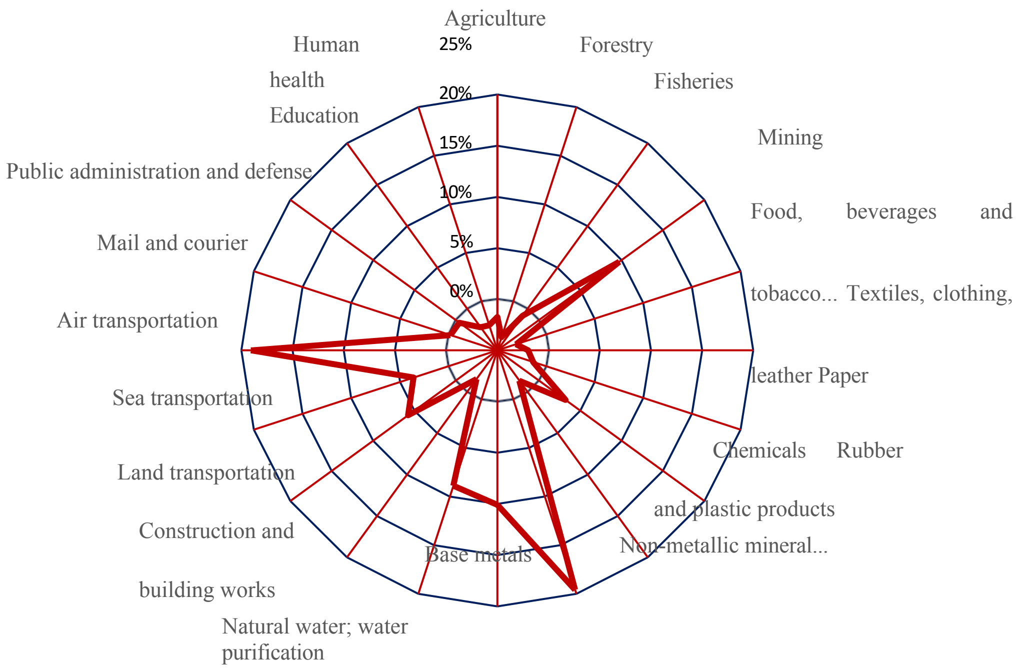


Figure 28: Percentages of energy input requirements of sectors of the Turkish economy

In the last decade, on average 70% of Turkey's greenhouse gas emissions have come from the combustion of fossil fuels, and nearly half of this from thermal power plants used in the energy industry used in the production of electricity

[160] Electricity generation, distribution and transmission use energy inputs at a rate of 75 percent, while the refinery sector, which produces petroleum products, uses energy inputs at a rate of 72 percent.

The energy sector is a responsible sector for the emission of greenhouse gases. Therefore, it can be said that the energy sector is one of the leading sectors affected by the consequences of climate change, as it is responsible for the emission of greenhouse gases. Considering the temperature data of the last half century, there is an increasing trend in daily average and minimum temperatures in the Mediterranean and Middle East region, where Turkey is located. This temperature increase points to the problem of drought in the future. Drought and reduced snow cover may reduce the volume of renewable surface water in rivers and reservoirs. Low rainfall and high water use can deplete groundwater in dry, subtropical regions. In arid regions, climate change could increase the frequency and severity of droughts.

The interrelationships between the energy, water and food sectors are as shown in the figure below. Water is used in the production of energy and electricity, energy is used in processes such as extraction, transportation and treatment of water. Energy is also used in food production and consumption, irrigation of crops, while plants are utilized in bio-fuel energy production. All of these are closely interconnected. Energy and food security are expected to be negatively impacted as the increasing accumulation of greenhouse gases in the atmosphere threatens the availability of safe water.

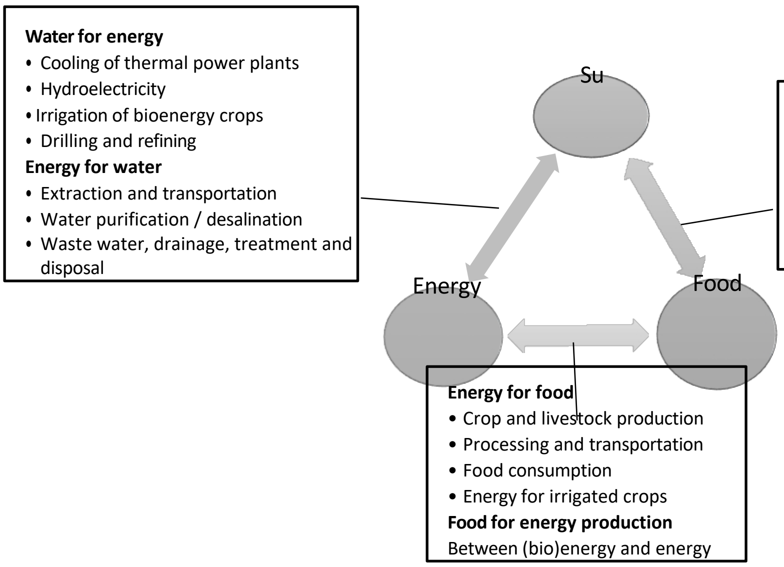


Figure 29: Energy, water and Food nexus*:*

As climate change threatens water resources across the countryenergy security is also at risk
is coming in.

The energy industry uses significant amounts of **water** in its daily operations. Almost all energy generating plants rely on a consistent supply of good quality water. Around 75% of the water used by the energy industry is freshwater. The occurrence of a freshwater deficit puts the energy industry in competition with other industries such as agriculture and human water consumption.

The 55 thermal power plants operating in Turkey require cooling from the source (open or closed circuit) and large quantities of water to convert heat into electricity, i.e. both to generate steam and to maintain the system at an operable temperature. For this reason, thermal power plants are usually located along the sea, lakes or rivers (see figure). In 2018, a total of 7.9 billion m$^{(3)\ of}$ water was withdrawn from the sea (98%), dams, rivers, wells and other sources (1.8%), with 53% open-circuit (946 m^3/GWh), 37% closed-circuit (2600 m^3/GWh) and 10% dry-cooled (106 m^3/GWh) systems of hard coal and lignite power plants in Turkey (table 20).

used as cooling water. The annual amount of water withdrawn by thermal power plants in Turkey It accounts for nearly half (45.1%) of the total 17.5 billion m(3) of water withdrawn [161].

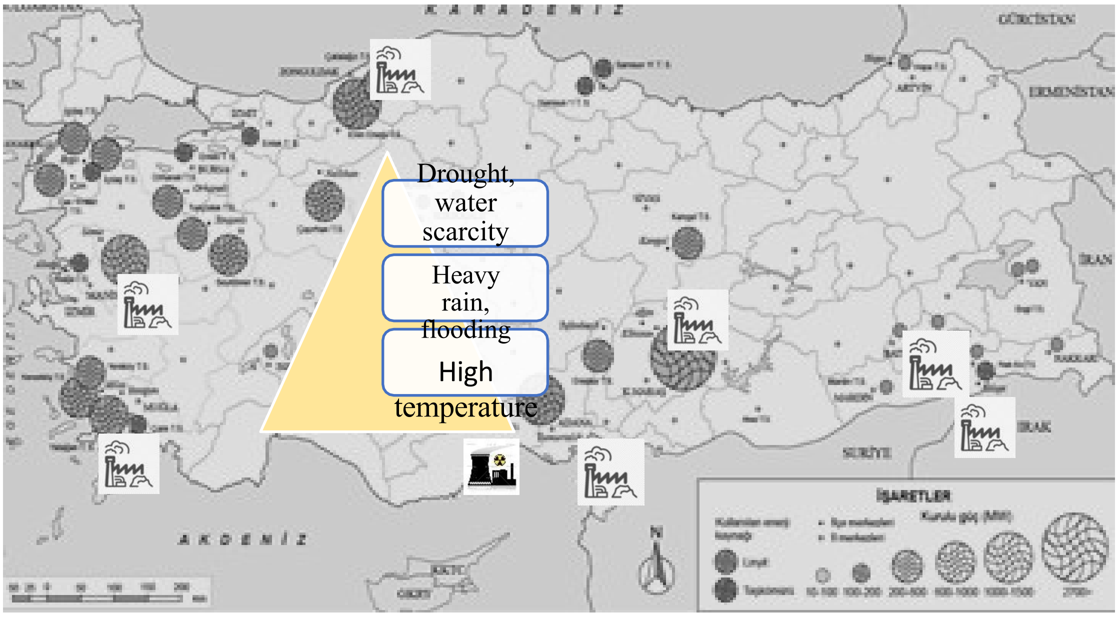


Figure 30: Thermal power plants in operation and nuclear power plants under construction in Turkey and climate change impacts

Table 20: Amount of water withdrawn and discharged from thermal power plants by source (2018)

			Thousand m3
Water source	Total water withdrawn	Cooling water	Discharged cooling amount of water
Sea	7.731.361	7.267.088	7.491.798
Dam	69.248	35.493	12.935
Stream	35.257	28.669	21.594
Well	12.285	3.259	
Other(1)	24.079	17.533	23.869
Total,	7.872.230	7.352.042	7.269.778

Source: TurkStatThermal Power Plant WaterWastewater and Waste Statistics, 2018

With climate change **altering hydrologicalmeteorological and climatological parameters,** coallignite and natural gas-fired thermal power plants increase the threat of water scarcity due to their use of water for cooling and process purposes, but also cause pollution of the wastewater water they produce. As a result of the processes carried out, wastewater such as washing and cleaning, slag trough overflows and oily water, coal stockyard drains, etc. significant social and environmental risks. The table below shows that thermal power plants generated a total of 26.1 million tons of waste, 14 thousand tons of which was hazardous, of which 89.2% was ash and slag waste and 10.7% was metal, paper, plastic waste, wastewater treatment sludge and domestic and similar wastes. While 87.5% of the total waste was disposed of in ash mountain, ash dam or sanitary landfill facilities, 12.4% was sent to licensed waste processing facilities and

[161] In 2018, 17.5 billion m(3) of water was withdrawn directly from water resources by organized industrial zones (OIS), thermal power plants, mining enterprises, manufacturing industry enterprises, municipalities and villages. Of the water withdrawn from water sources, 56.2% was from seas, 15.1% from dams, 14% from wells, 8.7% from springs and 3.9% from rivers,
1.8% was withdrawn from lakes/ponds and 0.2% from other water resources. (TurkStatDecember 30, 2019, , news release number, Issue: 30673)

0.1% was used for backfilling of mines/quarries and 0.1% was disposed of by other methods.

Table 21: Amount of waste by disposal and recovery method in thermal power plants, (Thousand tons)

Total amount of waste (Ton)	**26.127.134**
Amount of non-hazardous waste	26.113.329
Ash and slag waste	23.315.821
Other waste	2.797.508
Amount of hazardous waste	13.805
Disposal/recovery methods and amount of waste (Ton)	**26.127.134**
Sent to ash mountain/ash dam/regular storage facilities	22.870.562
Sold/sent to licensed waste treatment plants/backfilled to mines and quarries	3.233.835
Disposed of by other methods	22.737

Source: TurkStatThermal Power Plant WaterWastewater and Waste Statistics, 2018

The water requirement for generating electricity is closely related to the type of electricity generation plant that makes up that network. Different types of electricity generation plants require varying amounts of water during their operations. For example, thermal coal plants and nuclear power plants use relatively more water, while **solar and wind power** plants do not require much water. The government or companies should consider future water availability when deciding which types of generation facilities to build and what equipment and operational practices to use to reduce water requirements.

The type of fuel used to generate heat in thermal power plants determines their water use. Companies generating electricity from fossil fuel power plants in Turkey must therefore begin to assess whether their operations will be disrupted by climate-induced water scarcity. Increasingly frequent and severe droughts in southern Turkey can be expected to lead to a major climate hazard due to the concentration of thermal and hydro power plants in these regions. These drought hazards for the energy system include reduced availability of hydroelectric water, crop yields that could limit bio-fuel production, and shortages of cooling water for power plants.

Climate change adaptation measures for **bioenergy systems** can be modeled on the work done to improve climate change resilience in the agricultural sector. Biomass availability for energy under climate change impacts can be enhanced by robust, high biological heat tolerance and water stress tolerance of selected crops. Expanding irrigation systems or improving the efficiency of irrigation can eliminate drought impacts if sufficient water is available from sources outside drought zones. Improvements can be made by building levees and improving drainage to protect biofuels-intensive areas from flooding during extreme weather events. The use of salt-tolerant crops, including sugarcane, millet and maize varieties that grow in brackish water on saline soils, can provide biomass for energy without competing with conventional agriculture.

Solar photovoltaic panels, another energy system, have an operating life of 20 years or more, and photovoltaic systems are vulnerable to hail, wind and extreme temperatures. The most problematic component of a photovoltaic system in terms of safety is the inverter, which accounts for 69% of maintenance costs and also converts direct current power output to alternating. Inverters are generally not in direct contact with the air, so they are not vulnerable to climate change. Higher wind speeds and sun can increase dust particle deposits that reduce photovoltaic cell output, but high winds can also cool modules, increasing efficiency and output. In arid regions, high wind speeds can also cause panel damage due to increased abrasion.

The impacts of climate change can also be seen as a significant problem for **wind farms.** From wind
The energy generated is directly proportional to the wind speed and the area covered by the blades. Electricity generation is large

As wind speed is highly dependent on wind speed, a small change in wind speed has a significant impact on electricity generation, revenue and financial viability. Other variables that affect wind power generation are atmospheric pressure, ambient temperature, humidity and air density. A 1°C increase in temperature reduces air density and power by approximately 0.33%. Cold wing with precipitation can reduce aerodynamic efficiency and cause damage, especially if there is thick ice formation. Extreme events with ice formation or very strong and variable gusty winds pose a serious risk to installations, towers and other components. For offshore wind farms planned for the Aegean Sea, it will also be necessary to consider sea level rise in addition to extreme winds.

Figure 31: Impacts of climate change on and wind energy

Nuclear power plants operate at lower thermal efficiencies and require more steam per unit of power produced, which increases water requirements. In Turkey, the replacement of coal-fired power plants with natural gas or renewable power plants leads a gradual reduction in the water intensity of the Turkish electricity grid system. Smaller distributed microgrids, as well as greater reliance on wind and solar power, can eliminate some of the water requirements for large-scale thermal coal plants.

A variety of technologies can be installed relatively quickly to help traditional power generating plants reduce water use, which can a more immediate benefit to a power plant facing water shortages. Hybrid wet and dry cooling systems and closed-loop water cooling systems can reduce water withdrawals in areas where water is scarce. However, these technologies can increase water consumption by increasing evaporation and slightly reducing the thermodynamic efficiency of the power plant. In areas where water is more readily available, such as in northern Turkey, using cooling systems that return water at the same rate can reduce the rate of water consumption and increase the efficiency of the cooling system. Reclaimed wastewater can also be used as an additional source of cooling water if the infrastructure is in place. In the extractive sector, some oil and gas companies are using artificial intelligence and automation to provide the exact amount and timing of water required for operations, thereby reducing wastage.

Exploring collaborative partnerships between utilities, suppliers, government agencies and communities is important to ensure that all parties understand the common share of water security risks and can take coordinated actions to ameliorate these risks. Existing technologies and techniques can help existing or future energy installations reduce their exposure to water risk. However, these options should be evaluated on a site-specific basis, so that each installation or extraction site can be examined to determine the most effective mechanisms for reducing water use for that operation. No one option will fit all circumstances. Planning studies can help guide this process.

Extreme and gradual increases in water temperature can reduce electricity generation efficiency, especially where water availability is affected. However, increases in air temperature will reduce generation efficiency and production and increase customers' cooling demands, putting pressure on the capacity of generation and grid networks. Changes in rainfall patterns and surface water discharges, as well as increased frequency of droughts or floods, could adversely affect hydropower generation and affect water availability for thermal and nuclear power plants for cooling. Increases in precipitation may lead to lower coal quality due to higher moisture content of coal, and hence lower combustion efficiency. Extreme weather events, such as stronger and more frequent storms and changes in cloud cover, can reduce fuel supply and sometimes quality (coal, oil, gas), while also reducing electricity generation and affecting security of supply by damaging grid infrastructure for renewable energy plants such as wind and solar.

In some cases, more frequent and intense extreme rainfall events, storms and floods can seriously damage hydropower plants. For large dams, unexpected floods can be devastating if erosions in the river basin load large amounts of sediments into rivers, which are then carried by streams and settle in dams and lakes. The resulting floods can damage dam walls and turbines directly and indirectly by mobilizing debris from flooded areas. Floods lead to electricity generation losses due to the release of water from bypass channels. Extremely low rainfall reduces runoff and the amount of water stored in dams if operations continue at normal rates. How long dam-based facilities can manage their water reserves and continue regular operation depends on the magnitude and duration of low rainfall events. In the absence of buffer storage, run-of-river plants are more vulnerable to low rainfall and low flow events and may need to reduce power generation in such situations. Extreme high temperatures have similar effects to extreme low rainfall, as they remove water from basins and water bodies through evaporation and evapotranspiration. The implications for electricity supply and adaptation options to threats are similar to the low rainfall situation for both types of hydropower technology.

Another extreme weather event is severe wind conditions such as thunderstorms and hurricanes, which can compromise the structural integrity of wind turbines and damage various turbine components. Extreme weather events such as extremely hot and cold strong winds, sandstorms, hail and lightning can damage solar installations, but materials and technologies are available to reduce their vulnerability to these events. The vulnerability of power generation and transmission infrastructure to climate change is increasing as societal activities become increasingly dependent on electricity and the energy mix shifts to more vulnerable technologies such as wind power generation.

Within the energy sector, the sector where the negative effects of climate change may be least reflected is geothermal power plants used in electricity generation. Since the steam supplied to these plants, which have an installed capacity of 1,500 MW in Turkey, comes from geothermal sources, they will not be affected by water scarcity. Only in hot weather will there be a decrease in the efficiency of the plants. Reducing the vulnerability of the plants to floods and storms can be easily realized through administrative and engineering adaptation measures. Wave and tidal energy sources, which are under research and development, can increase wave electricity generation if offshore storms are frequent and intense. Tidal generation may be affected by high sea levels, but the effect may be small. Both wave and tidal energy sources are not yet included in Turkey's energy mix.

Although marine bioenergy resources and marine methane hydrate energy resources are not included in the scope of this adaptation as they are still in the research and development phase, it is known that research on methane hydrate, which is estimated to be abundant in the Black Sea in Turkey, is being carried out by university research centers and TPAO. This energy source, which aims to produce methane gas trapped in crystalline water in the deep seas, will be 28 times more effective than carbon dioxide, which is one of the greenhouse gases, and it will be necessary to pay special attention to both the reduction and harmonization of methane gas.

Rising air and water temperatures in Turkey are reducing the efficiency of electricity transmission and distribution lines and thermal power plants, and this will also have an impact on the Akkuyu nuclear power plant. For thermal and nuclear power plants that need water for cooling, warmer water temperatures (sometimes combined with water scarcity) lead to shutdowns or curtailments. Flooding from excessive rainfall and sea level rise can damage the plant's fuel storage, emission system, cooling system and turbines. In addition, interruptions in the power grid supplying the nuclear power plant can affect the operation of the cooling systems inside the plant.

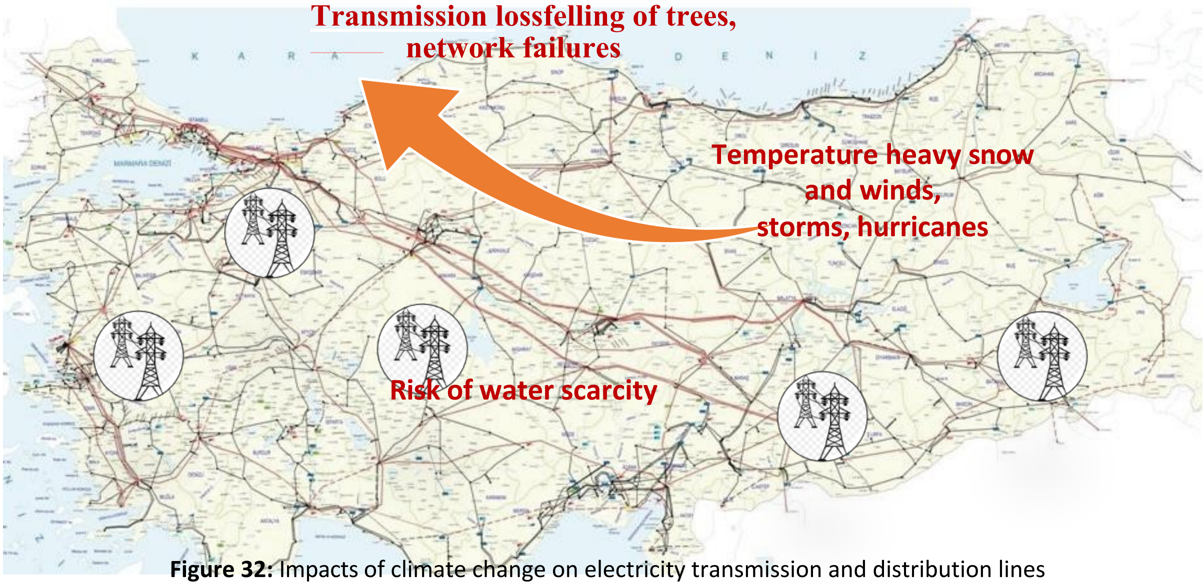


Figure 32: Impacts of climate change on electricity transmission and distribution lines

As shown in the figure above, various types of extreme weather events cause significant damage to the long transmission and distribution networks, which are already carried for many kilometers under the current climate. Strong winds, storms, hurricanes and tornadoes are predicted to continue to be the main cause of grid system failures due to the exposure of various grid system components to such events. Combinations of low temperatures, heavy rain or snowfall and high winds hit less frequently, but their simultaneous occurrence can cause severe damage to grid system services and longer outages.

Climate could pose a threat to Turkey's oil refining industry. Turkey has 5 refineries with a total capacity to process 40 million tons of crude oil, 3 of which - Aliağa, Star and Izmit refineries with a total capacity to process 30 million tons of crude oil - operate on the coasts of the Aegean and Marmara seas (Figure 33). With most of Turkey's refining on the coast, the potential for sea level rise and more severe storms pose a threat to the Turkish oil and gas industry. In addition, fuel distribution companies are also concentrating piers, tanks and piping facilities at ports in coastal areas for storage, stocking and loading activities to take advantage of maritime transportation. addition to large structures such as building seawalls and embankments, construction standards for storage tanks should be revisited and updated to reflect estimates of future risks.

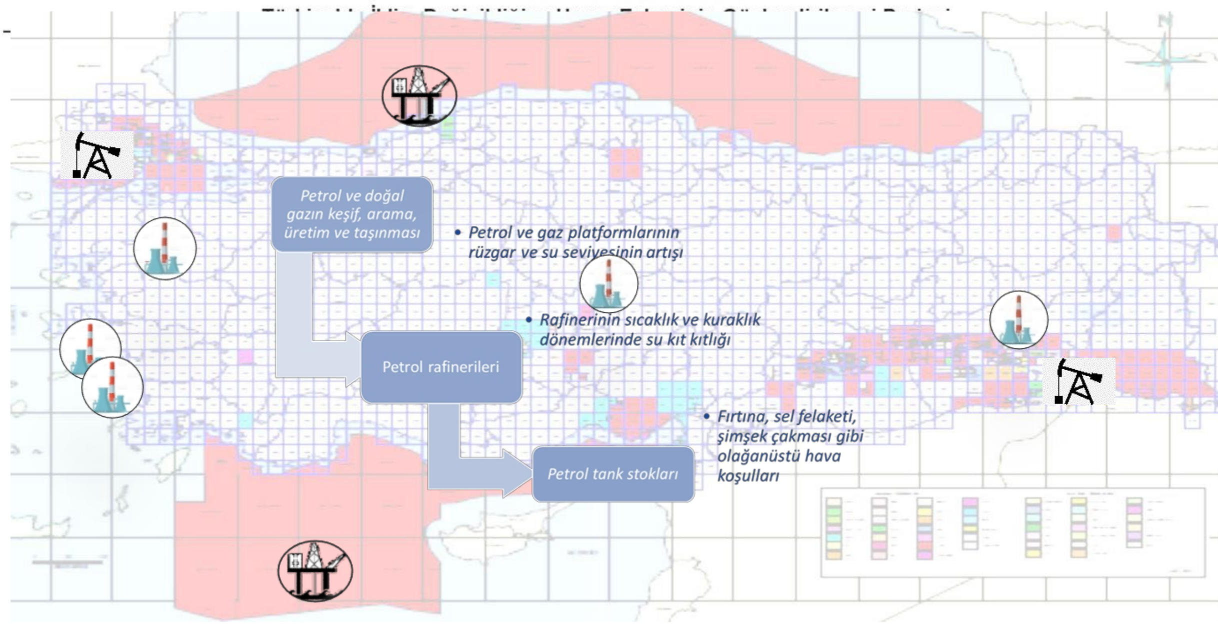


Figure 33: Climate hazards of oil exploration production and refinery facilities

The refining industry can move critical equipment to higher ground, but as sea level rises and greater storm surges occur, there is a need to reassess whether current standards will be sufficient. Existing storage tanks can be considered highly vulnerable to severe storms because they are designed to withstand winds, but the rising water level may not pose a danger. Better processes and storm preparation procedures are needed, including emptying (or perhaps filling by weight) tanks in anticipation of a storm. Equipment such as electrical systems, pumps, compressors and generators should be elevated well above ground level. Facilities should have flood management plans that account for the strength of coastal surge and consider the costs and liabilities of tank failure and leakage of toxic substances contained in equipment at refineries and petrochemical plants, which would be catastrophic for communities and surrounding neighboring areas. Extreme winds can damage overhead power lines and lead to loss of power supply in oil refineries, which can cause a delay or interruption in oil processing, resulting in a cascading failure. A sudden flood event could cause a shortage of electricity generation in the region, affecting the oil production of refineries, leading to a delay or interruption in the supply of fuel that could be used in the electricity infrastructure for production. Lack of electrical power could create economic, social or political disruptions over a wide area, creating domino effects by affecting other complementary critical infrastructure provided by the utility.

Extreme hydro-meteorological events damage large sections of roads, bridges and railroad crossings, leading to road accidents with the release of pollutants into the environment. The transportation sector is also heavily dependent on petroleum products. According to the International Energy Agency's 2018 energy balance table for Turkey, 27.2 million tons (70%) of the total 39 million tons of petroleum products produced from refineries and imported from abroad are used by the transportation sector.

On the other hand, the oil sector is highly dependent on electric power and electricity grids. Refineries in Turkey consume a very high amount of electricity on an annual basis. The petroleum industry uses its integrated combustion engines to generate electricity.

needs, large amounts of energy are also consumed by distribution utilities through transportation and distribution networks that are exposed to extreme weather events.

Today, the oil industry is making a strong effort for progressively sustainable and resilient development by incorporating extreme weather events into its broad risk management framework. Most processes and facilities are designed to withstand climate change risks. However, extreme events can exceed design and operational thresholds. Climate hazards are known to trigger chemical accidents leading to the release of toxic, flammable and explosive substances. The combination of increasingly complex industrial designs and the expected increase in the frequency and intensity of extreme weather events due to climate change could lead to potentially more catastrophic events in the future. Major oil and gas companies must develop and use integrated climate change risk management to identify, assess, characterize and manage climate-related risks.

Oil refineries use large volumes of water, mainly for cooling systems. is still a great need for water, even though the water needs of the oil industry are via sea or river water. Indeed, the water sector provides clean water through the drinking water network, wastewater and even flood water network. As energy and water are interconnected, energy production requires a significant amount of water and in turn the extraction, treatment, distribution and use of water together with wastewater treatment requires a large amount of energy. Oil refinery water consumption was found to 0.34 and 0.47 (L water / L crude) for cracking and heavy coking processes, while the largest amount is needed to produce gasoline, requiring 0.60-0.71 L water / L gasoline. Smaller amounts of water are needed for boiler feeding, processing, sanitary services and fire protection.

Research shows evidence that the oil sector is most exposed to hydrometeorological disasters (floods, hurricanes, storms and heat waves, etc.). This can cause serious complications and many problems in the vital processes of the petroleum sector, the supply chain, or the physical structures of the petroleum sector, such as buildings, grounds, facilities, machinery and cooling systems.

Finally the impact of climate change on the energy sector is on energy demand, reducing space heating demand and increasing space cooling demand. While climate change affects energy demand, energy efficiency and demand management can reduce demand, social and economic factors can increase energy demand. In Turkey, domestic space heating demand is met almost entirely by electricity, although not to a very large extent, while cooling is almost entirely provided by electricity. Therefore, changes in heating demand and even cooling demand will directly affect electricity demand. It is worth noting that increased peak electricity demand in summer will coincide with increased difficulty in obtaining sufficient cooling water for thermal power generation in very hot conditions.

2.6.2. Scope of Vulnerability and Risk Analysis

Vulnerability and Risk Analysis of the Energy Sector Climate Change should be addressed under the following headings.

- Water-related Risks and Impacts of Climate Change on Turkey's Energy System
  - Thermal power plants
  - Hydroelectric Power Plants
  - Akkuyu Nuclear Power Plant
  - Oil refineries and energy crops
- Risks and Impacts of Climate Change on Energy Infrastructure
  - Offshore and Onshore Energy exploration and production facilities
  - Renewable (Hydro, Solar Wind) power plants
  - Oil and gas pipelines
  - Electricity transmission and distribution lines

- Affectability of electricity demand with temperature change
- Climate Risk and Energy Firms in Financial Markets

2.6.3. Key Stakeholders

efficient and implementation of adaptation measures in the energy sector, all stakeholders need to act jointly and in concert. Stakeholders in the energy sector include public and private companies operating in the energy industry, regulatory bodies, University research centers and academics, local authorities and government, civil society organizations, professional associations and donor agencies providing technical and financial assistance.

The donor community or institutions can implement local or regional projects and provide financial support to existing funds. The public sector can contribute to adaptation by establishing an effective policy framework through central government and municipalities and supporting research and development in academic institutions. The Energy Market Regulatory Authority, as the regulator, plays an important role in ensuring medium and long-term investment security for energy investors by providing legal and administrative regulations for those segments of energy markets exposed to climate impacts.

Among stakeholders, public and private companies operating in industry, providing energy services such as oil, gas, coal, electricity, etc., have crucial roles to play in climate change adaptation. In the long term, utilities and private companies have a public or personal interest in protecting their assets from the impacts of climate change. To protect their large assets, energy utilities and industries need to know, or at least be aware of, how vulnerable they are climate changewhat climate resilience options are available, and how they can predict future vulnerabilities to better target investments. Stakeholders in the petroleum sector are upstream oil exploration and production companies such as Turkish Petroleum Exploration Corporation (TPAO) and other national and foreign companies, natural gas transportation companies such as BOTAŞ, and organizations and institutions such as Petroleum and Natural Gas Platform Association (PETFORM) formed by oil exploration companies. In the downstream of the petroleum sector TÜPRAŞ and STAR companies that carry out refinery operations, distribution companies that distribute petroleum products and stockpile these products, and the Petroleum Industry Association (PETDER) formed by these companies. Thermal power plants using coal and lignite fuels, owners of natural gas cycle power plants, public and private companies operating hydroelectric power plants based on dams or rivers, professional chambers and civil society organizations are important stakeholders for the adaptation policies and practices of the energy sector. However, final consumers of petroleum products and energy products such as electricity should also be considered within the scope of harmonization.

2.6.4. Sectoral Indicators

Vulnerability assessment by indicators can support a number of different policy-related objectives, such as measuring the effectiveness of adaptation activities, monitoring the process of reducing vulnerability, raising awareness and determining the allocation of financial or other forms of support (ETC/ACC, 2010). The actual impacts of climate change can be difficult to measure and distinguish from those caused by natural (currentclimate variability. It is also important to ensure that the indicators can be used for measurement for these purposes in order to obtain or access the necessary data. The actual impacts of climate change can be difficult to quantify and distinguish from those caused by natural (current) climate variability. Below is a list of energy indicators that can be used in climate change vulnerability assessment.

- In terms of energy diversity, fuel shares in total primary and final energy supply, total electricity generation and installed capacity can be used as indicators.

- As renewable energy is more vulnerable to changes in climate, the participation of renewables in total energy supply and electricity generation/installed capacity is also important in assessing climate resilience.
- Knowledge about both climate and energy should be considered as an indicator of resilience as it allows for better understanding and earlier action to adapt to the impacts of climate change.
- Impacts on thermal (fossil or nuclear) electricity generation are explained in terms of conversion efficiency or capacity changes.
- Climate impacts on liquid biofuel production can be assessed by changes in agricultural and adaptive productivity (e.g. energy per planted area).
- Differences in the energy intensity of a consuming sector at the end of the energy chain can paint a picture of vulnerability on the demand side.
- Located less than 1 meter above sea level and with a long current recurrence period
  Number of coal mining facilities located in an area that could be inundated by flooding.
- In the oil and gas sector, share (%) of offshore oil and gas installations likely to be affected by storms of more than 70 m/s in the next 20 years, share / number of refineries likely to be affected by storms of more than 70 m/s in the next 20 years.
- For all Fossil Fuels infrastructure, the number of thermal (coal, oil and gas) power plants located less than 1 meter above sea level and located in an area that would be inundated by a flood with a current long-term recurrence period.
- In the coming period, for example, in 30 years, the capacity of thermal power plants will increase by more than 10%.
  number of expected droughts that cause a reduction in the number of droughts.
- Change in precipitation expected over the next 20-50 years in areas with hydropower plants (%) and/or probability of flooding in each basin, number of multi-use dams in the country today: volume of water for each dam (m^3), percentage of water used for agriculture; power; drinking; additional runoff expected from snowmelt or flooding (million m^3).
- For biomass, the proportion of biomass used for energy purposes in total biomass production, (%) agricultural biomass harvest; electricity production amount, expected rainfall change in the future e.g. 20-50 years (%), probability of temperature increase beyond biological heat tolerance of key biomass crops in 20 years (%).
- For Transmission Systems, identify the length (km) of in-country, above-ground transmission and distribution lines, high (transmission); medium and low voltage lines (distribution), transnational lines, and length of power outages (weather-related outages or outages due to equipment failure and rationing), average annual outage hours.
- E.g. % of energy supply requiring regional transportation over 50 km, % fossil fuel transport, % biomass transport; information on the informal sector if possible.
- Number of wind turbines less than 1 meter above sea level for wind farms, projected change in average wind speed for the next 20 years based on regional climate models (%).
- For solar plants, available solar installation capacity (m^2) and PV power (MW), Ownership (private, government, public/private partnership, etc.), PV capacity related e.g. expected temperature (°C) increase over the next 20 years.

2.7. Industry

2.7.1. Assessment of the Impacts of Climate Change on the Industrial Sector

It is widely recognized that climate change can affect the ability of business and industry to produce goods and services. These impacts can be immediate, such as when flooding causes a business to temporarily close, or more dynamic over time, such as increased operating costs in a particular location. Furthermore, a business may face direct impacts, such as business interruption and damage to physical assets in the event of a severe storm, or indirect impacts through public policy, such as increased demand for flood-resistant materials, or increased competition for certain resources and changing market conditions [162].

It is important for the industrial sector to understand the risks of climate changebe prepared for these risksmitigate them and to take advantage of the opportunities that may arise. From a large scale, it is clear that the risks of the sector affect the entire economy and the sector's approach will determine the present and future, including investment decisions.

Climate change poses serious risks that companies and governments need to understand in order to take appropriate steps to mitigate its impacts. However, climate change risk assessment is a complex, dynamic and geographically diverse process with many challenges to overcome. Risks to businesses are further complicated by the nature of value chain creation, the location of the business, and relationships and interdependencies with customers and suppliers ([163]).

However, the scope and level of granularity in climate change adaptation and risk assessments will vary across companies and countries. Companies are expected to focus on activities prioritized according to criteria set at the country scale, while assessing the risks and opportunities across their facilities/services at a specific location and/or across the value chain in order to make timely and reasonable decisions on adaptation. These two processes can be carried out in parallel, or data from the sector through voluntary reporting and disclosures can be used by the relevant public institution for evidence-based studies to be carried out at the national scale, or a top-down approach can be used to bring to the attention and use of the sector a study on the risks that the industrial sector may face at the national scale.

Assessing climate risks requires decisions on a range of issues, including the timeframe, the type of climate scenarios to be used, which hazards to address, which impacts to investigate and what data to use. Some studies[164] show how risk assessments can vary depending on how vulnerability is conceptually positioned according to the methodology used (e.g. whether it is the 'outcome' or the 'starting point' of the risk assessment) or data uncertainty.

As a result of reviewing the academic literature and examining recent studies on climate risks prepared at the national level, Table 22 summarizes some of the issues that should be emphasized for determining the scope of analysis of climate change risks for the industrial sector.

[162] OECD. 2014. "Cities and Climate Change: National governments enabling local action. PricewaterhouseCoopers 2015 "Make It Your Business: Engaging with the Sustainable Development Goals" [163] Swenja Surminski, Manuela Di Mauro, J. Alastair R. Baglee, Richenda K. Connell, Joel Hankinson, Anna R. Haworth, Bingunath Ingirige and David Proverbs Assessing climate risks across different business sectors and industries: an investigation of methodological challenges at national scale for the UK

[164] Fellman, T. 2012. "The assessment of climate change-related vulnerability in the agricultural sector: reviewing conceptual frameworks". ~~In: Meybeck, A., J. Lankoski, S. Redfern, N. Azzu~~ and V. Gitz (eds.). "Building resilience for adaptation to climate change in the agricultural sector". Proceedings of a Joint FAO/OECD Workshop. Rome, 2012

The most common approach to scaling is a sectoral focus, based on the understanding that the impacts of climate change differ across sectors. Assessing climate risks can pose the challenge of capturing important risk differences across sub-sectors and the diversity of businesses and processes. Sector-specific risk assessments, such as the comprehensive energy, water, transport, tourism and insurance sectors in the IPCC 5th assessment report, show that dependence on natural resources, long-lived assets (e.g. transport, water and energy) and extensive supply chains a business or industrial sector more vulnerable to climate risks. This can be categorized into a first category for raw material acquisition, e.g. mining; a second category for manufacturing and assembly processes; and a third category for sectors with inputs of agricultural products, e.g. food and beverages. It is possible to define sub-categories under these categories in studies that will be progressively developed and improved.

However, when considered on a country scale, it seems inevitable that the scaling to be done carries the risk of overlooking the interdependencies and relationships between sectors. Because even within a given sub-sector, it may not be possible to include all the details in a country-scale study, as the risks analysis may result in different results due to different production sizes, differences in production flow, characteristics of the geography where the enterprise is located, etc.

Table 22: Summary of Risk Analysis Scope for the Industrial Sector

Evaluation scale	Sectoral focus is commonly applied. But different sectors within a sector operating characteristics affect the precision and depth of the study.
Evidence-based assessments	Both qualitative and quantitative evidence-based assessments can be made in risk analysis. Surveys and voluntary reporting are important sources of evidence. However, there may be difficulties in aggregating and linking them. The commercial confidentiality of non-public data also needs to be overcome. that could be a topic.
Previously received harmony measures	The assessment of previous adaptation studies at the country and organization level within the scope of risk analysis. Difficulties in accessing studies and data, and difficulties in measuring data quality are the main there may be constraints.
Scope of impacts	Climate change risks and opportunities for the industrial sector are multi-layered. Location of facilities, changes in demand for goods and services, affected trade routes in regions, geopolitical stability and commodity market prices is affected by many international dimensions, such as fluctuations.
Interdependencies	Climate risks for organizations in the industrial sector are affected by a number of interdependencies. Examples include interdependencies between different industries, between businesses and infrastructure, between climate and resource availability, and between business operations and socio-economic processes. Clustering around certain regions, sharing the same resources, depending services and products from near and far, to this complex web of interactions and relationships. In this case, climate risks have an impact on processes. can create multiple pressure areas and lead to cascading effects.
Public policy	The effects of public policies on climate change adaptation and risk analysis may differ according to situations. Some policies, especially those set by legal regulations such as by-laws, may have direct impacts on the ability of businesses to adapt to climate change. In the case of indirect impacts, mechanisms that require or incentivize businesses to report on climate risks and adaptation actions, or volunteer programs can be useful.

Source: (Swenja Surminski, Manuela Di Mauro, J. Alastair R. Baglee, Richenda K. Connell, Joel Hankinson, Anna R. Haworth, Bingunath Ingirige and David Proverbs Assessing climate risks across different business sectors and industries: an investigation of methodological challenges at national scale for the UK)

When the Intergovernmental Panel on Climate Change published its First Assessment Report in 1990research on vulnerability to climate change focused primarily specific sectors (e.g. water, agriculture) and regions (e.g. Andes, Southeast Asia).

However, studies on the vulnerability and risks from climate change on the industrial sector, which is mostly on the agenda with its mitigation pillar, came to the agenda in later years. In the intervening years, different methodological approaches, experimental findings and theoretical views on vulnerability to climate change have been put forward through numerous scientific studies and analyses. Despite these important developments, relatively few studies have been conducted on the analysis of the uneven distribution of risk and the vulnerability factors of the industrial sector.

The vulnerability of different industries to extreme weather events and climate hazards occurring around the world is due to a range of social, economic and political factors operating at multiple scales.

The report prepared by the Task Force on Climate-related Financial Disclosures (TCFD) established under the G20 Financial Stability Board and published in June 2017 presents a methodology for financial disclosures related to risks associated with climate change. The noteworthy point in the climate risks framework created by the TCFD is that opportunities are evaluated along with risks. The opportunity approach here is explained as capturing the opportunities that will arise in the process by focusing on solutions to climate change risks in the transition to a low-carbon economy. In summary, these opportunities are defined as resource efficiency, transition to low-carbon options in energy resources, development of low-carbon options for products and services, including marketing, packaging and labeling, development of new assets or new low-carbon asset management models, new market opportunities and building resilience to climate change to increase the adaptive capacity of organizations.

According to the report, climate change risks can present significant financial challenges as well as opportunities for investors today and in the future. The World Energy Outlook presented by the International Energy Agency at the Paris Climate Summit in 2015 estimates the transition to a low-carbon economy will require investments of around $1 trillion per year and create new investment opportunities. At the same timethe risk-return profile of organizations exposed to climate-related risks may be significantly affected, as they may be more vulnerable to the physical impacts of climate change, climate change policies and new technologies.

The Economist's "The Cost of Inaction: The Cost of Inaction: Recognising the Value at Risk from Climate Change" 2015 report by The Economist estimates the value at risk of the total stock of manageable assets globally as a result of climate change is estimated to 4.2 trillion and USD 43 trillion between now and the end of the century. It is also noted that investors may not be able to avoid climate-related risks by exiting certain asset classes and sectors in their portfolios, as a wide range of asset types may be affected. Therefore, both investors and the institutions in which they invest should take climate change risks into account to inform their long-term strategies and the most efficient allocation of their capital.

Organizations that invest in activities that may not be viable in the long term may be less resilient to the transition to a lower-carbon economy, and their investors are likely to face lower returns.

Since valuations based solely on financials provide insufficient information on climate change risks, the failure to take these risks into account in the analysis and forecasts of long-term returns creates a risk in itself. Therefore, climate change vulnerability and risk analyses will provide investors and organizations with valuable information for their valuation and investment plans.

In the report, which does not make a distinction for the industrial sector, the physical impacts of climate change, climate change
is given as one of the 2 main categories of linked risks.

Table 23: Climate Change Risks of the TCFD Business World

Transformation Risks	Physical Risks
Political and Legal Risks	Acute Risks
Risks Linked to Technology	Chronic Risks
Market Related Risks	
Reputation Risks	

TablePhysical risks from climate change are defined as risks that develop due to events (acuteor long-term changes projected in climate models (chronic).

Physical risks can have financial consequences for organizations, such as direct damage to assets and impacts on the supply chain. Organizations' financial performance can be affected by changes such as access to water, changes in resource use and quality, food safety, and extreme temperature changes that affect organizations' facilities, operations, supply chain, transportation needs and worker safety.

Acute physical risks are categorized as case-driven risks, including weather events such as severe hurricanes or floods. Chronic physical risks refer to changes such as an increase in the frequency of extreme weather events that can lead to sea level rise or heat waves. However, the TCFD study does not recommend a methodology for conducting assessments of risks and vulnerability.

The impact chain methodology described in the first section is presented to enable assessments on how to minimize the vulnerability of the industrial sector to climate hazards. An example of an impact chain framework that includes projected climate hazards, possible exposure points of the industrial sector to them, vulnerability analysis including sensitivity and adaptive capacity, risks as a function of the first steps and indicators to be developed for monitoring this entire chain can be given through the exposure of raw material supply and production processes to the physical impacts of temperature and precipitation regime changes. Sensitivity factors include scarcity of water for production, difficulty in accessing energy sources and damage to production facilities from extreme events. Efficiency efforts, risk management practices, high awareness and the existence of a flood management plan will indicate adaptive capacity. The measures taken can prevent increased production costs, yield losses and market loss. .

This chain leading to indicators is a sector-specific and dynamic process. In order for the system to serve its purpose, it is important to measure the effectiveness of the results of the monitoring activities carried out with indicators in eliminating risks through actual situations. Within the scope of review studies to be carried out at intervals to be determined, it can be ensured that the sectors benefit from the risk analysis and monitoring studies at highest level with the contribution of updated meteorological predictions, realizations and corrective actions.

2.7.2. Scope of Vulnerability and Risk Analysis

Scientific approaches to industrial sector vulnerability aim to provide guidance on the root causes of climate change threats and how sectors can adapt to them.

As vulnerability is a multidimensional process and not a static state, a dynamic approach to vulnerability will be critical in implementing adaptation planning.

It is aimed to identify the key vulnerability factors for the industry sector and to provide a framework covering the entire value chain as a basis for more detailed studies by sub-sectors/organizations. In this context, vulnerability factors have been classified into 3 main tiers: basic operations, including physical assets, efficiency of production processes, cost of operation and maintenance activities, health and safety, labor and labor productivity; value chain, including the ability to supply raw materials and services, customer demand for specific products and services; and the wider network of public services such as infrastructure, electricity, water services, etc. required to export or import.

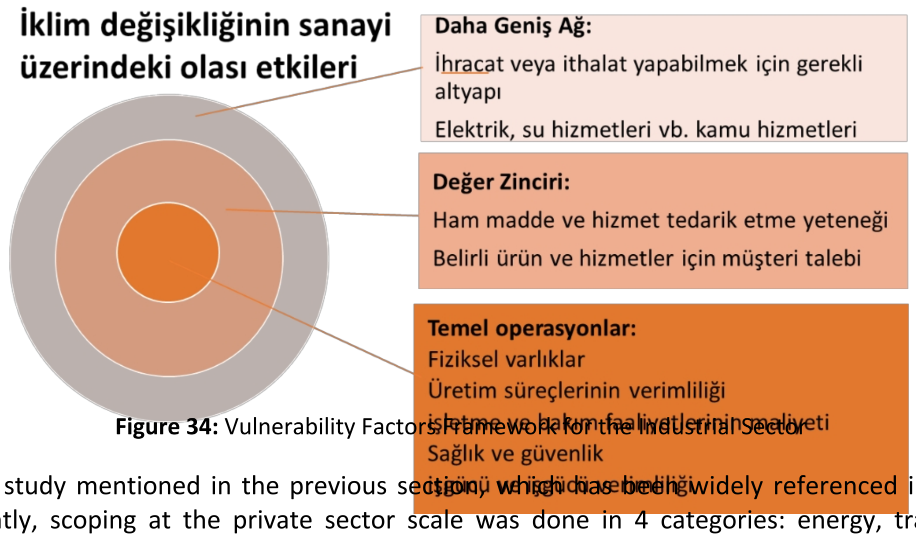


Figure 34: Vulnerability Factors Framework for the Industrial Sector

In the TCFD study mentioned in the previous section, which has been widely referenced in the private sector recently, scoping at the private sector scale was done in 4 categories: energy, transportation, materials and buildings, and agriculture, food and forestry products. However, in the scope of this project, this classification was not deemed appropriate as there would be overlaps with other sector categories already identified under the industrial sector category.

Within the scope of national vulnerability and risk analysis, it would be appropriate to design the detailed study to be conducted for the industrial sector in 3 layers: "core operations", "value chain" and "wider network". Thus, the vulnerability and risks of the sector in many dimensions and layers can be analyzed in detail.

It would be beneficial for the comparability and coordination of assessments over time if the vulnerability factors of the detailed studies to be carried out by the sub-sectors in the future are also shaped under this main roof.

2.7.3. Key Stakeholders.

Engaging stakeholders in the vulnerability and risk assessment process for adaptive capacity and practices is an important step in generating comprehensive and detailed sectoral data on adaptation.

Representatives of the industrial sector and their associations and unions are the stakeholders in the primary sphere of influence of the study. Their participation and contributions will play a shaping role in the assessment of the existing adaptation capacity and the work carried out, and in setting the framework for the vulnerability and risk analysis. At this stage, a good understanding of the purpose and objectives of the study and internalization of the importance of the analysis that will emerge as a result of the study will be decisive in terms of stakeholders' participation in the process and transparency and sharing in the following stages. In this sense, it will be useful to support the process with events such as meetings, workshops, etc. with broad participation or for smaller groups, depending on the purpose. Another important issue is the transformation of this national study into more detailed analyses at the level of sub-sectors and organizations. One of the domino effects of the results of the project will be for the sector to include climate risks in the risk management studies carried out on the basis of organizations and to evaluate their impact on competitiveness and financial sustainability in the medium and long term.

Sector associations and unions play a focal point role in the process in terms of centralized dissemination and collection of data and information, identification of sub-sector priorities, and opportunities for joint work and cooperation with international peer organizations.

On the other hand, civil society representatives within the sphere of influence of industrial organizations are also one of the important stakeholders as a highly vulnerable group that will be exposed to the consequences of climate risks. Especially in cases and accidents that may occur as a result of the impacts of climate hazards on the processes of industrial facilities (e.g. release of hazardous substances from waste dams damaged due to heavy rainfall and/or flooding), employees and the surrounding community are among the groups that will be primarily affected. Based on this example, it will be another important stage in strengthening adaptation capacity for stakeholders to share information and communicate on climate risks and vulnerability issues, and organize activities to increase each other's level of awareness when necessary. Other important stakeholders for the industry sector are listed below.

- Public organizations
- Universities
- Industrial organizations
- Civil society organizations
- International organizations
- Project team

2.7.4. Sectoral Indicators

With regard to indicators, it is important to elaborate on how they will be evaluated within the scope of adaptation policies and at the same time how they will be affected by existing policies. The monitoring of indicators and the realization of exposures and risks related to the monitored data are directly affected by climate hazards as well as the policies that regulate the implementation areas of these indicators. For example, although the indicator "disruption in water distribution services due to extreme weather events" is an indicator of sensitivity to climate hazards, it will also be affected by the practices shaped by the top policy such as early warning systems and disaster management, emergency plans and practices of water distribution services, control and management of the overall effectiveness of the system. This impact may be positive or negative, as can be expected. In this context, it will be useful to evaluate the vulnerability and adaptation status to be monitored through indicators in terms of the effects of national/local policies and their implementation.

Quantitative data to be obtained through indicators be supplemented with relatively more qualitative information and data such as surveys, workshops, interviews, topic/sector-specific analyses, reports, etc. in order to strengthen adaptation capacity. In addition, voluntary reporting and disclosures industry representatives in the private sector should also be considered as one of the channels to provide data input to the system.

In addition, the mutual influence of sectors is another issue that needs to be taken into account. For example, the success of the energy sector in terms of implementation of existing policies and analysis of data monitored through indicators and its contribution to the system will directly affect the adaptive capacity of the industrial sector. Likewise, the state of water supply and management will be decisive in the adaptation profile of the industrial sector. The level of awareness of employees and the public about non-climate factors, and the fact that they have received emergency trainings and are able to apply them will be effective in the adaptation capacity of many sectors such as industry. It is critical to implement improved data collection and data sharing practices to characterize adaptive capacity across different sectors.

Identifying regional and subsector-specific sub-indicators in subsequent phases will reduce the uncertainty of the data to be collected through indicators and contribute to a higher level of adaptation capacity. The adaptation policies and measures to be developed in this way will also be useful in terms of achieving results that are tailored precisely to the needs and have high qualitative and quantitative sectoral representativeness.

The list of indicators in the Annex also includes indicators related to industry. Some issues that were not included in this set of indicators, which is intended to provide a country-scale assessment, due to difficulties in obtaining data, can be taken into account on the basis of sub-sectors or on a country scale in future studies. These are "production losses due to climate hazards in countries with trade ties other than Turkey", "turnover losses due to climate hazards in countries with trade ties other than Turkey" and "the indicator of the ratio of insurance coverage of damage due to natural disasters resulting from extreme weather events outside Turkey". For monitoring activities to be conducted on a sub-sectoral basis, monitoring and evaluating climate risks specific to the regions where value chains are located will enable more comprehensive analyses.

2.8. Tourism

Tourism is a sector that has been continuously growing and differentiating globally for the last 30 to 40 years. The business and trade volume of the tourism sector, which acts as an important locomotive in the socio-economic development of cities, regions and countries, is larger than the volume of oil exports, food products and the automotive sector. With this potential and capacity, the tourism sector has become one of the leading sources of income for many regions and cities, especially in developing countries. The increasing share of tourism in local and national economies and its socio-cultural importance has led to a rapid increase in the number of destinations seeking to make headway in tourism, in the diversity of services and, most importantly, in the competition among them. The goal of this competition is to increase the quality of tourism services and the income from tourism.

According to the United Nations World Tourism Organization (UNWTO), tourism generated 7% of total global exports, 28% of services exports and 10% of gross domestic product in terms of global economic indicators in 2019. In addition, one out of every 10 employment opportunities in the world is by the tourism sector. The number of international travelers worldwide increased by 7% in 2017, 1,333 billion. In 2018, this growth rate was 5.7% and the number of tourists
1.408 billion. In 2019, the last best tourism year before the pandemic, the number of tourists increased by 3.5%.
1,458 billion. In contrast, tourism revenues worldwide increased from US$ 1.6 trillion in 2017 to US$ 1.7 trillion in 2019. By 2030, the number of tourists worldwide is expected to reach 1.8 billion.

Tourism is defined as an individual or group travel organization. This definition
organization activity within the organization activity, which is offered to provide unforgettable experiences to visitors.

It refers to an industry of services and activities. This industry consists of a value chain that includes various service lines. These services include transportation, transportation and accommodation, food and beverage, shopping, entertainment, event organization and other hospitality services. Considering all these, the common goal of the sectors in the value chain is to maximize the satisfaction of the tourist and the pleasure he/she derives from his/her experience. A three-stage approach is adopted in the value chain that takes into account tourist satisfaction for a destination (Table 24).

Table 24 Tourism value chain analysis diagram

	Travel Before	During Travel							Travel The post
	Introduction	**Transportation**	**Accommodation**	**Eating & Drinking**	**Creative Industries**	**Tourism Assets**	**Entertainment and day-trippers**	**Support Services**	**Quality Assurance**
Actors and Activities	Travel Agencies	Airlines	Hotels	Restaurants	Handicrafts souvenirs	Cultural Assets*	Shows	Information Centers	Scoring systems
	Tour Operators	Cruise and Ferries	Apartments	Cafe & Patisserie	Music - dance artists	Natural assets**	Tourist guides organization	Grocers, retailers	R & D Institutions
	Airline Companies	Car, motorcycle, bicycle rental	Guesthouses	Fast food	Local markets	Authorities responsible for the following;	Tour Packages	Internet/ telephone	Tourism businesses e guidance
	Call Centers	Bus, train companies	Hostels	Bars and nightclubs	Handicrafts / souvenirs	Area signage	Guides and escorts	Health and security services	Certification and Control Institutions
	Recognized Brand Products	Taxis	"Lodges"	Local Food Products	Homemade goods / food	Restoration	Wellness & SPA	Bank & foreign exchange	
	Official website sites	Informal transportation	Kamping Fields	Kiosks	Storage & Distribution	Space management	Local Guides	Technology store	
	Responsible authorities	Customs Offices	Consumables	Gift	Handicrafts trade	Maintenance and repair	Daily activity organizers	Laundry oil, hairdresser vs.	
	Press and Media	Airport Authority	Care Services	Food products		Coordination			
	Sales and Marketing	Transportation Ministry of	Sales and Marketing	Storage Distribution					
	Supportive Institutions	Migration Management		Beverage Production					
		ConstructionEnergyWaterWasteEducationCommunicationsPublic Health and Public Safety							
		Support Services: Ministries of Culture and Tourism, Trade, Transport, Interior, Environment, etcpromotionorganizationtrade chamber, banks, licensing and standard-setting NGOs							

	Directly related to tourism		Indirectly related to tourism

*Archaeological societies, ethnography museums, tourism attractions, intangible cultural heritage assets (music, dance, legends, etc.), festivals etc.**Lakes, rivers, coral reefs, mountains, forests, flora & fauna species Source: Casas (2019)[165]

The first of these stages is the "pre-travel" decision-making stage. During the decision-making phase, tourists mostly conduct research and consultation activities, while destinations, tour operators and responsible authorities carry out promotional and marketing activities. The second stage includes the departure after the decision and the activities carried out in the destination "during the trip". Almost all of the efforts and services provided to ensure tourist satisfaction are included in this stage. The third stage is the process after leaving the destination and refers to the "post-travel" period. At this stage, the level of satisfaction is mostly indicated. When these three approaches are evaluated, the stage most affected by climatic conditions and climate change is the second stage. This stage includes transportation and

[165] Casas J. 2019. Tourism and sustainable mobility in cities Lesson learnedt and new challenges. GO SUMP High Level Training, Barcelona.http://www.medcities.org; www.cinesi.es; http://www.civitas.eu

is the section that includes the activities carried out. Service production activities that may be affected by meteorological conditions in the tourism sector take place at this stage.

Tourism in Turkey

The tourism sector in Turkey can provide services at every stage and sub-sector of the value chain mentioned above. According to a study conducted by the Mediterranean Association of Touristic Hoteliers and Operators ([166]), a one-unit development in tourism in Turkey causes a two-unit contribution to the national economy and tourism directly affects 54 sub-sectors in its value chain. These include food and beverages, furniture, agriculture and animal husbandry, real estate, energy, design, décor, copyright, banking, private hospitals, fuel dealers and construction markets.

Tourism is one of the most dynamic and fastest growing sectors in Turkey. In 2018, the sector was responsible for 7.7% of total employment, employing 2.2 million people. Total tourism revenues accounted for 3.8% of the country's gross domestic product (GDP) in 2018 and 4.6% in 2019. Travel expenditures accounted for 51.9% of total services exports (OECD 2018). With 45.8 million international tourists, Turkey had a 21.7% increase in the number of tourists 2018 compared to 2017, while generating TL 142.4 billion in revenues, representing a 12% increase compared to the previous year.

According to border statistics, Russia is the largest tourist destination (13.0%), followed by Germany (9.8%), Bulgaria (5.2%), the UK (4.9%) and Georgia (4.5%). Domestic tourism activities are also increasing in Turkey. In 2018, 126.4 million trips were made, an increase of 4.6% compared to 2017. Of these trips, 78.5 million (62.1%) were overnight visitors, while 47.9 million were day visitors (37.9%). In the last 10 years before the pandemic (before 2020), the number of tourists, revenues and the share of tourism revenues in GDP have been increasing in Turkey.

Table 25: Tourism statistics in Turkey

Years [167]	TOURISM REVENUE ($)	AVERAGE TOURIST $)	REVENUE SHARE IN
2010	24.930.997	755	3,2
2011	28.115.692	778	3,4
2012	29.007.003	795	3,3
2013	32.308.991	824	3,4
2014	34.305.903	828	3,7
2015	31.464.777	756	3,7
2016	22.107.440	705	2,6
2017	26.283.656	681	3,1
2018	29.512.926	647	3,8
2019	34.520.332	666	4,6

Although Turkey started and maintains its claim in the tourism sector with sea-sand-sun tourismit aims to "increase the contribution of tourism to the economy by increasing the diversity and quality of tourism services" as a policy in forward-looking strategy documents [168]. In addition, diversification of tourism in line with increasing trends, increasing the length of the season, service quality, number of visitors with high spending tendency, length of stay and non-accommodation expenditures have been adopted as medium and long-term targets. In the Plan, tourism targets for 2023 are as follows

[166] https://turizmguncel.com/haber/turizmdeki-1-birimlik-gelisme-ekonomiye-2-birim-olarak-yansiyor-h18069.html
[167] TÜRSAB 2020. Distribution of Tourism Revenue, Average Expenditure by Years
Share of Tourism Revenues in GDP https://www.tursab.org.tr/istatistikler-icerik/turizm-geliri
[168] Presidency of the Republic of Turkey, Presidency of Strategy and Budget, 2019 "11th Development Plan 2019-2023"

revenues are targeted to increase to US$ 65 billion, the number of visitors to 75 million (67.7 million foreign visitors) and the average expenditure per visitor to US$ 867 from US$ 647 (2018). Among the types of tourism planned to be developed are gastronomy, golf, health, cruise, wedding, faith, congress and shopping, all of which generate higher revenues. The plan also states that land allocations for large-scale tourism investments will be made as a policy priority.

2.8.1. Assessment of the Impacts of Climate Change on Tourism Sector

Tourism is one of the sectors that will be most affected by climate change, as it includes a large number and variety of sub-sectors in its value chain and tourist satisfaction needs to be at the highest level due to competitive conditions. In addition, the tourism sector also contributes to the emission of greenhouse gas emissions that trigger climate change. Due to this two-way interaction, climate change adaptation activities in tourism are of great importance for the resilience of the sector risks. Globally, UNWTO publishes reports on climate change adaptation and mitigation in the sector to increase the resilience of the sector in the future, taking into account the views of stakeholders in the tourism value chain, guidance studies to strengthen the capacity to adapt to the impacts of climate change. Inaction on adaptation to the impacts of climate change in the tourism sector will lead to crises with much higher costs in the long run.

Considering that the main objective of the tourism sector is to increase the number of tourists and revenues by focusing on customer (tourist) satisfaction, it can be predicted that the sub-sectors in the second region (Activities During Travel) in the tourism value chain analysis given above will be the sectors that will be most affected and impacted by climate change. The following sub-sectors in this region are expected to be affected by the risk components (hazard, exposure and vulnerability) arising from climate change.

The sub-sectors in the tourism value chain focused on tourist satisfaction and their vulnerabilities are as follows
is provided:

Transport, travel, transportation; travel and transportation services are in a position to develop hazards, exposure and sensitivity to the negative impacts of climate change in all modes of transportation. It is known that meteorological events that change in intensity, frequency, type and duration with climate change have an impact on all modes of transportation, sometimes causing loss of life and property and sometimes causing dissatisfaction of tourists. In this regard, a wide variety of meteorological events and disasters such as flight cancellations and delays caused by visibility obstructing meteorological events such as fog and haze, road closures and floods caused by severe storms, hail, rain and snowfall cause hazards (damages) and negative impacts in the tourism travel, transportation and transportation sector.

Tour operations; tour organization and operations require tour companies to include tourists in their pre-prepared thematic or destination-based tour packages through promotion and marketing and to satisfy their customers at the highest level while providing the services included in the entire package. At this point, the impact of changing weather events caused by climate change emerges as an important factor for all actors and stages serving within the tour package. All activities planned to take place outdoors are likely to be exposed to and susceptible to extreme weather events and heat waves. Increasing frequency and severity of events such as the elderly being affected by guided outdoor excursions that require physical energy expenditure, and the increasing frequency of adverse events such as heat strokes will also affect this sub-sector.

Daily activity - organization; Sudden changes and extreme weather events are also effective in daily activities and outdoor organizations. Similar to those described above, it may be inevitable that risk factors may occur by developing exposure and sensitivity in all kinds of daily activity organizations.

Guiding services; Guiding services, which are a part of tour operations and daily activities, are extremely important in terms of tourist satisfaction as they are directly exposed to the effects of the atmosphere, especially outdoors, and are among the service branches that may be affected by climate change. It is clear that if tourism is negatively affected, this professional group will also be negatively affected. In the event that events such as extreme heat waves, adverse weather conditions that dominate the season and extreme meteorological events continue throughout the years, the disappearance of the dominant tourism types in destinations or their replacement by other types may cause guidance services to be negatively affected.

Accommodation; although the accommodation sector is less affected by climate change in terms of physical structure, except for some accommodation preferences, it can be considered that the conditions mentioned above for guidance services are also valid for this sector. Climate characteristics can have an enhancing effect on tourism activities in a destination as well as an inhibiting effect. In this case, changing tourist preferences due to the effects of changing climate variables eliminating the potential of the dominant tourism type will also affect the accommodation sector.

The food and beverage sector has the potential to be affected by climate change in two ways. The first one is that destinations may be less preferred due to the effects of climate change and the size of this sector in the tourism value chain may decrease. The second is that agricultural products that cannot be grown due to climate change cannot be offered to tourists as local products and gastronomic delicacies, and there may be difficulties in conducting tours such as tasting tours in accordance with their purpose.

The *souvenirs - local products*, souvenirs and local products sector is, above all, a vital sector for local people to earn income from tourism, to embrace tourism and to spread tourism revenues to the grassroots. However, a decrease in the number of tourists and income due to the risks that climate change brings with it for the tourism sector (such as a decrease in the number of tourists, loss of areas that will be a source of tourism) may also create exposure and sensitivity in the souvenirs and local products sector.

Cultural and tourism assets; the development of tourism activities in an area depends first and foremost on the value assets that can make that area a destination for any type of tourism. These assets are a range of natural and cultural commodities, from tangible and intangible cultural heritage to flora and fauna. In the tourism sector, one of the areas that climate change may affect the most is the natural and cultural assets that can serve as a source of tourism. Physical and mechanical deterioration of historical monuments and natural resources, such as acidic precipitation, strong winds, floods, extreme temperature differences, etc. will expose these sensitive assets that cause tourism development to extreme conditions. This will directly affect the number of tourists, satisfaction and income levels.

Promotion, marketing, branding; this sector will similarly be negatively affected by climate change as a whole. Although this sector is not a sector that directly serves tourist satisfaction, it estimated that this sector may also be negatively affected due to reasons such as reservation cancellations, decreases in customer loyalty, and decreases in the rate of recommendation due to complaints arising from disruptions in tourism activities and the inability to provide the promised service as a result of climate change. In general, revenue losses in the tourism sector will directly affect the promotion and marketing sector.

Support services; the sectors in the support services group are units that are not directly related to tourism, but serve the basic needs of both tourists and local people. These are service providers such as banking, internet, markets, hairdressers, etc. While these sectors are positively affected during the tourism season and when there are tourists in a destination, they may be negatively affected in terms of economic gain in case of tourist losses due to climate change.

The lowest level of vulnerability to climate change in the tourism sector in the world is in OECD countries located latitudes (North America and Europethe highest level of climate change vulnerability is in OECD countries located in the upper latitudes (North America and Europe);

- Countries with a high share of tourism in national GDP (GVA)
- It was found to be in regions where strong growth is expected in the tourism sector [169].

Globally and nationally (also in Turkey), the high socioeconomic contribution of the tourism sector is hampered by its vulnerability to climate change, and globally, the contribution of the tourism sector to the United Nations Sustainable Development Goals (UNSDGs) is hampered by climate change, and the emphasis on climate change in national tourism development and development plans should be strengthened.

2.8.2. Scope of Vulnerability and Risk Analysis

The interaction between tourism and climate requires strengthening the adaptive capacity of the sector to climate change risks. Infrastructure, human resources, service quality and, consequently, tourism revenues in the sub-sectors in the tourism value chain may be exposed and sensitive to the impacts of climate change and may harbor risks. The adaptation of Turkey's tourism sector to climate change will make it much more competitive on a global scale. This is possible through adaptation actions to be developed with the participation of all parties in the value chain of the sector. In order to have an idea about the level of impact of various types of tourism on climate change, it is necessary to address the intersection of the components (Human ResourcesInfrastructure/Resources, Service Quality, Loyalty/Recommendation, Tourism Revenue) and the risk components of hazard, exposure and vulnerability, which are suitable for the goals of increasing customer satisfaction, number of tourists and tourism revenues that tourism aims as a holistic sector.

Table 26: Intersection of risk components and customer satisfaction components

Risk Components			**Vulnerability**		
Tourism Types	**Danger**	**Exposure**	**Sensitivity**	**Adaptive Capacity**	**Risk**
Culture - Faith tourism	2	2	2	2	2
Sea - sand - sun tourism	1,2	1,2,3,4,5	1,2	1,2	4,5
Winter and mountain tourism	1,2	1,2,3,4,5	1,2	1,2	4,5
Health - medical - thermal	2	1,2,3,4,5	2	2	5
Nature and adventure sports tourism	2	1,2,3,4,5	2	2	4,5
City tourism	1,2	1,2,3,4,5	1,2	1,2	3,4,5
travel (MICE)	2	1,2,3,4,5	2	1,2	3,4,5
Interest tourism and creative tourism (gastronomy, etc.)	1,2	1,2,3,4,5	1,2	1,2	3,4,5
Eco-tourism activities	1,2	1,2,3,4,5	1,2	1,2	3,4,5
Agro - rural tourism activities	2	1,2,3,4,5	2	1,2	3,4,5
Tourist Satisfaction	**1**	**2**	**3**	**4**	**5**
	Human Resources	Infrastructure/ Source	Service Quality	Commitment/ Recommendation	Tourism Revenue

[169] Scott, D., C. M. Hall and S. Gössling (2019). Global tourism vulnerability to climate change. Annals of Tourism Research, 77: 49-61, https://doi.org/10.1016/j.annals.2019.05.007

Culture - faith tourism is considered to be an activity centered around tangible and intangible cultural assets, with visitors coming to see and experience these assets. Although it plays a complementary role by integrating with other types of tourism, it is considered more as a separate tourism activity. Within culture and faith tourism, the resource values (such as historical and cultural buildings) that enable this tourism come first among the areas that will be exposed to climate hazards. Damage and destruction of historical buildings in the face of different meteorological events and weather conditions (such as high winds, rainfall, air pollution, acid rain) are common and expected to increase in frequency in the future. In addition, visitors to these structures, especially in urban centers and built environments, may be exposed to heat stress caused by the urban heat island, visitors may experience health problems during periods of heat waves, and organizations may not be completed or customer satisfaction may decrease. The loss of tourism income caused by such disruptions and the destruction of visited places and structures will lead to a decrease in human resources and service quality in the entire value chain of the sector.

Sea - sand - sun tourism is a type of tourism that uses the sea, which is potentially a natural resource, the coast, the suitable climate and the physical infrastructure (accommodation, food and beverage structures) created on the basis of these, and visitors travel for recreation and entertainment. The dangerexposure and sensitivity to the effects of climate change on this type of tourism is the loss of the characteristics of natural assets, which are primarily potential. For example, the loss of suitable characteristics of the seas (salinity, alien species invasion, rising levels, increase in water temperatures, etc.) and the measures to remedy this may lead to additional economic losses. In this type of tourism, the thermal comfort level, which is seen to be suitable especially in the current tourism season, may show negative characteristics in the projection periods, which may cause extensions at the beginning and end of the season, but may cause fragmentation due to thermally uncomfortable (temperature stress dominated) periods in the middle of the season. In this case, with the creation of tourism infrastructure in new areas, both the transformation of natural areas and the idleness of existing facilities may cause shifts in tourism periods, decreases in tourist satisfaction and loss of tourists and income in destinations.

Winter and mountain tourism is a type of tourism where the potential created by climatic conditions and topographical features form a source. Its most important feature is that it is carried out with a surface structure and equipment that allows people to move at a certain speed by utilizing the snow cover accumulated on the ground. Two important elements here are the presence of snow cover on the ground and the presence of a facility infrastructure that will take skiers to higher elevations. In this type of tourism, the hazards that will occur due to climate change can increase the exposure and sensitivity of the sector, and the levels can be quite high in this type of tourism. According to the results obtained from climate projections, changes in temperature and precipitation regime will affect the thickness and duration of snow cover on the ground number of days with snow cover, reducing the number of days suitable for skiing, while new infrastructures and additional expenditures will be required to realize snow-guaranteed tourism with artificial snowmaking systems (such as snow storage). As the temperature rises, the snow cover level will be pushed to higher and higher elevations, requiring more investment in chairlift infrastructure. When snow conditions are not favorable, it is likely that customer satisfaction will decrease, the destination will be less preferred, and as a result, revenue and jobs will be lost.

Health - medical - thermal tourism, health tourism is the travel of individuals to places other than where they reside in order to receive preventive, therapeutic, rehabilitative and health-promoting services. The Department of Health Tourism of the Ministry of Health categorizes health tourism under three main headings. These are; Advanced Age and Disability Tourism, Thermal Health and SPA-Wellness Tourism and Medical Tourism. Turkey aims to develop health tourism as a policy in the 11th Development Plan. For this purpose, large investments are being made, especially in hospital infrastructure. Climate hazards due climate change will negatively affect health tourism in terms of hazards, exposures and

It has the potential to increase the risk by creating sensitivity. In terms of advanced age and disability tourism, which are among the components of health tourism, the extreme weather conditions brought by climate change will affect the normal health conditions and daily lives of individuals defined as tourists in this sector, which may higher care costs, higher expenses and higher wage demands. Especially in the elderly, the impact of heat waves much higher and even fatal. Therefore, it is clear that keeping both customer satisfaction and the number of tourists high in this sub-branch will require additional infrastructure investments and costs. In terms of thermal health and SPA - wellness, it is clear that this type of tourism will be forced to change in some destinations if climate change and changing rainfall regimes have an impact on these resources. As for hospital tourism, the fact that the infrastructure created will have to be used at full capacity by the local population due to diseases that arise directly or indirectly due to climate change poses a risk for medical tourism. Similarly, the change in personal priorities due to climate change in the regions with the highest number of tourists may lead to a decrease in the number of tourists coming for aesthetic surgery and hair transplantation.

Nature and adventure sports tourism is a type of tourism based on natural resource potentials arising from water resources and geographical features. This type of tourism, which has a wide target group and does not require as much infrastructure investment as other types of tourism, is important in terms of localizing the effects of tourism. Since climate change will affect water resources, flora and fauna, which are potential for this type of tourism, it will cause a decrease in the number of tourists and the satisfaction of tourists who cannot find what they expect. Again, changing weather conditions, extreme events (sudden heavy rains, lightning, etc.) may directly affect the tourists who carry out this tourism activity outdoors, and there may be a decrease in the number of tourists with increasing extreme events.

Urban tourism and business travel (MICE); travel for meetings, incentives, congresses and training purposes; and the tourism type called urban tourism, which is centered on the attractions in urban centers, are together in terms of exposure and sensitivity to climate change since they have similar activities and tourist types. In both of these tourism types, the suffocating effect of the urban environment and thermally uncomfortable environments may become more uncomfortable with climate change and the duration of these periods may be extended. Damage to the tourism values and infrastructure that provide these opportunities, and the impact of severe weather events on the enjoyment of the activities can also be considered as risks that may arise for these types of tourism.

Although *interest tourism and creative tourism* are considered as a sub-branch of cultural tourism, they are handled separately because they are practiced differently. In this type of tourism, which is based on experiencing local cultural assets, including gastronomy, tourists a learning process. In this type of tourism, the risks brought by climate change may be related to this learning and experiencing process. Here, the loss of local values due to climate change (such as the disappearance of a product that is grown, collected from nature or produced) is one of the most important risks in this type of tourism. In addition, another risk factor may be that the human resources engaged in these activities may leave such traditional occupations due to lack of earnings.

Eco-agro (rural) tourism is considered together in terms of climate change since these activities have similar contents and levels of impact. It is a type of tourism that involves tourists in activities such as agricultural production, which is not intensive in rural areas but includes regular tourism activities. In this type of tourism, visitors, especially young people, seek local flavors integrated with nature. The possible impact of climate change on this type of tourism depends on the impact on local people engaged in production and the increase in the severity of weather events. In this case, the conditions that will increase tourist satisfaction will be eliminated.

2.8.3. Key Stakeholders

In the development and implementation of action plans for the adaptation of the tourism sector to climate change, there is a need for effective stakeholders who can contribute to the provision and collection of data, provide institutional opinions while developing action plans, play a role in the promotion of adaptation actions and raising awareness on this issue, and an active role in the implementation of projects and activities included in the adaptation action. In categorizing these stakeholders, an approach based on the stages in the value chain of the tourism sector has been adopted. Accordingly, the pre-travel stage focuses on stakeholders whose functions are generally related to tourism promotion, while the second stage, during travel, the transportation, accommodation, food & beverage, creative industries, tourism assets, leisure and day-trippers, and support services sub-sectors. The final stage, post-travel, includes stakeholders related to quality and feedback.

Accordingly, stakeholders who can take part in adaptation actions against climate change in accordance with the above description and who have primary or secondary functions in the value chain related to promotion before travel are the Association of Turkish Travel Agencies (TÜRSAB) representing travel agencies, airline companies that promote the countries they travel to, business people and associations that support tourism promotion with the products they produce (TÜSİAD, MÜSİAD, TÜMSİAD, etc.).The Ministry of Culture and Tourism, the Turkish Tourism Promotion and Development Agency and Development Agencies, and tourism journalists, writers and associations that cover all aspects of the tourism sector, including promotion, can also be among the stakeholders.

In the second stage, during travel, stakeholders include public institutions, private sector associations and local governments involved in tourism transportation, as well as NGOs and associations of chambers belonging to touristic operators and investors in the accommodation, food and beverage and creative industries sectors. Local governments and the ministries with primary responsibility, such as the Ministry of Environment and Urbanization, the Ministry of Agriculture and Forestry, and the Ministry of Culture and Tourism, are likely to be stakeholders in the protection of tourism assets and the provision of tourism services. For leisure and day-trippers, local and national guide associations, transportation cooperatives and local governments are in a position to contribute. Support services are the most comprehensive part of the tourism value chain and involve a wide range of actors. However, institutions and organizations directly responsible for secondary services can be considered stakeholders in this area.

The relevant presidencies under the Presidency (such as the Presidency of Strategy and Budget), international organizations and funds (MDBs) should also be included as stakeholders to ensure that climate change adaptation action is included in official strategies and financed.

The main stakeholders are decision-making institutions and financing institutions. Relevant presidencies under the Presidency (such as the Presidency of Strategy and Budget), international organizations, and development funds that provide financing are also important stakeholders. Stakeholders categorized according to the value chain are listed below.

1. **Pre-travel Promotion**
   - Travel Agencies and Tour Operators,
   - TÜRSAB
   - Airline Companies
   - Brand Products (People Associations)
   - Ministry of Culture and Tourism
   - Turkey Tourism Promotion and Development Agency
   - Development Agencies
   - Tourism journalists and writers, associations

2. **During Travel**
   - Transportation Airline Companies, TCDD TÜRSAB, Municipalities, Transportation Cooperatives
   - Accommodation: Associations and federations related to accommodation; TTYD, TUROB, TÜROFED, ATİDAKTOB
     like, TOBB
   - Food and BeverageAssociations of touristic enterprisesChambers of Commerce and IndustryChambers of Tradesmen and Craftsmen
     Unions
   - Creative Industries: Associations of local souvenir producers, Chambers of Commerce and Industry, Municipalities
   - Tourism Assets: Ministry of Culture and Tourism, Ministry of Environment and Urbanization, Ministry of Agriculture and Forestry, General Directorate of Foundations, Municipalities, Governorships
   - Entertainment and day-trippers: Tour guide associations, Transportation Cooperatives, Municipalities
   - Support Services: Ministry of Trade, Ministry of Transport and Infrastructure, Ministry of Health
3. **After Travel**
   - Quality Assurance: Booking websites, Review websites, TurkStatMinistry of Culture and Tourism

2.8.4. Sectoral Indicators

In the process of developing a set of indicators to be used in the monitoring and evaluation of actions to be taken to adapt the tourism sector to climate change, it will be important to have data covering the second stage of the value chain diagram for the tourism sector (the value chain during travel) in order to examine vulnerability in more detail. It is necessary to identify indicators covering the transportation, accommodation, food & beverage, creative industries, tourism assets, leisure and day-trippers, and support services sub-sectors.

In general, the hazard indicators to be used for vulnerability and risk analysis of the tourism sector are similar to other sectors. In regions where GDP and employment are based on tourism, climate hazards need to be analyzed accurately. Indicators such as changes in the number of overnight stays in accommodation facilities, snow cover height for winter sports, and bathing water quality can show the sensitivity to hazards. Natural and cultural assets in climate threatened regions may also stand out as sensitivity indicators.

2.9. Transportation-Communication

2.9.1. Assessment of the Impacts of Climate Change on Transportation - Communication Sectors

The transportation and communication sectors are among the most vulnerable sectors to the hazards of climate change. When assessing the impacts of climate change on the sector, it is necessary to consider both the impacts on **infrastructure** and the impacts on transportation and communication **activities**namely passenger and freight transportation and data transmission. Due to the dangers posed by climate change, damages and losses in transportation and communication infrastructures as well as disruption of transportation and communication activities have the effect of disrupting all economic and social activities, education services, health and emergency services. This situation concerns the national economy, the sustainability of economic and social activities, individuals' incomes and access to social services, and thus all economic and social development issues. In addition to these comprehensive impacts, it should not be forgotten that climate change hazards and the infrastructure damage they cause can create serious traffic safety problems and threaten public health in this respect.

Therefore, it is of utmost importance to improve adaptation capacity, preparedness and resilience to the impacts of climate change in the transportation and communication sectors, which have a significant impact on the national economy, social activities and development processes.

Climate change hazards affecting the transportation and communication sectors can be listed as follows:

- Floods and floods caused by excessive and heavy rainfall
- Sea level rise
- Rising temperatures and heat waves
- Drought
- Extreme weather events (storms, tornadoes, etc.)

These climate signals and hazards affect transportation and communication infrastructures and activities differently in each of the sub-sectors. These impacts, which are described in detail in various sources [170] [171] [172]), are discussed for each sub-sector below.

For example, the impacts of these climate change hazards **on highways** can be summarized as follows:

- Extreme and heavy rains cause flooding on highways, inundation of tunnels, landslides, collapse of bridges, and damage to rural and dirt roads with limited drainage, resulting in loss of carrying capacity and disruptions in transportation activities. These developments also cause permanent damage, increase the rate at which infrastructure wears out and hence maintenance costs, and reduce the lifespan of infrastructure.
- As a result of sea level rise, flooding and inundation of the highway infrastructure in coastal areas is experienced, and the deformation caused by this affects the infrastructure or causes permanent loss of the infrastructure. Even if sea level rise occurs in a limited area, transportation infrastructures are a network system, it has a negative impact on the functioning of the entire road network and causes disruption of transportation.
- Increasing temperatures and heat waves lead to deformation of highways, melting of asphalt, expansion of bridge pavements and deterioration of materials.

[170] Arkel, B.P. & Darch, G.J.C (2006) Impact of Climate Change on London's Transport Network. Proceedings of the Institution of Civil Engineers, *Municipal Engineer*, 159, 231-237.
[171] Markolf, S.A., Hoehne, C., Fraser, A., Chester, M.V. & Underwood, B.S. (2019) Transportation Resilience to Climate Change and Extreme Weather Events - Beyond Risk and Robustness. *Transport Policy*, 74, 174-186.
[172] Vajjarapu, H., Verma, A., & Allirani, H. (2020) Evaluating Climate Change Adaptation Policies for Urban Transportation in India. *International Journal of Disaster Risk Reduction*, 47, 1-20.

- As a result of drought and reduced moisture in the soil, road safety problems arise due to increased dust and sand on highways. In addition, excessive rainfall after periods of drought leads to landslides, subsidence and deterioration of road foundations, resulting in permanent infrastructure damage, serious disruptions in transportation and traffic safety risks.
- Extreme weather conditions, especially when the effect of increasing storms and power outages are taken into account, cause lighting problems on highways, damage to signage and signaling, safety problems with difficult access conditions on structures such as bridges and viaducts, as well as disruptions in transportation and safety problems due to falling trees.

In railways, these hazards created by climate change also have impacts on infrastructure and transportation:

- As a result of excessive and heavy rainfall, railways are also affected by floods; flooding in underground tunnels, landslides, collapse of bridges, loss of carrying capacity and disruptions in transportation activities. In addition, signaling problems are also experienced during extreme and heavy rains, and various safety issues arise, such as the inability to detect the presence of trains on the track. As in the case of highways, these developments cause permanent damage to railways, increasing the rate of wear and tear of infrastructure and thus maintenance costs, and reducing the lifespan of the infrastructure.
- Sea level rise can also cause flooding and inundation of railway infrastructure located in coastal areas, which can lead to permanent loss of infrastructure. To emphasize again, since transportation infrastructures are a network system, even if sea level rise occurs in a limited area, this danger has a negative impact on the functioning of the entire railway network, leading to disruption of transportation.
- As a result of the increase in temperatures and heat waves, railroad tracks are subject to buckling, expansion, safety problems and disruptions. In addition, passenger health risks caused by extremely hot weather on trains are among the important impacts.
- In case of drought, landslides and collapses may occur on railways as a result of excessive precipitation from time to time with this climatic event. can lead to permanent infrastructure damage, serious disruptions in transportation and traffic safety risks.
- Extreme weather conditions and storms, as well as lightning strikes, can cause power outages and disrupt rail operations. The effect of power outages also causes lighting problems, damage to signage and signaling on railways as well as on highways. In addition, during weather events such as storms, transportation disruptions and safety issues may occur due to fallen trees, and rail safety issues may occur due to the density of fallen leaves.

Climate change hazards also significant impacts on **maritime** and **waterways**:

- The reduction of under-bridge gaps in waterways as a result of excessive and heavy rainfall is an important issue that disrupts transportation and poses a safety threat. An increase in silt deposits also adversely affects transportation. Excessive rainfall also changes the water flow in canals and rivers, causing serious disruptions in transportation.
- Flooding and inundation can also occur in port infrastructures as a result of sea level rise, which can lead to permanent loss of infrastructure. Rising sea levels also affect canal and river transportation, causing disruptions in transportation services and damage to infrastructure.
- The increase in temperatures and the increase in aquatic vegetation as a result of heat waves and related blockages and disruptions have a negative impact on river and canal transportation.

- Drought results in reduced water availability and disruptions in canal and river transportation.
- Extreme weather conditions also adversely affect shipping and transportation. Increasing storms damage ports and waterways; fallen leaves and other debris block canals and riverways, causing transportation disruptions and safety problems.

In airlines, the dangers posed by climate change also affect infrastructure and transportation in this sub-sector. :

- As a result of excessive and heavy rainfall, floods and overflows may occur in airport infrastructure areas (terminal, runway, etc.) and ground collapse may occur. In addition, excessive rainfall can also cause flooding problems in the underground technical infrastructure (such as electricity infrastructure, sewerage) at airports and disrupt operations. Disruptions in local electricity supply in the region where airports are located, as well as disruptions in road and rail connections to the airport due to flooding and flooding, also have a negative impact on air transportation.
- As a result of sea level rise, flooding and inundation of airport infrastructures (terminals, runways, etc.) occur; temporary or permanent capacity loss occurs; and permanent damage and deformation occur in the infrastructure. In addition, disruptions in road and rail system connections that provide access to the airport as a result of floods and floods cause disruptions in air transportation.
- Increasing temperatures and heat waves lead to a decrease airplane performance and a corresponding increase in noise impact. In addition, rising temperatures increase the need for cooling and affect costs. Another effect of temperatures is damage such as deformation and melting on the runway at airports. These not only disrupt operations but also create security problems.
- As can be expected, extreme weather events and increased storms in this context have a serious impact on airlines. Disruptions service and route changes as a result of such climatic events, disruptions in local electricity supply in the region where airports are located, as well as disruptions in access to road and rail connections to the airport due to flooding and flooding also have a negative impact on airline transportation.
- Disruptions and route changes due to convective air as a result of changes in wind characteristics and increase in turbulence intensity and number are also important impacts for airline transportation. Changes in local wind patterns can also cause disruptions in operations.

While evaluating the components of the transportation sector, it is necessary to address the issue separately under the title of **urban transportation**. Urban transportation, which has its own unique dynamics, conditions and different components, is of particular importance due to the high and constantly increasing population level living in cities. Pedestrian and bicycle transportation, which should be taken into consideration within the scope of urban transportation, may be out of scope when only the four sub-sectors listed above are evaluated. Therefore, the impacts of climate change hazards on urban transportation are evaluated separately:

- Excessive and heavy rainfall can cause flooding on motor vehicle roads, bicycle paths, pedestrian paths and rail systems; tunnels, underpasses and multi-level intersections used by motor vehicles, bicycles and pedestrians can be flooded. The problem of bridges being washed away also poses risk both for the connections used by motor vehicles and for bicycle and pedestrian bridges. In addition, landslides by rainfall negatively affect all urban transportation systems and accessibility. In addition, excessive and heavy rainfall in cities causes sewerage systems to overflow, which increases the risk of flooding and flooding and their impacts listed above, and poses health risks. All these impacts have an impact on urban transportation infrastructures.

permanent damage; increase the rate at which infrastructure wears out and maintenance costs; and reduce the lifespan of infrastructure. These impacts pose life-threatening and health risks, as well as traffic safety risks.

- As a result of sea level rise, coastal cities may experience flooding and inundation of vehicular roads, bicycle and pedestrian paths, underground and aboveground routes of rail system lines, and passenger piers; the deformation caused by these events may affect the infrastructure or cause permanent loss of infrastructure. As mentioned earlier, transportation infrastructures are a network system, even if sea level rise is effective in a limited area of the city, it has a negative impact on the functioning of the entire urban transportation network, causing serious disruption of accessibility.
- Rising temperatures and heat waves create serious safety risks in terms of deformation of vehicular and pedestrian roads, melting of asphalt, deterioration of materials, deformation of urban rail tracks, and so on. In addition, the health risks associated with reduced comfort conditions in public transportation (especially underground networks) due to extreme heat are significant. Similarly, extreme heat and heat waves pose serious health risks for pedestrians and cyclists.
- As a result of drought and decreased soil moisture, road safety problems arise due to increased dust and sand. In addition, excessive rainfall after periods of drought leads to landslides, subsidence and deterioration of road foundations, resulting in permanent infrastructure damage, disruptions in urban transportation and traffic safety risks.
- Extreme weather conditions, especially increased storms and power outages, cause lighting problems on roads, pedestrian and bicycle paths, and damage to signage and signaling. These developments also cause service disruptions in urban rail systems. In addition, structures such as bridges and viaducts, which are used for all types of transportation in cities, are experiencing security problems due to difficult access conditions. In addition to these, road closures due to fallen trees and the unusability of parked vehicles disrupt transportation and access, and pose a serious security risk. The leaf density caused by such extreme weather events can also create safety problems on the rails of urban rail systems on the surface.

Finally, the impacts of climate change hazards **on communication infrastructures and activities** can be summarized as follows:

- Extreme and heavy rainfall damages the underground infrastructure and facilities of communication systems. In addition, erosion and flooding caused by heavy rains can expose underground cables and systems as a result of damage to transportation infrastructures. These developments cause permanent damage, increase the rate of wear and tear of infrastructures and hence maintenance costs, and reduce the lifespan of the infrastructure. In addition, the inability to receive transmitted signals during heavy rains is also an important problem that disrupts communication.
- Permanent loss of communication infrastructures in coastal areas is also possible as a result of sea level rise. In addition, even in cases where there is no permanent loss, salt water damages infrastructures; damages occur; the wear rate and maintenance costs of infrastructures increase and the lifetime of the infrastructure decreases.
- As a result of rising temperatures and heat waves, additional load is created to cool the equipment in power plants and base stations. Increased failure rates during these periods disrupt communication and to a reduction in the lifetime of infrastructures. Rising temperatures also mean an increase in the risk of fire, which of course causes permanent damage to communication infrastructures and disrupts communication.
- In drought conditions, landslides and collapses occur with excessive rainfall after periods of drought, exposing and damaging underground communication infrastructures.

- In extreme weather conditions, especially as a result of increasing storms, damage to the above-ground transmission infrastructure occurs and disruptions in communication are experienced as a result of power outages.

The comprehensive assessment given above in terms of the transportation and communication sectors and the components of the sector reveals the dangers posed by climate change and the risks for the transportation and communication sectors. In this framework, when an assessment is made regarding the assets that will be most **exposed to** the impacts and risks listed above, it first be noted that all transportation and communication infrastructures located in flood and flood zones, as well as those located in areas where sea levels are rising, have a high degree of **exposure**. On the other hand, seen in the above assessments, it is clear that infrastructures are likely to be exposed to such flood and flood disasters in every region due to extreme rainfall even if they are not located in flood and flood zones. Similarly, although the issue of exposure is particularly prominent in terms of cities and populations located in flood and flood zones, it is known that the effects of extreme rainfall are experienced in every city, depending on factors such as sewerage and storm water infrastructure capacity.

It is also evident from the assessments given above **that** transportation and communication infrastructures and activities **are exposed to multiple climate hazards**. Heavy rains, sea level rise, heat waves, as well as extreme weather events adversely affect and damage all transportation and communication infrastructures, severely disrupting transportation, accessibility and communication.

It also be noted **that** all individuals, i.e. **the entire population, are exposed to** both damage to infrastructure and disruptions in transportation, accessibility and communication. When it comes to the transportation sector, indirect impacts as well as direct impacts on transportation infrastructure are also an important issue [173]. It should not be forgotten that the need to travel applies to almost all economic and social activities of individuals. In other words, reductions in the capacity to travel and disruptions in access may affect individuals' livelihood and working conditions, limit their ability to access education, health and cultural services, and even negatively affect **public health** by limiting the accessibility of emergency services. Add to this the damage and disruption to the communications sector, and it becomes clear that **all economic and social activities may be exposed to these hazards and impacts**.

In line with this assessment, it is of course understood that **the national economy** is also an asset that needs to be addressed within the scope of exposure. Problems and disruptions in all economic and social activities as a result of damages and service disruptions in the transportation and communication sectors will of course negatively affect the national economy. In addition, it should not be forgotten that transportation and communication infrastructures are extremely **costly investments** and include structures (such as bridges, tunnels, railways, highways, ports, airports, airports, metro and similar rail systems) **that are planned to be used for long periods of time**. **A reduction in the lifetime of** these structures or **permanent loss of infrastructure** means a major economic loss, which has a significant impact on the national economy [174].

Considering the assets that will be most **susceptible** to the impacts of climate change hazards as a result of these exposures, it should once again be noted that all sub-sector infrastructures, namely road, railway, marine/waterway, airway, urban infrastructures and communication infrastructures are highly susceptible. However, **cities** and **urban infrastructures** are also highly vulnerable due to their population density and the concentration of social and economic activities that create travel and access requirements.

[173] Markolf, S.A., Hoehne, C., Fraser, A., Chester, M.V. & Underwood, B.S. (2019) Transportation Resilience to Climate Change and Extreme Weather Events - Beyond Risk and Robustness. *Transport Policy*, 74, 174-186.
[174] Eisenack K., Stecker, R., Reckien, D. & Hoffmann, E. (2011) Adaptation to Climate Change in the Transport Sector: A Review of Actions and Actors. Mitigation and Adaptation Strategies for Global Change, 17, 451-469.

transportation emerges as the most sensitive systems [175]. Cities are also places where the natural surface has been transformed into asphalt and built environment through construction processes; and therefore, they are both places where temperature levels (in line with the heat island effect) are relatively high and the effects of heat waves are experienced more intensely; and where there is relatively little natural surface where water can be absorbed during extreme and heavy rainfall. In case of inadequate capacity of sewerage and storm water infrastructures in cities, flood and flood impacts increase exponentially. In this context, the issue of vulnerability is important for all cities, but for coastal cities, the degree of vulnerability increases when the effects of rising sea levels are taken into account.

The degree of sensitivity is of course also related **to the quality of the infrastructure**. Infrastructure investments made with relatively better quality materials and technologies, or infrastructures with high resilience as a result of certain measures, may be relatively less susceptible to climate change hazards and impacts, even though they are exposed to climate change hazards and impacts. , road surfaces made of materials that are problematic in terms of temperature resistance, road surfaces that are problematic in terms of flooding and flooding, roads or ports built on filled areas on the sea, roads built on rivers and streams by closing them significantly increase the degree of sensitivity. Therefore, the quality of infrastructure is a factor affecting vulnerability. Here, both the quality of transportation and communication infrastructures should be taken into consideration, and the capacity and quality of sewerage and storm water infrastructures should be evaluated, as mentioned above in relation to urban transportation.

In addition to the quality of infrastructure in the transportation and communication sectors**, the intensity of use** is also an important factor. For example, the fact that 90% of freight and passenger transportation in Turkey is carried out **on highways** increases the sensitivity in this sub-sector. This is because disruptions in transportation as a result of damages and impacts on road infrastructure will have an impact on relatively more people and products across transportation, and thus the potential for serious access disruptions and socio-economic impacts. In addition, the that multi-modal transportation infrastructure has not yet been implemented across the country shows that alternative mode choices may not be feasible in the face of road disruptions. In fact, strategies such as encouraging multi-modal transportation in our country, developing infrastructure networks in this direction and ensuring integration between different modes, planning logistics centers for freight transportation for this purpose, and increasing transshipment opportunities for passenger transportation are included in many policy documents (Development Plans, Transportation Councils, Transportation Master Plan Strategy, Climate Change Action Plan, etc.). However, an infrastructure and operating system that provides such alternatives, flexibility and interchange has not yet been realized.

Although transportation infrastructures are in place to enable multi-modal transportation, it should be noted that for some long-distance journeys, alternatives to one mode of transportation are limited. This is the case for long-distance air travel. It is known that for **airline** journeys up to a distance of 600 km, high-speed railway systems can be an effective alternative if they are located on the same route. However, for journeys over 600 km, it is not possible to provide the speed advantage of the airline with another type. For this reason, the level of sensitivity is high in air transportation, which is disrupted during extreme weather events and heavy rainfall. Similarly, in geographies that require the use or crossing of a water body, the sensitivity of **sea and waterway** transportation is also high in the face of extreme weather conditions and storms.

While almost all populations and individuals are exposed to the impacts of climate change hazards in the transportation sectorit**most vulnerable segments of society**i.e. access, who are most susceptible

[175] Carter, Jeremy G., Cavan, G., Connelly, A., Guy, S., Handley, J. & Kazmierczak, A. (2015) Climate change and the City: Building Capacity for Urban Adaptation. Progress in Planning, 95, 1-66.

are those with limited opportunities and alternatives [176] [177]. These vulnerable users include people with reduced mobility, the elderly, children, parents with children or prams and low-income people. For these people, access opportunities may be limited. For example, in the face of climate hazard impacts, they have limited freedom and opportunity to abandon one mode of transportation in favor of another. They may not have alternatives other than public transportation or walking. Therefore, for these vulnerable groups, a decrease in accessibility may have significant economic impacts, and may also have the impact of not being able to receive or access services in the fields of education and health. In to these, the elderly among this vulnerable group will have both reduced accessibility and increased health risks in the face of increasing heat and hot weather conditions.

Climate change hazards, their impacts on the sector, exposure and sensitivity to these hazards and impacts can be visualized with impact chains (Figure 5-6).

For example, when considering climate change hazards such as extreme heavy rainfall and the resulting flooding and inundation impacts, it is highlighted that all transport infrastructure, transport activities, all individuals and populations, especially cities and urban transport systems, are exposed to these impacts. Examples of factors that determine the level of vulnerability of these exposed entities (systems and users) include the quality of transport infrastructure, as well as the capacity and quality of infrastructure systems such as sewers and stormwater, the number or proportion of vulnerable users, and the location of emergency service points. This emphasis on location suggests that in the event of flooding and inundation, planning for the location of emergency services should be reviewed, particularly if in an affected area. Indeed, such implications are included in the column on adaptive capacity. In addition to emergency services planning, planning for green infrastructures and green spaces is also highlighted. It is well known that in the event of floods and inundation, green spaces and green infrastructure areas in buildings (e.g. green roofs) can absorb some of the rainfall and reduce the severity of flooding. Within the scope of adaptive capacity, improving the quality of infrastructures to increase resilience, as well as taking physical infrastructure measures against flooding and flooding (presence and strengthening of infrastructure components such as culverts and retaining walls) are also given as examples. In addition to these, diversity of modes of transportation, diversity of routes, i.e. multi-modal transportation opportunities are also listed among the factors that can ensure adaptation. When all these factors are examined together, it is possible to assess the main risks that the impacts of the climate signal in question may create as traffic safety, economic losses due to damages in infrastructure and disruptions in access, disruptions in social service provision and in this context, for example, disruptions in emergency service accessibility and public health risks. A similar impact chain is given in the related graphic for extreme weather events.

2.9.2. Scope of Vulnerability and Risk Analysis

Vulnerability and risk analysis in the transport and communications sectors should address both **impacts to infrastructure** and **impacts to** freight, passenger and data transportation **activities**. Impacts from climate change hazards can cause significant damage to infrastructure and temporary or permanent loss of infrastructure, and it is important to identify such exposures. However, it is also possible for transportation and communications to be disrupted, accessibility to be affected, and economic and social activities to suffer as a result, even without any damage to infrastructure. The scope of the assessment should therefore include both the impact and damage to infrastructure and the disruption to access, transportation and communication, both as a result of this impact and damage to infrastructure and during the impacts of climate change.

[176] Anguelovski, I., Chu, E. & Carmin J. (2014) Variations in Approaches to Urban Climate Adaptation: Experiences and Experimentation from the Global South. Global Environmental Change, 27, 156-167.
[177] Reckien, D., Creutzig, F., Fernandez, B., Lwasa, S., Tovar-Restrepo, M., Mcevoy, D. & Satterthwaite,D. (2017) Climate Change, Equity and the Sustainable Development Goals: An Urban Perspective. Environment and Urbanization, 29 (1), 159-182.

In addition, as mentioned in the previous section, vulnerability and risk analysis in the transportation and communication sectors
should be addressed in a way that includes all sub-sectors:

- Highways
- Railways
- Sea/waterways
- Airlines
- Urban transportation:
  - Pedestrian
  - Cycling
  - Public transportation (road, rail, water)
  - Automobile
- Communication/communication

each sub-sector, it is necessary to identify risks, examine exposure factors and sensitivity levels, and make assessments to develop adaptive capacity. However, it is also necessary to assess the sub-sectors of the transportation sector in an integrated manner with a systems approach. In this context, it be possible to examine issues such as intermodal integration, multi-modal transportation, flexibilities and alternative possibilities in infrastructure and transportation, as well as possibilities such as emergency management and travel demand management at national and urban level. While these relationships between sub-sectors will enable alternatives in accessibility and flexibility in the face of hazards[178], they will also enable an assessment of the indirect impacts of sectors on each other. For example, considering the possible impact of transportation infrastructure damages on communication infrastructures, as well as the significant effects of the impacts experienced in the communication sector on transportation traffic management, air traffic control, signaling, real-time monitoring and information systems, etc., the importance of both examining the sectors separately and addressing them with an integrated approach is understood.

2.9.3. Key Stakeholders

There are many stakeholders at national and local level that need engaged in strengthening climate change adaptation action in the Transport and Communications sectors. The main ones are listed below:

- Ministry of Transportation and Infrastructure: Relevant General Directorates and Departments
- Ministry of Environment and Urbanization
- Ministry of Industry and Technology
- Ministry of Health
- Ministry of Energy and Natural Resources
- Ministry of Culture and Tourism
- Ministry of Interior: General Directorate of Security, Coast Guard Command, Disaster and Emergency Management Presidency, Security and Emergency Situations Coordination Center, especially in relation to transportation and traffic)
- Ministry of Agriculture and Forestry: General Directorate of State Hydraulic Works, General Directorate of Meteorology
- Municipalities
- Governorships and Provincial Directorates of Security
- Ministry of Transport and Infrastructure (and other relevant Ministries) Provincial Directorates

[178] Eisenack K., Stecker, R., Reckien, D. & Hoffmann, E. (2011) Adaptation to Climate Change in the Transport Sector: A Review of Actions and Actors. Mitigation and Adaptation Strategies for Global Change, 17, 451-469.

- Development Agencies
- Universities and research centers
- TMMOB and related professional chambers
- Turkish Industrialists and Businessmen's Association
- Private sector representatives: passenger transportation, freight forwarding and logistics services
- Foundations and associations (issues such as environment, nature, disasters and individuals with mobility limitations,
  cyclists, etc. platforms and associations)
- Experts
- Every section of the population.

2.9.4. Sectoral Indicators

It would be useful to consider indicators for the Transport and Communication Sector at both national and urban and local levels.

At the **national** level, both as indicators of exposure, sensitivity and adaptive capacity, the following examples can be given:

- National Transportation Plan and climate change adaptation strategies in this plan
- National transportation emergency action and management plans, e.g. flood management plans
- National communication emergency action and management plans
- Amount/proportion of infrastructure that will be exposed to danger in flood/flood risk areas in extreme and heavy rainfall due to its location
- Amount/proportion of infrastructure that will be exposed to the effects of sea level rise due to its location
- Amount/amount of damaged infrastructure caused by floods/floods to date, damage cost
- Amount/amount of damaged infrastructure caused by extreme temperatures and heat waves to date, damage cost
- Amount/proportion of damaged infrastructure caused by extreme weather events to date, damage cost
- Annual statistics on the cost of road maintenance expenditures
- Annual statistics on communication infrastructure maintenance expenditures
- Strengthened/converted existing transportation infrastructure and its ratio to total infrastructure (road, railway, waterway, airway, communication)
- Inclusion of resilience in planned new infrastructure investments and assessments (feasibility studies)
- Service interruption during climate hazards: Road, rail, waterway,
  airline, communication (statistics)
- Accident statistics during climate hazards
- Service interruption due todamage caused by climate hazards:
  Road, rail, waterway, air, communication (statistics)
- Accident statistics due todamage caused by climate hazards
- Road, rail, waterway and air transport statistics (freight and passenger)
- Integration and transfer opportunities between transportation systems
- Multi-alternative, multi-modal flexible trip planning facilities/platforms

At the urban level, the following examples can be given as indicators of exposure, sensitivity and adaptive capacity:

- Existence of Urban Transportation Master Plans and climate change adaptation strategies in these plans
- Urban Transportation emergency action plans
- Urban infrastructure plans and flood measures

- Availability and carrying capacity of sewerage and rainwater separation systems
- Flood management plans at urban scale
- Area/amount of damaged infrastructure as a result of flood/flood events, damage cost
- Amount of infrastructure (motorized and non-motorized transportation) that will be exposed to hazards in flood risk areas
- Public transportation service disruption during climate hazards
- Public transportation service due to damage caused by climate hazards
outage
- Strengthened/converted public transportation infrastructure (ratio to total infrastructure)
- Distribution of urban transportation modes (pedestrian, bicycle, public transport and automobile usage rates)
- Sidewalk infrastructure, quality and continuity
- Bikeway infrastructure, quality, continuity, comprehensiveness
- Number/proportion of public transportation vehicles equipped for disabled people
- Sidewalk infrastructure and continuity for disabled people
- Housing and working areas and population in flood risk areas
- Education area, health service area, emergency services in flood risk areas
- Amount and continuity of green areas and natural grounds that can reduce water flow during floods

When these indicators are analyzed in relation to each other, they will provide the opportunity to assess the level of exposure to the impacts of climate change, the level of sensitivity and the level of adaptive capacity, and will provide guidance on areas of intervention and action.

2.10. Social Development

There is consensus in the literature that climate change will have far-reaching consequences for social development goals such as poverty reduction, food and nutrition security, livelihoods, social equity, gender equality, health, housing, and economies. Existing inequalities and social injustices, demographic and socioeconomic factors such as gender, age, livelihood strategies and poverty shape people's exposure, sensitivity and vulnerability to the impacts and hazards of climate change, and hence their resilience.

The ultimate goal in assessing the impacts of climate change on societies and individuals is to analyze the impacts of climate change on the social development goals of countries and to produce solutions on how interventions to be made in this direction can reduce the vulnerability of society/individuals and increase their adaptive capacities and resilience. Because, after all, societies and individuals are the target audience of the fight against climate change. One of the most important topics that every climate change adaptation policy and action should focus on is the empowerment of groups at risk against social and economic injustices caused/to be caused by climate change.

In order to be able to analyze how climate change affects society/individuals in a healthy way, it is essential to consider all sectors that make up the development economics of countries together with their vulnerabilities. Whether it is sectors that produce goods (agriculture, food, livestock, fisheries, energy, industry, etc.) or sectors that produce services (infrastructure, transportation, communication, waste, water and sewerage, tourism, health, construction, insurance, education, etc.), it is useful to address the intersections of social vulnerability in these sectors one by one. The urbanization "sector", which is a thematic area category, is broader in scope as it includes many of the above-mentioned sectors, and is therefore envisaged to be addressed as a separate focus in social vulnerability and risk assessments.

Disaster risk management is also emphasized in terms of the effects of hydro-meteorological and climatological disasters created/to be created by climate change in cities. As a matter of fact, in the existing guidelines for vulnerability and risk assessments of communities in general practices around the world, the issue **of disaster risk reduction** has come to the forefront as a basic social development strategy.

From a sectoral perspective, for example, if the agriculture sector is severely affected by climate change, it could affect production, food security, incomes and livelihoods for people. Changes in water levels and temperatures and increased water scarcity will also affect rural populations whose livelihoods depend on aquatic ecosystems (e.g. fishers) and people living in urban areas. Resource scarcity in many sectors due to climate change could cause people to relocate and change migration dynamics.

Urban areas are also more vulnerable to increased meteorological disaster risks due to overpopulation, unsafe infrastructure and inadequate planning and risk management mechanisms. This situation also increases the vulnerability and risk levels of urban dwellers (such as loss of life, property, health, water scarcity, etc.). Disaster risk reduction policies and practices can increase the adaptive capacity of people living in cities against climate change.

2.10.1. Assessing the Social Impacts of Climate Change

In many studies on the impact of reducing the vulnerability of societies to climate change, increasing their resilience and adaptive capacities on the social development goals of countries, the need to include the impacts of climate change on societies and necessary measures in social development policy designs is emphasized. In these studies, it is also stated that the social dimension is an important integrative element of policies to adapt to the impacts of climate change.

Climate change threatens the resilience of societies around the world and increases the vulnerability of people in regions where livelihoods depend on natural resources and ecosystems. This makes it necessary to conduct vulnerability and risk analyses by including social dimensions. These analyses and interventions are undertaken to understand why various layers of society and/or households will be affected differently by the impacts of climate change and the consequences for their quality of life and well-being (e.g. livelihoods).

Social vulnerability assessments of climate change are generally conducted through inclusive and participatory social impact analyses that address many impacts together. It is particularly noted that the use of social analysis approaches and tools in combating climate change is also crucial for deepening the understanding of vulnerability and adaptation processes.

In vulnerability and risk analyses, the importance of society's awareness of risk and preparedness against disasters is constantly emphasized. In this case, as people can foresee the potential impacts of climate hazards, their resilience can be strong. However, awareness and preparedness levels of different layers of society and individuals may be different. For these differences, a number of reasons can be listed such as different degrees of access to information due to inaccessibility of information sources and lack of technology, ability to react and act in case of danger due to lack of resources for disaster preparedness.

One of the key challenges in vulnerability and risk analyses is that research often addresses factors affecting vulnerability and adaptive capacity parameters with single quantitative measures. Here, governance can be taken as an example. For example, it will not be sufficient to evaluate participation in climate meetings with numerical ratios. The high rate of female participation in the meetings shows that in a system where gender equality norms are not applied to the impacts of climate change, vulnerability and risk factors related to women are not truly evaluated. Research also emphasizes that static quantitative approaches are not sufficient to measure vulnerabilities, and that the important thing is to capture *the dynamic nature of* vulnerability.

In some cases, spatial location alone may not be sufficient, and a series of general factors (poverty, inequality, marginalization, access to resources, insurance, etc.) considered individually and/or together to conduct vulnerability and risk analyses. For example, a household's location in a coastal area or riverbed indicates exposure to climate hazards. The need to take these "**multiple impacts**" into account a number of specific indicators in the literature to use scaled vulnerability indices. Some of these indicators are data-driven while others are more theory-driven.

Unlike the impactvulnerability and risk assessments that form the basis of climate science, community-based vulnerability and risk analyses take approach. These analyses are generally based on qualitative data, spatial and location-oriented, social context, expert opinions and individual views. This increases the subjectivity of the analysis.

As noted above, there are views that it is almost impossible to measure society's vulnerability and risks to climate change because of the many facets of social vulnerability, and that vulnerabilities are only visible after disasters occur.

From this perspective, the challenge may be to measure in detail the individual characteristics related to social vulnerability (age, ethnicity, gender, etc.) that make people less vulnerable (such as their socioeconomic status) or more vulnerable (such as the community's limited transportation connectivity). Although many studies analyzing the impacts of climate change on society use various (unweightedindices of social vulnerability to climate hazardsespecially local

It is widely emphasized in the literature that it is necessary to determine variable weightings using the knowledge and experience of various stakeholders at the level.

Not only production and consumption patterns affect climate change, but also the level of human development of people. The effects of human development on climate change have long been discussed in the context of globalization using various methods. The basic assumption that as the human development index (life span, literacy rate, education, quality of life level) increases, the effect of this situation on carbon emissions is negative. The fact that vulnerability and risk analyses on climate change generally focus on physical vulnerabilities, and that the social dimension is the subject of secondary literature in the world and in countries causes the inability to produce detailed social vulnerability data that should be evaluated together with climate scenariosmodeling and projections, and to ensure social matching

In general, the fact that the contribution of human development to climate change has been addressed has also led this field to have an approach predominantly in the context of emission reduction policies. However, the inadequacy of looking at human development elements only from this framework has been recognized over time, and the distinction between people affecting climate change and people affected by climate change began to surface in the 90s.

In addition to basic phenomena such as poverty, inequality, etc. in the United Nations (UN) Human Development Reports, analyzing other social determinants of climate change (such as health, migration, etc.) within the framework of the sustainable development paradigm has started to be addressed as an important field of study.

At this point, accepted that addressing climate change from a sociological, economic and ecological perspective in the context of its effects on society and the individual is indispensable for the survival of human civilization, and that policies that put people at the center and provide equal opportunities to all segments of society will directly and indirectly have restorative effects on climate change. For nearly a decade, human development index rankings have been used in some countries and regions to assess the capacity to adapt to the social impacts of climate change.

For example, in a study conducted in Southeast Asia, education, poverty, income inequality, access to electricity, communication, road density, irrigation services were used as indicators of society's capacity to adapt to climate change in the Human Development Index (HDI) ranking as one of the statistics of development indicators.

In the climate change literature, there are many sets of indicators that take into account all factors related to the adaptive capacity of the society/individual. For example, the combination of adaptive capacity indicators such as literacy rates (human resources capacity), GDP per capita and income inequality measures (economic capacity)pollution emissionsland usesocio-spatial location (environmental capacity) increases the resilience of society and individuals climate hazards. However, there is a great need for field studies to generate data. Adaptive capacities are also evaluated according to culturally shaped systems. The existence of social networks is important for coping with climate hazards socially and economically. For example, local networks such as agricultural production cooperatives, fishing, farming, irrigation unions, etc., neighborhood committees, community support networks, permaculture platforms, community/neighborhood gardens, etc. are stated as elements that will strengthen climate resilience.

Global legal basis: The United Nations Framework Convention on Climate Change (UNFCCC, 1994) is the first global legal basis for taking into account the social dimension and its impacts on society/individuals in combating climate change. The relevant articles of the Convention are as follows:

"Article 1 - Climate change not only adversely affects natural and managed ecosystems, but also has "significant detrimental effects" on "the functioning of socioeconomic systems or human and well-being

"Article 4.1 - Parties shall therefore not only address climate change from an economic and environmental perspective, but shall also take climate change into account in their "relevant social policies and actions" to minimize its adverse impacts on human societies and health in mitigation and adaptation projects".

The Paris Agreement (2016) strongly emphasized that the integration/ mainstreaming of the social dimension into every stage of the fight against climate change is a prerequisite for effective climate policies and practices and even a practical necessity. The IPCC Special Report 1.5^0 C (2018) has also addressed adaptation to the impacts of climate change in the context of sustainable development and poverty eradication. The social impacts of climate change have been and continue to be studied in IPCC AR5 and AR6.

Shared Socio-economic Pathways scenarios for socio-economic assessments in IPCC scenarios are addressed in the studies.

The UN System supports countries to develop a comprehensive conceptual framework on the social dimensions of climate change, advocate for a multidimensional approach to climate change policies and develop climate-related measures to ensure better living conditions for humanity. To this end, various methods and tools have been developed to assess the risks of climate change on societies and identify their vulnerability and adaptive capacities. There are various tools, guidelines and best practices prepared by the UN System addressing gender, health, food security, migration, population dynamics, housing, employment, etc. in a changing climate.

While these studies as a whole are comprehensive and allow for mutual assessments across sectors and scales (national, local), they do not provide a complete picture of the social impacts of climate change as they often focus on a single social aspect. Integrated guidelines/tools that take into account all relevant social aspects and integrations could support a better understanding of social risks and vulnerabilities and the development of more adequate and reliable preparedness and response mechanisms in this area (to improve human well-being).

Many UN organizations are working on social impact assessments of climate change. These include the Food and Agriculture Organization (FAO), the World Food Programme (WFP), the World Health Organization (WHO), the International Labour Organization (ILO), the United Nations Population Fund (UNFPA), the United Nations Strategy for Disaster Reduction (UNSDR, UNDRR), the United Nations Entity for Gender Equality and the Empowerment of Women (UN Women), United Nations Habitat and United Nations migration agencies. These organizations publish various guides, technical implementation tools, etc. facilitate the understanding of the social dimensions of climate impacts and risks and to guide decision-makers, and in this direction, they conduct practices/case studies in some countries.

FAO has a number of activities that address the link between gender equality and food security in the context of the social impacts of climate change. FAO's policy instruments on this issue include training guidance on gender and climate change related information gathering for rural development, gender sensitive strategies for climate change adaptation, research on gender equality in agriculture and food security strategies for rural development.

The implementation guidelines of the UN Sendai Framework for Disaster Risk Reduction (2015-2030)[179] social impacts of disasters and social resilience in cities. The Sendai Framework for Disaster Risk Reduction has also provided an inclusive approach for climate change-induced disaster risks. The Framework considers climate change as one of the dynamics affecting disaster risk, thus emphasizing climate change.

[179] The Sendai Framework for Disaster Risk Reduction is the successor instrument to the Hyogo Framework for Action (HFA) 2005-2015: Building the Resilience of Nations and Communities to Disasters, which is in force from 2005-2015.

is mentioned throughout the document. The Framework, the Paris Agreement and the 2030 Agenda for Sustainable Development
with indicators that will work together.

UNDP has social vulnerability assessment implementation tools for its climate change and disaster risks program (2017).

The World Bank also supports various projects in some countries to identify the impacts of climate change on society and to take measures. The World Bank has published guidelines on "*Coalition Framework for Adaptation*" to ensure community resilience to climate change.

Some local governments have city-specific implementation tools for community climate resilience (e.g. New York City Community Based Assessments of Adaptation and Equity, 2019; "New York City, the Macro Adaptation Resilience Toolkit").

Far from eliminating the negative impacts of climate change on societiesclimate action that takes into account the interaction between fundamental human rights (the right to life, nutrition, water, shelter, security and health) and the of climate impacts has recently taken its place as a complementary climate agenda in the world. Human rights mechanisms such as the special procedures of the United Nations (UN) Human Rights Council, human treaty bodies and the Universal Periodic Review have increasingly begun to address the human rights dimension of climate change, and the Council's decisions in this regard provide a legal basis for UN member states to take concrete steps in this regard. The main message of the UN Human Council that climate change
In the 21st century, it poses a serious threat to human rights, and the Council has also resolutions on women's equal participation in climate policymaking. The July 14, 2018 UN Council Resolution is historic as it is the first UN resolution to reference the 1.5°C target in the context of human rights.

Situation in Turkey: In Turkey, socio-economic challenges related to adaptation to the impacts of climate change are not yet on the agenda in a planned manner. Although have been included in relevant strategies, action plans (national/local) and some studies, concrete guidance on the vulnerability of society and risks is badly needed.

Turkey's climate scenarios do not address socio-economic factors from an integrated perspective, thus impact assessments do not examine the social dimension. In climate disasters, solutions that will save the day are generally produced on the vulnerability of the livelihoods of the society/individual. In terms of sectors (agriculture, health, disaster, infrastructure, etc.), it is evaluated that social vulnerability data is insufficient in the process of estimating the social dimension of the impacts of climate change. In Turkey, there are some academic studies, albeit few in number, that relate agricultural production to the social dimension and focus on the poor and migrants.

"Participatory Vulnerability Analysis (PVA)", the first study on climate change and social vulnerability in Turkey, was conducted during the "National Climate Change Adaptation Strategy and Action Planprepared with the support of UNDP-Turkey (2009-2010this analysis, which was carried out in 11 provinces selected according to some criteria determined in relation to climate change, the areas of vulnerability to climate change at the local level were identified and the effects of changing climate conditions on the relevant sectors and citizens were questioned. The most prominent social determinant in this study was the concern about the decrease in livelihoods due to climate change.

Groups working on climate change and sustainability in Turkey focus more on human health in their projects. These studies are empirical studies in which the relationship between climate change and human health is investigated with different econometric tests.

Among the studies conducted at the local level, a study titled "Urban Poverty in Ankara" (December 2020) identified problem areas that cannot be covered by existing micro data, such as: nutrition, gender, security, *climate*, environment, social adaptation to urban life, rights, dignity and social exclusion.

as determinants of the urban environment. Again, it is evaluated that *Urban Gardening* practices in Istanbul are important in terms of establishing the connection between the poor living in the city and the livelihood problems.

, the Human Rights Action Plan of the Republic of Turkey, prepared under the responsibility of the Human Department the Ministry of Justice and shared with the public in March 2021, includes the target *"The impacts of climate change on fundamental human will be analyzed and the results will be taken into account when formulating public policies*", which has provided an extremely important opening in terms of addressing the social dimension of combating climate change in a rights-based manner in Turkey.

In Turkey, the most fundamental need to determine the impacts of climate change on society and individuals and to ensure resilience is to make and implement data-based decisions as in every field. The first step will be to make use of the existing database and statistical data (such as income distribution and living conditions statistics) to analyze the social impacts of climate change through econometric and statistical methods. In the following stages, the compilation, comparison and spatialization of data and the creation of a set of indicators that point to new data needs can be addressed.

In determining the impacts of climate change on societyis important to evaluate Turkey's human development index indicators and sustainable development indicators. The Human Development Index (HDI), published periodically by the United Nations Development Program (UNDP), is one of the indices that aim to measure progress in this area in the UN Human Development Reports. This study was born out of the need to establish a healthier relationship between economic growth and human development, as it was observed that social problems could not be solved in many economically developed countries.

The HDI uses indicators that aim to measure human development such as income, education, health, employment, wages, gender disparities, participation in decision-making mechanisms, environmental pollution, access to electricity services and clean water, type of fuel used for heating, and vehicle ownership. The education, health and income components used in the HDI calculation are the three main components that come to the fore at all stages of development. In HDI studies, opinions that more indicators should be included in determining the quality of life of people, but due to data supply problems, *income*, which is a measurable and accessible data, is frequently used as a measure of welfare.

Turkey's sustainable development[180] indicators are prepared by TurkStat. The Sustainable Development Indicators for Turkey, which covers data collected between 2010 and 2019, was published by TurkStat in February 2021.([181]) There are a total of 131 indicators for Turkey, including existing indicators from global sustainable development indicators and substitute indicators that are assessed to be suitable for measuring the relevant target.([182]) In this indicator set, the poverty rate that can be associated with climate change and the social dimension; the proportion of the working population at risk of poverty; the proportion of individuals at risk of poverty or social exclusion; schooling by education levels

[180] The 2030 Agenda for Sustainable Development was adopted at the United Nations Summit on Sustainable Development on September 25, 2015. To measure progress on the Sustainable Development Agenda, 17 goals and 169 targets have been set to achieve these goals and targets. A global indicator set of 231 individual indicators is used to monitor the level of achievement of the Sustainable Development goals and targets.

The global indicators under the [181]2030 Agenda aim to measure progress under 17 goals and 169 targets. Therefore, presenting each indicator on independent platform where the relationship of each indicator with the relevant goal and target can be easily demonstrated and changes in the indicator base can be expressed effectively and with data visualizations
is aimed. In this context, TurkStat will launch the web portal where 2030 Agenda indicators can be presented online by making an announcement on its website (www.tuik.gov.tr) in the coming days. For this reason, no more news bulletins will be published on Sustainable Development Indicators, and the data within the scope of the indicators will be followed up the web portal. In addition, when the updates to be made regarding the indicators are made available on the web portal, users will be informed by making an announcement on the TURKSTAT website.

[182] These indicators are published in the annex of the TurkStat News Bulletin Kalkinma-Gostergeleri-2010-2019-37194&dil=1).

completion rates; the proportion of women in the 20-24 age group who were married before the age of 18; the proportion of individuals in the 15-24 age group who do not attend formal and non-formal education and are not employed; the average share of built-up areas in cities that are fully open to public use, consisting of publicly accessible areas such as parks, recreation areas, urban parks, gardens, squares and plazas and areas reserved for streets and avenues; the proportion of individuals using the internet; the proportion of people working without being registered with a social security organization in total employment; the proportion of forested land to total land area; the proportion of reliably treated domestic and industrial wastewater.

Environmental indicators should also be taken into account when studying climate change and social dimension. When the Environmental Indicators published by the Ministry of Environment and Urbanization under 16 main headings are analyzed, it is seen that improvements have been achieved in some areas. Progress has been achieved especially in access to drinking water. According to TURKSTAT data, the municipal population served by drinking and potable water network to total municipal population is 98.6% and the ratio of municipal population served by drinking and potable water treatment plants to total municipal population is 60.1%.[(183)]

The Water Use Index (WEI) is rising rapidly, bringing Turkey closer to the position of a country experiencing severe water scarcity. The decreasing available water resources due to the increasing water demand with the effect of increasing population and urbanization, together with the effect of climate change, the results of which have started to be seen more frequently in recent years, show that effective solutions should be developed in water management. [184]

In the classification of environmental indicators in relation to adaptive capacity, indicators in Climate Change[(185]and Disasters[(186]) and Health[(187)] are *directly* related to the indicators in Agriculture[(188)], Fisheries[(189)], Energy[(190)], Industry and Mining[(191)], Infrastructure and Transport[(192)], Biodiversity[193], Land Use[194], Water, Wastewater[195], Air Pollution[196], Population[197], Economy,[198] Tourism[199] indicators can be considered as indicators indirectly linked to the social dimension of climate change.[200]

2.10.2. Scope of Vulnerability and Risk Analysis

Some of the study topics needed to analyze the impacts of climate change on society and individuals in Turkey are listed below.

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183 https://tuikweb.tuik.gov.tr/PreHaberBultenleri.do?id=30668
184 https://webdosya.csb.gov.tr/db/cevreselgostergeler/duyurular/cevresel-gostergeler--8230-46250-20210105115222.pdf
185 Greenhouse Gas Emissions, Total Greenhouse Gas Emissions by Sector, Absorption Areas and Carbon Sequestration, Consumption of Depleting Substances, Precipitation, Temperature, Sea Water Temperature, Sea Water Temperature in the Mediterranean Sea, Sea Water Temperature in the Aegean Sea, Sea Water Temperature in the Black Sea, Sea Water Temperature in the Sea of Marmara, Heating and Cooling Day-
Degrees, number of storm disasters.
186 6.1- Forest Fires, Burned Forest Area, Disasters by Type, Risk Assessment and Emergency Response, Liability Insurances within the Scope of Environmental Legislation
187 Ratio of access to safe drinking water
188 Agricultural area per capita
189 Aquaculture production
190 Energy Consumption per Capita
191 Environmental Impact Assessment Decisions
192 Amount of Passengers and Freight Transported by Transportation Types, Road Passenger Transportation Rate (passenger-km) Rail Passenger Transportation Rate (passenger-km)
193 Invasive SpeciesProtected AreasProtected Coastal LengthWildlife Protection ActivitiesDistribution of Forested AreasDistribution of Forests by Main Functions, Protected Coastal Length
194 Agricultural Areas Used for Unintended Purposes, Wetlands
195 Total Water Use, Municipal Drinking and Potable Water Resources
196 Number of Air Quality Monitoring Stations
197 Population Growth - Urban-Rural Population Ratio - Migrating Population
198 Sectoral Distribution of EmploymentSectoral Distribution of Gross Domestic ProductEnvironmental Protection Expenditures
199 Number of Blue Flag Beaches
200 https://webdosya.csb.gov.tr/db/cevreselgostergeler/duyurular/cevresel-gostergeler--8230-46250-20210105115222.pdf

- Adaptation of the methods of analyzing the social dimensions of climate change and the tools used for the integration of the social dimension to the country conditions, preparation of some guidelines
- Conducting a pilot study for overlapping and linking climate projections with social parameters (Studies on overlapping/linking hazard data such as extreme precipitation, temperature, etc. produced from climate models with social data such as poverty at local scale)
- Conducting a pilot study to reduce climate projections to socio-spatial level
- Conducting detailed assessments using regional climate projections in geographically more vulnerable areas,
- Conducting a study to reveal and develop the complementary potentials of the social dimension to the sectors (a study can be conducted by considering one or more indicators and impact chains in the dashboard)
- A sample study: Selecting a stratum of the society and assessing vulnerability and resilience by comparing "sensitivity" and "adaptive capacity" in line with the identified system of indicators/impact chain
- Conducting an awareness-raising study on identifying livelihoods of communities living inareas (e.g. deltas
- Prioritization of social determinants (livelihood, nutrition, inequality, welfare justice, health, housing, migration, education) through communication and participation methods such as workshops etc. in order to integrate existing social development parameters into climate change risks and transform them into a systematic study
- Conducting a study that will address the main reasons why women are more exposed to the dangers of climate change on urban and rural grounds, collecting disaggregated data and information for vulnerability by gender, making an actor map
- The content of each sector to address the social dimension of climate change, work on social impact assessment, social dimension review and revisions to existing sector-specific guidelines and tools
- More detailed study of the impacts of climate change on society/individuals one or selected social strata, in cities (especially metropolitan areas)
- Detailed review of existing statistical data on the social impacts of climate change.

2.10.3. Key Stakeholders

Important stakeholders for vulnerability and risk analysis of society/individuals within the scope of combating climate change in Turkey are listed below.

- Turkish Statistical Institute (TurkStat)
- Presidency of the Republic of Turkey, Presidency of Strategy and Budget (National Focal Point for Sustainability)
- Social Policy Implementation and Research Centers of Universities (such as HUSPAM)
- Social Sciences Institutes of Universities
- Civil Society Organizations (such as TESEV, Gender Equality Monitoring Center/CEIM, Support to Life
- District Governorships
- Mukhtar Offices
- Municipalities (Metropolitan Municipality, provincedistrictneighborhood based data)
- Ministry of Family, Labor and Social Services (social security, gender equality data)
- Ministry of Environment and Urbanization (General Directorate of Environmental Management, General Directorate of GIS, General Directorate of Spatial Planning)
- Ministry of Agriculture and Forestry (Social data in farmer registration system, women farmer business area/livestock, fisheries)
- AFAD (loss and damage data)
- Ministry of National Education (data on girls not sent to school after disasters, etc.).

2.10.4. Sectoral Indicators

Many direct or indirect social issues need to be studied in adapting to the impacts of climate change. This makes social vulnerability and risk analyses difficult. The indicators to be identified for these analyses can be divided into two groups according to the level of data collection: The first group consists of individual-level indicators (e.g. education, age and gender, family structure, job ownership, etc.) that are aggregated to produce community-level data.

The second group includes community-level indicators such as population growth, urban/rural ratio, infrastructure quality, migration phenomenon, health, justice, equity, population in flood risk areas, proportion of farmers experiencing income loss due to changes in crop yields. These indicators are considered together with various parameters that affect each other such as geographical scope (national, regional, local), association with sectors [201], economic, environmental and social capital (civic engagement, social solidarity, social networks, sense of belonging, cultural ties, etc.) measure the vulnerability of the community and the individual.

While climate change affects society and individuals in many dimensions, it also affects and poses risks to the social determinants necessary to ensure a full quality of life and well-being in society. these impacts are of different magnitudes in each sector (such as nutrition and agriculture), the international literature has highlighted some common social determinants. These are livelihood stability, nutrition, shelter and health.

Table 27: Key Social Determinants Affected by Climate Change

Key Social Determinants Affected by Climate Change	
Livelihood Stability	Inequality
Housing	Welfare inequality
Nutrition	Education
Health	Migration

For example, housing, which is a social determinant, causes the poor to live in critical areas of cities that provide opportunities for climatic vulnerabilities due to socio-spatial segregation in cities and thus to be more vulnerable to climate hazards. Again, the resettlement of migrants to regions that will be more exposed to climate change and its hazards may be another example where social vulnerability is not taken into account.

In some cases, addressing the social dimension of climate change may be seen as a side benefit, but the consequences that create a social vulnerability gap are important to ensure that vulnerability and risk analyses in many sectors are addressed in a holistic manner.

Aside from negative examples, multiple indicators for social vulnerability and risk analyses is valuable for finding cross-cutting points and converging benefits in many areas. For example, mainstreaming social dimensions of climate change into climate change policy responses can address data and information gaps. Again, linking the social dimensions of climate change with various sectors and revealing their complementary potentials will also be beneficial for climate adaptation.

The following indicator proposals based on international literature, national human development index, national sustainable development indicators, statistics and country conditions.

[201] Water resources, agriculture, tourism, cultural heritage, health, industry, urban, transportation, communication, education, energy, ecosystem services.

In the absence of quantitative and measurable data on the indicators identified, qualitative and empirical data and expert opinions may be used.

Here, it is important to work collectively with sociologists, educators, statisticians, etc. as well as experts working in the field of climate change. The purposes of using these indicators within the scope of vulnerability and risk analysis are to evaluate existing data in order to identify the impacts of climate change on social determinants in Turkey, to bring together data on the social dimension in different sectoral and thematic issues, and to produce new data and information that will be needed.

Indicators related to vulnerable populations

- Farmer population
- Female farmer population
- Number of seasonal field workers
- Number of seasonal tourism workers
- Fisher population
- Forest villagers
- Households at risk of flooding
- Foreign migrant population
- Minority population
- Physically disabled population
- Population 65 and over
- Single elderly household
- Population with chronic diseases
- Unemployed population
- Population living in rented accommodation
- Host population
- Proportion of population aged 4 and under
- Poor population
- Population density
- Number of reverse migration

Indicators related to income level and inequality

- Regional income distribution
- Sociospatial income distribution
- Socioeconomic development index of provinces
- Agricultural crop productivity
- Income inequality between men and women
- Socioeconomic drought indicator
- Interruption in energy distribution services
- Interruption in water distribution services
- Disruption of public transportation services
- Crop damage
- Proportion of farmers with insurance
- Insurance coverage of people and their assets
- Loss-loss costs
- Loss-loss compensation policies
- State insurance coverage of damage caused by natural disasters
- Loss of employment due to disasters

Many of the structural indicators recommended below overlap with other sectors.

- Number of early warning systems
- Socioeconomic drought indicator
- Interruption in energy distribution services
- Interruption in water distribution services
- Disruption of public transportation services
- Affected educational institutions
- Population of girls not attending compulsory education
- Population of boys not attending compulsory education
- Affected communication infrastructure
- Population without access to the Internet
- Recreation areas indicator
- Urban building density
- Number of municipalities with a climate adaptation plan
- Urban-rural population ratio
- Ratio of impervious asphalt to city area
- Number of early warning systems
- Number of local social networks (Koop. Unions, etc.)
- Citizen awareness of vulnerability
- Number of civil society organizations accessing climate finance
- Number of social departments in universities
- Proportion of bicycle use
- Maladaptation practices
- Rate of stormwater line
- Number of drought management plans
- Number of flood management plans
- Number of river basin management plans
- Effectiveness of urban information systems
- Number of active city councils
- Urban open green area ratio
- Cohesion funds
- Monitoring and evaluation mechanisms of adaptation policies
- Existence of women's research units in universities
- Urban gardening practices

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Data Scale	Available/ Recommendation	Indicator Name	Related Sector
National - Local	Available	Environmental protection expenditure indicator	Multiple Sectors
National	Recommendation	Integrating climate change and adaptation into development planning integration indicator	Multiple Sectors
Local	Recommendation	Climate change adaptation indicator	Multiple Sectors
National - Local	Available	Socio-economic development indicator	Multiple Sectors
National - Local	Available	Number of stormy days indicator	Multiple Sectors
National - Local	Available	Heating and cooling degree day display	Multiple Sectors
National - Local	Available	Number of days with snow cover indicator	Multiple Sectors
National - Local	Available	Temperature anomaly indicator	Multiple Sectors
National - Local	Available	Heavy rainfall indicator	Multiple Sectors
National - Local	Available	Indicator of change in precipitation	Multiple Sectors
National - Local	Available	Number of dams indicator	Multiple Sectors
National - Local	Available	Population indicator	Multiple Sectors
National - Local	Available	Environmental impact assessment indicator	Multiple Sectors
National - Local	Available	Income inequality indicator	Multiple Sectors
National - Local	Available	Migration indicator	Multiple Sectors
National - Local	Available	Urban-rural population ratio indicator	Multiple Sectors
National	Available	Poverty indicator	Multiple Sectors
National	Recommendation	Sea level indicator	Multiple Sectors
Local	Available	Early warning systems indicator	Natural Disaster Risk Management
National - Local	Available	Indicator of number of drought management plans prepared	Natural Disaster Risk Management
National - Local	Available	Indicator of number of flood management plans prepared	Natural Disaster Risk Management
Local	Available	Civil protection and emergency response force indicator	Natural Disaster Risk Management
National - Local	Available	Flood-protected area indicator	Natural Disaster Risk Management
Local	Available	Average arrival time to fires indicator	Natural Disaster Risk Management
Local	Available	Drought indicator	Natural Disaster Risk Management
National	Available	Indicator of the area where economic activities and public services are realized in areas under flood risk	Natural Disaster Risk Management
National - Local	Available	Number of properties under flood risk indicator	Natural Disaster Risk Management
National - Local	Available	Number of population under flood risk indicator	Natural Disaster Risk Management
National - Local	Available	Number of settlements under flood risk indicator	Natural Disaster Risk Management
National - Local	Available	Indicator of area at risk of drought	Natural Disaster Risk Management
Local	Available	Potentially affected by wildfire risk population indicator	Natural Disaster Risk Management
National-Local	Available	Flood, number of floods indicator	Natural Disaster Risk Management
Local	Available	Awareness training work indicator	Education
National	Available	Education expenditure per student indicator	Education

Local	Available	Indicator for organizing social events	Education
Local	Recommenda tion	Education strengthened as part of harmonization work institutions infrastructure indicator	Education
Local	Available	Days of suspension of education due to extreme weather events indicator	Education
Local	Available	Educational institutions affected by extreme weather events indicator	Education
Local	Available	Indicator of forest area under afforestation activities	Ecosystem-Biodiversity
Local	Available	Indicator of forest area under erosion control activities	Ecosystem-Biodiversity
Local	Available	Indicator of forest area rehabilitated	Ecosystem-Biodiversity
National - Local	Available	Forest areas indicator	Ecosystem-Biodiversity
National - Local	Available	Recreation areas indicator	Ecosystem-Biodiversity
Local	Available	Indicator of change in the number and variety of fish	Ecosystem-Biodiversity
Local	Available	Indicator of trees planted by the municipality	Ecosystem-Biodiversity
Local	Available	Silvicultural maintenance and restoration by the municipality tree made indicator	Ecosystem-Biodiversity
National - Local	Available	Protected areas indicator	Ecosystem-Biodiversity
National - Local	Available	Protected coast length indicator	Ecosystem-Biodiversity
National	Available	Forest area under forest management planning indicator	Ecosystem-Biodiversity
National	Available	Indicator of support for forest villagers	Ecosystem-Biodiversity
National - Local	Available	Indicator for combating forest pests and diseases	Ecosystem-Biodiversity
National - Local	Available	Indicator of forest area under silviculture activities	Ecosystem-Biodiversity
National - Local	Available	Indicator of number of wetland management plans	Ecosystem-Biodiversity
National	Available	Number of species conservation action plans indicator	Ecosystem-Biodiversity
National - Local	Available	Wildlife protection activities indicator	Ecosystem-Biodiversity
National - Local	Available	Number of forest fires	Ecosystem-Biodiversity
National - Local	Available	Biodiversity indicator	Ecosystem-Biodiversity
National	Available	Indicator of coniferous and leafy forest	Ecosystem-Biodiversity
National - Local	Available	Number of species based on endemism and conservation status indicator	Ecosystem-Biodiversity
National	Available	Invasive species indicator	Ecosystem-Biodiversity
National - Local	Available	Mid-winter waterbird count indicator	Ecosystem-Biodiversity
National	Available	Monitoring indicator of the forest ecosystem	Ecosystem-Biodiversity
National - Local	Available	Area indicator of forest fires	Ecosystem-Biodiversity
National-Local	Recommenda tion	Forest fragmentation indicator	Ecosystem-Biodiversity
National-Local	Recommenda tion	Non-wood forest products indicator	Ecosystem-Biodiversity
Local	Recommenda tion	Energy infrastructure strengthened as part of harmonization work indicator	Energy
National	Available	Indicator of hydroelectric power generation	Energy
Local	Available	Energy distribution as a result of extreme weather events indicator of cuts in services	Energy
Local	Available	Energy infrastructure affected by extreme weather events indicator	Energy

National - Local	Available	Per capita energy consumption indicator	Energy
National	Available	Indicator of wind and solar power generation	Energy
National	Available	Sectoral electricity consumption indicator	Energy
Local	Recommendation	Fuel shares in energy supply, installed capacity	Energy
Local	Recommendation	Renewable energy share	Energy
National - Local	Available	Insurance coverage ratio indicator for damage due to natural disasters caused by extreme weather events	Finance/Insurance
National - Local	Available	Natural disasters due to extreme weather events damage amount indicator	Finance/Insurance
Local	Available	Indicator of health services provided by the municipality	Public Health
National-Local	Available	Proportion of population served by sewerage network indicator	Public Health
National - Local	Available	Health service indicator	Public Health
National - Local	Available	Number of health institution beds indicator	Public Health
National - Local	Available	Heat or cold wave warning number indicator	Public Health
National - Local	Available	Excessively hot air indicator	Public Health
Local	Available	Indicator of the number of hot days and tropical nights	Public health
National - Local	Available	UVR level indicator	Public Health
National - Local	Available	Proportion of population aged 4 and under and 65 and over indicator	Public Health
National - Local	Available	Disaster indicator due to extreme weather events	Public Health
National - Local	Available	Number of cases of waterborne diseases indicator	Public Health
National - Local	Available	Number of cases of vector-borne diseases indicator	Public Health
National-Local	Recommendation	Fertility rate	Public health
National-Local	Recommendation	Crude birth rate	Public health
National-Local	Recommendation	Proportion of female population aged 15-49	Public health
National-Local	Recommendation	Infant mortality rate	Public health
National-Local	Recommendation	Life expectancy at birth	Public health
National-Local	Recommendation	Disability rate	Public health
National-Local	Recommendation	Crude mortality rate	Public health
National-Local	Recommendation	Number of people per physician	Public health
National-Local	Recommendation	Number of beds per 100000 people	Public health
National-Local	Recommendation	Population per ASM	Public health
National	Available	Indicator of the use of modern communication tools	Contact
Local	Available	Indicator of points with free internet service	Contact
Local	Recommendation	Communication strengthened as part of harmonization work infrastructure indicator	Contact
Local	Available	Communication as a result of extreme weather events outage indicator	Contact
Local	Available	Communication infrastructure affected by extreme weather events indicator	Contact

Local	Available	Infrastructure master plan indicator	Urban Planning
Local	Available	Indicator of municipality with city information system at provincial level	Urban Planning
Local	Available	City council indicator	Urban Planning
Local	Available	Urban green space indicator	Urban Planning
Local	Available	Open and green area per capita indicator	Urban Planning
Local	Available	Indicator of protection, implementation and supervision activities	Urban Planning
Local	Available	SCADA system usage indicator	Urban Planning
Local	Available	Housing or urban transformation project design indicator	Urban Planning
Local	Available	Building density indicator	Urban Planning
Local	Available	Urban blue infrastructure (water surface ratio) indicator	Urban Planning
Local	Available	Illegal building rate indicator	Urban Planning
Local	Available	Amount of built-up area-covered surface indicator	Urban Planning
Local	Recommendation	Urban sprawl speed	Urban Planning
Local	Recommendation	Urban transformation area size	Urban Planning
Local	Recommendation	Loss of agricultural land due to urbanization	Urban Planning
Local	Recommendation	Building density distribution	Urban Planning
Local	Recommendation	Number of vehicles in urban area	Urban Planning
Local	Recommendation	Road density - amount of surface	Urban Planning
Local	Recommendation	Population more than 500 meters from public transport	Urban Planning
Local	Recommendation	Amount and % of public space	Urban Planning
Local	Recommendation	Amount of industrial area and % in the city	Urban Planning
Local	Recommendation	Indicator of industrial facilities where adaptation measures are applied	Industry
National	Available	Manufacturing industry production indicator	Industry
National - Local	Available	Organized industrial zone indicator	Industry
Local	Available	Industry as a result of extreme weather events indicator of loss in production	Industry
National	Available	Indicator of thewater withdrawn in the manufacturing industry	Industry
National-Local	Recommendation	Farmer Population	Social Development
National-Local	Recommendation	Female Farmer Population	Social Development
National-Local	Recommendation	Number of Seasonal Field Workers	Social Development
National-Local	Recommendation	Number of Seasonal Tourism Workers	Social Development
National-Local	Recommendation	Fisherman Population	Social Development
National-Local	Recommendation	Forest Villagers	Social Development
National-Local	Recommendation	Households at Risk of Flooding/Flooding	Social Development
National-Local	Recommendation	Foreign Immigrant Population	Social Development

National-Local	Recommendation	Minority Population	Social Development
National-Local	Recommendation	Physically Disabled Population	Social Development
National-Local	Recommendation	Single Elderly Household	Social Development
National-Local	Recommendation	Population with Chronic Diseases	Social Development
National-Local	Recommendation	Unemployed Population	Social Development
National-Local	Recommendation	Population Living in Rent	Social Development
National-Local	Recommendation	Host Population	Social Development
National-Local	Recommendation	Poor Population	Social Development
National-Local	Recommendation	Regional Income Distribution	Social Development
National-Local	Recommendation	Sociomegetal Income Distribution	Social Development
National-Local	Recommendation	Socioeconomic Development Index of Provinces	Social Development
National-Local	Recommendation	Number of Reverse Migration	Social Development
National-Local	Recommendation	Income Inequality between Men and Women	Social Development
National-Local	Recommendation	Crop Damage	Social Development
National-Local	Recommendation	Affected Educational Institutions	Social Development
National-Local	Recommendation	Population of Girls Not Attending Compulsory Education	Social Development
National-Local	Recommendation	Population of Boys Not Attending Compulsory Education	Social Development
National-Local	Recommendation	Population Without Access to the Internet	Social Development
National-Local	Recommendation	Recreation Areas Indicator	Social Development
National-Local	Recommendation	Number of Municipalities with Climate Adaptation Plan	Social Development
National-Local	Recommendation	Proportion of Farmers with Insurance	Social Development
National-Local	Recommendation	Urban-Rural Population Ratio	Social Development
National-Local	Recommendation	Ratio of Impervious Asphalt to City Area	Social Development
National-Local	Recommendation	Number of Local Social Networks (Koop. Unions, etc.)	Social Development
National-Local	Recommendation	Insured Rate of People and Their Assets	Social Development
National-Local	Recommendation	Loss-Loss Costs	Social Development
National-Local	Recommendation	Loss and Damage Compensation Policies	Social Development
National-Local	Recommendation	State Insurance Coverage of Damage Caused by Natural Disasters	Social Development
National-Local	Recommendation	Citizen Awareness of Vulnerability	Social Development

National-Local	Recommendation	Number of Civil Society Organizations Accessing Climate Finance	Social Development
National-Local	Recommendation	Number of Social Departments in Universities	Social Development
National-Local	Recommendation	Rate of Bicycle Use	Social Development
National-Local	Recommendation	Maladaptation Practices	Social Development
National-Local	Recommendation	Effectiveness of Urban Information Systems	Social Development
National-Local	Recommendation	Number of Active City Councils	Social Development
National-Local	Recommendation	Urban Open Green Area Ratio	Social Development
National-Local	Recommendation	Harmonization Funds	Social Development
National-Local	Recommendation	Monitoring-Evaluation of Compliance Policies Mechanisms	Social Development
National-Local	Recommendation	Existence of Women's Research Units in Universities	Social Development
National-Local	Recommendation	Employment Loss due to Disasters	Social Development
National-Local	Recommendation	Urban Gardening Practices	Social Development
Local	Recommendation	Wastewater, storm water and rainwater systems retrofitted within the scope of harmonization water infrastructure indicator	Water Resources Management
National - Local	Available	Wastewater treatment rate indicator	Water Resources Management
National-Local	Available	Municipal drinking and potable water resources indicator	Water Resources Management
National - Local	Available	Indicator of access to safe drinking water	Water Resources Management
National	Available	Indicator of number of river basin management plans prepared	Water Resources Management
National	Available	To the environmental objectives of River Basin Management Plans indicator of progress towards	Water Resources Management
Local	Recommendation	Indicator of change in agricultural water consumption	Water Resources Management
Local	Available	Rainwater, gray water usage indicator	Water Resources Management
National - Local	Available	Proportion of population served by drinking water treatment plant indicator	Water Resources Management
Local	Available	Water distribution resulting from extreme weather events indicator of service failure	Water Resources Management
National - Local	Available	Indicator of sectoral groundwater allocations	Water Resources Management
National	Available	Indicator of sectoral surface water allocations	Water Resources Management
Local	Available	Indicator of network losses in the water distribution system	Water Resources Management
National - Local	Available	Agricultural irrigation area indicator	Water Resources Management
National	Available	Proportion of water bodies under diffuse pressure indicator	Water Resources Management
National-Local	Recommenda	Water usage indicator	Water Resources

	tion		Management
Local	Available	Groundwater level indicator	Water Resources Management
Local	Available	Provincial agricultural drought indicator	Agriculture, animal husbandry
National	Available	Closed system irrigation area ratio indicator	Agriculture, animal husbandry
National	Available	Fishing fleet capacity indicator	Agriculture, animal husbandry
National - Local	Available	Indicator of aquaculture production	Agriculture, animal husbandry
National	Available	Control of harmful organisms in plant products indicator of pesticide use	Agriculture, animal husbandry
National	Available	Agricultural area per capita indicator	Agriculture, animal husbandry
National	Available	Proportion of grassland areas indicator	Agriculture, animal husbandry
National	Available	Share of agriculture, forestry and fishing in GDP indicator	Agriculture, animal husbandry
National	Available	Agricultural irrigation water indicator	Agriculture, animal husbandry
National	Recommendation	Soil moisture indicator	Agriculture, animal husbandry
Local	Available	Indicator of change in crop planting dates	Agriculture, animal husbandry
Local	Available	Indicator of change in crop yield	Agriculture, animal husbandry
National	Available	Rainfall-dependent agricultural area ratio indicator	Agriculture, animal husbandry
National - Local	Available	Indicator of farmer training and extension activities	Agriculture, animal husbandry
National - Local	Available	Good agricultural indicator	Agriculture, animal husbandry
National	Available	Indicator of the amount of organic crop production	Agriculture, animal husbandry
National	Available	Irrigation area with irrigation efficiency of 55% and above indicator	Agriculture, animal husbandry
National	Available	Indicator of the amount of support provided in agricultural basins	Agriculture, animal husbandry
National - Local	Available	Agricultural insurance indicator	Agriculture, animal husbandry
National - Local	Available	Agricultural insurance damage payment indicator	Agriculture, animal husbandry
National	Available	Agricultural R&D expenditures indicator	Agriculture, animal husbandry
Local	Recommendation	The increase in crop yields after adaptation practices change indicator	Agriculture, animal husbandry
Local	Recommendation	After harmonization practices, animal products shows the change in the amount of production	Agriculture, animal husbandry
National - Local	Available	Number of frosty days indicator	Agriculture, animal husbandry
National - Local	Available	Soil erosion risk indicator	Agriculture, animal husbandry
National - Local	Available	Animal production indicator	Agriculture, animal husbandry
National	Available	Crop production indicator in selected crops	Agriculture, animal husbandry
Local	Available	Agricultural area indicator	Agriculture, animal

			husbandry
National - Local	Available	Indicator of agricultural land used for non-purpose	Agriculture, animal husbandry
Local	Available	Loss of livestock due to extreme weather events indicator	Agriculture, animal husbandry
Local	Available	Crop loss due to extreme weather events indicator	Agriculture, animal husbandry
National - Local	Available	Number of farmers indicator	Agriculture, animal husbandry
Local	Available	Indicator of change in phenological growing season	Agriculture, animal husbandry
National - Local	Available	Environmentally sensitive accommodation facility indicator	Tourism
National - Local	Available	Number of blue flags indicator	Tourism
National - Local	Available	Indicator of sea water temperatures	Tourism
National - Local	Available	Snow cover height indicator for winter sports	Tourism
Local	Available	Number of overnight stays in accommodation facilities indicator	Tourism
National	Available	Number of seasonal overnight stays in accommodation facilities indicator	Tourism
National	Available	Indicator of bathing water quality	Tourism
Local	Available	Population served by public transportation	Transportation
Local	Available	Public transportation as a result of extreme weather events service interruption indicator	Transportation
Local	Available	Public transportation equipped for disabled people indicator	Transportation
Local	Recommendation	Public transportation strengthened as part of harmonization work infrastructure indicator	Transportation
National	Available	Road maintenance expenditure indicator	Transportation
National	Available	Road and rail network indicator	Transportation
Local	Available	Transportation infrastructure in flood risk areas indicator	Transportation
National	Available	Indicator of freight and passenger transportation by road	Transportation
Local	Available	Bicycle path length indicator	Transportation

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