Türkiye

2053

LONG TERM
CLIMATE STRATEGY

Foreword

Türkiye is taking significant steps towards its Net Zero Emission Target, which is vital for a sustainable environment and societal welfare. By ratifying the Paris Agreement in 2021 and announcing its Net Zero Emission Target for 2053, Türkiye has affirmed its dedication to contributing to global climate action.

Article 4, Paragraph 19 of the Paris Agreement calls on Parties to submit long-term low greenhouse gas emission development strategies, with consideration for common but differentiated responsibilities and respective capabilities, as well as national circumstances. Furthermore, at the 28th Conference of the Parties to the UNFCCC in 2023, the Global Stock Take decision urged parties that have not yet submitted their Long-Term Low Greenhouse Gas Emission Development Strategies to do so promptly and to revise them as necessary.

In this context, Türkiye's Long-Term Climate Strategy was developed under the coordination of the Ministry of Environment, Urbanization, and Climate Change, along with the Presidency of Strategy and Budget of the Republic of Türkiye. The preparation process of the Strategy was conducted in parallel with the Updated First Nationally Determined Contribution and the 2024-2030 Climate Change Mitigation and Adaptation Strategies and Action Plans. The strategy is built upon national and sectoral long-term policy documents and incorporates a broad perspective, shaped by input from around 6,000 participants across approximately 175 stakeholder institutions (including public and private sectors, civil society, academia, etc.) over more than 200 meetings since 2022.

The Long-Term Climate Strategy not only outlines strategies for climate change mitigation and adaptation sectors but also addresses sectoral strategies related to technology, just transition, climate finance, and capacity building. These sectoral strategies are crucial for guiding Türkiye’s long-term national development process towards a low-carbon and environmentally compatible path. In total, the mitigation section of the strategy includes 35 strategies across 7 sectors, while the adaptation section encompasses 38 strategies across 11 sectors. Additionally, there are 16 strategies covering technology, just transition, climate finance, and capacity building. Altogether, the Long-Term Climate Strategy comprises 89 strategies across 18 sectors and 4 cross-cutting areas.

This strategic roadmap will make a significant contribution to Türkiye’s 2053 Net Zero Emission Target. As a tangible expression of this commitment, we are honored to share Türkiye’s 2053 Long-Term Climate Strategy, renewing our support for global climate action.

Content

Abbreviations

BIM	Building Information Modelling
BVKm	Billion Vehicle Kilometer
CBAM	Carbon Border Adjustment Mechanism
CCACB	Climate Change and Adaptation Coordination Board
CCMSAP	Climate Change Mitigation Strategy and Action Plan
CCUS	Carbon Capture, Utilization and Storage
CH_4	Methane
CO_2	Carbon Dioxide
CoHE	Council of Higher Education
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
DRI	Direct Reduced Iron
ED	Excise Duty
EPB	Energy Performance in Buildings
EPC	Energy Performance Certificate
ETS	Emission Trading System
EU	European Union
EV	Electric Vehicle
FT	Fast Train
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GPP	Green Public Procurement
GW	Gigawatt
ha	Hectare
HFC	Hydrofluorocarbons
HST	High Speed Train
IPCC	Intergovernmental Panel on Climate Change
ITMO	Internationally Transferred Mitigation Outcomes
ITS	Intelligent Transportation System
LCE	Low Carbon Economy
LTS	Long Term Climate Strategy
LULUCF	Land Use, Land Use Change and Forestry
mha	Million Hectares
MRV	Monitoring, Reporting and Verification
Mton	Million Ton
MTP	Medium Term Programme
MW	Megawatt
MWh	Megawatt Hour
N_2O	Nitrous Oxide
NDC	Nationally Determined Contribution
NF3	Nitrogen Trifluoride
NIR	National Inventory Report

NPP	Nuclear Power Plant
NWMAP	National Waste Management and Action Plan
NZE	Net-Zer Emission
nZEB	Nearly Zero Emission Building
PA	Paris Agreement
PFC	Perfluorocarbons
R&D	Resarch and Development
RDF	Refuse Derived Fuel
SF6	Sulfur Hexafluoride
SME	Small and Medium-sized Enterprises
SPP	Solar Power Plant
SULP	Sustainable Urban Logistics Plan
SUMP	Sustainable Urban Mobility Plan
TL	Turkish Lira
TOE	Tonne of Oil Equivalent
TSI	Turkish Statistical Institute
TÜBİTAK	The Scientific and Technological Research Council of Türkiye
TWh	Terawatt Hour
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VKT	Vehicle Kilometers Traveled
YEKA	Renewable Energy Resource Areas
YEKDEM	Renewable Energy Sources Support Mechanism
YEK-G	Renewable Energy Sources Support Scheme
YeS-TR	National Green Certificate System

1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) aims to "stabilize greenhouse gas concentrations in the atmosphere at a level that prevents dangerous human-induced interference with the climate system." Achieving this stabilization requires a timeline that enables ecosystems to adapt naturally to climate change, ensures food security remains intact, and supports sustainable economic development.

The Paris Agreement, adopted on December 12, 2015, at the 21st Conference of the Parties (COP21) to the UNFCCC and entering into force on November 4, 2016, seeks to accelerate global efforts to combat climate change and establish more ambitious targets. Its primary objective is to keep the global average temperature increase well below 2°C above pre-industrial levels, while striving to limit it to 1.5°C. As a legally binding international treaty, the Paris Agreement provides a comprehensive framework for climate action. According to the Intergovernmental Panel on Climate Change (IPCC), limiting global warming to 1.5°C requires greenhouse gas emissions to peak before 2025, be reduced by 43% by 2030 and 60% by 2035 compared to 2019 levels, and reach net zero by mid-century[1].

Nationally Determined Contributions (NDCs) provide a vision and direction for countries in the context of their long-term planning and development priorities. Long-term climate strategies offer a forward-looking perspective and a roadmap to achieve these NDCs. Article 4, paragraph 1 of the Paris Agreement emphasizes that all parties must achieve net-zero emissions in the second half of this century to meet the Agreement's temperature goals. Additionally, paragraph 19 of the same article calls on parties to submit "long-term low greenhouse gas emission development strategies," considering common but differentiated responsibilities and respective capabilities. The First Global Stock Take urged countries that have not yet submitted their Long-Term Low Greenhouse Gas Emission Development Strategies to do so promptly and to update them as necessary.

Türkiye announced its target of achieving net-zero emissions by 2053 on September 27, 2021. The Long-Term Climate Strategy has been developed to establish a comprehensive roadmap for climate change mitigation and adaptation, and it was approved by the Climate Change and Adaptation Coordination Board (CCAB), on November 4, 2024.

In addition to the Paris Agreement, the Sustainable Development Goals (SDGs), which consist of 17 Goals and 169 Targets aimed at achieving a balanced approach to the economic, social, and environmental dimensions of sustainable development, were adopted in 2015 at the UN Development Summit under the 2030 Agenda for Sustainable Development. Since its adoption, this agenda has served as a comprehensive reference point in Türkiye's human-centered development efforts and has enabled a shared approach alongside the international community. The issue of combating climate change, critical for achieving sustainable development, is integrated into many of the SDGs. Within this framework, the SDGs address a wide range of targets that can be directly or indirectly associated with mitigation and adaptation to climate change, from food security to health, accessible and clean energy to clean water and sanitation, decent work to sustainable production and consumption, and from biodiversity to sustainable cities.

The primary goal that directly focuses on combating climate change is SDG 13: Take urgent action to combat climate change and its impacts. In line with the principle of inclusivity, SDG 13 envisions strengthening resilience and adaptive capacity to climate change, developing policies related to climate change, raising awareness, enhancing human and institutional capacity, and ensuring funding for all these targets. Efforts to combat climate change and

achieve the SDGs require a holistic approach. From this perspective, Türkiye addresses the SDGs and the fight against climate change with a comprehensive approach across all major policy documents, especially Development Plans, and prioritizes alignment in these areas at every stage.

1.1. Preparation Process of the Long-Term Climate Strategy

Türkiye announced its target of achieving net-zero emissions by 2053, followed by its ratification of the Paris Agreement in 2021. This commitment has accelerated national efforts to combat climate change. The initial step in this process was the first Climate Council, held from February 21-25, 2022, where 217 recommendations were adopted to establish a vision for Türkiye's 2053 net-zero emissions goal. These decisions, shaped by over 6,000 participants from a wide range of stakeholders, including public and private sectors, academia, and NGOs, have formed the basis for key policy documents, including the Nationally Determined Contribution (NDC), Climate Change Mitigation and Adaptation Strategy and Action Plans, the Long-Term Climate Strategy, and the draft Climate Law. Furthermore, the Twelfth Development Plan (2024-2028) outlines specific initiatives to create roadmaps, strategies, and action plans aimed at reducing greenhouse gas emissions and enhancing climate change resilience, in alignment with the Paris Agreement and Türkiye's NDC.

The Climate Law is being drafted to incorporate international agreements ratified by Türkiye into domestic legislation and to establish a legal framework for climate change action. The law aims to enhance Türkiye’s legal infrastructure for combating climate change, supporting green growth, and achieving the 2053 Net-Zero Emission target. It will provide a legal basis for greenhouse gas emission reductions, adaptation activities, planning and implementation tools, and an institutional framework.

The preparation of Türkiye’s Long-Term Climate Strategy has been carried out in parallel with other national climate policy document, such as the NDC and action plans. Over two years, meetings were held at various levels with thousands of participants representing diverse stakeholders from public and private sectors, as well as civil society. On April 13, 2023, Türkiye’s first updated NDC was submitted to the UNFCCC Secretariat. Subsequently, the Climate Change Mitigation Strategy and Action Plan (2024-2030) and the Climate Change Adaptation Strategy and Action Plan (2024-2030), designed as implementation tools for the NDC, were published on March 21, 2024. As part of the preparations for the Long-Term Climate Strategy, the Working Groups under the Climate Change and Adaptation Coordination Board (CCAB) convened and the strategies were drafted in collaboration with stakeholder institutions. (Figure 1).

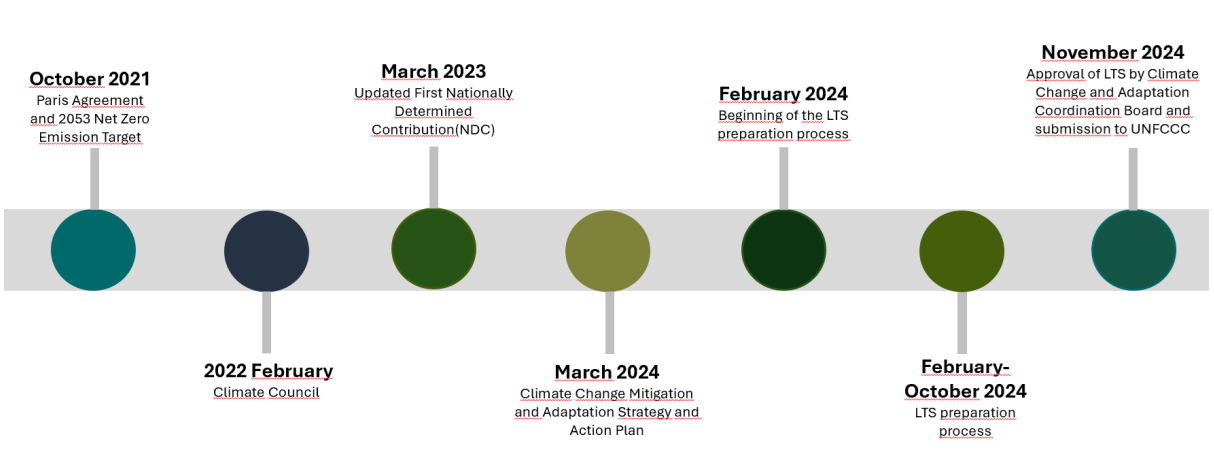


Figure 1 - Preparation Processes of LTS

2. Current State

2.1. Economic Profile

In 2023, Türkiye's GDP at current prices reached 1.13 trillion USD, with a per capita GDP of 13,243 USD (Figure 2). The sectoral distribution of GDP in 2023 shows that the services sector—including wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation, and food services—accounted for the largest share at 26.8%. This was followed by industry at 22.9%, public administration, education, human health, and social work activities at 10.3%, agriculture, forestry, and fishing at 6.2%, construction at 5.5%, and professional, administrative, and support service activities at 5.1%.[2]. Türkiye's total foreign trade volume in 2023 amounted to 617.6 billion USD, with 255.6 billion USD in exports and 362 billion USD in imports [3].

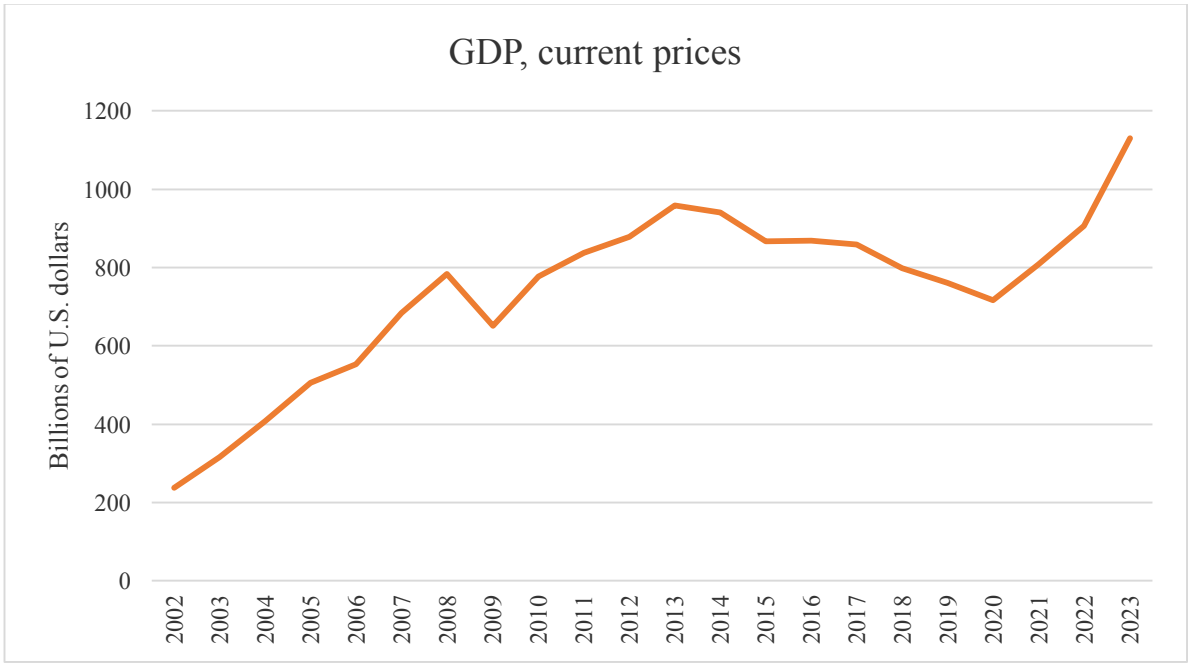


Figure 2 - Gross domestic product (at Current Prices)), 2010-2023[4]

The industry sector's pivotal role in driving productivity improvements suggests that its share of national income will likely continue to grow in the future. Within a production framework that supports sustained added value growth, primary energy consumption rose at an average annual rate of 3.5% from 2018 to 2021, while electricity demand increased at an average annual rate of 2.1% between 2018 and 2022. Additionally, the share of R&D expenditures in GDP grew from 1.18% in 2017 to 1.32% in 2022 (NIR)[5].

As of 2023, the labor force participation rate in Türkiye stands at 53.3%, with 35.8% for women and 71.24% for men. Between 2019 and 2023, a total of 2.941 million jobs were created, bringing employment to a historic high of 31.632 million people in 2023[6]. Additionally, Türkiye improved its position in the Global Innovation Index, rising from 39th among 132 countries in 2022 to 37th among 133 countries in 2024[7].

2.2. Türkiye's Greenhouse Gas Emissions

Türkiye's national greenhouse gas inventory includes direct greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), fluorinated gases (F-gases), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). The inventory covers emissions from energy, industrial processes and product use, agriculture, and waste, as well as emissions and removals from land use, land-use change, and forestry (LULUCF).

Excluding the LULUCF sector, Türkiye's total greenhouse gas emissions in 2022 decreased by 2.4% compared to the previous year, amounting to 558.3 million tons (Mt) of CO_2 equivalent (CO_2-eq). Per capita greenhouse gas emissions, which were 6.8 tons CO_2-eq in 2021, fell by 2.94% to 6.6 tons CO_2-eq in 2022 (Figure 3, Table 1)[8]. In 2022, Türkiye's per capita CO_2 emissions stood at 4.4 tons, remaining below the OECD average of 7.78 tons (Figure 4)[9].

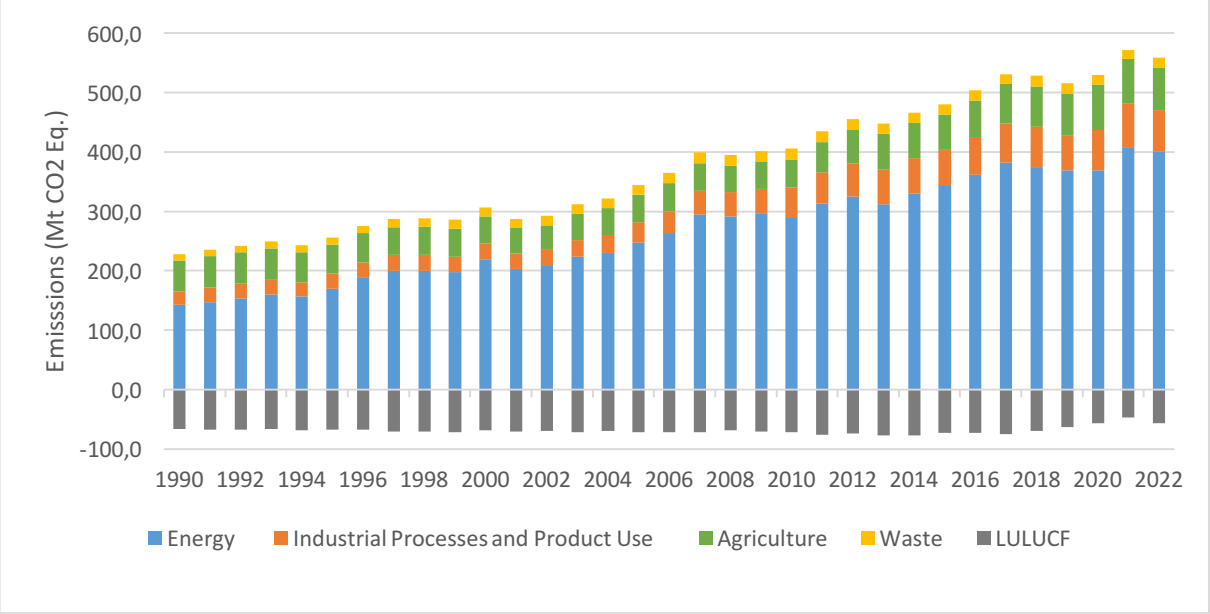


Figure 3 - Greenhouse Gas Emissions and Removals (1990-2022)

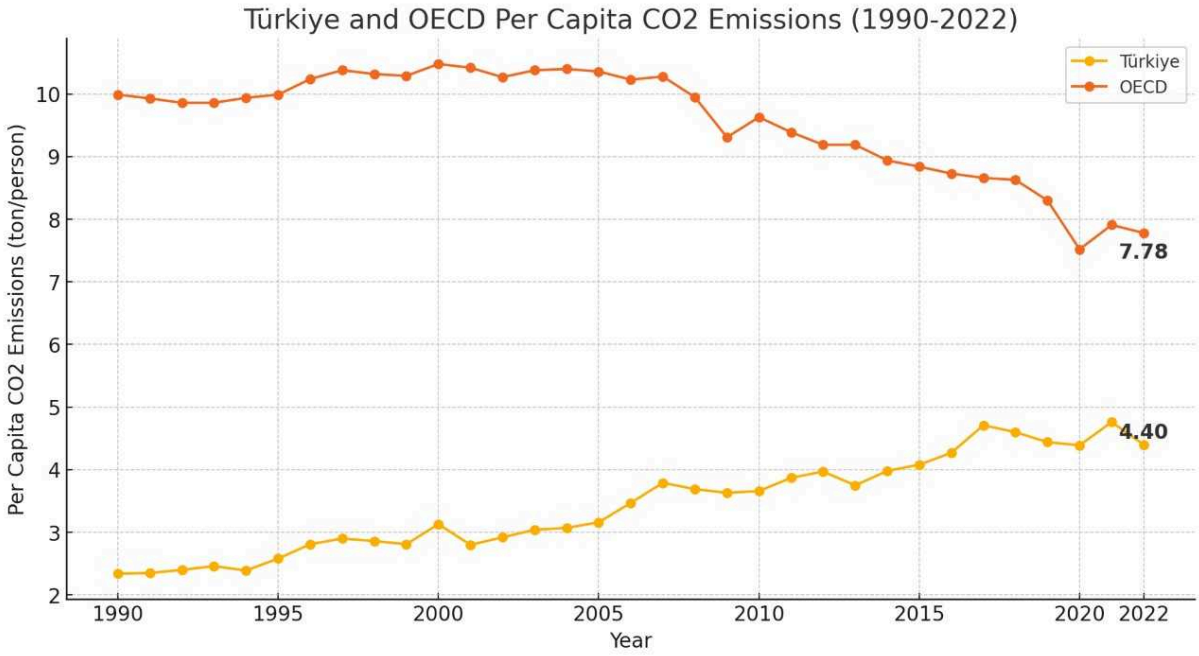


Figure 4 - Comparison of per capita CO_2 emissions of Türkiye and the OECD

Table 1 - Greenhouse Gas Emissions and Removals (1990-2022)

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2021**	**2022**	**Between 2021-2022**
Energy	143,1	170	219	247	290,9	344	369,5	406,5	400,6	-1,4
Industrial Processes and Product Use	22,7	25,4	26,1	34,0	48,6	59,2	67,2	74,4	69,9	-6,4
Agriculture	51,8	49,0	46,0	46,3	47,7	59,2	76,4	75,4	71,5	-5,1
Waste	10,3	12,1	15,5	16,9	18,1	17,7	17	15,4	16,3	5,5
Total	228	256,5	306,4	344,8	405,3	480,1	530,2	572	558,3	-2,4
LULUCF	-66,51	-67,77	-68,05	-71,78	-71,88	-72,81	-56,95	-47,15	-56,1	-8,98

The breakdown of the national inventory into four main emission categories is presented in the pie chart on the left side of Figure 4. In 2022, the energy sector accounted for the largest share of total emissions at 71.8%, followed by agriculture at 12.8%, industrial processes and product use at 12.5%, and the waste sector at 2.9%. The pie chart on the right side of the same figure

illustrates the share of emissions from sub-sectors within the energy sector in total emissions (Figure 5).

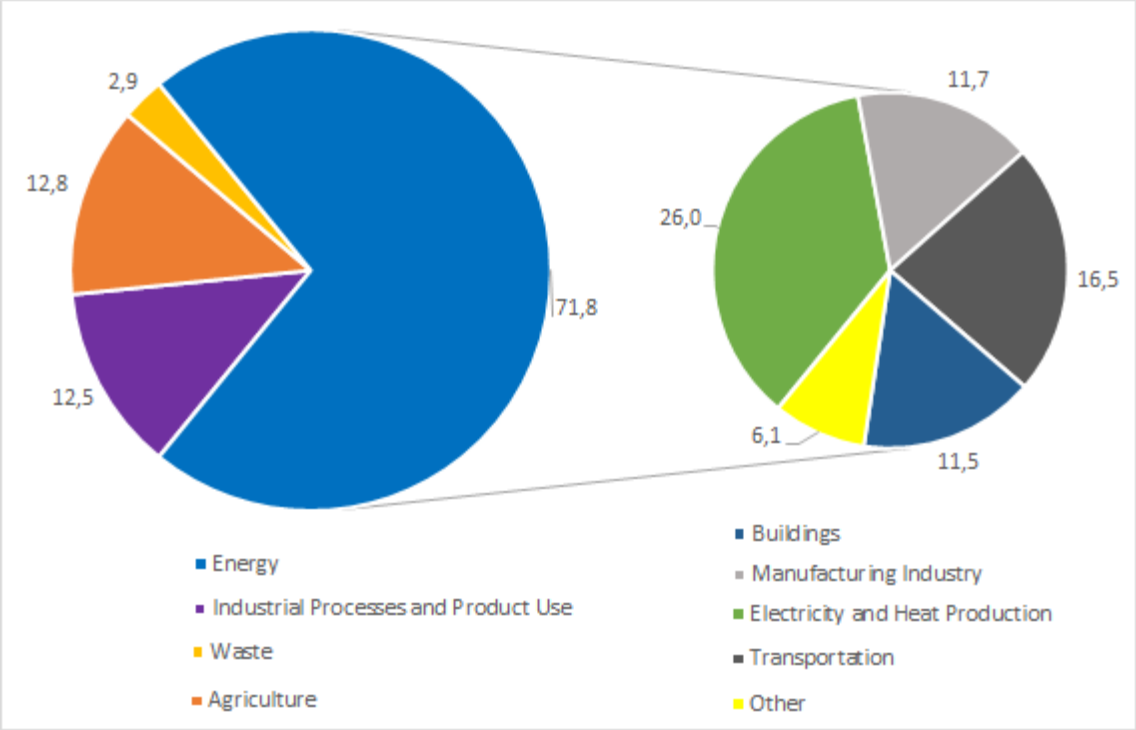


Figure 5 - Sectoral Distribution of Greenhouse Gas Emissions in 2022

The distribution of total emissions by greenhouse gases shows that carbon dioxide (CO_2) held the largest share at 79%, followed by methane (CH_4) at 13%, nitrous oxide (N_2O) at 6%, and fluorinated greenhouse gases (F-gases) at 2% (Figure 6).

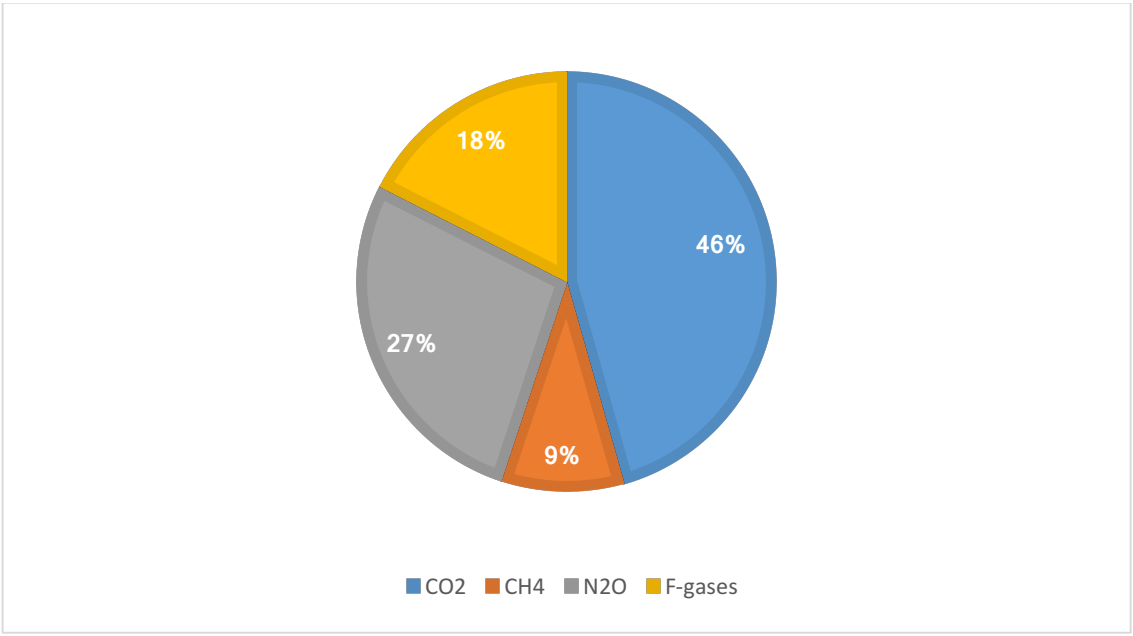


Figure 6 - Distribution of 2022 emissions by greenhouse gases

3. Key Policy Documents on Climate Change

The Directorate of Climate Change is responsible for coordinating Türkiye's national climate change policies. The preparation of sectoral strategy documents related to climate change is carried out under the Directorate's coordination, involving all relevant public institutions, private sector representatives, and civil society organizations. To facilitate stakeholder coordination in shaping climate policies, the Climate Change and Adaptation Coordination Board (CCAB) was established by Presidential Decree No. 4. The Board includes representatives from all relevant ministries, the private sector, and civil society organizations. Various working groups have been formed under CCAB to support the development of national policy documents. Core climate change policy documents, such as the Long-Term Climate Strategy, the Nationally Determined Contribution, and the Climate Change Mitigation and Adaptation Strategies and Action Plans, have been collaboratively developed and adopted in an inclusive and participatory manner with input from CCAB members.

3.1. Updated First Nationally Determined Contribution (NDC)

Türkiye submitted its Intended Nationally Determined Contribution (INDC) to the UNFCCC Secretariat in September 2015, in line with decisions 1/CP.19 and 1/CP.20, to support the Convention's ultimate objective as outlined in Article 2. Through its INDC, Türkiye announced a target of reducing greenhouse gas emissions by up to 21% by 2030 compared to the reference scenario. The Paris Agreement requires parties to submit their Nationally Determined Contributions (NDCs) to the UNFCCC every five years, with each submission reflecting increased ambition in emissions reduction targets and, optionally, in adaptation efforts. In this context, Türkiye submitted its Updated First Nationally Determined Contribution on April 13, 2023, pledging a 41% reduction in greenhouse gas emissions by 2030 compared to the reference scenario, equating to 695 Mt CO_2 equivalent by 2030[10]. Türkiye's Updated First NDC is economy-wide and includes comprehensive mitigation and adaptation actions, along with means of implementation such as finance, technology, and capacity-building measures. The Climate Change Mitigation Strategy and Action Plan (2024-2030) and the Climate Change Adaptation Strategy and Action Plan (2024-2030) were prepared and put into effect as of March 2024 to support the implementation and for monitoring of the NDC[11].

3.2. Climate Change Mitigation Strategy and Action Plan (2024-2030)

The Climate Change Mitigation Strategy and Action Plan (2024-2030) (CCMSAP) has been developed as the implementation plan for the NDC, serving as a guide for the necessary sectoral transformation to achieve the mitigation target outlined in the NDC. The Plan addresses seven main mitigation sectors: energy, industry, buildings, transportation, waste, agriculture, and LULUCF, along with two cross-cutting areas: just transition and carbon pricing mechanisms. The preparation process of the Action Plan was inclusive and transparent, involving over 2,000 participants from more than 100 stakeholders from the public and private sectors as well as civil society, with a focus on gender balance.

The strategies detail the actions needed across various areas, including legislation, technical infrastructure, technology, finance, capacity building, education, and public awareness at the sectoral level (Table 2). Each action within these strategies has assigned responsible institutions and monitoring indicators. The Plan will be transparently monitored through an online monitoring system integrated into the Climate Portal[12].

A summary of the strategies included in the Climate Change Mitigation Strategy and Action Plan (2024-2030) can be found in Table 2.

Table 2 – Sectoral Strategies

ENERGY
• Reducing the carbon intensity of electricity generation • Integrating the electricity sector with other sectors and promoting demand-side participation • Strengthening electricity infrastructure, improving efficiency, and reducing technical losses in transmission and distribution • Promoting use of low-carbon production technologies and strengthening alternatives in electricity generation • Developing a roadmap for carbon capture, utilization, and storage to mitigate unabated greenhouse gas emissions
INDUSTRY
• Maximizing the potential for energy efficiency in the manufacturing industry • Increasing the use of renewable energy in the manufacturing sector • Reducing the carbon footprint of the manufacturing industry and lowering CO_2-equivalent intensity per unit of GDP • Promoting the widespread adoption of sustainability reporting • Enhancing the capacities of stakeholders in the manufacturing sector • Promoting circular economy practices and resource efficiency across all manufacturing industry sectors • Developing sustainable investment instruments and establishing suitable financing resources for investors
BUILDINGS
• Improving energy efficiency in existing buildings • Enhancing energy efficiency in new buildings • Increasing energy efficiency in the use of electrical appliances, equipment, and devices in buildings • Promoting and expanding the use of district heating and cooling systems • Encouraging the use of environmentally friendly design and construction materials through the implementation of the National Green Certification System (YeS-TR) • Facilitating, promoting, and encouraging the use of Building Information Modeling (BIM) tools to achieve digital transformation in the construction ecosystem
TRANSPORTATION
• Facilitating a modal shift to maritime and rail transport • Enhancing efficiency in the transportation sector • Utilizing sustainable/clean energy sources in transport systems • Implementing necessary infrastructure activities for the decarbonization of the sector
WASTE
• Preventing and reducing the generation of waste and wastewater • Increasing recycling and recovery rates for waste • Reducing the proportion of waste sent to landfills without prior treatment • Improving wastewater management and treatment infrastructure

• Capacity building and raising public awareness within the scope of zero-waste practices and greenhouse gas emission reduction • Creating incentives and financing mechanisms to improve waste management in line with circular economy principles and greenhouse gas emission reduction • Enhancing research and development activities and advancing technological infrastructure to improve waste management, considering circular economy principles and greenhouse gas emission reduction • Increasing the use of waste as raw materials/resources in production • Reducing greenhouse gas emissions from vehicles used in waste management
AGRICULTURE
• Reducing methane emissions from livestock • Ensuring efficiency in the use of chemical fertilizers • Minimizing the use of pesticides and antimicrobials • Improving the management of loss, waste, and residues in agricultural production • Enhancing land and soil management • Providing farmers with access to suitable financing options • Expanding training, awareness, and capacity-building activities for stakeholders in the agricultural sector, with a focus on gender balance
LAND USE, LAND-USE CHANGE, AND FORESTRY (LULUCF)
• Enhancing annual greenhouse gas sequestration through the protection, sustainable management, and expansion of sinks, while reducing ecosystem-based emissions • Facilitating the transition of forestry and agricultural enterprises to a high-value-added circular bioeconomy • Doubling project support for R&D and innovation in the sector by 2030 compared to 2020 levels • Increasing the number of trained technical staff and professionals in carbon management within the sector • Developing technological infrastructure for the LULUCF sector
JUST TRANSITION
• Capacity building for a just transition and employment transformation
CARBON PRICING MECHANISMS
• Establishing an Emissions Trading System (ETS) in Türkiye • Conducting studies for other carbon pricing instruments • Creating infrastructure for the voluntary carbon market and national offset mechanisms • Carrying out studies to evaluate participation in Article 6 of the Paris Agreement

3.3. Climate Change Adaptation Strategy and Action Plan (2024-2030)

The Climate Change Adaptation Strategy and Action Plan (CCASAP) for 2024-2030 has identified 11 priority sectors that are highly vulnerable to climate change. These sectors include agriculture and food security, biodiversity and ecosystem services, water resources management, tourism and cultural heritage, industry, urban development, social development, public health, transportation and communication, energy, and disaster risk reduction.

Regional climate projections produced by various institutions were utilized to analyze the anticipated climate hazards associated with climate change for the upcoming period, and the

results were evaluated. Based on the findings, vulnerability and risk analyses were conducted for the identified sectors in the Action Plan using internationally recognized risk analysis methodologies. Preliminary studies were completed to identify gaps and actions recommended in the international literature as a result of the vulnerability and risk analyses.

Cross-cutting issues related to climate change adaptation were also included in the Action Plan. Meetings involving sector experts and stakeholders from 180 different institutions led to the identification of a total of 40 strategies and 129 actions for the 11 sectors and cross-cutting issues. Implementation plans have also been prepared for monitoring the sectoral actions, and the Plan will be transparently monitored through an online monitoring system integrated into the Climate Portal [12].

3.4. Other National Policy Documents on Climate Change

Türkiye places the fight against climate change at the center of its economic transformation. The alignment of key climate policy documents such as the NDC, CCMSAP, and IDUSEP with all short, medium, and long-term national plans and policies has been taken into account. In this context, the fundamental policy documents considered during the preparation processes of the Long-Term Strategy (LTS) are listed below.

- Twelfth Development Plan (2024-2028)
- Medium-Term Program (2025-2027)
- Türkiye National Energy Plan (2022-2035)
- Energy Efficiency Strategy 2030 and 2nd National Energy Efficiency Plan (2024-2030)
- 2053 Transport and Logistics Master Plan
- Low-Carbon Pathways for the Aluminum, Steel, Cement, and Fertilizer Sectors
- Türkiye Hydrogen Technologies Strategy and Roadmap
- Mobility Vehicles and Technologies Roadmap
- Green Growth Technology Roadmap
- National Strategy and Action Plan for Combating Desertification
- Water Efficiency Strategy Document and Action Plan in the Context of Climate Change Adaptation (2023-2033)
- Türkiye Agricultural Drought Mitigation Strategy and Action Plan (2023-2027)
- Türkiye Building Sector Decarbonization Roadmap
- Green Deal Action Plan
- Ministry of National Education Climate Change Action Plan
- Sustainable Banking Strategic Plan (2022-2025)
- National Biodiversity Strategy and Action Plan (NBSAP) (2018-2028)
- National Biodiversity Additional Action Plan (NBAP) (2018-2028)

4. Climate Change Policies for 2053

4.1. Long-Term Development Strategy (2024-2053) and Türkiye's 2053 Development Vision

Türkiye aims to reach a peak in greenhouse gas emissions by 2038 at the latest, after which emissions will gradually decline, with the goal of achieving net-zero emissions by 2053. Türkiye plans to reach this goal within the framework of the Long-Term Development Strategy (2024-2053) outlined in the Twelfth Development Plan. This Long-Term Development Strategy provides a roadmap for maximizing the benefits of the profound changes and transformations expected globally. The strategy envisions Türkiye as an effective, powerful, and prosperous country by 2053, contributing to humanity while preserving its national and spiritual values, thus guiding global developments for peace, tranquility, and prosperity in its region and the world.

The strategy establishes a vision for combating climate change across all dimensions of development in line with the 2053 net-zero emission target. Through structural transformations across all sectors, including agriculture, industry, energy, transportation, and services, Türkiye aims to become a central hub in global production and trade by 2053. Human capital will be strengthened to meet the needs arising from this transformation, ensuring that the labor market adapts to green and digital transitions. Türkiye's export vision will be built sustainably in international goods and services trade with high-value-added, environmentally friendly, branded products and services, considering global trends.

Decisive steps will be taken in areas such as the sustainable management of natural resources, energy transformation, green infrastructure, and investments in the circular economy, as well as in the domestic production of environmental protection and green technologies, to achieve the net-zero emissions target by 2053 without compromising our development priorities. Within this framework, it is anticipated that additional investments needed in sectors such as energy, buildings, services, industry, transportation, agriculture, and forestry should reach an annual average of at least 1.7% of national income compared to the current scenario where pre-Plan trends continue. Of this, approximately 1 percentage point should come from the private sector, while 0.7 percentage points should be sourced from the public sector. Türkiye will become one of the leading countries in global green finance, with diversified and increased financing opportunities for green investments aimed at achieving the net-zero target.

The provision of sustainable, high-quality, secure, uninterrupted, and affordably priced energy supply is targeted by maximizing the utilization of domestic and renewable energy sources and improving energy efficiency, based on the 2053 net-zero emissions target. The structure of electricity generation will be transformed through renewable energy, electrification, energy efficiency, green hydrogen, energy storage, and the establishment of nuclear power plants (NPPs) and small modular reactor investments.

By 2053, Türkiye will maintain its position as one of Europe's largest countries in terms of agricultural national income while ranking seventh in the world, having ensured the sustainability of its natural resources. The country's natural resources, particularly its genetic resources in the agriculture and food sector, will be effectively protected, with increased efficiency, production growth, self-sufficiency, and supply security. Efforts will be made to enhance carbon sink areas, especially concerning forests and soil quality. Sustainable and efficient use of water resources will ensure that all irrigable agricultural lands are irrigated. Quality of life and prosperity will be maximized, and resilient, connected rural settlements will be established.

The tourism sector will adopt an approach that protects, develops, and ensures the sustainability of the natural, historical, and social environment, with green transformation accelerated within the sector. Natural resources and unique tourism values will be preserved, and technological and physical infrastructure that reduces adverse environmental impacts will be developed. The vulnerability of cultural heritage to climate change will be managed to ensure its transfer to future generations.

In the transportation and logistics sector, priority will be given to railway and maritime transport to minimize environmental impacts and enhance energy efficiency, establishing a safe, uninterrupted, effective, integrated, and sustainable transportation network. Roads will be developed with new smart routes suitable for electric vehicles, intelligent transportation systems, and autonomous systems. Cooperative Intelligent Transportation Systems, utilizing Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication technologies, will be established to enhance traffic safety, optimize signal durations based on traffic density at signalized intersections, reduce unnecessary waiting times, stops, fuel consumption, and harmful emissions, while shortening travel times and increasing traffic safety, road capacity, and service levels. Türkiye's maritime trade fleet will be developed, and the number of green ports will be increased based on digitalization and energy efficiency.

Across the country, prioritization will be established for all types of disaster risks considering the socioeconomic and physical characteristics of the regions, and efforts will be made to reduce disaster risks and damages. By 2053, Türkiye will have fully transformed its building stock and infrastructure, becoming resilient and prepared for disasters, adapted to the effects of climate change, and a leader in disaster management worldwide.

It is anticipated that the green transformation achieved through investments carried out under this strategy will provide economic and environmental benefits that could reach an annual average of 7.8% of national income by mitigating negative effects related to energy imports, fossil fuel resources, air pollution, agricultural production loss, and disruptions in transportation.

4.2. Mitigation

4.2.1. Energy Sector

According to the 2022 Energy Balance Table, Türkiye’s total energy supply amounted to 157.8 million TOE (tons of oil equivalent), while electricity and heat generation reached 328,379 GWh that year[13]. From 2000 to 2022, the global average annual increase in electricity demand was 3.3%, whereas in Türkiye, driven by its growing economy, this rate was 4.4%[14]. As of the end of September 2024, Türkiye’s installed electricity capacity had risen to 114,215 MW[15], with renewable energy sources making up almost 57% of the total capacity. The substantial increase in total installed capacity was primarily driven by solar and wind energy, with solar power capacity reaching 18,731MW and wind energy capacity reaching 12,335 MW.

The greenhouse gas emission inventory published by TurkStat indicates that emissions from electricity and heat generation amounted to 145.03 $MtCO_2$-eq, with emissions from the electricity sector alone totaling 138.48 $MtCO_2$-eq (Figure 7). Additionally, emissions from electricity generation accounted for 24.80% of the total emissions [16]. Moreover, the trend in greenhouse gas emissions from the energy sector in recent years has been significantly influenced by the economic impacts of the COVID-19 pandemic and regional conflicts.

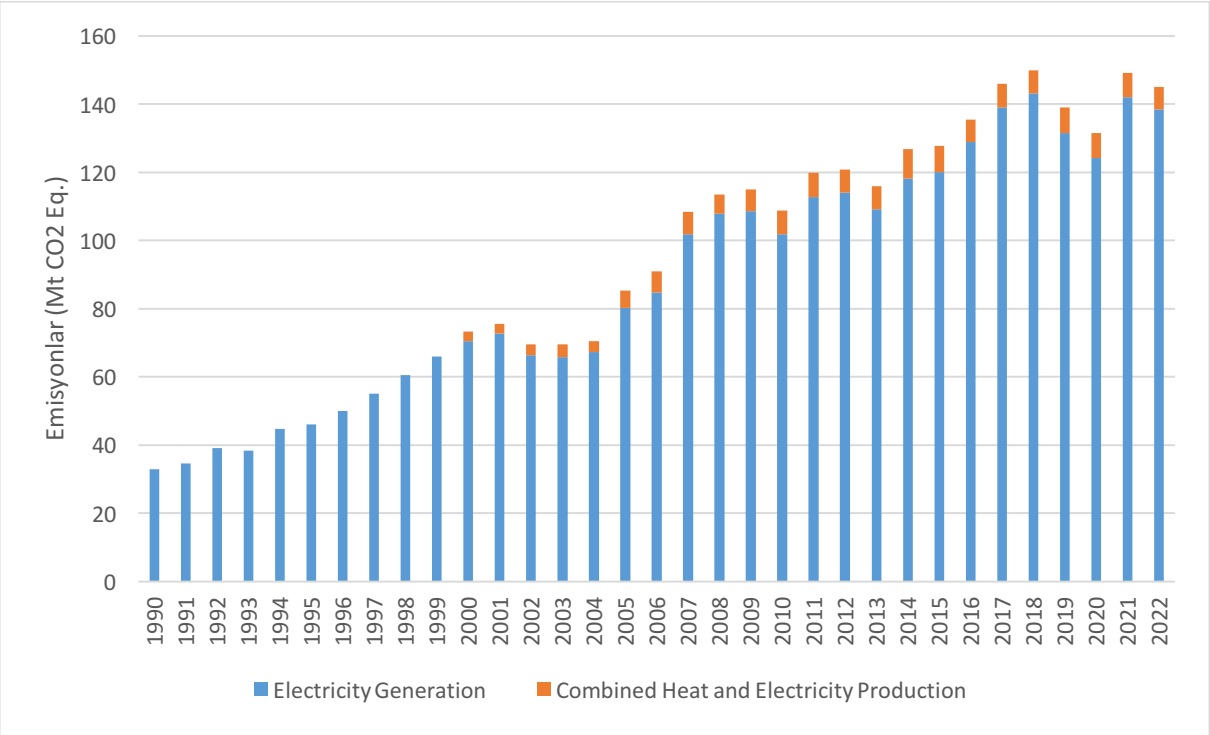


Figure 7 - Emissions from Electricity Generation and Combined Heat and Electricity Production

Türkiye is a country where energy demand has been increasing due to its growing population and expanding economy. Over the past decade, the population has grown by 13%, and GDP has increased by 67%. Alongside this economic growth, energy consumption has risen by 34%, while emissions from the energy sector have increased by 26% [15], [17]. Recently implemented renewable energy policies and incentives have successfully redirected private sector investments from fossil fuels to renewable energy.

Key incentives crucial for the green transformation in energy include the Renewable Energy Support Mechanism (YEKDEM), which promotes local production by offering long-term purchase guarantees to effectively utilize renewable energy resources and increase investments. Another important initiative is the Renewable Energy Resource Areas (YEKA) model, which facilitates large-scale projects and supports domestic production. Under YEKDEM, more than 506 billion TL has been allocated to renewable energy projects between 2011 and 2023. As a result of these measures, the renewable energy capacity has more than doubled over the past decade, meeting growing energy demand while significantly curbing emissions growth [18].

Türkiye ranks 11th globally and 5th in Europe in terms of renewable energy-based power capacity [19]. The country aims to quadruple its existing renewable energy capacity, reduce energy intensity by 35%, and integrate renewable energy technologies into the national energy system as part of its short- and medium-term targets set for 2030 and 2035 (Table 3). These objectives align with the First Global Stocktake decision (1/CMA.5) adopted at the 28th Conference of the Parties (COP28) to the UNFCCC in 2023. To achieve these short-term goals in energy efficiency, renewable energy, and energy technologies, Türkiye plans to invest approximately $59 billion in renewable energy, $2.5 billion in energy storage, $4.1 billion in demand-side participation by 2035, and $20.2 billion in energy efficiency by 2030.[1]

[1] This information has been provided by the Republic of Türkiye's Ministry of Energy and Natural Resources.

Table 3 Türkiye's Energy Sector Goals [20]

Energy source/technology	2020	2024 (August)	2030	2035
Total electricity consumption	306,1 TWh	335,2 TWh (2023)	455,3 TWh	510,5 TWh
Total installed electricity capacity	95,9 GW	113,9 GW	149,1 GW	227,2 GW
Installed capacity of hydropower	30,9 GW	32,2 GW	35,1 GW	35,1 GW
Installed capacity of solar energy	6,7 GW	18,5 GW	32,9 GW	76,9 GW
Installed capacity of wind energy	8,8 GW	12,3 GW	18,1 GW	43,1 GW
Installed capacity of geothermal and biomass energy	3 GW	4,1 GW	5,1 GW	5,1 GW
Installed capacity of nuclear energy	-	-	4,8 GW	7,2 GW
Battery capacity	-	-	2,1 GW	7,5 GW
Electrolyzer capacity	-	-	2 GW	5 GW
Demand-side participation	-	-	0,9 GW	1,7 GW
Energy source/technology	0,145 tep/thousand $2015	-	0,113 tep/thousand $2015	0,093 tep/thousand $2015

Türkiye is continuing its energy transformation to sustainably meet growing energy demand and achieve its 2053 net zero emission target. This transformation focuses on increasing electricity generation from renewable energy sources and developing low-carbon fuel systems, which not only reduce the environmental footprint of energy systems but also promote innovation, create new job opportunities, and enhance energy independence and security. However, these technological advancements require significant investment.

4.2.1.1. Strategies for the Energy Sector within the Scope of the 2053 Net Zero Emission Target

Reducing greenhouse gas emissions and achieving the 2053 net zero emission target require critical investments in renewable energy, electrification, energy efficiency, nuclear technologies, green hydrogen, and energy storage. To decrease reliance on fossil fuels, the use of clean energy sources—such as solar, wind, hydroelectric, geothermal, and nuclear—will become more widespread. In addition, carbon capture, utilization, and storage (CCUS) and the use of green hydrogen will gain importance, especially in sectors where emission reductions are more challenging. As the transition to low-carbon energy accelerates, the demand for critical minerals in the energy sector will increase, making their sustainable use and supply even more essential.

Achieving the 2053 net zero emission target will require leveraging local resources and transitioning to a knowledge- and technology-intensive, high value-added production structure. Structural transformations in energy processes through green and digital technologies will ensure the sustainability of natural resources. The sustainable management of these resources,

coupled with investments in green infrastructure and a circular economy, will help Türkiye achieve the 2053 net zero emission target while considering national development priorities.

Strategy 1. Increasing the Share of Electricity Generation from Renewable Energy Sources

Türkiye's 2053 targets include plans to significantly increase the use of renewable energy sources and boost their share in the energy supply. It is projected that total electricity demand will reach 1,271.39 TWh by 2053. The share of renewable energy sources, which was 42.4% in 2020, is expected to rise to 69.1% to meet this demand in 2053. Solar and wind energy, in particular, are anticipated to play a crucial role in transitioning to a low-carbon electricity generation system. The aim of increasing renewable energy installed capacity is to enhance energy supply security and reduce external dependency. Existing clean technologies will be leveraged cost-effectively, maximizing renewable energy potential. Additionally, the use of innovative technologies such as hybrid power plants, floating solar, and offshore wind energy systems will be expanded, even if they are not yet fully commercialized. Beyond boosting renewable energy capacity, the use of YEK-G certificates will be encouraged in both the private and public sectors. Efforts to reduce foreign dependency in renewable energy technologies and increase global competitiveness will involve research and development (R&D) to strengthen local production capacity.

Strategy 2. Development of Low-Carbon Solutions

The Strategy for Developing Low-Carbon Solutions encompasses increasing the use of transition fuels and nuclear energy. These sources will play a critical role in enhancing Türkiye's energy supply security and will contribute significantly on the path to achieving the 2053 net zero emission target, serving as cleaner alternatives until desired levels of low-emission technologies are reached. The existing natural gas transmission and distribution infrastructure will be strengthened, and natural gas access will be provided in areas where renewable sources and waste heat-based district heating/cooling systems are not technically or economically feasible.

In the short and medium term, the use of transition fuels will be expanded, including energy-from-waste technologies—both thermal (combustion, gasification, and pyrolysis) and biological (anaerobic digestion and landfill gas-to-energy)—as well as biofuel technologies (biodiesel, bioethanol, and biogas).

As of 2024, Türkiye, which currently has no nuclear energy production, will integrate nuclear electricity generation into its energy portfolio and carry out efforts to establish and localize nuclear technologies. The Akkuyu Nuclear Power Plant (NPP) will commence full-scale electricity production with all its units operational. Once all units of Akkuyu NPP are commissioned, it is expected to supply 10% of Türkiye's electricity needs and reduce greenhouse gas emissions by 30 million tons of CO_2-eq annually.

Strategy 3. Development and Expansion of Flexibility Technologies

This strategy involves the development of power-to-gas systems, the increased use of hydrogen, and the expansion of energy storage systems. This strategy encompasses the widespread adoption of energy storage systems through the use of hydrogen and synthetic metals, powered by electricity. In net-zero energy systems, a rise in electricity consumption by end-users is anticipated. With greater electrification, the use of flexibility technologies will become essential to enhance the security and quality of the electricity grid.

Green hydrogen, recognized as a key approach for achieving net zero emission targets, is expected to play a significant role in enhancing grid flexibility. In this context, it is projected that our country's electrolyzer capacity will reach 2 GW by 2030, and 5 GW by 2035. Ongoing efforts to develop hydrogen technologies and local electrolyzer production will continue to be expanded, with support for international collaborations. Efforts will also be made to facilitate the transport and storage of hydrogen and to promote the widespread use of green hydrogen nationwide. Furthermore, hydrogen-based carriers such as ammonia and synthetic hydrocarbons will be utilized in energy-intensive processes, contributing to emission reductions. As the consumption of alternative fuels like biofuels, hydrogen, ammonia, and synthetic methane increases, the energy system will become even more low-carbon.

The increase in intermittent renewable energy capacity will create a greater need for grid flexibility. One of the methods to address this need is through battery storage systems, whose installed capacity is projected to reach 7.5 GW by 2035. This growth is expected to be primarily driven by solar and wind energy plants equipped with storage solutions. Additionally, energy storage systems based on pumped-storage hydropower plants are planned. Efforts will also continue to increase natural gas storage capacity to minimize the impact of fluctuations in commodity prices.

Strategy 4. Achieving Digital Transformation

Türkiye aims to enhance supply security and system efficiency by transitioning to a digitalized energy system. Increased electrification and the integration of energy systems, supported by smart control systems, will enable more efficient use of existing infrastructure. Digitalization will facilitate the transition to zero-emission energy systems through advanced control systems, such as energy storage, demand management, and flexible production.

Digital technologies will optimize the interconnected and complex conditions in energy-dependent sectors, reducing the need for additional energy infrastructure investments. Smart control systems will enable better utilization of infrastructure at local, regional, national, and international levels, resulting in significant savings. Energy efficiency will be enhanced through data collection and analysis technologies, the deployment of smart meters, and the real-time monitoring of energy systems. This will be achieved using the Internet of Things, artificial intelligence, big data operating systems, blockchain, and cloud storage systems.

Strategy 5. Improving Energy Efficiency in Generation, Transmission, and Distribution

Efficiency in energy systems will be enhanced at every stage, from generation to transmission, distribution, and consumption, with the electricity grid forming the backbone of low-carbon energy systems. As the integration of renewable energy sources introduces economic and technical challenges, the grid will be strengthened, and its flexibility increased. Energy efficiency improvements will be made from transformers to transmission and distribution equipment, and hybrid renewable energy systems along with storage technologies will be promoted.

Developing a distributed electricity infrastructure is crucial, as it will enable local energy generation near consumption points, manage peak loads from electric vehicle charging stations, and seamlessly integrate prosumers into the energy market. It will also enhance the grid's capacity for bidirectional energy flow and provide efficient energy storage solutions. To ensure effective electricity transmission, technologies such as high-voltage alternating current (HVAC), high-voltage direct current (HVDC), and ultra-high-voltage direct current (UHVDC) will be adopted whenever they prove to be technically and economically feasible.

Aligned with the 2053 net zero emission target, international electricity interconnection capacity will be expanded, and smart grid solutions and smart meters will be widely

implemented. According to the Renewable Energy 2035 Roadmap published in October 2024, by 2035, 90,500 km of AC lines and 942 substations will be established. The interconnection capacity will reach 6,750 MW for exports and 6,600 MW for imports. Efficiency improvements in electricity generation plants will continue, with efforts to minimize equipment and operational efficiency losses in dam-based hydropower plants. For solar power plants, measures such as automatic cleaning systems for surface maintenance and performance monitoring software to continuously track pollution levels will be employed to prevent efficiency losses due to dirt buildup.

Under the Energy Efficiency 2030 Strategy and the Second National Energy Efficiency Action Plan (2024-2030), a total of $20.2 billion will be invested in energy efficiency across all sectors (buildings, industry, transportation, agriculture, and energy), with a cumulative target of 37.1 million TOE in primary energy savings. By 2030, Türkiye aims to achieve a 16% reduction in primary energy consumption and a reduction of 100 million tons of CO_2-eq in greenhouse gas emissions.

Strategy 6. Ensuring Demand-Side Management

With the increase in electrification, energy demand will rise. Additionally, the need for additional installed capacity will not decrease; rather, it will increase along with the growing demand for renewable energy capacity.Between 2020 and 2035, energy intensity in Türkiye is expected to decline by 35.3%. The final energy intensity, estimated at 0.0902 TOE per thousand dollars (in 2015 prices) in 2025, is targeted to decrease to 0.0674 TOE per thousand dollars (in 2015 prices) by 2035.

Reducing energy demand is crucial for the electricity sector to achieve the 2053 net zero emission target. This reduction will be achieved through increased efficiency and the identification of surplus demand. Sector coupling will also be enhanced through the implementation of advanced technologies, such as regional heating infrastructure that produces both heat and electricity, and the use of smart controls for electric vehicles to provide grid balancing services.

Awareness, outreach, and educational activities will be carried out to promote energy efficiency and inform consumers, encouraging the adoption of energy-saving devices. To manage demand-side transformation, the number of skilled personnel in the energy sector will be increased, and higher education programs will be aligned with new technologies. On the supply side, efforts will focus on increasing the number of qualified personnel and improving the quality of education and training to ensure efficient energy use. The transition to smart grid systems and the widespread adoption of energy storage technologies will be promoted to maintain the balance between supply and demand. Regional energy use plans will be developed, led by local authorities, to facilitate demand-side transformation.

The transition to smart grid systems will support the efficient balancing of supply and demand, the expansion of energy storage systems, and the creation of flexibility under competitive market conditions through innovative business models. Waste heat potential will be utilized, and the use of cogeneration and trigeneration systems will be expanded. Local governments will contribute to energy transformation by preparing heat supply plans.

4.2.2. Manufacturing Industry

The industrial sector in Türkiye represents a significant portion of the country's GDP. In 2023, the share of the industrial sector in national income reached 22.9%, with the manufacturing industry accounting for the largest share at 86%. Of the total exports amounting to $255 billion in 2023, the manufacturing industry contributed $241 billion, representing 94% of total exports.

Emissions from the industrial sector are categorized into two primary categories: energy emissions from fossil fuel use and process-related emissions. In 2022, energy emissions resulting from fossil fuel consumption in the industrial sector amounted to 65.5 $MtCO_2$-eq, while process emissions reached 69.9 $MtCO_2$-eq (Figure 8). Industrial emissions comprised 24.2% of Türkiye's total emissions of 558.3 $MtCO_2$-eq [8].

In 2021, the manufacturing industry sector had the highest share of final energy consumption, at 34.7% [21]. Assuming sectoral transformations across the subsectors of the manufacturing industry, this share is projected to increase to 38.7% by 2035. Additionally, electricity consumption in the sector is expected to grow at an average annual rate of 3.7% until 2035 [20].

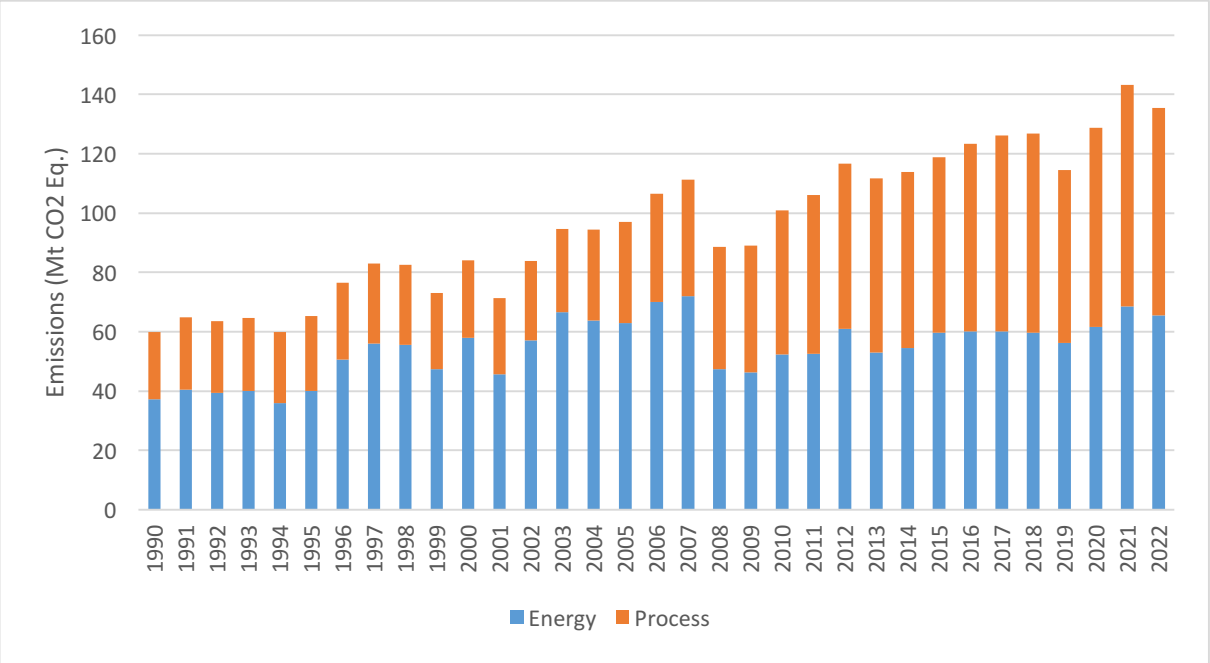


Figure 8 - Manufacturing Industry Emissions

Efforts under the "Century of Sustainability" vision in Türkiye's "Türkiye's Century" initiative are focused on reducing and preventing industrial pollution at the source. This is being achieved through clean, environmentally friendly, and innovative technologies as part of the green transformation in industry, aligned with the 2053 zero emission and zero pollution policies. As part of these efforts, the "Industrial Emissions Management Regulation" has been prepared, and industrial facilities that implement the cleanest techniques for environmental, energy, and resource efficiency will be awarded the "Green Transformation in Industry Certificate." The "Green Transformation in Industry" initiative aims to promote eco-friendly production, improve environmental outcomes, and boost the competitiveness of Turkish industry.

The Twelfth Development Plan for 2024-2028 outlines policies that aim to make the manufacturing sector a leader in digital transformation, aligned with sustainability standards, and efficient in production. By 2053, the goal is for the sector to surpass the OECD average in high-tech manufacturing and exports. By the end of the plan period, the manufacturing industry's share of GDP is expected to exceed 30%, positioning Türkiye among the top 10 global manufacturing economies. The share of high-tech industries in manufacturing exports, currently at 3%, is projected to increase to 17% by the end of the period. Measures to boost

competitiveness, productivity, and technological capacity are expected to yield an average annual growth rate of 5.9% in the industrial sector throughout the plan period. The sector's share of GDP is targeted to reach 26.9% by 2028, with fixed capital investments projected to grow at an average annual rate of 5.5%.

Furthermore, investments in large-scale and innovative projects focused on technology, green, and digital transformation will be prioritized. These efforts aim to reduce import dependency, enhance efficiency, and foster a more competitive industrial sector. Priority sectors include chemicals, pharmaceuticals and medical devices, electronics, electrical equipment, machinery, automotive, and rail system vehicles. The focus is on increasing economic value, ensuring environmental sustainability, and reducing emissions from the manufacturing sector through advanced, high-tech production methods.

Since the European Union (EU) remains Türkiye's primary export market, the EU's Carbon Border Adjustment Mechanism (CBAM) is expected to have a significant impact on Turkish exports. This mechanism, designed to prevent carbon leakage and promote a more sustainable economic model, has prompted the development and implementation of the Green Deal Action Plan to help affected sectors adapt to new market conditions. Updates to the plan are ongoing, with a new plan period expected to commence in 2025. National carbon pricing mechanisms also present an opportunity to mitigate CBAM's economic impact, accelerate industrial decarbonization, and improve energy efficiency. To support these measures, infrastructure for data collection and analysis will be developed.

4.2.2.1. Strategies for the Manufacturing Industry Sector within the Scope of the 2053 Net Zero Emission Target

Türkiye aims to significantly reduce greenhouse gas emissions while maintaining and enhancing the competitiveness of the industrial sector in line with its long-term strategy. By 2053, the widespread implementation of energy efficiency measures, increased use of renewable energy, resource efficiency, and the adoption of advanced technologies, circular economy principles, and sustainable practices in the manufacturing industry are expected to substantially lower emission intensity.

Türkiye has developed low-carbon roadmaps for sectors subject to the EU's CBAM, including iron and steel, aluminum, cement, and fertilizers. These roadmaps outline the use of the best available techniques and emerging clean production technologies, along with policy measures and financing requirements. Implementing these roadmaps, establishing necessary financial mechanisms, and initiating pilot projects are crucial for aligning the industrial sector with the 2053 net zero emission target.

In the steel sector, the roadmap indicates that total emissions could be reduced by 20,6 % by 2040 and by 99,7 % by 2053 compared to a scenario based on current policies and conditions. The total investment required to achieve net zero, considering all feasible low-carbon technologies and supportive financial and regulatory policies, is estimated at approximately $33.6 billion. For the cement sector, it is estimated that the sector's total emissions could be reduced by 29.8% by 2040 and by 92.8% by 2053 compared to a scenario that takes current policies and conditions into account, with the total investment cost for transformation over the next 30 years estimated at $29.8 billion. In the aluminum sector, projections indicate that total emissions could be reduced by 53% by 2040 and by 75% by 2053, relative to a baseline scenario based on current policies and conditions. The estimated total investment required for the sector is $4.4 billion. For the fertilizer sector, a complete reduction of emissions by 100% is targeted by 2053, with an expected investment cost of $5.3 billion.

Sectors like iron and steel, petrochemicals, and cement are classified as "hard-to-abate sectors" because of their high energy consumption requirements and significant process-related emissions. Addressing this challenge requires the development of transition financing instruments to support investments aimed at reducing emissions. By offsetting the substantial investment costs associated with production and operations, these instruments can expedite the transformation process.

Strategy 1. Maximizing Energy Efficiency Potential

The industrial sector holds a significant share in energy consumption and, consequently, in greenhouse gas emissions. Maximizing the energy efficiency potential will play a decisive role in reducing emissions, particularly those from industrial combustion sources. The primary goal under this policy is to reduce energy intensity in the industrial sector by at least 10% by 2053, compared to 2022. In line with the 2030 targets, the first step involves creating an energy efficiency inventory for the industrial sub-sectors and regularly updating this inventory to form a foundation for subsequent measures.

On the other hand, with the exception of investments not encouraged, this strategy will be implemented in existing manufacturing facilities with an annual energy consumption of at least 500 TOE. Investments aimed at energy efficiency, which provide at least a 15% energy saving compared to the current situation, are among the priority investment areas. The continuation of incentives for energy efficiency investments is intended.

The replacement of old technology facilities with efficient electric motors and equipment will be supported. For facilities receiving support, a monitoring system will be established, and increases in efficiency will be recorded.

Green Organized Industrial Zone (OIZ) certification and green certification systems targeting SMEs will promote energy efficiency. As part of digital transformation, the use of artificial intelligence systems in the sector and digital twin applications will contribute to increased energy efficiency in facilities.

Strategy 2. Increasing the Use of Renewable Energy in Industry

Increasing the use of renewable energy in industry has gained importance in achieving innovation, growth, and competitiveness. It is projected that electricity consumption in the industrial sector will see an average annual increase of 3.7% until 2035, and this growth is expected to continue, especially after 2040, with the accelerated shift to electrification in systems that involve direct fuel combustion. In this context, boosting renewable energy production and usage in industrial facilities will contribute to the sector’s decarbonization process in the medium and long term.

Encouraging the use of small-scale renewable energy-based heating and cooling systems in the industrial sector, particularly among SMEs, will play a role in reducing the carbon footprint. Additionally, green OIZ certification, green certification systems, and the Renewable Energy Guarantee of Origin (YEK-G) system will promote renewable energy production and use. Furthermore, setting renewable energy usage targets based on total energy consumption for sectors within the scope of the EU Emission Trading System (EU-ETS) is considered a priority policy for the post-2030 period.

Under the current investment incentive system, investments in green energy production facilities for self-consumption, classified as unlicensed production, are supported without interest/profit share support, and this support is planned to continue.

The low-carbon roadmaps prepared for the cement, steel, fertilizer, and aluminum sectors for 2053 include goals related to establishing renewable energy production infrastructure and

activating necessary additional incentive mechanisms. Achieving these goals will significantly increase the sector's renewable energy usage.

Strategy 3. Reducing the Carbon Footprint of Products

Measures have been implemented to reduce the carbon emissions of construction materials and to promote the use of "green cement" in public procurement contracts. This policy mandates that, between January 1, 2025, and December 31, 2029, cement used in public construction and procurement contracts must have a maximum clinker ratio of 0.80, which will be further reduced to 0.75 from January 1, 2030. This ratio will be periodically reviewed and revised in line with advancing technologies and the 2053 net-zero target.

Efforts are also underway to establish low-carbon intensity criteria for industries producing construction materials other than cement, such as iron and steel, in public construction and infrastructure projects. Additionally, all public procurement processes will prioritize low-carbon intensity products and services. Criteria will be developed based on a product life cycle perspective, and firms that do not meet these standards will be supported in reducing their carbon intensity. Another element of this strategy includes supporting the technical and financial infrastructure needed for Direct Reduced Iron (DRI) pilot applications in the iron and steel sector. For the cement sector, initial activities will focus on increasing the use of alternative raw materials and fuels, followed by pilot projects involving the use of hydrogen with Carbon Capture, Utilization, and Storage (CCUS) technology.

Technical and financial support mechanisms will be considered for transformative technological investments in emissions- and energy-intensive manufacturing sectors, particularly steel and cement. Additionally, energy-intensive businesses will be required to monitor and calculate direct and indirect emissions, covering all greenhouse gas emissions released from the consumption of purchased electricity, steam, heat, and cooling.

Consumer awareness activities will be conducted to encourage the consumption of low-carbon products, supported by informational campaigns and an eco-labeling system. In line with EU standards, efforts will continue to develop and implement environmentally conscious design guidelines, a sustainable product initiative, and a digital product passport system. These actions will contribute to reducing the carbon footprint of products while promoting and expanding the circular economy model. Additionally, the use of alternative raw materials will be encouraged, supporting the adoption of low-carbon production processes.

A "Digital Transformation Support Program" has been implemented for all manufacturing sector enterprises in the country. This program supports the integration of high-value technological products and solutions into existing business processes, aiming to reduce costs, improve efficiency, and enhance quality, thereby contributing significantly to the green transition across all sectors. Within the scope of the Green Transformation Support Program, improvements in manufacturing enterprises for green transformation will be supported under the Priority Investments framework of the "Decision on State Aid for Investments" No. 3305. The investments made will receive incentives including VAT exemption, customs duty exemption, tax reduction, employer's share of social security premium support, and interest or profit share support.

Strategy 4. Utilization of Hydrogen Technologies

The decarbonization of production processes, particularly in the iron and steel and cement sectors, is targeted through the use of green hydrogen technologies. In line with the 2053 net-zero emission goal, hydrogen technologies will begin to be used on a pilot scale in the manufacturing industry.

To meet the industry's heat requirements, projects and pilot studies will be conducted to assess the addition of hydrogen to natural gas in gas networks or its direct use. Various studies have been carried out to evaluate the use of hydrogen as a reducing agent in different production processes. Additional efforts will focus on integrating green hydrogen into processes in refineries, desulfurization, ammonia/fertilizer, and glass production. Studies on the transmission and storage of green hydrogen will also be conducted.

In the steel sector, research will be conducted on using hydrogen in blast furnaces, integrating hydrogen with natural gas as a reducing agent in Direct Reduced Iron (DRI) production, applying hydrogen plasma reduction for smelting, and achieving high temperatures needed in burners and other heating processes.

For the cement sector, efforts will be expanded to identify and apply existing and viable technologies that can make green hydrogen commercially feasible and cost-effective.

In aluminum production, there will be a shift from fossil fuels to electricity or green hydrogen to fully decarbonize the alumina calcination process.

In the fertilizer sector, policies will be developed to encourage the advancement of green and blue hydrogen and ammonia technologies, with incentives for new blue and green ammonia projects after 2030. Investment incentives will not be granted for new gray ammonia facilities in alignment with these sustainability goals.

Strategy 5. Carbon Capture, Utilization, and Storage (CCUS)

The use of CCUS in the manufacturing sector will be explored, with implementation planned for sectors where it is technologically feasible. This includes assessing the integration of CCUS technology into electrolysis cells and furnaces used in aluminum processing, as well as its application in the cement sector, particularly for reducing process emissions.

In the cement sector, where most emissions arise from chemical reactions during the calcination process, effective CCUS usage is essential for decarbonization. The widespread application of CCUS technology in this sector after 2040 is expected to significantly reduce emissions.

The total investment needed for the cement sector’s transition to carbon-neutral production is estimated at $29.8 billion, with CCUS investments accounting for approximately $27 billion, or around 90% of the total requirement.

In the steel sector, the adoption of new technologies such as hydrogen, biofuel usage, and CCUS will enable the industry to move closer to net-zero emissions. For Direct Reduced Iron (DRI) processes, natural gas-based CCUS technologies will play a critical role in achieving this goal.

National and international collaborations, especially university-industry partnerships, will be enhanced to advance carbon capture efforts, and developments in this field will be closely monitored to foster an ecosystem. In this context, efforts will also be made to support the transportation and storage of captured carbon.

Strategy 6. Promoting Sustainability Reporting

Türkiye published the Decision on the Scope of Implementation for the Türkiye Sustainability Reporting Standards (TSRS) on December 29, 2023. According to this decision, companies exceeding certain thresholds are required to prepare sustainability reports as of January 1, 2024. Initially, this system will be implemented for large companies surpassing the specified thresholds. In subsequent years, it will be expanded in phases to include medium- and small-sized enterprises, aligning with a schedule similar to the European Union's Corporate Sustainability Reporting Directive. This process is expected to contribute significantly to Türkiye's goal of achieving net-zero emissions by 2053.

The promotion of sustainability reporting will make companies' sustainability performance visible to the finance sector and consumers, thereby guiding financial resources. Additionally, voluntary initiatives will be developed at both the company and sector levels to support the net-zero emissions target and foster sustainable practices.

Strategy 7. Reduction of Ozone-Depleting Substances and Fluorinated Greenhouse Gases

The Regulation on Ozone-Depleting Substances, effective since 2017, controls the import of these substances, which are not produced domestically. By January 1, 2025, their use will be phased out entirely. Import quotas are reduced annually, and certain ozone-depleting substances (ODS) are permitted solely for servicing, laboratory, or essential use, under conditions specified in the Communiqué on the Import Control of Chemicals Subject to Environmental Protection. The import of many of these gases remains prohibited. An electronic tracking system monitors these substances from import through to domestic use in service applications.

Türkiye's commitments under the Montreal Protocol, to which it became a party in 1991, have guided a progressive reduction in the allowable import quantities of ODS. The phase-out program reduced imports from 13,200 tons in 2009 to 200 tons in 2019, then to 100 tons in 2020 and 2021, and further to 50 tons in 2022, 2023, and 2024, resulting in 99.9%. The graph below (Figure 9) illustrates annual consumption of ODS over the years.

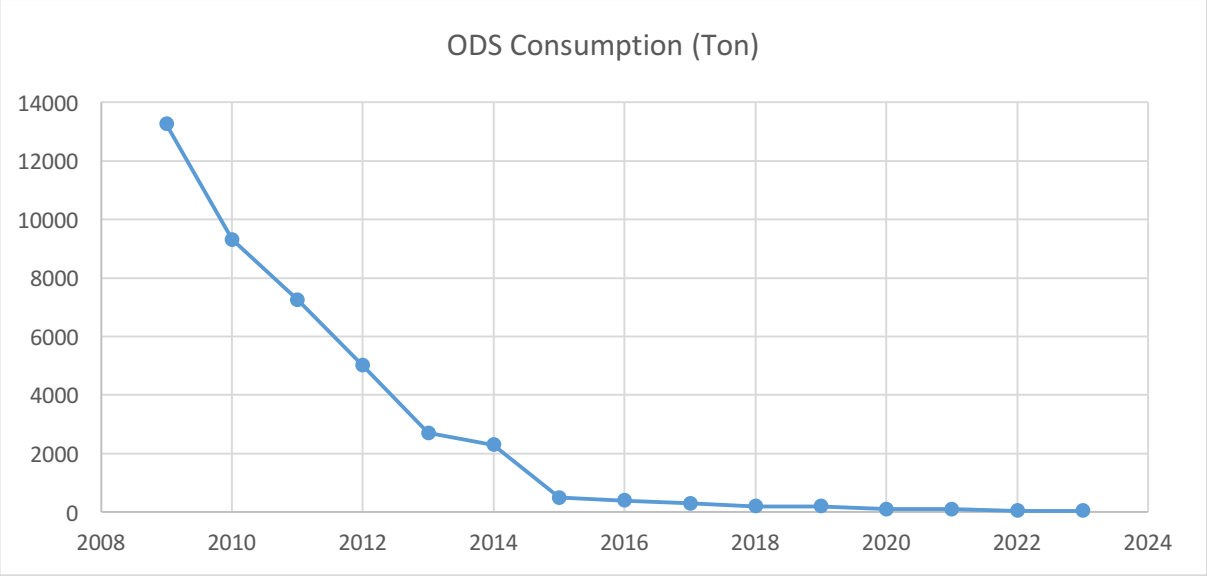


Figure 9 – ODS Consumption

Türkiye ratified the Kigali Amendment to the Protocol in November 2021 as an Article 5 (developing) country. Consequently, a phased reduction schedule was established to decrease the consumption of hydrofluorocarbons (HFCs), which have a high global warming potential. In alignment with international obligations, HFC reductions will commence in 2024, with an initial 10% reduction by 2029 and an overall 80% reduction targets by 2045 (Figure 10).

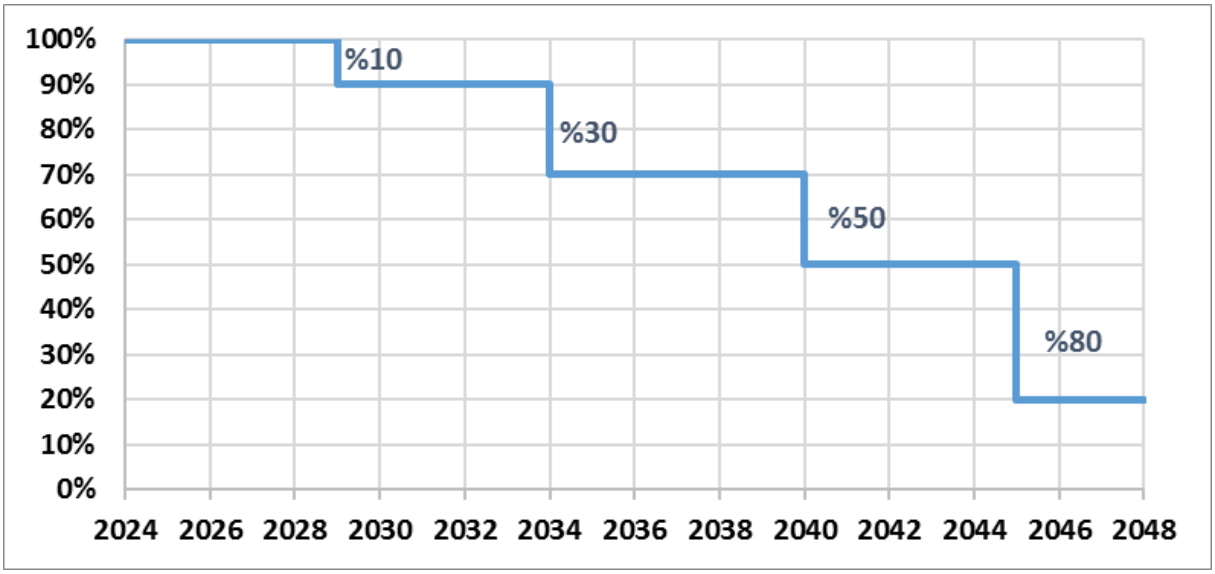


Figure 10 - HFC Mitigation Calender

The HFC reduction schedule introduced control certificates (licenses) for import and export in May 2023. As of October 31, 2024, approximately 1,450 control certificates had been issued. In line with the Kigali Amendment's reduction timeline shown in Figure 17, an import quota system for HFCs was initiated on January 1, 2024.

The "Communiqué on Import Control of Chemicals Subject to Environmental Protection" prohibits the import of HFCs in single-use pressurized containers, except for laboratory purposes. Certain HFCs specified in the Communiqué can still be imported in bulk if they are in pure, used, recycled, or reclaimed form within a container, provided they are documented with an HFC Control Certificate for regulated import.

4.2.3. Buildings

Türkiye has over 9.5 million buildings (residential and non-residential) with a total floor area of approximately 3.6 billion square meters [23]. Over the past five years, the number of residential units has increased from 38.4 million to 41.3 million [14]. The growth in population and households has led to an increase in the number of residential units and energy consumption in the residential sector in Türkiye.

According to Türkiye's Greenhouse Gas Emission Inventory Report, in 2022, greenhouse gas emissions from commercial and service sectors amounted to 15 $MtCO_2$-eq, while emissions from the residential sector reached 49.2 $MtCO_2$-eq (Figure 11). The share of building-related emissions in total emissions was 11.5% [24].

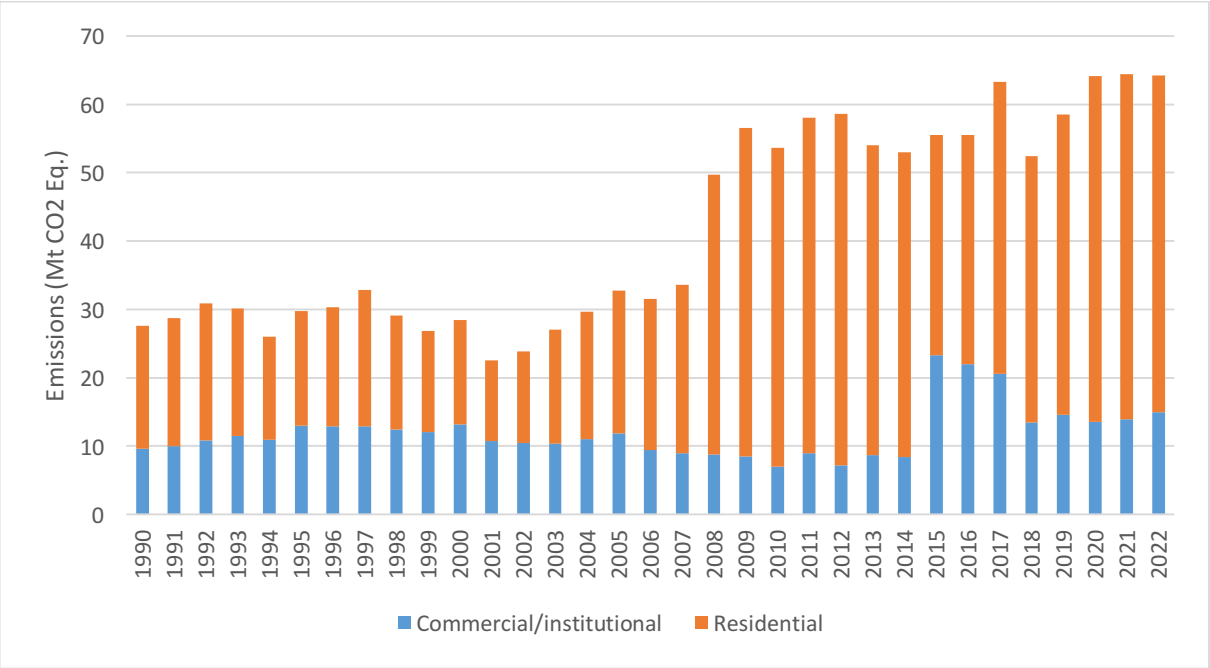


Figure 11 - Residential and Non-Residential Greenhouse Gas Emissions

According to building occupancy permit statistics, 86,654 new buildings were added to the existing stock in 2023. The building sector continues to grow rapidly [25]. Based on a study analyzing national targets, economic indicators, and construction sector growth projections, the growth trends of building stock and total usable area between 2021 and 2053 indicate that the total area is expected to reach 5.9 billion square meters by 2053 [26].

The Energy Performance Regulation in Buildings, published in 2008, established procedures and principles for the efficient use of energy and energy resources, prevention of energy waste, and environmental protection in buildings. Approximately 1.5 million buildings in the building stock have been certified with Energy Performance Certificates, reaching a certification rate of 18.5%. Similar distributions are observed in the subcategories of residential and non-residential buildings [26]. The Regulation on Green Certification for Buildings and Settlements, published in 2022, aims to establish evaluation and certification systems to reduce the negative environmental impacts of buildings and settlements by promoting the efficient use of natural resources and energy. Additionally, the Presidential Circular No. 2023/15 on Energy Savings in Public Buildings, updated and published in 2023, revises the energy efficiency target for public buildings requiring the appointment of energy managers, increasing it from 15% to 30% by 2030.

With the amendment to the Energy Performance Regulation in Buildings, as of January 1, 2022, it has become mandatory for buildings with a total construction area of 2,000 m² or more to be constructed as Nearly Zero Energy Buildings (nZEBs). Buildings classified as nZEB must have an energy performance class of B or higher on their Energy Performance Certificate and meet at least 10% of their primary energy needs through renewable energy sources. During the transition period between January 1, 2023, and January 1, 2025, the minimum renewable energy share of "10%" will be applied as "5%," and the total construction area threshold of "2,000 m²" will be applied as "5,000 m²."

The Twelfth Development Plan (2024–2028) primarily aims to increase the design of climate-responsive, energy-efficient, smart, and sustainable buildings based on life cycle analyses, as well as to ensure the renovation of existing structures. The plan also seeks to promote the

adoption of nZEB and YES-TR certification, expand the use of district heating and heat pumps, and implement policies that support these objectives. Additionally, the introduction of Digital Product Passports and Environmental Product Declarations, based on life cycle analysis (LCA) to assess the environmental, economic, and social impacts of a building throughout its lifecycle, will play a significant role in reducing emissions and environmental impacts in the building sector.

4.2.3.1. Strategies for the Building Sector within the Scope of the 2053 Net Zero Emission Target

To reduce emissions from buildings in Türkiye, the primary focus is on improving energy performance and enforcing building regulations and standards starting from the design and construction phases. The promotion of green building practices and the widespread adoption of zero-energy building designs aim to minimize energy demand and ensure on-site energy production. In this regard, the following strategies will be implemented:

Strategy 1. Decarbonization of Energy Directly Used in Buildings

The building sector will contribute to the net zero emission target by reducing the carbon intensity of the energy it directly consumes. By increasing the use of on-site and renewable energy sources, adopting clean energy technologies, and implementing energy efficiency measures, emissions from the building sector will approach zero. In this context, a potential assessment will be conducted, especially for residential buildings, to increase the use of renewable energy sources in Türkiye. A roadmap will be developed based on cost-benefit analysis to expand the use of on-site and renewable energy sources. Integrating renewables into buildings, transforming buildings into prosumers (producer-consumers), and enhancing energy storage integration will improve energy efficiency and reduce emissions.

As buildings transition to electrification, emission reductions in space heating/cooling and water heating, as well as energy use per unit area, will be assessed. In this context, studies on heat market legislation will be completed, and the use of heat pumps to support district heating in technically and economically suitable areas will be promoted. Efforts will also be undertaken to increase geothermal heating. Additionally, regulations will be introduced to encourage the use of renewable heat and micro-cogeneration systems in buildings to expand the adoption of renewable energy.

In district heating and cooling systems, the use of low-carbon fuels and renewable energy sources will be prioritized, alongside expanding the utilization of waste heat from industrial and energy sectors. Currently, district heating systems, primarily geothermal-based, are utilized in 25 locations across Türkiye. As of 2022, a total of 140,000 households benefit from district heating. According to studies, connecting an additional 2.5 million existing homes to district heating systems, along with 900,000 new homes planned for construction by 2030, is projected to generate a net benefit of €230 million annually. In collaboration with local governments, efficient and low-emission cooling systems will be expanded, and opportunities for centralized cooling systems will be explored. Urban transformation areas will be prioritized for improving energy efficiency in the existing building stock, ensuring the consideration of disaster and climate risks in urban transformation applications.

Within the construction ecosystem, the digitalization of processes, including the widespread use of Building Information Modeling (BIM), life cycle analysis, and AI-based smart building solutions, will optimize resources such as airflow, electricity, and water, thereby reducing emissions from buildings. Under the Building Management System framework, sensors and systems for heating, cooling, and lighting will enable continuous data collection and monitoring, ensuring high comfort levels for end-users with reduced emissions.

Strategy 2. Advancing the Implementation of Nearly Zero Energy Buildings (nZEB)

Nearly Zero Energy Buildings (nZEB) represent a rational choice for Türkiye on the path to achieving the 2053 net zero emission target. The nZEB approach is feasible for both new and existing buildings, with designs tailored to climate, location, solar, and wind parameters being promoted. Over time, the mandatory share of renewable energy usage in nZEBs will be gradually increased. Furthermore, raising the minimum energy performance criteria for new buildings will contribute to emission reductions.

Energy efficiency improvements, such as upgrading transparent and opaque components of building envelopes, will enhance energy performance in existing buildings, significantly reducing emissions.

The Türkiye Building Sector Decarbonization Roadmap includes an analysis of the existing building stock based on statistical data from TURKSTAT and municipalities for the 2000–2022 period. This roadmap projects the growth of building stock and outlines a portfolio of nine mitigation measures aimed at effectively reducing operational and embodied carbon emissions during the building lifecycle. Constructing all new residential and non-residential buildings as nZEBs during 2023–2032, as Energy Performance Certificate (EPC) Class A buildings during 2033–2042, and as Net Zero Operational Carbon Buildings—balancing annual operational carbon emissions with renewable energy—during 2043–2053. Gradual replacement of residential buildings constructed before 2000, renewing the stock. Buildings constructed between 2000 and 2010 will undergo energy efficiency retrofits at an annual rate of 5% of the stock through 2043, upgrading them to nZEB standards. Replacing low-efficiency household appliances in residential buildings with modern, energy-efficient devices at an annual rate of 10% from 2023 onwards, resulting in a cumulative reduction of 76 $MtCO_2$-eq emissions by 2053. The roadmap estimates a total reduction of 2,075 $MtCO_2$-eq greenhouse gas emissions over the 2023–2053 period, corresponding to a 32% decrease compared to business-as-usual emissions [26].

Strategy 3. Promoting the Adoption of YeS-TR

The Regulation on Green Certification for Buildings and Settlements, published in 2022, specifies that obtaining a green certificate is voluntary. Within this framework, priority will be given to constructing new public buildings, and during the 2023–2032 period, all new residential and non-residential buildings with a total construction area of 2,000 m² will be required to meet nZEB standards. Starting in 2026, all new public buildings with a total construction area exceeding 10,000 m² will be mandated to obtain green building certification [26].

The regulation aims to evaluate and certify the sustainable environmental, social, and economic performance of existing and new buildings and settlements. The YeS-TR initiative promotes building practices that are sustainable, environmentally harmonious, and leverage the geographic characteristics of their location, evaluating structures throughout their lifecycle—from site selection to demolition. It also seeks to expand the use of eco-friendly designs and building materials. In terms of environmental impacts, legislation on rainwater and greywater harvesting systems in buildings will be progressively enhanced over time. It is estimated that these systems will result in approximately 400 million m³ of water savings during the 30-year period from 2023 to 2053.

4.2.4. Transportation Sector

Over the past two decades, parallel to Türkiye's economic development, there has been more than a threefold increase in vehicle ownership and vehicle-kilometers traveled [27]. According

to 2022 data, road transportation holds the largest share of domestic passenger (91.2%) and freight transport (89.3%) [28].

In 2022, greenhouse gas emissions from the transportation sector amounted to 91.9 MtCO2-eq, with the majority—86.4 MtCO2-eq—originating from road transportation. Based on 2021 data from TURKSTAT, the transportation sector accounted for 16.5% of Türkiye's total greenhouse gas emissions (Figure 12) [24]. Additionally, the final energy consumption of the transportation sector increased by 4.4% during the 2000–2022 period. However, energy efficiency measures implemented between 2017 and 2023 resulted in energy savings of 1.2 million tons of oil equivalent (TOE) in the transportation sector [29].

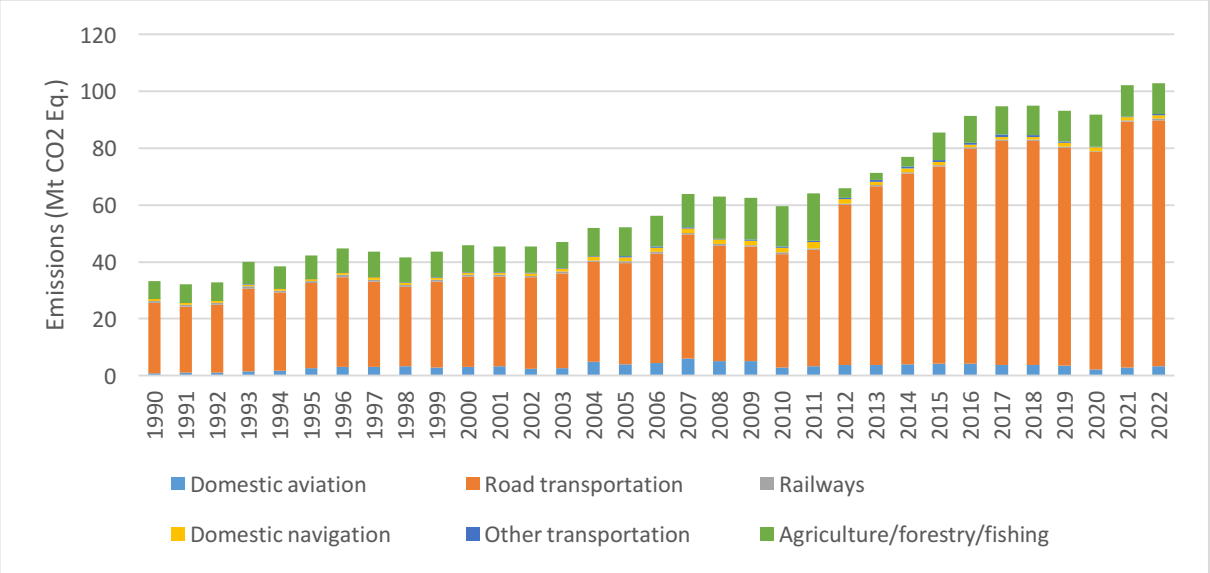


Figure 12 - Distribution of Greenhouse Gas Emissions from the Transportation Sector

According to 2023 statistics, the total number of registered automobiles in Türkiye stands at 15.2 million, accounting for 53% of the national motor vehicle fleet [27]. Considering Türkiye's population of 85.37 million in 2023 [30], the car ownership rate is 178 vehicles per 1,000 people. In comparison, the average car ownership rates in the EU [31] and OECD countries [32] are 560 and 530 vehicles per 1,000 people, respectively, highlighting that Türkiye lags behind developed countries in this regard. This rate is expected to increase in parallel with future economic development.

The development of Türkiye's electric vehicle (EV) sector saw a significant leap with the introduction of the domestically produced electric car, TOGG. With the entry of other brands into the Turkish market, the share of EVs in new vehicle sales rose from 1% to 10% between 2022 and 2023 [33]. In 2023, over 952,000 cars were produced in Türkiye [34], and by the end of the year, the number of registered electric cars reached 302,000, including 222,328 hybrids and 80,043 fully electric vehicles [35]. By the first half of 2024, this number increased by 36%, reaching 410,000 electric and hybrid cars. Türkiye has also made significant progress in developing the charging infrastructure necessary for the electrification of the transportation sector. As of August 2024, the number of charging sockets reached 22,400 (14,200 AC and 8,200 DC) [36].

One of the key steps in advancing the charging infrastructure was the “Technological Product Investment Support Program for Fast Charging Infrastructure for Electric Vehicles”, initiated by the Ministry of Industry and Technology between April 15 and June 15, 2022. By January

2024, this program supported the installation of 1,053 fast charging units across 81 provinces. Preparations for the second phase of this support program have also commenced.

Over the past two decades, intercity mobility in Türkiye has significantly increased [37]. In 2004, intercity vehicle mobility stood at 57.8 billion vehicle-km, rising to 154.5 billion vehicle-km in 2023, marking a 168% increase. Of this, 102.4 billion vehicle-km (66.2%) occurred on state roads, and 30.4 billion vehicle-km (19.5%) on highways. During the same period, highway mobility surged from 7.8 billion vehicle-km to 30.4 billion vehicle-km, a 289.74% increase, driven by the expansion of the road network and increased vehicle ownership [38].

Türkiye has also made significant investments in rail transportation, particularly in high-speed trains (HST), conventional rail systems, electrification, signaling, track renewal, and modernization. As of 2024, the country has a total railway network of 13,919 km, including 11,668 km of conventional lines and 2,251 km of HST lines. Since their inception in 2009, HST journeys have increased, reaching 11.9 million passengers in 2023, largely driven by shifts from conventional trains, intercity buses, and air travel. In 2023, the total number of passengers on intercity railway lines, including HST and mainline trains, was recorded at 24.9 million, while suburban train services transported 317.6 million passengers. The Marmaray line, connecting Halkalı (Istanbul) and Gebze (Kocaeli), which serves as the main transportation axis between these cities, transported nearly 1.2 billion passengers, contributing to reduced traffic congestion, private vehicle use, and fossil fuel consumption.

Significant progress has also been made in urban public transportation and micromobility. Between 2015 and 2023, metro ridership increased from 691.8 million to 975.3 million, with the metro network length growing from 222.1 km to 338.5 km. Light rail transit ridership doubled from 159.4 million to 317.6 million, with the network expanding from 130.6 km to 287.6 km. Tram ridership rose from 335.3 million to 482.3 million, and the tram network length grew from 203 km to 336.8 km [39]. Additionally, the length of urban cycling paths has reached 2,000 km [29], and the General Directorate of Highways has developed a bicycle path cross-section for intercity roads, completing 86.82 km of bicycle paths, primarily in urban transitions, since 2013.

Smart Transportation Systems (ITS) aim to reduce travel times, enhance traffic safety, improve the efficient use of existing road capacities, increase mobility, optimize energy usage, and minimize environmental harm. The main objective for mobility and new vehicle technologies is to increase electrification in transportation systems. Enhancing public transportation usage, integrating public transport services, and implementing real-time mobility services such as "Mobility as a Service (MaaS)" will contribute to the widespread adoption of ITS in Türkiye. As part of these efforts, the number of smart stops in metropolitan and provincial municipalities has reached 11,000.

Similarly, significant advancements have been made in Türkiye's air and sea transportation sectors. Supported since 2003, air transportation has experienced rapid growth, particularly in domestic routes. Total passenger traffic increased from 33.8 million (8.7 million domestic passengers) in 2002 to 181.8 million in 2022, with 78.3% of this growth occurring on domestic flights. This period saw an overall increase of over 400% in total air passenger numbers and over 800% in domestic passenger numbers. Additionally, 20 ports in Türkiye have been certified as "Green Ports," adhering to high environmental sensitivity standards and improving the quality management system at these facilities [40].

4.2.4.1. Strategies for the Transportation Sector within the Scope of the 2053 Net Zero Emission Target

The transportation sector, which has grown in parallel with economic development, accounted for 16.13% of Türkiye's greenhouse gas emissions in 2021, according to TURKSTAT data. To achieve the 2053 net zero emission target, long-term goals aligned with global emission reduction strategies will be developed for the transportation sector.

Key strategies emphasized within the 2030 targets and actions, including intermodal integration, a shift towards more sustainable rail and maritime transport, increased efficiency, and the adoption of clean energy in transportation, will be updated and pursued in light of new technological advancements beyond 2030. Enhancements to these strategies for achieving the 2053 target are presented below.

Strategy 1. Prioritizing More Sustainable Modes of Maritime and Railway Transport

Efforts to increase the share of the railway and maritime sectors will continue to achieve a more balanced transportation system, reducing the dominance of road-based services. Expanding the high-speed train (HST) and conventional train (CT) networks aims to boost the share of railway passenger transportation. Planned HST projects target a significant modal shift from road and air transport to railways by 2053. The "2053 Türkiye National Transportation and Logistics Master Plan", the primary policy document for transportation, reiterates the goal of increasing the share of railways. Additionally, constructing new ports with railway connections is expected to promote more sustainable and environmentally friendly transportation. Within this framework [41]:

- A total of 8,554 km of railway lines are planned for construction by 2053, including 6,425 km of high-speed train lines, 1,474 km of conventional train lines, 393 km of high-speed train lines, and 262 km of very high-speed train lines.
- Of these, 3,703 km are scheduled for completion between 2024–2029, 2,992 km between 2030–2035, and 750 km between 2036–2053.

The estimated investment in railways between 2024 and 2053 is projected to reach $70 billion.

Investments in expanding high-speed and conventional train networks will increase capacity for both passenger and freight transport. To enable a modal shift to railways, addressing bottlenecks by converting single-track sections to "double tracks", enhancing signaling systems, and increasing train capacity are critical. In addition to these investments, "freight-priority" railway lines will be developed to improve connections to ports, logistics hubs, and organized industrial zones.

Plans to construct 31 new ports aim to advance international maritime freight transportation while identifying routes with emission reduction potential for national freight transport.

Urban rail system investments, including suburban rail and urban transit systems (metros, light rail, and trams), will integrate public transport systems to create a seamless network capable of competing with private automobiles. Similarly, in coastal cities, the share of maritime transport will be increased through integration with urban public transport systems and intercity passenger transport.

Strategy 2. Enhancing Efficiency in the Transportation Sector

Roadmaps will be developed to increase the load or passenger ratio per vehicle in road transportation to improve efficiency. The prioritization of effective public transportation systems will continue, and cities will be divided into sustainable mobility districts, with strengthened public transport connections between these districts encouraged. To reduce private

vehicle ownership and usage, the establishment of car-sharing systems will be supported during this planning process. Efficiency in road transportation will be further enhanced through eco-driving practices and routing support, supported by the development of physical and technological “”Intelligent Transportation Systems (IT)” infrastructure. Efforts will also be made to expand energy-efficient driving practices, which have been piloted in railway passenger transport, to all railway routes across Türkiye.

In addition to motorized vehicles, a long-term urban "re-planning" strategy will be developed to support sustainable modes of transport such as public transportation, walking, and cycling. This will include the development of "sustainable transportation districts/regions" and low/zero-emission mobility plans that address daily mobility needs through micromobility solutions.

After 2030, improvements will be made to enhance the efficiency of existing technologies in air transportation, with measures introduced to modernize aircraft fleets. Similarly, outdated technology in maritime and road vehicles will be phased out to align with sustainability goals.

Strategy 3. Promoting the Use of Sustainable/Clean Energy Sources in the Transportation Sector

The transition to electric vehicles will be encouraged, with a focus on expanding the charging infrastructure in line with the sector's growth. By 2035, the number of registered hybrid (currently 317,000) and electric (currently 137,000) vehicles is projected to reach 1.8 million under a low scenario and 4.2 million under a high scenario. To support this growth, it is estimated that the total number of publicly accessible charging sockets will need to reach 147,000 under the low scenario and 348,000 under the high scenario, 35% of which are expected to be DC chargers [42].

The Ministry of Transport and Infrastructure has conducted spatial analyses of electric vehicle charging demand and supply for intercity travel, focusing on transportation infrastructure such as highways, railway stations, and ports [43]. Based on this analysis, the number of charging sockets required on the national highway network was estimated for the years 2029, 2035, and 2053. The total required number of sockets, which was 3,378 in 2023, is expected to increase to 5,624 by 2029, 14,250 by 2035, and 39,944 by 2053.

Given Türkiye's geopolitical position as a key hub for international transportation routes, efforts are underway to develop charging infrastructure for heavy commercial electric vehicles. A support program for this purpose is expected to be implemented starting in 2025.

The current investment in Türkiye's charging infrastructure stands at $137 million. To meet the targets set for the sector, investments are projected to reach approximately $1 billion by 2030 and $2 billion by 2035[2].

The goal of establishing "more than one domestic manufacturer of electric passenger and light commercial vehicles" aims to achieve a domestic content ratio of at least 75% in electric vehicles by 2030 [44]. Under high-growth scenario estimates, the number of electric vehicles is projected to reach 4.2 million by 2035 [42]. The development of a national electric vehicle brand and charging infrastructure, along with the electrification of shared vehicles, has the potential to contribute significantly to emission reductions.

Additionally, by 2053, it is planned to complete the electrification of railway lines, increase the use of hybrid rail vehicles during this transition, and support the electrification of maritime transport systems, vessels, and ground services in air transportation. The fleet of rail vehicles

[2] This data is based on information provided by the Ministry of Energy and Natural Resources.

will be enhanced with domestically produced electric train sets and locomotives, in line with electrification investments.

Although electrification is the most prominent measure for emission reduction in the transportation sector, a critical factor is ensuring that the electricity used in transportation is derived from renewable energy sources. Therefore, the electrification process in transportation must be supported by a transition to renewable energy. Decarbonizing the electricity sector forms the foundation for decarbonizing transportation. In this context, the commitment to renewable energy in the electricity sector also addresses the increasing electricity demand caused by transportation electrification, ensuring that this demand is met through renewable sources [20].

Research and investments in hydrogen-based fuel/engine technologies for large and heavy road vehicles (e.g., buses, trucks) will be increased. In air transportation, the use of "sustainable aviation fuel (SAF)" and synthetic fuels, as defined under ICAO LTAG 2050, CAAF/3 Global Framework decisions, and CORSIA, will be promoted. Efforts are underway to produce and incentivize these fuels domestically, with the aim of significantly reducing the trade deficit caused by jet fuel imports.

Strategy 4. Implementing Digital Infrastructure Activities in the Transportation Sector

A transportation emissions database will be established to monitor demand and emissions data by transportation mode for passenger and freight transportation, as well as for long- and short-distance transportation services across road, maritime, air, and rail systems. Developments in methodologies and standards for voluntary emissions reporting and comparisons, as outlined in the European Green Deal, will be closely followed, and alignment with national emissions data will be ensured. Additionally, studies will be initiated to determine demand and mobility for tracking the emissions from sectors categorized under "Agriculture/Forestry/Fisheries (Off-road Vehicles and Other Machinery)" within total transportation emissions.

To implement strategies beyond 2030, the institutionalization of port operators and logistics companies will be encouraged. Furthermore, an electronic freight system will be established to manage freight transportation demand, enabling the monitoring of vehicle-km and freight metrics within this framework.

In the transportation sector, where electrification will play a critical role, the following activities will be implemented: development of a national integrated interface for smart electric vehicle charging and parking management, preparation of regulations for the market supply and recycling of electric vehicle batteries, provision of research support for electric vehicle battery recycling, and enabling passenger and freight transport to calculate transportation-based carbon footprints on a per-person or per-product basis.

4.2.5. Waste Sector

The waste sector's emissions were calculated as 16.3 Mton CO2-eq in the 2022 Türkiye Greenhouse Gas Statistics [8]. This corresponds to 2.9% of the total greenhouse gas emissions. Although the waste sector is seen as a low-emission sector, it actually plays an indirect role in reducing emissions, particularly from industrial processes, through the increase in material recovery, thus positioning itself as an emission-reducing sector.

According to the Turkish emission inventory, in 2022, the disposal of waste in managed and unmanaged landfills accounted for 65.2% of all emissions from the waste sector (16.4% from managed landfills, 48.8% from unmanaged landfills). The second largest source of emissions is wastewater treatment and discharge, which accounts for 34.6% of waste emissions. The

emissions under other categories are negligible. Greenhouse gas emissions from the waste sector by year are shown in Figure 13.

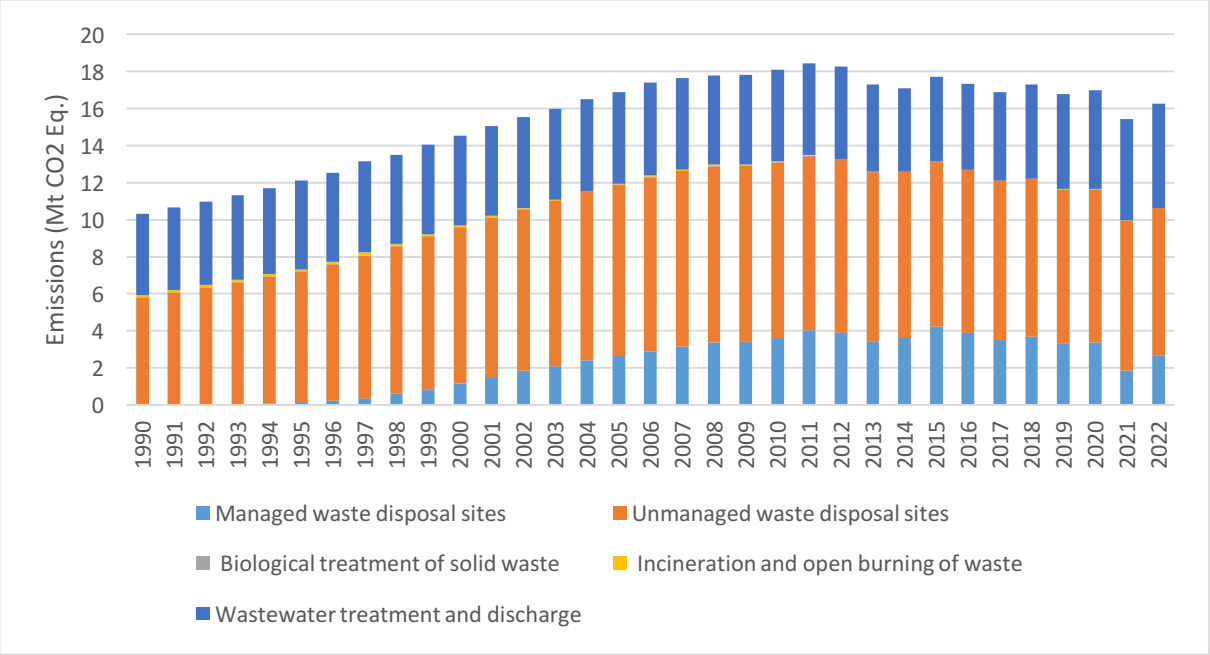


Figure 13 - ***Greenhouse Gas Emissions from the Waste Sector by Year***

According to the national emission inventory, methane (CH_4) from the decomposition of biodegradable waste was the largest source of greenhouse gas emissions in the waste sector in 2022. Methane accounted for 86.2% of the emissions from the waste sector. Another notable greenhouse gas is nitrous oxide (N_2 O), which originates from wastewater treatment facilities and constitutes 13.7% of total emissions in the waste sector[3].

Municipalities collected 30.3 million tons[4] of refuse in 2022, as indicated by TURKSTAT data [45][5]. This amount is equivalent to 1.03 kg of waste per person per day, which is lower than the EU-27 average of 1.38 kg/day*person[46] for the same year but higher than the global average of 0.74 kg/day*person[47].

Managed landfill sites have been established in nearly all provinces, and the transition to managed landfilling in waste management has been expedited in recent years. The material recycling sector has swiftly developed and made a significant contribution to the economy, and there has been significant progress in the management of waste. Biodegradable waste is now being utilized as a product in energy production and agriculture, without the need for storage, as biomethanization and decomposition facilities have been established. YEKDEM[48] in Türkiye provides support for the generation of electricity from renewable energy sources, while landfill gas and biomethanization facilities are eligible for tariff guarantees[6]. In accordance with the 2023 YEKDEM data, the annual production capacity of 99 energy production facilities

[3] Methane (CH_4) and nitrous oxide (N_2O) have a much higher short-term global warming potential (GWP) than carbon dioxide (CO_2).

[4] Municipal solid waste statistics are published biennially.

[5] In Türkiye, municipalities report data on the waste they are responsible for collecting to the Turkish Statistical Institute (TÜİK). The waste referred to here generally originates from households. The calculations also include similar types of waste from commercial establishments, offices, public institutions, and schools.

[6] The relevant incentive mechanism has been revised to reduce the amount of waste sent to landfills and ensure efficient recovery at processing facilities.

(biomethanization + landfill gas) in 60 provinces is 5,293,425 MWs, resulting in a total installed capacity of 501 MW. These facilities have contributed to the reduction of greenhouse gases and the production of renewable energy.

The "Zero Waste Project," initiated in Türkiye in 2017, has evolved into a global movement. In 2022, the United Nations General Assembly adopted a “zero waste” resolution, designating March 30 as International Zero Waste Day. Reflecting the positive impact of this project in Türkiye, the municipal waste recycling rate accelerated to reach 34.92% by the end of 2024 [49]. Through this initiative, zero waste systems have been implemented in 193,000 buildings, resulting in the recycling of 59.9 million tons of waste. Additionally, since 2018, the Ministry of National Education has been implementing the "Zero Waste Management System" in public and private schools and institutions. As part of this effort, 32,000 schools and institutions have registered in the Integrated Environmental Information System, and Waste Management Systems have been completed in 43,921 institutions. Moreover, 37,300 schools have received the "Basic Level Zero Waste Certificate," and 9.5 million students have received "Zero Waste" training. Through the Teacher Informatics Network (ÖBA), 157,301 teachers have completed “Zero Waste” training, while 161,691 teachers have participated in seminars on "Climate Change and Environmental Education." Furthermore, "Recycling Libraries" have been established in 1,544 schools across 81 provinces, promoting the reuse of waste materials and supporting awareness initiatives. The recycling processes for textbooks distributed each school year also continue[7].

According to studies conducted within the framework of the National Waste Management Strategy and Plan (2024-2035), in 2023, 53.38% of municipal waste was disposed of in sanitary landfills, 11.7% in uncontrolled landfills, and 34.92% was recovered in waste treatment facilities (including biomethanization, composting, incineration, and MBT). Based on the Ministry of Environment, Urbanization, and Climate Change’s findings, the recycling rate reached 34.92% in 2023. Türkiye’s updated First Nationally Determined Contribution (NDC) includes a goal of increasing the municipal waste recovery rate to 60% by 2035 as part of its greenhouse gas reduction policies. By 2053, the target is to dispose of only 30% of waste in sanitary landfills, eliminate uncontrolled dump sites, and achieve a total recovery rate of 70%.

As of 2024, data from the Ministry of Environment, Urbanization, and Climate Change indicate that the number of urban wastewater treatment plants has reached 1,231. Among these facilities, 344 provide advanced biological treatment, 830 provide biological treatment, three offer chemical treatment, and 54 conduct preliminary treatment before deep-sea discharge. These plants collectively provide wastewater treatment services to 90.7% of the municipal population.

4.2.5.1. Strategies for the Waste Sector within the Scope of the 2053 Net Zero Emission Target

Eight different strategies have been developed to contribute to the 2053 net-zero emissions target in the waste sector. These strategies aim to increase waste recovery, reuse, and recycling rates by adopting a circular economy model. Additionally, steps such as waste separation at the source, processing biodegradable waste, and implementing technologies to prevent methane emissions are of great importance in supporting environmental sustainability. Along with these strategies, strengthening public-private sector collaboration and creating financial mechanisms will ensure significant progress towards Türkiye's net-zero emissions target.

[7] This data was provided by the Ministry of National Education.

Strategy 1. Prevention and Reduction of Waste and Wastewater Formation

The largest share of greenhouse gas emissions in the waste sector originates from uncontrolled methane emissions released from landfills. Reducing the amount of organic, biodegradable waste that leads to methane formation in these areas will directly reduce methane emissions. The Twelfth Development Plan and Green Deal Action Plan emphasize the importance of awareness-raising activities to combat food loss and waste. Additionally, the reuse of waste within the principles of the circular economy is a strategy for waste reduction and prevention. By promoting actions that support reuse, such as repair, refurbishment, and remanufacturing, direct contributions to greenhouse gas emission reduction can be achieved. The efficient use of industrial and urban water, the prevention of leakages, and the reduction of per capita water consumption are also aimed for. This will reduce the wastewater generated and the associated greenhouse gas emissions.

Strategy 2. Increasing the Rates of High-Quality Recycling and Recovery of Waste

Plans are in place to expand dual collection at the source and deposit-return systems for waste. The separation of waste at its source is regulated by relevant legislation. Under the national deposit management system, the Environmental Agency has been established, initially covering plastic, glass, and aluminum beverage containers and will eventually include other products. With the expansion of this system, access to clean secondary raw materials will be facilitated, and greenhouse gas emissions will be reduced. This system is expected to ensure the annual collection of approximately 1.3 million tons of glass, plastic, and aluminum packaging at the source for direct recycling. The deposit system for beverage packaging is projected to generate annual revenues of €120 million, material savings of €250 million, gains from imports of €50 million, and savings of €525 million by preventing waste from going to landfills. The recycling rate of municipal waste is targeted to reach 60% by 2035. Accordingly, the separate collection of biodegradable waste at the source will be encouraged, the capacity of biological treatment facilities will be increased, and compost production will be supported. While reducing methane emissions, renewable energy support mechanisms will be revised to promote waste reduction and recovery. Additionally, the recycling of battery and solar panel waste will be considered as part of waste management strategies; this will reduce the carbon footprint and contribute to circular economy goals by recovering strategic raw materials, especially critical minerals like cobalt, lithium, nickel, and silicon.

Strategy 3. Reducing the Rate of Waste Sent to Landfill Facilities Without Pre-Treatment

Türkiye has adopted a resource recovery strategy, moving away from waste disposal to reduce greenhouse gas emissions and resource wastage. According to the updated Nationally Determined Contribution, the regular disposal of untreated municipal waste will be terminated by 2053. For this purpose, tools such as landfill taxes will be considered, and during the transition period, landfill gas collection and management systems will continue to be used in existing and new facilities.

Strategy 4. Improvement of Wastewater Management Infrastructure with Innovative Technologies

As of 2024, wastewater treatment services are provided to 90.7% of the municipal population, with a target to increase this rate to 100% by 2028. The share of advanced biological treatment processes in wastewater treatment has been increasing in recent years. With the use of innovative technologies for nitrogen removal in wastewater, greenhouse gas emissions will be reduced. One of the mitigation policies stated in the updated NDC is the transformation of wastewater treatment facilities into biorefineries. Additionally, the efficiency and capacity of existing anaerobic digesters in wastewater treatment plants will be increased, or new plants will

be established. Efforts to increase and expand the reuse of treated wastewater will be implemented, including the creation of incentive mechanisms for this purpose, with a goal to increase the wastewater reuse rate to 15% by 2030 and 20% by 2053.incentive mechanisms for this purpose.

Strategy 5. Development of Human Resources and Ensuring Social Transformation for Transition to Circular Economy and Effective Waste Management

Stakeholder education and societal transformation are essential for sustainable waste management in the transition to a circular economy. For this purpose, topics such as climate change, zero waste, circular economy, and green skills will be introduced as elective courses in formal education; public and private sector stakeholders will be trained on current legislation and best practices. Various segments of society will be reached through written, visual, audio, and social media, raising awareness and encouraging behavioral changes to develop skills for the circular economy. Furthermore, efforts will be made to improve working conditions in the waste sector, meet the demand for skilled labor, and make vocational certification mandatory in required areas. To ensure just transition and economic inclusivity, measures will be taken to identify and value the contributions of women and men separately in waste collection, sweeping, and sorting activities.

Strategy 6. Development of Incentives and Financing Mechanisms for Transition to Circular Economy and Improvement of Waste Management

It is essential to develop and expand incentive and favorable financing mechanisms to support the waste sector's alignment with climate change mitigation targets and circular economy principles. In this context, studies will be conducted to align Green Public Procurement (GPP) principles with the requirements of the circular economy.

Strategy 7. Increasing the Use of Waste as Raw Material/Resource in Production

In line with the requirements of the circular economy transition, studies to determine mandatory usage rates of recycled products will be conducted in coordination with stakeholders in the waste sector and relevant institutions (ministries, municipalities, relevant sectors, etc.). The National Circular Economy Strategy and Action Plan prepared for Türkiye will cover the design, production, consumption, waste management, and secondary raw material use of products throughout their life cycle. The plan will focus on specific areas such as plastics, textiles, critical raw materials, construction, and biomass and include horizontal activities such as innovation, investment, and monitoring. Specific measures will be taken to reduce the consumption of products with high natural resource and fossil fuel use, such as plastics and textiles, or make them fully circular. The plan will guide towards 2053 and aim for long-term sustainability in the economy. An environmental labeling system will be developed and expanded for various products and services to encourage products/services with reduced environmental impacts throughout their supply chain. These labels will provide consumers with comprehensive information on the recycled content of products, the energy used in production and supply, and the carbon footprint, guiding their preferences.

Strategy 8. Reducing Greenhouse Gas Emissions from Vehicles Used in Waste Management

Separate collection of waste at the source and transfer to waste processing facilities are essential. Vehicles used in these operations contribute significantly to greenhouse gas emissions. Through the use of applications such as route optimization, sensor technologies, and reverse logistics, as well as the promotion of electric vehicles and alternative fuel use, these emissions are expected to be reduced.

4.2.6. Agriculture Sector

The agriculture sector in Türkiye plays a vital role, accounting for 6% of GDP[50], 4% of exports[51], 15% of employment[52], and 19% of female employment. It supports the development and sustainability of Turkish industries, particularly the food industry, by supplying essential raw materials. Agriculture is the primary economic activity for women, who constitute 41% of the agricultural workforce, and it remains a cornerstone for rural development[53].

Agricultural production is predominantly conducted using traditional methods. Organic farming accounts for 1.5% of the total cultivated area, while Good Agricultural Practices (GAP) are applied on 2.8%. In terms of chemical fertilizer usage, nitrogenous fertilizers represent the largest share, followed by phosphatic and potassic fertilizers.

The number of animals and animal production has increased over the years in parallel with population and income growth. Emissions from the agriculture sector were 51.8 Mton CO_2-eq in 1990, and by 2022, they had increased by 36% to reach 71.5 Mton CO_2-eq (Figure 14) [8]. Compared to other sectors, the agriculture sector had the lowest emission increase rate during the 1990-2022 period. In Türkiye, 60% of methane emissions originate from the agriculture sector, reaching 1.56 million tons in 2022[54].

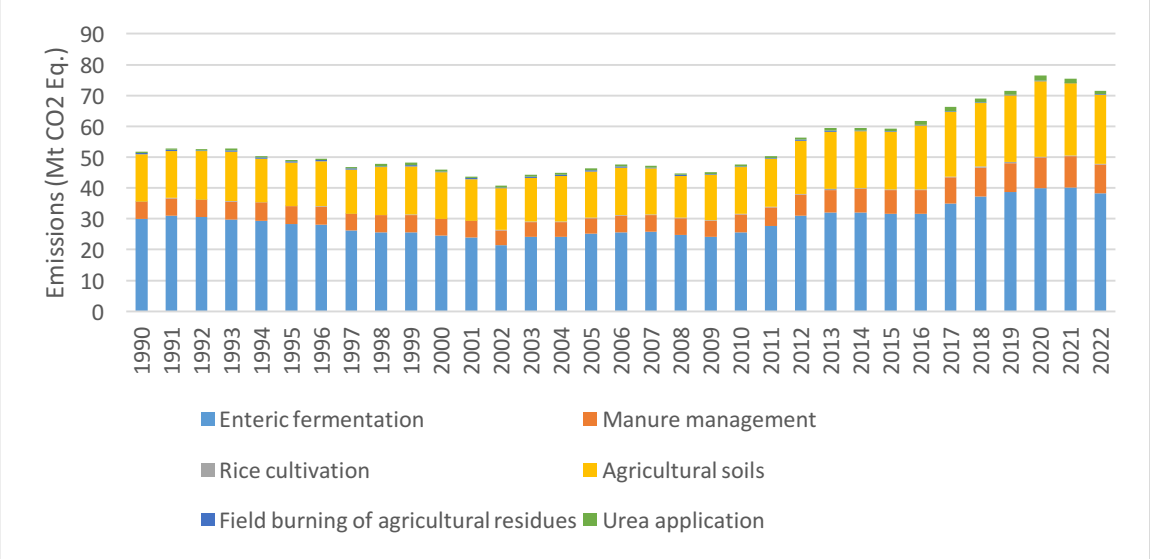


Figure 14 - Greenhouse Gas Emissions from the Agriculture Sector in Türkiye

A large portion of agriculture sector emissions is composed of enteric fermentation. The share of enteric fermentation in total agricultural emissions is 53.5%. This is followed by emissions from the cultivation of agricultural land at 31.2% and fertilizer management at 13.1%. The share of chemical fertilizer use, stubble burning, and rice cultivation is approximately 1.6% in total.

4.2.6.1. Strategies for the Agriculture Sector within the Scope of the 2053 Net Zero Emission Target

The 2023-2100 Population Projections study conducted by TÜİK projects that Türkiye's population will reach approximately 94 million by 2053, with per capita income expected to exceed 50 thousand USD. In line with the increase in per capita income, demand for agricultural products, particularly food, is anticipated to rise [55]. In addition, global food demand and exports will also increase. The main focus of reducing Türkiye's agriculture-related greenhouse gas emissions is to ensure sustainability in production, meet the increasing demand, and

maintain competitive advantage. In the agricultural sector, four main strategies have been identified towards the 2053 net zero emissions target.

Strategy 1. Improvement of Soil and Water Management

The protection of Türkiye's 24 million hectares of cultivated agricultural land until 2053 will be ensured, preventing its conversion to non-agricultural use, fragmentation, degradation, and misuse. The consolidation of all fragmented lands will be completed by 2053. In addition to agricultural lands, activities will also be carried out for the protection, improvement, management, and monitoring of pasture, meadow, grassland, and shrub areas.Soil health will be improved by increasing organic matter, and the soil's capacity to retain water and carbon will be strengthened.

The average annual rainfall in Türkiye for the period 2013-2023 was recorded at 591.5 mm. Total annual water consumption amounts to 57 billion cubic meters, with 44 billion cubic meters (77 percent) allocated for irrigation purposes. Therefore, the efficient use of water in agricultural irrigation is critically important. To enhance vegetation cover in pasture improvement efforts, methods will be developed to maximize the benefits of rainfall, and rainwater harvesting techniques will be widely adopted in pasturelands [56].

The irrigation efficiency rate will be increased to 65% by 2050[56]. All open systems in the water network transmission and distribution lines will be modernized by converting them into closed systems, the rehabilitation of closed systems that have reached the end of their economic life will be carried out, automation will be widespread, water use efficiency measurement and monitoring systems will be established, and irrigation investments, land consolidation, and on-farm development works will be completed together. In plant production, production will be carried out according to the product suitability maps prepared on a regional basis using data on climate, soil, water, topography, and land classification.

In animal production, planned, sustainable production will be carried out by considering the production plans prepared based on climate, land structure, enterprise size, existing livestock population, the rate of meeting roughage needs, and pasture availability, as well as the natural resources foreseen in the Livestock Roadmap.

Within the framework of planned production, product patterns will be determined based on the condition of soil and water resources and climate change projections, and work on preparing land use plans will be completed. Agricultural supports will be revised according to the production planning goals to be carried out on the basis of agricultural basins. In irrigation networks, the use of measurement devices that consider parameters such as soil moisture and temperature, as well as tools like automation, remote sensing, and digitalization, will be promoted. Irrigation will be carried out according to the water consumption needs of the plants. In agricultural irrigation, land applications for the use of water returning from irrigation, treated wastewater, and water obtained from rainwater harvesting in small-scale areas will be promoted.

In areas irrigated by pumping, the electricity consumed for lifting irrigation water will be met from renewable energy sources, reducing or fully covering the energy costs that burden irrigation unions and farmers who operate, maintain, and repair irrigation facilities, thereby increasing the net income of farmers and ensuring the technical, economic, and social sustainability of irrigation facilities are among our country's goals. In order to meet the energy needs of pumped irrigation, it is aimed to establish renewable energy production facilities in irrigation areas and provide them to our farmers. Through the establishment of these facilities, it is aimed to reduce the energy costs of our farmers, ensuring that irrigation facilities operate

more efficiently, leading to increased agricultural production and the provision of food supply security.

Strategy 2. Widespread Adoption of Climate-Smart Agricultural Practices

Before the use of chemical fertilizers in agricultural lands, soil and water analyses will be promoted. In order to ensure the conscious use of fertilizers, training and dissemination activities aimed at farmers will be increased. The use of organic (such as farmyard manure, compost) and organomineral fertilizers will be increased through subsidies, and the solid-liquid fermented products from biogas plants, as well as all kinds of organic waste, will be utilized in the production of green fertilizers and compost. Infrastructure investments will be supported to promote the use of agricultural and other organic wastes in the form of compost fertilizer.By 2053, at least 10% of cultivated agricultural land will be used for organic farming, and climate-smart agricultural techniques will be applied to all of it. For this purpose, climate-smart, sustainable plant production and livestock farming application systems will be prepared according to regions and their implementation will be ensured.

The use of pesticides and antimicrobials will be reduced, and the use of alternative products will be promoted. Biological and biotechnical control methods will be supported and promoted. The dissemination of methods such as direct seeding, proper and reduced tillage that increase carbon retention in the soil will be ensured.

In order to reduce emissions from livestock, the use of appropriate alternative feed rations will be ensured. By 2030, planned animal production will be carried out according to the recommendation reports for suitable animal species, breeds, and systems for each geographical region. Animal waste will be developed with necessary infrastructure support for proper storage and processing by directing it to biogas facilities. By accelerating pasture improvement efforts, enhancements in grazing will be achieved, and the absorption capacity of pastures will be increased. The support given to farmers in Türkiye will be reviewed through the lens of climate change[61]. Support for climate-smart agriculture, conservation agriculture, or ecosystem-based agricultural practices will be increased. Agroforestry practices, direct seeding, mulching (organic material and living mulch), and green manure applications will be supported.

Strategy 3. Improvement of Loss, Waste, and Residue Management in Agricultural Production

Studies on the recovery of agricultural waste and residues will be completed[58], and R&D and awareness-raising activities will be increased, taking into account the communication channels, roles in production, interests, and the needs of different target groups (such as employers, workers, farmers) to reduce food loss and waste.

Strategy 4. Widespread Implementation of Education, Awareness, and Capacity Development Activities with Gender Balance Consideration

To enhance the knowledge and skills of farmers and ensure their utilization of technological opportunities in the transition to low-carbon production in the agriculture sector, education and awareness activities will be increased for all stakeholders in the agriculture sector, especially technical personnel. Practical training will be increased at every stage of agricultural production, along with educational and instructional publications. In the agriculture sector, where women's labor is highly prevalent, women will be given priority in the training sessions on the effects of climate change.

4.2.7. LULUCF Sector

The LULUCF sector is critically important due to its contribution to negative emissions (sequestration) towards the net zero emission target.Within the framework of sustainable forestry practices in Türkiye, importance is given to activities such as afforestation and rehabilitation projects, erosion control efforts, and combating forest and stubble fires. In this context, planning and managing forests and land categories that constitute the sector with climate-smart approaches will increase carbon removal potential, improve ecosystem services, and reduce disaster risks in the upcoming period.

Our country is in a sensitive position to erosion in terms of its geographical location, climate conditions, population distribution, and land use. In Türkiye, 8.24 tons of soil per hectare are displaced each year. According to land use conditions, the most erosion occurs in pastures at 53.66%, in agricultural areas at 38.71%, in forests at 4.17%, and in other areas at 3.46%. The main land use category that constitutes the carbon sink in the LULUCF sector is forests. The biomass and associated carbon stocks in Türkiye's forests have been increasing since 1990, but in recent years, the trend of increasing biomass and associated carbon stocks has slowed down as a result of production increases aimed at meeting the continuously rising demand for wood raw materials. The standing volume (stock) increased from 935.5 Mm^3 to 1,773.7 Mm^3 during the period from 1973 to 2023. The stock value per hectare has also increased in parallel from 46.31 m3/ha to 75.92 m3/ha.

According to forestry statistics, the forest area increased from 20.19 million hectares to 23.36 million hectares during the 1973-2023 period. In line with this increase, the amount of productive forest has risen, leading to a significant increase in total biomass (Figure 15).

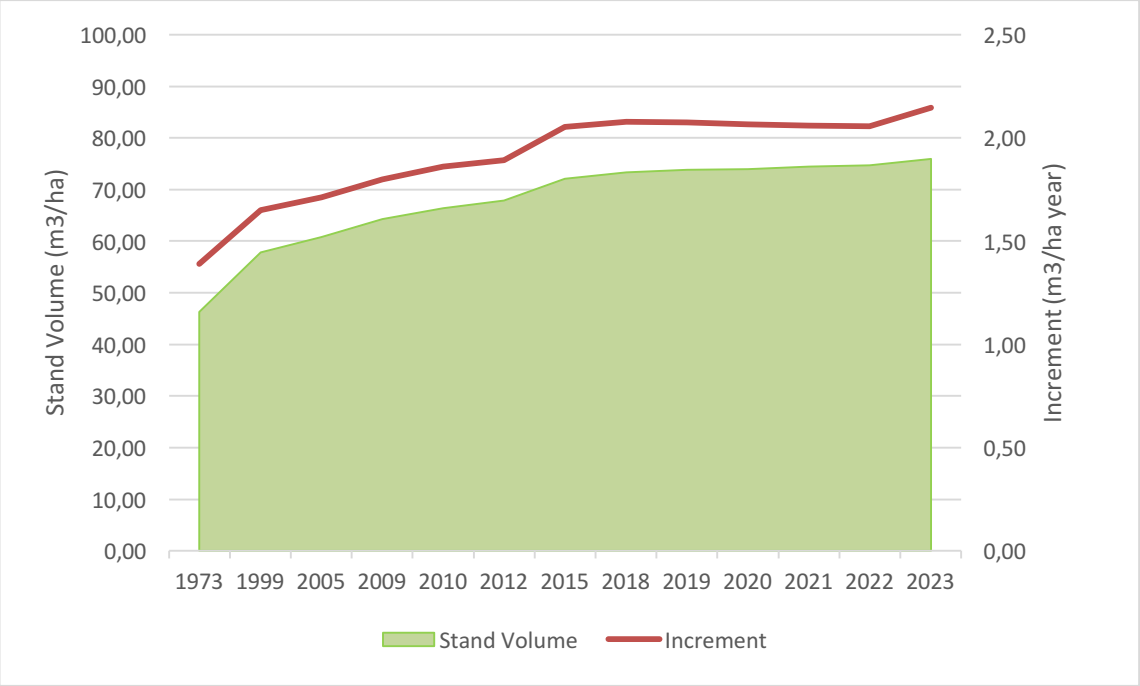


Figure 15 - The long-term change in growth and standing volume in Türkiye's forests

Similar to other Mediterranean countries, a significant portion of LULUCF emissions in Türkiye is also composed of forest fires. While firefighting efforts are being strengthened in the battle against fires, investments aimed at preventing fires are also being expanded. Volunteer training, among other things, is being emphasized in awareness-raising efforts. Despite all these preventive efforts, 2,579 forest fires were intervened in 2023, and 15,520 hectares of forest area were damaged. It is anticipated that the risk of fire will continue to increase in the coming years;

however, it is expected that the risk can be reduced by investing in the improvement of fuel management and technology usage.

In 1990, the annual greenhouse gas absorption amount of the LULUCF sector was 66.4 Mton CO_2-eq., which reached 76.9 Mton CO_2-eq. in 2014, but gradually decreased over time, falling to 56.1 Mton CO_2-eq. in 2022 according to the latest inventory figures (Figure 16). Among the reasons for this decline are the trees damaged by the major forest fires in 2021 and the decrease in productivity due to climate change. Additionally, due to the decrease in sink capacity and the increase in emissions across the economy, the carbon sinks of the LULUCF sector, which accounted for approximately 30.2% of emissions in 1990, fell to 10.1% in 2022.

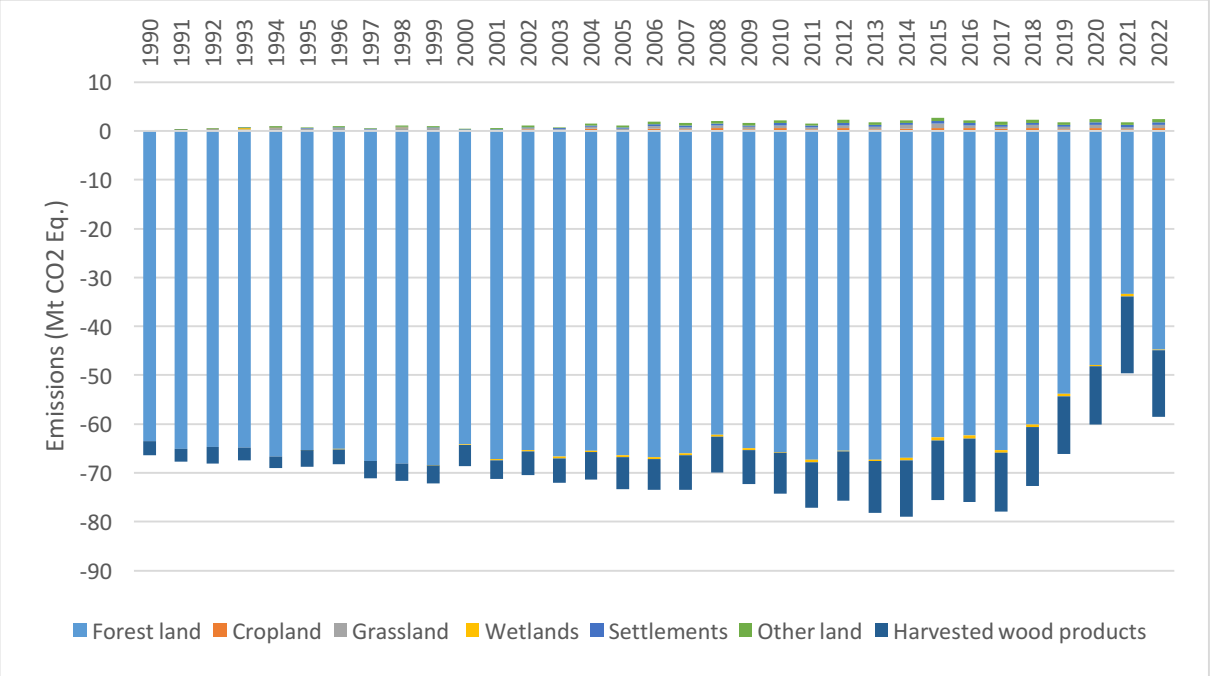


Figure 16 - Distribution of LULUCF Sector Attitudes by Categories

4.2.7.1. Strategies for the LULUCF Sector within the Scope of the 2053 Net Zero Emission Target

In the LULUCF sector, the fundamental component of the long-term strategy is the sustainable expansion of the national carbon sink area over time and ensuring that other sectors' emissions are brought to a level that can be balanced. The long-term strategies of the LULUCF sector are structured under three main headings. The carbon reduction capacity of the land use sector, which focuses on degraded lands, forest areas, and wood products, places proactive restoration and conservation strategies at the core of reduction efforts. Strengthening circularity will enable more efficient use of wood raw materials and enhance substitute benefits, while R&D and innovation will support efficiency in the sector (Figure 17).

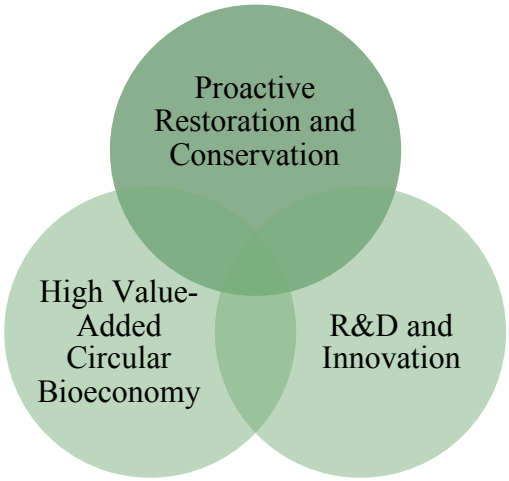


Figure 17 - The Three Pillars of the Long-Term Strategy: Proactive Restoration and Conservation (S1), High-Value Circular Bioeconomy (S2), and R&D and Innovation (S3)

Ecosystem-based functional management plans aimed at increasing efficient forest resources should be prepared within the framework of climate change adaptation strategies. In afforestation efforts, the selection of species resilient to the challenges posed by climate change will play a critical role in the sustainability of forest ecosystems and the conservation of biodiversity.

In this context, with the aim of strengthening Türkiye's forestry strategy, it should be aimed to review the current structure of the forestry organization and restructure it to meet new needs. Especially within the framework of combating climate change and drought, the infrastructures of Forestry Research Institutes should be developed, and these institutes should be equipped to investigate the effects of climate change on forest ecosystems, develop adaptation strategies, and work on new afforestation techniques.

Strategy 1. Implementation of Proactive Restoration and Conservation Measures

With the proactive restoration and conservation strategy, the aim is to enhance the quality and quantity of forests, develop and promote ecosystem-based functional planning, and increase the resilience of forests on a national scale while reducing human pressure. By increasing the productivity of forests, on one hand, the growing and diversifying societal demands and expectations will be met, while on the other hand, forests resistant to changing climate conditions will be created. In afforestation and rehabilitation efforts, fire-resistant species that do not disrupt the ecosystem will be selected, and the effectiveness of these practices will be monitored through scientific studies.

The sustainable management of forests will be planned and implemented in a way that contributes to the fight against climate change, promoting the carbon sink function of forests, the conservation of biodiversity, and sustainable production.

Within the scope of this strategy, climate-smart agriculture and settlements, which are important components of the LULUCF sector, will also be supported. The climate-smart agriculture and pasture practices and restoration targets included in the 2030 Climate Change Mitigation Action Plan are aimed to be strengthened and continued beyond 2030, with the goal of converting the agricultural and pasture areas calculated as emissions in the sector into negative emissions and increasing the sink capacity in these areas. It is aimed to strengthen and continue actions to increase the proportion of woody green areas in settlements beyond 2030

Both restoration and conservation/use processes will be prioritized to increase carbon sink capacity. It is aimed to create new protected areas that preserve biodiversity and contribute to

the retention of carbon in ecosystems. In the coming years, the aim is to develop mechanisms that the private sector and landowners can benefit from, similar to and compatible with the EU Carbon Removal Certification regulations.

Green belts, corridors, boundary and roadside afforestation that will provide ecological transition areas within and around the city will be considered as alternatives. In this way, natural life and ecosystem integrity will be ensured. These forest belts will both positively contribute to the urban climate by improving air quality and provide disaster-preventive or mitigating ecosystem services, including flood and urban heat island reduction. Within the framework of proactive restoration, nature-based solutions will be emphasized at the watershed scale. With AI-supported remote sensing and digital systems, forest products and production processes will be monitored digitally, and production will be managed more effectively in terms of time and space. Advanced monitoring systems will also support restoration efforts in the industry. The characteristics of the saplings used (such as species, age, origin), the purpose of the restoration/afforestation (such as timber production, water production), and the exact location of the restoration/afforestation (such as geographical coordinates, area) will be shared with the public in real-time.

Necessary measures will be taken to address the risk of decreasing and aging village populations in the forestry sector. In this context, emphasis will be placed on the widespread implementation of projects that increase livelihoods and improve living conditions in rural areas, and on the proper design of support mechanisms to enhance the attractiveness of rural areas, especially forest villages. Especially, projects will be developed to ensure that women and young people in rural areas take an active role and lead in the protection and expansion of forests. Additionally, an integrated support mechanism will be established in collaboration with other sectors, primarily the education sector, to encourage the return to rural areas.

Strategy 2. Transition to a High Value-Added Circular Bioeconomy

By planning according to long-term production projections, the sector's investment and production predictability will be ensured. To reduce pressure on forests, circular economy components will be developed and implemented, thereby decreasing the wood raw material needs of the forest products industry.

In addition to the total production volume, the spatial distribution of production is also important for the conservation and enhancement of growth and standing volume in forests. By focusing on high value-added products, the overall economic size of the forest products industry will be increased and sustainability will be ensured. With the development of the incentive mechanism, not only will the issue of access to raw materials be resolved, but support will also be provided for global reduction efforts. Additionally, regulations to be made in production and marketing processes will ensure that raw materials are utilized in the most optimal and efficient manner. In the field of forest products, within the framework of a circular economy-based recycling and renewal, the recovery and reuse of used wood and waste materials will be ensured, storage and logistics will be improved, and necessary legislative work in these areas will be completed. It will be ensured that the principles of a circular, low-carbon, and high-value-added economy are adopted by the public and private sectors for the sustainable expansion of AKAKDO sectors without excessive resource use. With innovations in the construction and furniture production chains, the highest efficiency with the lowest waste level will be achieved for each forest product, primarily wood raw material. Within the scope of the fair distribution of wood raw materials, efficiency will be increased by ensuring the correct use of raw materials in the right sectors.

Strategy 3. Promoting R&D and Innovation

It is aimed to reduce the need for raw materials obtained from forests by increasing efficiency and strengthening circularity through R&D and innovation investments without causing a decrease in the capacity utilization rate in the sector. New forestry management approaches will be based on scientific findings and technological developments such as remote sensing and artificial intelligence. In this context, it is aimed to focus on public, university, and private sector technology initiatives and collaborations by increasing existing supports and adding new ones.

In order to initiate efforts for certified production of wood and non-wood forest products, standards will be established and inspection mechanisms will be created, particularly for the production of structural wood (such as GLT, CLT) to transition to certified production. By establishing infrastructures such as certification, inspection, and production process control, the use of wood in buildings will be promoted, thereby strengthening the sector.

On the other hand, genetic improvement studies will be increased in fast-growing species to both enhance carbon sink capacity and meet the demand for wood raw materials and develop industrial plantations.

To support these strategies, capacity development activities will be carried out, and the number of trained professionals in carbon management within the sector will be increased. By considering gender balance in training and awareness activities, equal representation of women and men in specialization will be ensured.

4.3. Adaptation and Resilience to Climate Change

4.3.1.Effects of Climate Change and General Overview

Türkiye is located in the Mediterranean Basin, which is identified as one of the most vulnerable regions against the adverse effects of climate change, as described in reports of the Intergovernmental Panel on Climate Change (IPCC).

According to the World Meteorological Organization's (WMO) 2023 Global Climate Status Report, 2023 was recorded as the hottest year, with global temperature increases reaching 1.45°C [59] When focusing on the Mediterranean Basin specifically, the IPCC's Mediterranean Region Report published in 2022 notes that the temperature rise in this region exceeds global averages, with surface temperatures increasing by 1.5°C compared to pre-industrial levels [60]. Current data, however, shows that this value has now reached the 2°C threshold [61]

The effects of climate change-related hazards in the Mediterranean Basin have been intensifying over time. Particularly, the frequency and severity of droughts and extreme precipitation events have increased, with the North Mediterranean Region, including Türkiye, experiencing more intense impacts. Over the course of the 21st century, the effects of climate change are expected to intensify, with a significant increase in the frequency and severity of climate-related hazards, especially heatwaves in the region. By the end of the century, the projected annual average warming on land could reach up to 5.6°C, depending on emission scenarios, compared to the last two decades of the 20th century [64].

The temperature increases due to climate change observed in the Mediterranean Basin are also affecting Türkiye. According to the Turkish State Meteorological Service, the hottest year recorded in Türkiye was 2010, with an average temperature of 15.5°C [62]. In comparison to the previous two years, the average temperature for Türkiye in 2022 was 14.5°C, 0.6°C higher than the 1991-2020 average of 13.9°C. Moreover, the number of extreme weather events in 2022 was recorded at 1,030 [63]. In 2023, the average temperature in Türkiye reached 15.1°C,

1.2°C above the 1991-2020 average, with 1,475 extreme weather events occurring that year [62].

The increasing frequency and intensity of climate change-induced disasters are causing significant economic and social losses in Türkiye. According to the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), floods in Türkiye between 1970 and 2021 caused damages amounting to 28 billion USD and resulted in 758 fatalities. Losses due to droughts have been estimated at 1.2% of GDP during this period[64]. ESCAP data shows that the annual average loss from climate-related disasters represents 2.2% of GDP. Under medium (RCP 4.5) and pessimistic (RCP 8.5) emission scenarios, these losses are projected to rise to 2.8% and 3.2% of GDP, respectively [65].

In addition to mitigation policies aimed at enhancing Türkiye's resilience to the impacts of climate change, sector-specific adaptation strategies and actions have been developed. In the process of defining these strategies, climate hazards for both current and future periods have been calculated, and sectoral risk analyses have been conducted. These analyses have served as the primary basis for determining the adaptation strategies and actions.

4.3.2. Climate Models and Projections

In Türkiye, climate projection studies have been conducted in line with the IPCC's Fifth Assessment Report (AR5) using Representative Concentration Pathways (RCPs). In the first study carried out by the Turkish State Meteorological Service (MGM), the reference period was set as 1971-2000, while the future period was defined as 2013-2100. Three models—HadGEM2-ES, GFDL-ESM2M, and MPI-ESM-MR—were selected from the Coupled Model Intercomparison Project Phase 5 (CMIP5) archive. Outputs were generated at a 20-kilometer resolution using the RegCM4 3.4 Regional Climate Model. The study considered two emission scenarios: RCP 4.5 and RCP 8.5 [66].

In the study conducted by the General Directorate of Water Management (SYGM), the HadGEM2-ES, MPI-ESM-MR, and CNRM-CM5.1 models were selected from the CMIP5 archive. The RegCM4.3 Regional Climate Model was run under the RCP 4.5 and RCP 8.5 scenarios, producing outputs at a 10-kilometer resolution. The reference period for the study was defined as 1971-2000, and the future period was set as 2020-2100 [67]. The results of the studies have been used in conducting local and national vulnerability and risk assessments. The selected models and scenarios are summarized in Table 4.

Table 4 - Climate Projection Studies Conducted in Türkiye within the Scope of the IPCC Fifth Assessment Cycle

Selected Global Circulation Models (GCMs) – (MGM)	Selected Global Circulation Models (SYGM)
HADGEM2-ES	HADGEM2-ES
MPI-ESM-MR	MPI-ESM-MR
GFDL-ESM-2M	CNRM-CM5.1

Institutions	Regional Climate Model	Resolution	Scenarios
MGM	RegCM4.3	Outer Domain 50 km Inner Domain 20 km	RCP 4.5 & RCP 8.5

SYGM	RegCM4.3	Outer Domain 50km Inner Domain 10 km	RCP 4.5 & RCP 8.5

In the IPCC Sixth Assessment Cycle, the scenarios have been updated, and Shared Socioeconomic Pathways (SSPs) have been published. The SSPs are climate change scenarios that encompass projected global socioeconomic changes up to the year 2100, as defined in the IPCC's 2021 Sixth Assessment Report. [68]. With the completion of the Sixth Assessment Cycle and the update of scenarios, along with the transition to the CMIP6 phase of the Global Circulation Models archive, Türkiye has initiated a study to update its national climate projections.

As part of the study conducted by the Directorate of Climate Change, 30 different GCMs from the CMIP6 archive were analyzed in terms of temperature and precipitation parameters for the study area shown in Figure 19. The six GCMs that best represented the parameters were selected, as outlined in Table 7[8]. As Regional Climate Model, WRF RCM is used to dynamically downscale the GCMs to 3 km resolution. The outputs will have a resolution of 27 kilometers in the green regions, 9 kilometers in the blue regions, and 3 kilometers in the red regions of the study area, given in Figure 19.

The study uses the SSP 2-4.5 and SSP 5-8.5 scenarios, with the reference period set from 1950 to 2015 and the future period covering 2015-2100. Bias correction for the model outputs will be performed using ERA-5 and national observation data obtained from the Turkish State Meteorological Service.

[8] Technical reports related to the conducted study can be accessed at https://yereliklim.org/en/kategori/publications/reports/.

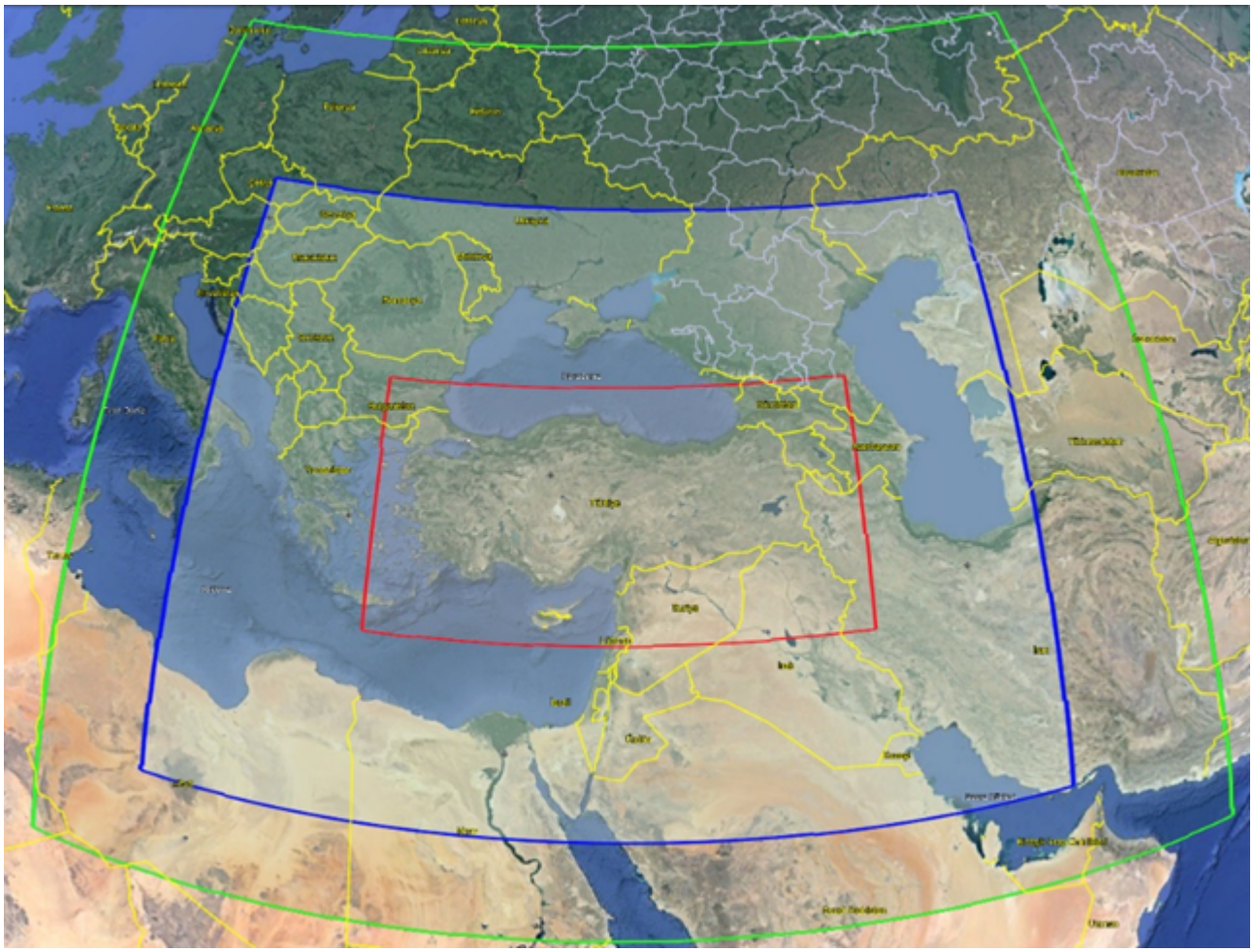


Figure 18 - Climate Projections Work Area

In the study, a large area was selected due to the inclusion of atmospheric factors affecting the study area, highlighted in red, which represents Türkiye. The selected Global Climate Models and scenarios for the study are summarized in Table 5.

Table 5 – Global Circulation Models and Scenarios

GCMs	**Scenarios**
CMCC-ESM2	SSP2-4.5 – SSP 5-8.5
EC-Earth3-Veg	SSP2-4.5 – SSP 5-8.5
HadGEM3	SSP2-4.5 – SSP 5-8.5
MPI-ESM1-2-HR	SSP2-4.5 – SSP 5-8.5
MRI-ESM2-0	SSP2-4.5 – SSP 5-8.5
NorESM2-MM	SSP2-4.5 – SSP 5-8.5

The study was initiated in May 2023 and is expected to be completed in April 2026. Using the results of this study, climate indices will be generated, which will be utilized for updating vulnerability and risk assessments within the framework of the IPCC Sixth Assessment Cycle. Following the completion of the study, high-resolution vulnerability and risk analyses will be conducted for selected sectors at the level of Nomenclature of Territorial Units for Statistics - 12 (NUTS-12).

Moreover, the results of the study will establish a scientific foundation for climate change and will facilitate the integration of climate-related hazards and risks into national and local policy documents and investment programs.

4.3.3.Vulnerability and Risk Assessments

Türkiye's national vulnerability and risk analysis has been conducted in accordance with the risk definition provided in the IPCC Fifth Assessment Cycle. The components of risk—hazard, vulnerability, and exposure—were considered, and climate hazards, including Drought (SPEI-3), Heavy Precipitation (R95P), Heatwave (HWI), Wildfire (FWI), Cold Wave (CWF), and Heavy Wind (W98) indices, were calculated.

In the hazard calculations for the historical period, meteorological observation data provided by the Turkish State Meteorological Service (MGM) were used, with the period from 1990 to 2019 defined as the current period. For the future period analyses, results from the MPI-ESM-MR model, produced by the General Directorate of State Hydraulic Works (SYGM) under the RCP 4.5 and RCP 8.5 scenarios, were employed.

Following the hazard analyses, sectoral impact chains were developed, and the components of vulnerability, exposure, sensitivity, and adaptive capacity were calculated. Climate change-related risks were then assessed for the identified hazards across 11 specific sectors.

In the calculation of drought hazard, the 3-month Standardized Precipitation Evapotranspiration Index (SPEI-3) was used to represent meteorological drought. The spatial distribution of the average values for the most severe drought conditions during the current period is shown in Figure 19.

When examining the drought values calculated for the current period (1990-2019), it is observed that the severity of drought decreases as one moves towards the northwest of Türkiye. Specifically, the West of the Black Sea region experiences the lowest drought values in the country. The provinces of Konya and Karaman, where the highest meteorological drought values are observed, are followed by the provinces of Hatay and Kahramanmaraş. Additionally, it is noted that meteorological drought in the Eastern Anatolia and Southeastern Anatolia regions is above the national average for Türkiye.

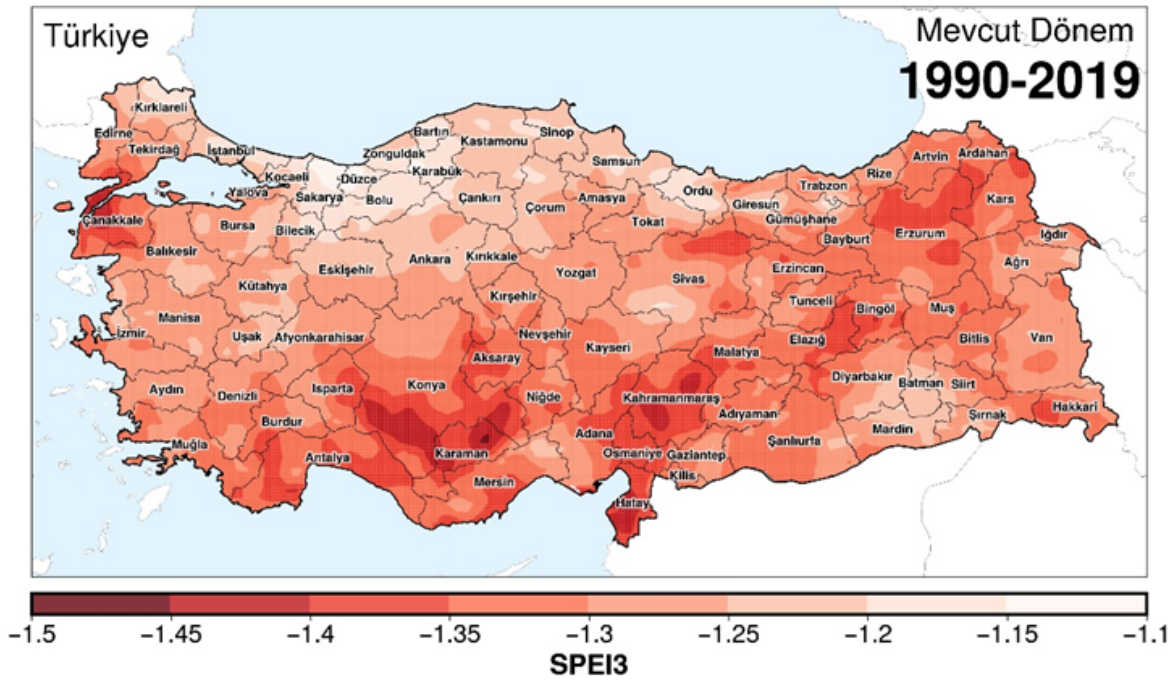
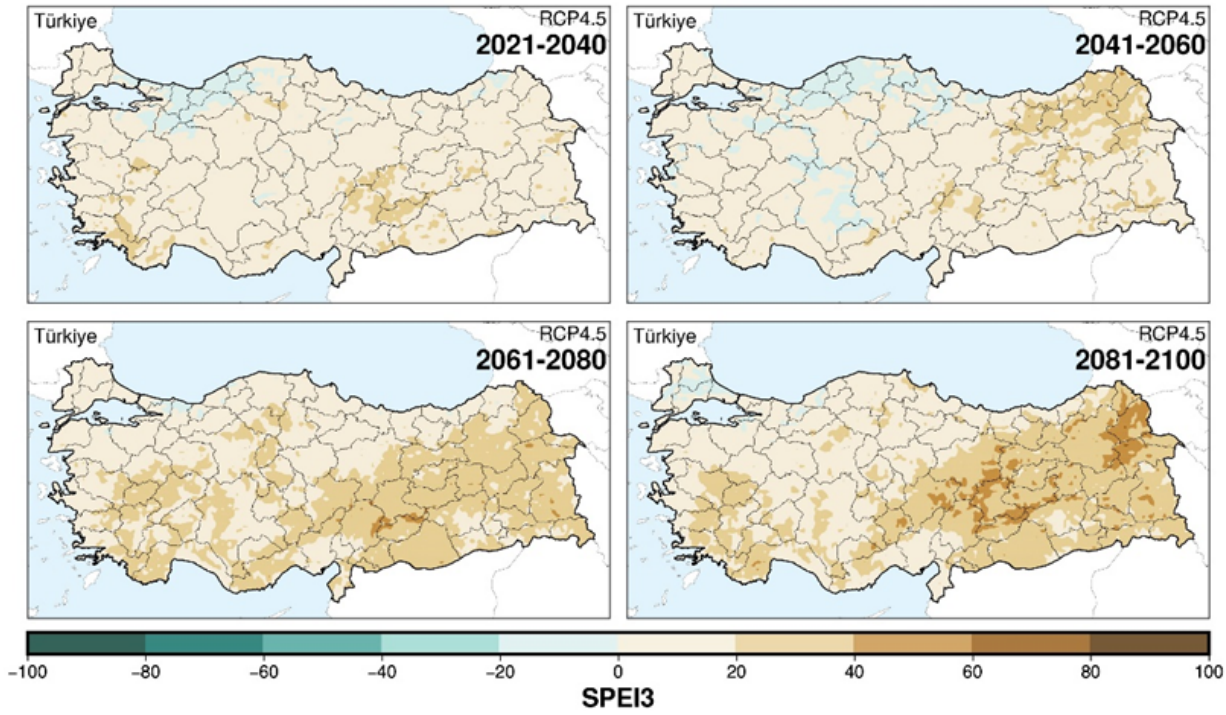


Figure 19 - Current Period Meteorological Drought Severity

The percentage changes in the future period of meteorological drought hazard compared to the reference period are shown for the RCP4.5 and RCP8.5 scenarios in Figure 20.

For the future period, based on the relatively optimistic (RCP4.5) and pessimistic (RCP8.5) scenarios, it is projected that the intensity of meteorological drought will exhibit an increasing trend towards the end of the century. Under the RCP4.5 scenario, particularly in the 2060s, the increase in meteorological drought intensity is expected to reach up to 40% in the Aegean Region, while in the eastern and southeastern regions of Türkiye, this increase could exceed 80%.

a)



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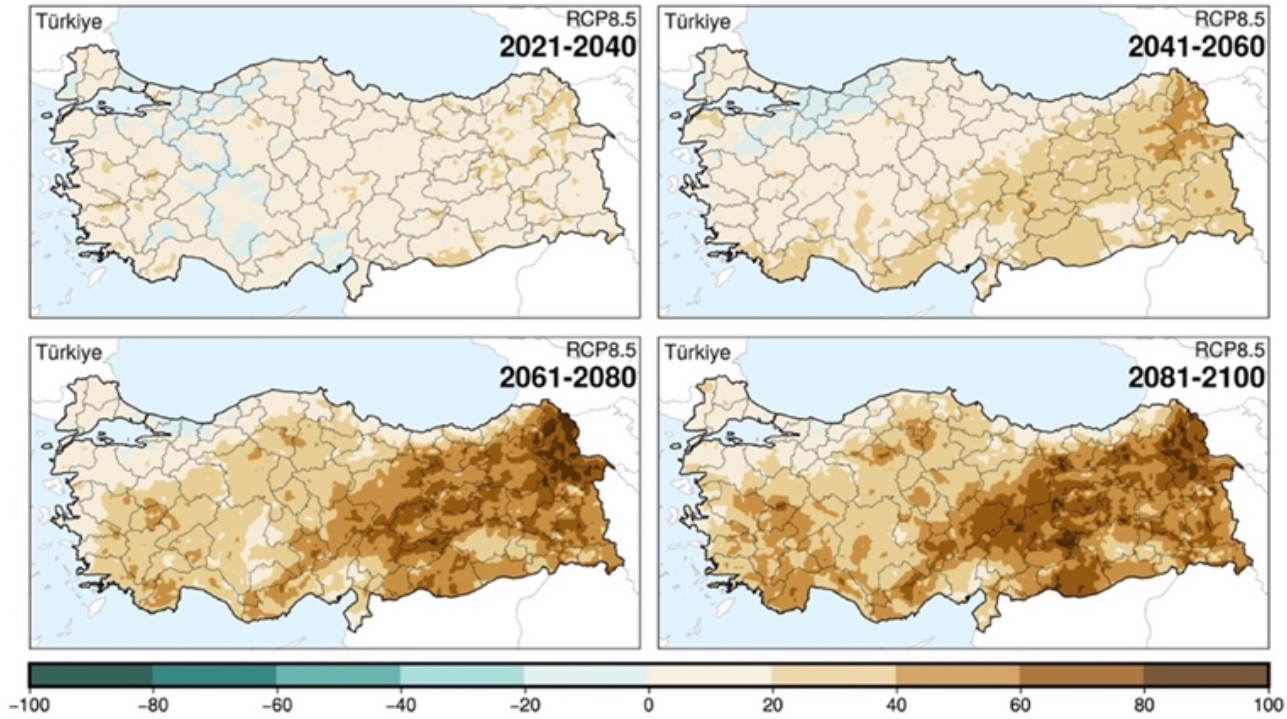


Figure 20 – a-) Future Period SPEI-3 Intensity Changes Relative to the Reference Period under the RCP4.5 Scenario b-) Future Period SPEI-3 Intensity Changes Relative to the Reference Period under the RCP8.5 Scenario

The R95P index was calculated to determine the total amount of precipitation from extreme rainfall events. The average for the current period (1990-2019) for the R95P index is shown in Figure 21. In the current situation, low values are observed in the Central Anatolia Region, while the Eastern Black Sea and Mediterranean regions show significantly higher values. The total amount of rainfall in Central Anatolia, as well as in the provinces of Van, Denizli, and Burdur, does not exceed 60 mm. In the Southeastern Anatolia Region, particularly in the provinces of Şanlıurfa, Mardin, Gaziantep, and Kilis, total rainfall is between 40 and 60 mm. In contrast, the total precipitation from extreme rainfall in the Mediterranean Region reaches 280 mm, and in the Eastern Black Sea Region, this value increases to 360 mm.

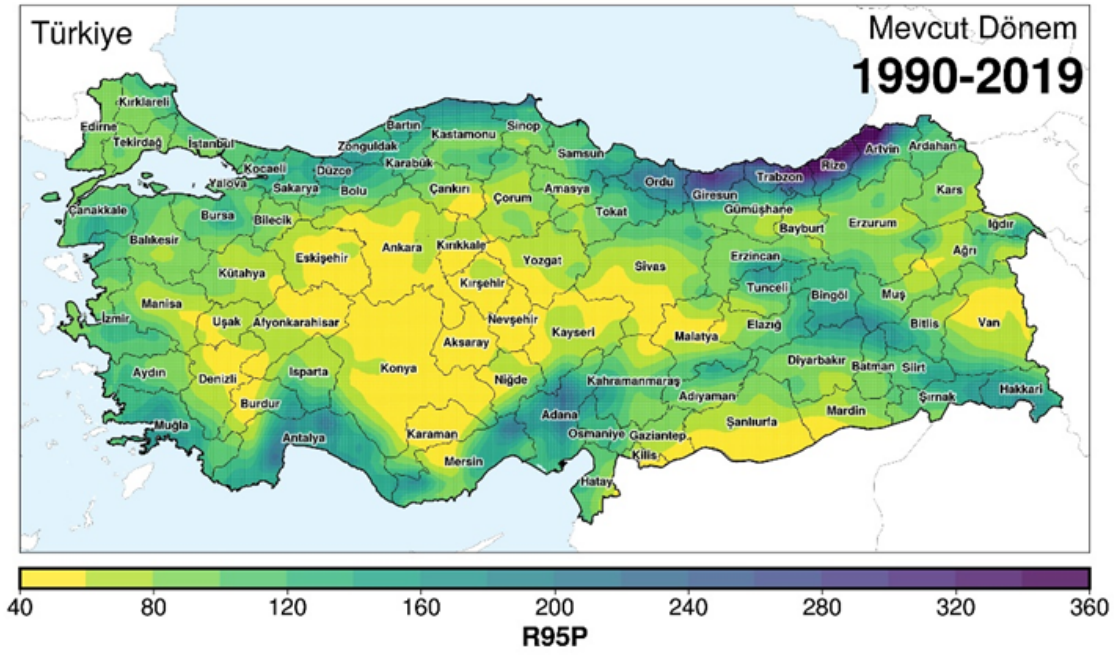
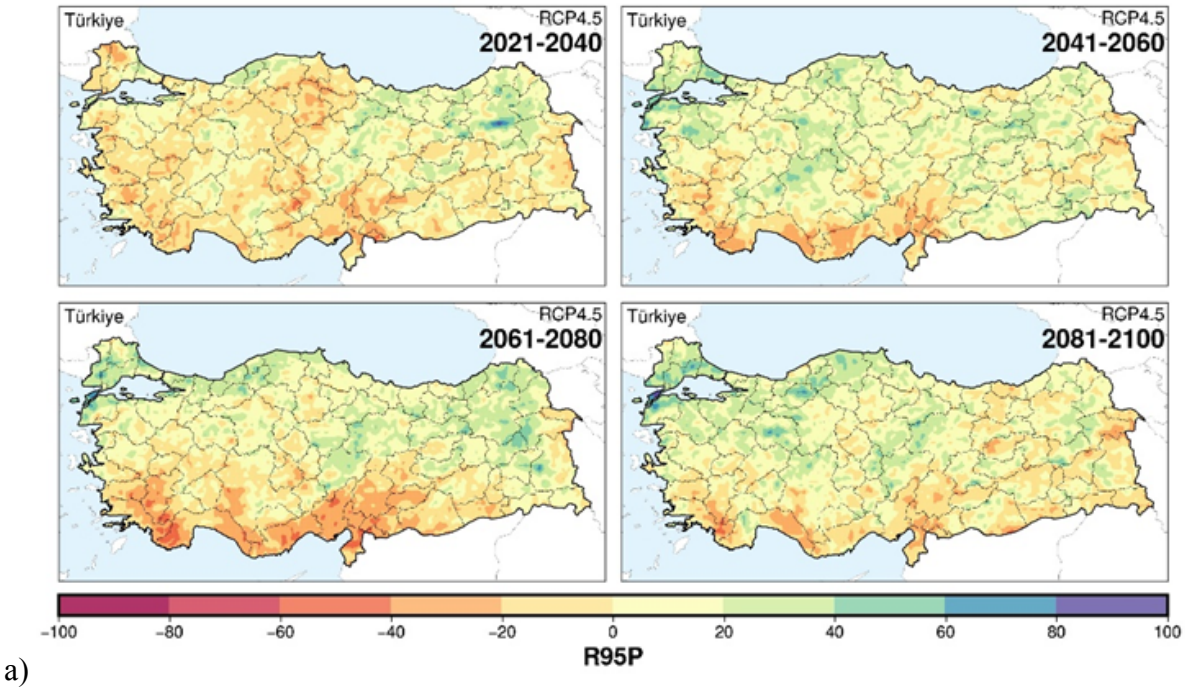


Figure 21 - The Current Period Extreme Precipitation Changes

The reference period is shown in Figure 22. When analyzing the future projections, both scenarios generally predict an increase in the total precipitation from extreme rainfall in northern Türkiye, while a decrease is expected in the south. According to the RCP 4.5 scenario, the most significant decrease is anticipated in the Mediterranean region during the 2061-2080 period. Similarly, according to the RCP 8.5 scenario, the most severe decrease is expected to occur in the Mediterranean region during the 2081-2100 period.



a)

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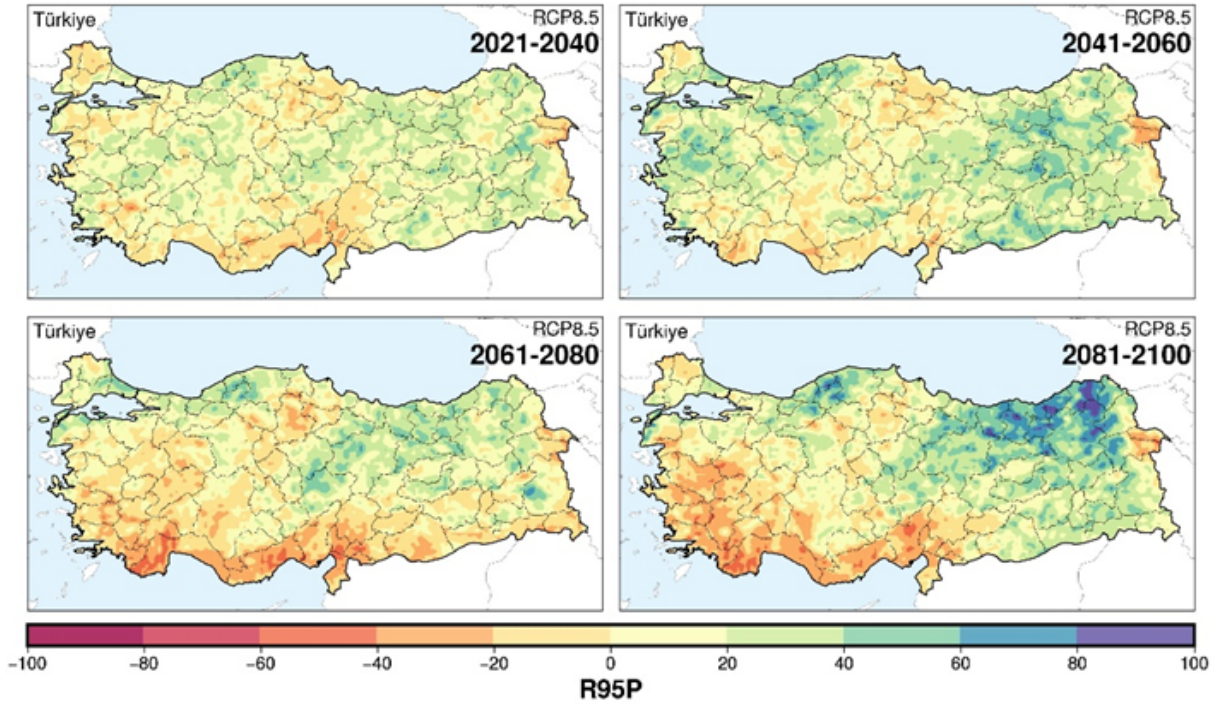


Figure 22 - According to the reference period a) RCP4.5 scenario b) RCP8.5 scenario for the future projections of R95P changes

The Heat Wave Frequency (HWF) index was examined to assess the hazard of heat waves as calculated above 90 percent of temperature. A period in which the index is observed for at least 5 days or more was considered as a heat wave frequency. The distribution of the HWF for the current period is shown in Figure 23. According to the analysis results, at least three instances of heat wave events are observed in Türkiye. The lowest frequency of heat waves is recorded

in the provinces of Army and Giresun. In contrast, the highest frequency of heat waves is found in Mersin, where it reaches 12 days per year. It is noted that, particularly in northern Türkiye, the frequency of heat waves is low, but increases to the south.

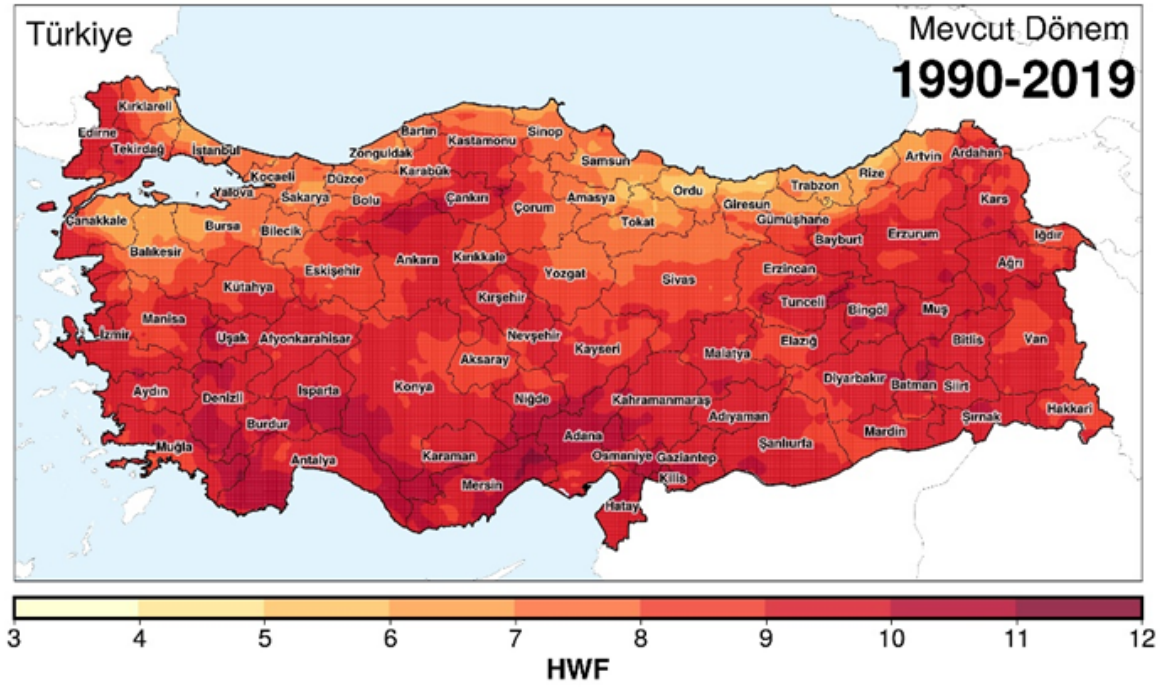
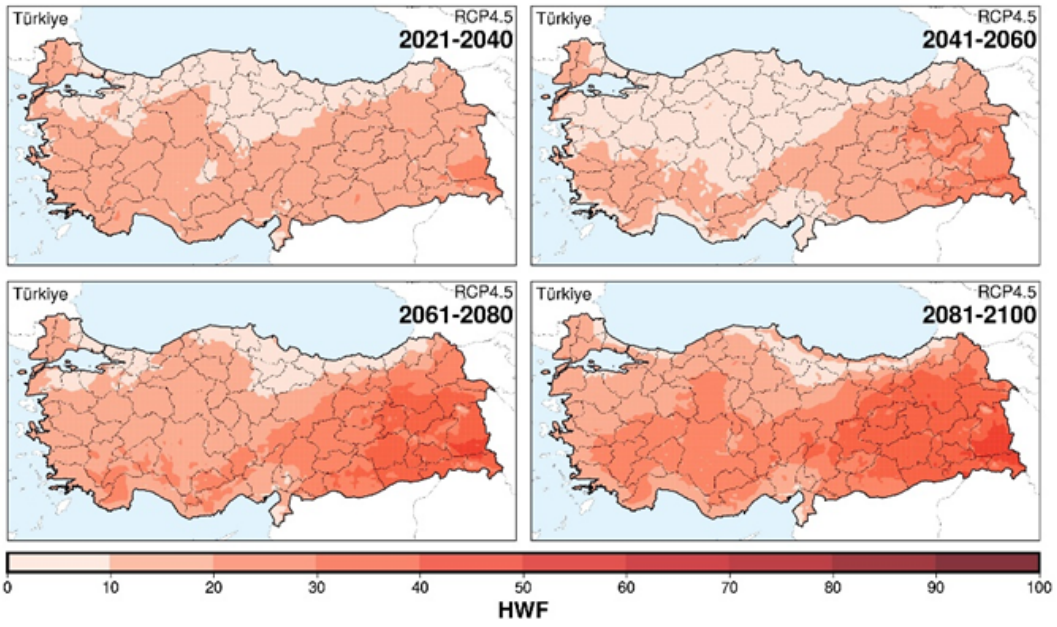
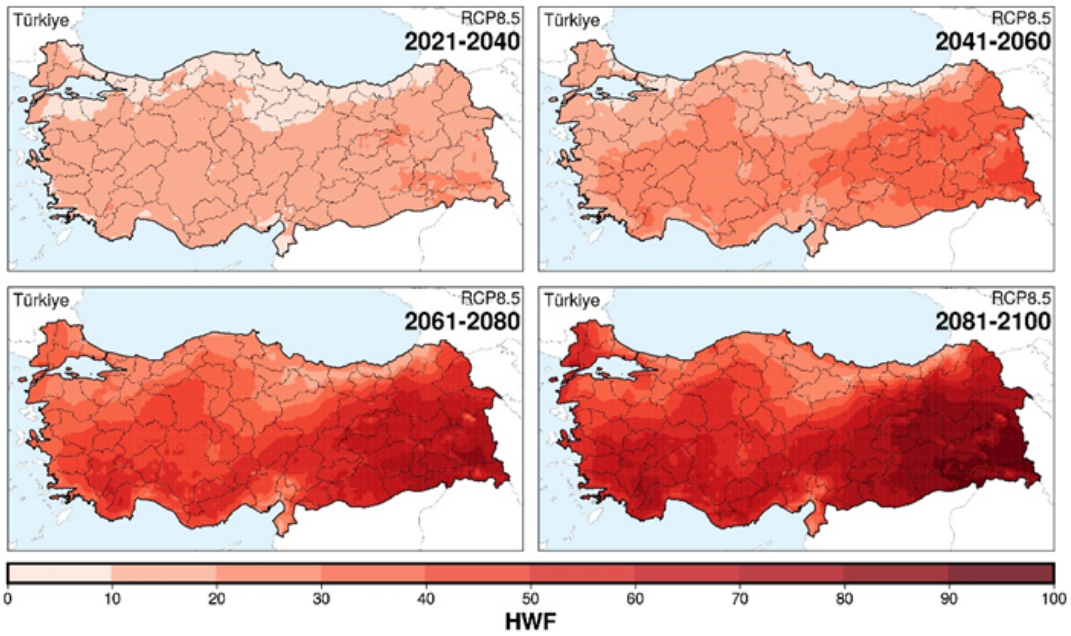


Figure 23 - Current Period Heat Wave Frequency (Day)

Future projections according to the reference period are shown in Figure 24 for the RCP 4.5 and RCP 8.5 scenarios. When examining these future changes, both emission scenarios indicate that, alongside rising temperatures, the frequency of heat wave events will increase significantly during the last 20 years of the 21st century. Particularly in the South Aegean and Mediterranean regions, it is expected that the total number of heat wave days will increase by approximately 60 days under the RCP 4.5 scenario by the 2060s, while this increase could reach up to 100 days under the RCP 8.5 scenario. Overall, it is estimated that the change in heat wave frequency across Türkiye will be most significant according to the RCP 8.5 scenario, with an increase of nearly five times compared to the early part of the century.



a)



b)

Figure 24 - According to the reference period a) RCP4.5 scenario b) RCP8.5 scenario for the future projections HWF frequency

The Canadian Fire Weather Index (FWI), which represents fire-conducive weather conditions for forest fire risk, has been calculated, and the areal distribution of the average FWI values for the current period is shown in Figure 25. According to the FWI index, the Black Sea Region, with the lowest values in the current period, is classified as low risk for fire, while the Southeastern Region is at high risk. The Aegean, Marmara, and Eastern Anatolia Regions fall into the medium-low fire risk categories.

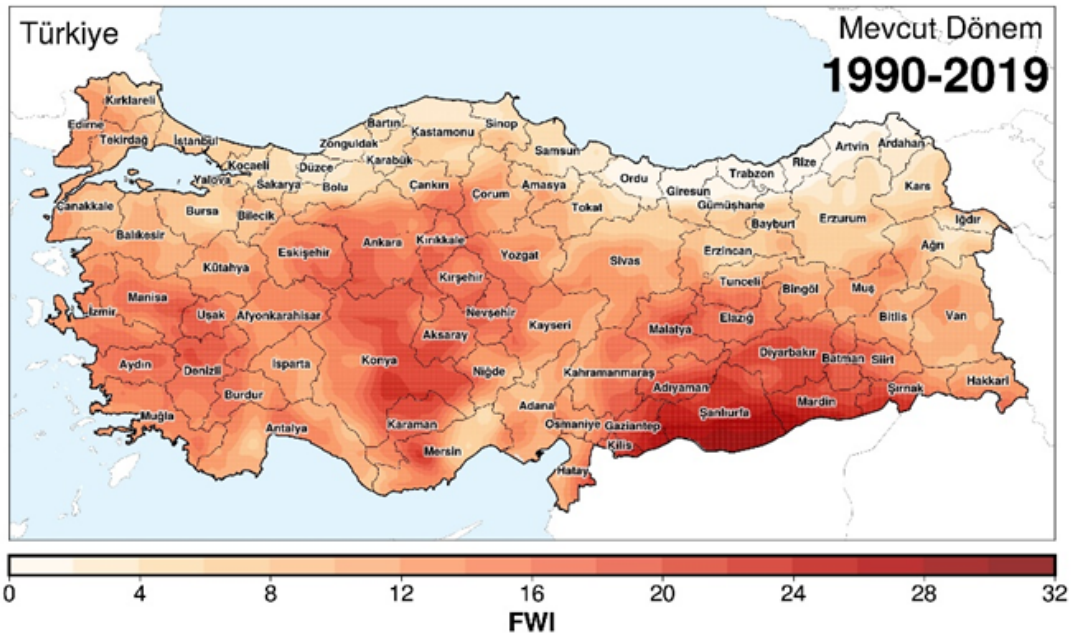
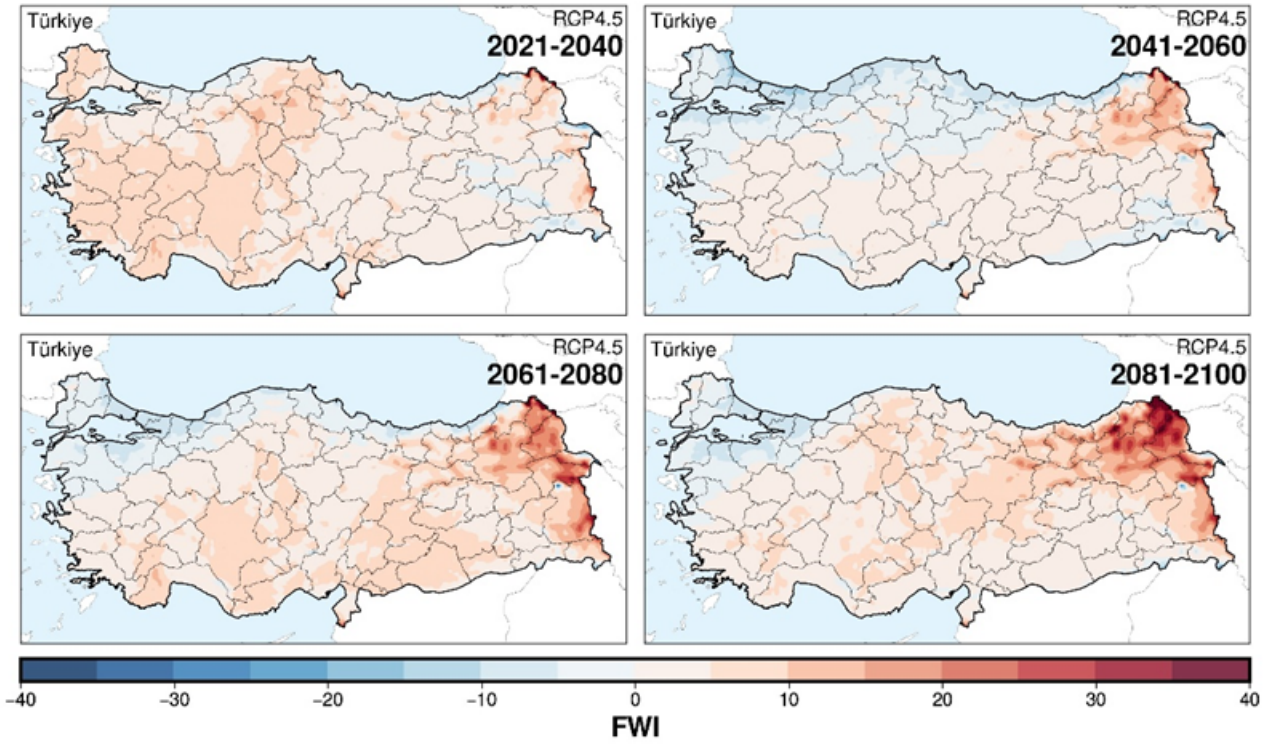


Figure 25. Current Period Forest Fire Weather (FWI) Index

Future projections percentage (%) changes according to the reference period are shown in Figure 26 for the RCP 4.5 and RCP 8.5 scenarios. Examining the results for the future projections, a change of approximately ±20% is expected across Türkiye over the next 100 years according to the RCP4.5 scenario. Fire-conducive weather conditions are projected to increase by 30%, particularly in the provinces of Antalya and Burdur in the Mediterranean Region and in Çankırı and Çorum in Central Anatolia. In the Southeastern Anatolia Region, which currently has a high fire risk, the amount of change is predicted to increase by 20% by the end of the next century.

a)



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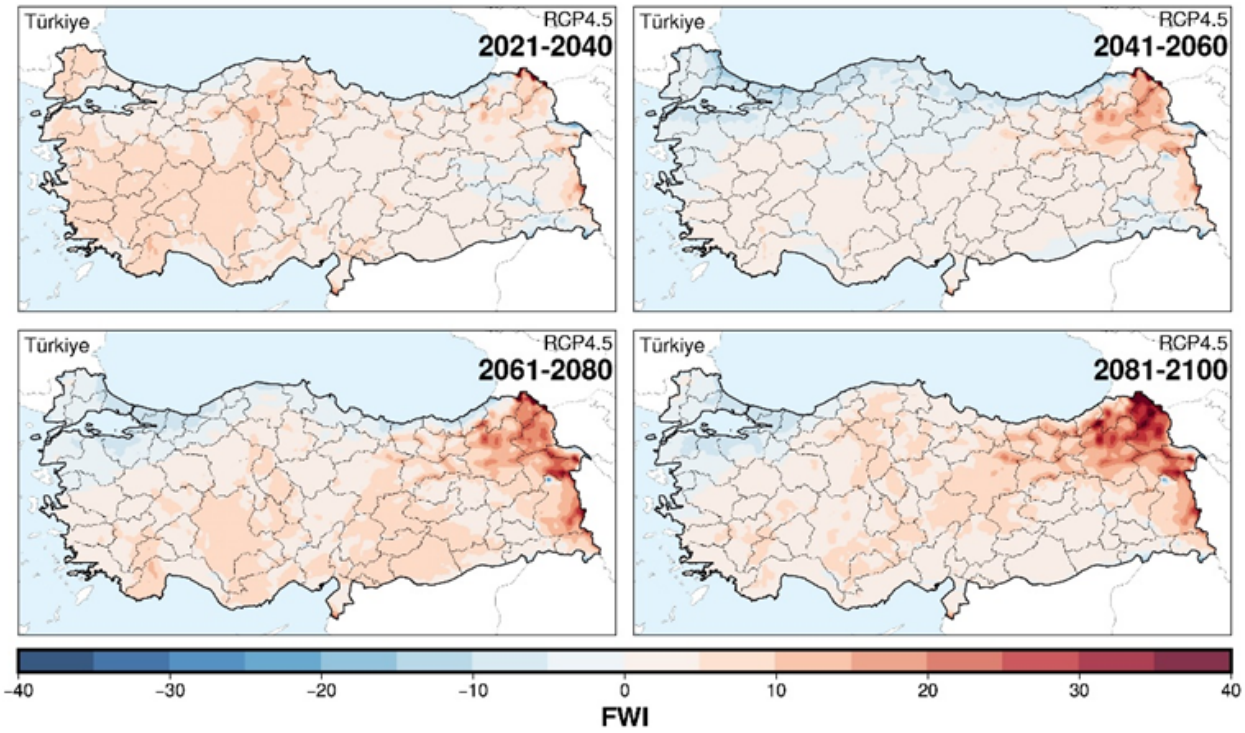

Şekil 26 - According to the reference period a) RCP4.5 scenario b) RCP8.5 scenario for the future projections FWI percentage (%) changes

4.3.4. Water Resources Management

The demand on water resources worldwide due to population growth, along with drought and water scarcity, water pollution, degradation of aquatic ecosystems, floods and inundations exacerbated by poor practices, and increasing competition among water users, has intensified with the effects of climate change.

Since 2010, Türkiye has been preparing basin-scale management plans based on an integrated water resources management approach, which includes the basin protection action plan, basin water allocation plan, river basin management plan, flood management plan, and drought management plan.

As a candidate country for EU membership, Türkiye has largely aligned with the EU Water Framework Directive, undertaking efforts to adopt basin-based management to protect and develop water resources in surface and groundwater and to prevent the deterioration of water quality, aiming to achieve good status in all water bodies.

To ensure sustainable water resources management, the strategic framework outlined below will be followed.

4.3.4.1. Water Resources Management Strategies within the Scope of Adaptation Goals for 2053

Strategy 1. Strengthening Water Resources Management

To ensure basin-based management, the preparation, implementation, and monitoring of basin-scale management plans will be enhanced through the establishment of committees at the national, basin, and local levels, adopting a participatory approach. In the long term, basin and urban management plans will be completed and periodically updated, while monitoring and

evaluation mechanisms for the actions included in all prepared plans will be enhanced[69]. Financing opportunities for investments will be increased, and legislation will be updated.

The Water Law will clarify the legal nature of water, facilitate the preparation of basin management plans, and ensure that allocations are made in a centralized manner. This will involve protecting, improving, developing, and efficiently utilizing water resources, as well as preventing pollution to achieve sustainable water management.

The Flood Law will establish necessary regulations to mitigate the adverse effects of floods on life and property safety, environmental, social, and economic activities, and define the responsibilities of relevant institutions. This will enable coordination and the efficient use of public resources through collaborative implementation. By disseminating flood forecasting and early warning systems, the impacts of floods that cause loss and damage will be minimized.

Effective flood management will enhance the safety of living areas, prevent interventions in river and stream beds, and shift the approach from crisis management to risk management.

Strategy 2. Enhancing the Water Information System

In the long term, necessary legal, administrative, and technical regulations will be established to identify all monitoring points related to the quantity, quality, and sectoral water consumption of surface and groundwater resources, to set up monitoring systems, and to transfer and share the collected data with the National Water Information System (NWIS)[70].

Advanced technologies, including remote monitoring and remote sensing systems, will be utilized in data collection, transmission, storage, and sharing.

Strategy 3. Protection of Water Resources

In Türkiye, situated in the Mediterranean Basin—one of the regions most impacted by climate change—a comprehensive strategy will be implemented to manage water quality and quantity. This approach aims to tackle potential problems caused by climate change, a growing population, and the pollution resulting from that population.

River Basin Management Plans will be prepared for all 25 river basins in Türkiye, aimed at the holistic protection of all surface and groundwater resources, including coastal waters, excluding seas, and ensuring sustainable management of water resources in terms of quality and quantity.

Sectoral Water Allocation Plans will be developed on a basin basis to sustainably meet the water needs of all sectors, including drinking and utility water, environment, agriculture, livestock, industry, and energy, based on the development projections of each sector. Plans specific to drinking water basins will be implemented to protect, prevent pollution, rehabilitate contaminated waters, and ensure sustainable use of surface and groundwater sources from which drinking water is supplied or planned to be supplied.

Drinking Water Safety Plans will be prepared to identify hazards that could negatively affect water quality and quantity or hinder the efficient operation of the drinking water supply and distribution system, through appropriate risk analysis methods. These plans will prioritize hazards, establish necessary measures, and monitor their implementation and effectiveness.

To prepare for drought and minimize the negative impacts of drought risks, Drought Management Plans have been developed for the 25 river basins. Efforts will continue to implement and monitor the measures identified in these Plans. Early detection of drought is crucial for the protection and sustainable management of water resources. To this end, Drought Forecasting and Early Warning Systems will be disseminated.

Strategy 4. Developing Innovative Approaches to Water Efficiency

To adapt to the changing climate, protect water resources, and ensure sustainable management, efforts will be made within the "Water Efficiency Mobilization" initiative, focusing on sectors with high water consumption, including urban, agricultural, and industrial uses.

Under the Framework for Climate Change Adaptation, a Water Efficiency Strategy Document and Action Plan (2023-2033) will be implemented, involving collaboration, monitoring, and guidance for stakeholder institutions and organizations to bring sectoral water efficiency strategies and actions to life.

To reduce water losses in cities, innovative technologies such as smart meters, leak detection sensors, and remote sensing systems will be employed for asset and pressure management, enabling real-time leak detection. Regional measurement areas will be established, and night flow measurements will be conducted, with the aim of reducing the water loss rate in all municipalities to 25% by 2033[55]. Additionally, awareness and education initiatives will be carried out to reduce per capita daily water consumption to 120 liters by 2030 and to 100 liters by 2050.

Measures will be implemented to increase irrigation efficiency by promoting applications that enhance agricultural water use efficiency, aiming for an irrigation efficiency of 60% by 2030 and 65% by 2050.

Supporting nature-based solutions such as rainwater harvesting, drought-resistant landscaping practices, artificial wetlands, green roofs, permeable pavement, and blue-green infrastructure will contribute to creating climate-resilient urban infrastructure.

In industries with high water consumption, such as textiles, food, chemicals, and machinery, efforts will be made to promote the efficient and circular use of water through the application of best available techniques and innovative technologies, achieving up to 50% water efficiency [56].

To promote the efficient use of water resources in agriculture and increase irrigation efficiency to 60% by 2030 and 65% by 2050, agricultural production planning will be aligned with water availability. Support will be provided for the use of modern irrigation methods and agricultural techniques that ensure effective water use, along with the widespread adoption of measurement, remote monitoring, and control systems (SCADA). The use of returning agricultural waters and treated urban wastewater for agriculture will also be facilitated.

To manage the entire process of water delivery from source to end user as effectively and efficiently as possible, a Smart Water Management System that includes end-to-end modern water management systems will be implemented.

The dissemination of materials, equipment, and systems that support water efficiency, along with technologies and applications across all sectors, will be encouraged. The use of alternative water sources, such as rainwater harvesting and greywater reuse, will be promoted to support the recovery and reuse of utilized water[56].

A Water Efficiency Information System will be established to assess the current status of water use and identify, implement, monitor, and report on measures that will ensure efficient water use.

Strategy 5. Strengthening Education, Awareness, Capacity Building, and R&D Activities

Efforts will be intensified to establish a culture of water efficiency and enhance public awareness. Implementation tools will be identified for capacity building, technology, and necessary resources for education, awareness, and volunteer activities. Collaboration will be

fostered with public institutions, academia, NGOs, and the private sector to raise public awareness about the efficient use of water. Research and development activities aimed at increasing water use efficiency will be supported. Additionally, initiatives will be expanded to encourage and incentivize farmers in preserving soil moisture and using water efficiently in agricultural production.

4.3.5.Transportation Sector

The transportation sector is one of the most affected ones by climate change-related hazards. Extreme weather events such as floods and inundations caused by heavy rainfall, storms, and strong winds, as well as heatwaves and wildfires, have serious impacts on transportation infrastructure.

During climate hazards, the transportation sector is also vital for emergency response, intervention, and evacuation. The negative effects of climate change-related disasters on the transportation sector necessitate an enhancement of disaster and emergency management capacity. Therefore, it is essential to develop adaptation strategies in addition to mitigation strategies within the transportation sector.

In urban transportation, public transport systems, biking routes, and pedway should be designed to be climate-resilient, minimizing their vulnerability to major climate hazards such as heavy rainfall and heatwaves. The critical role of urban rail systems in achieving greenhouse gas reduction targets necessitates the strengthening of these infrastructures to protect them from climate hazards.

Underground urban transportation infrastructures, in particular, are vulnerable to heavy rainfall and flood risks. Therefore, the design of effective drainage systems and the safe evacuation of water are crucial for increasing the resilience of such infrastructures against climate hazards. Furthermore, as the transition to clean energy is essential, it is necessary to ensure that the charging and related infrastructure for electric vehicles are protected from climate hazards and made resilient.

4.3.5.1. Transportation Sector Strategies within the Scope of Adaptation Goals for 2053

Strategy 1. Enhancing the Resilience of Critical Infrastructures

In line with climate projections, critical transportation infrastructures in our country will be prioritized based on their exposure level, usage intensity, and regional characteristics. Technological advancements and engineering solutions will be implemented to enhance their preparedness and resilience against climate change hazards. The design criteria and technical specifications that these infrastructures must comply with will be updated according to additional loads and capacity needs arising from climate change.

Resilience against floods and inundations caused by heavy rainfall, which most affect railways, will be increased. Protective barriers and embankments will be constructed where necessary on high-speed trains (HST) and conventional high-speed lines based on future climate projections. In the maritime sector, measures will be taken against risks such as flooding, inundation, strong winds, and storms at ports, considering usage intensity or vulnerability. Evaluations will be conducted on the technical equipment of vehicles used in domestic and international ferry services to enhance climate resilience. Infrastructure measures will also be implemented at airports to protect against risks related to heavy rainfall, winds, and storms.

The resilience of urban transportation infrastructures will be improved. To this end, additional structural elements will be constructed at river crossings for vehicles and pedestrian paths to

address the risk of heavy rainfall, and drainage pumps will be installed at multi-level intersections. Drainage systems on roadways will be enhanced, and the use of materials resilient to heatwaves will be encouraged to bolster the resilience of urban transportation infrastructures. In coastal cities, protective barriers and embankments will be implemented to safeguard roads from storm surges and sea waves. Additionally, urban rail systems such as metros, light rail, and trams will be made resilient to all effects of climate change.

Charging stations for electric vehicles will also be adapted to withstand the impacts of climate change as part of the transition to sustainable and clean energy.

Protective measures will be implemented against risks such as landslides, avalanches, rockfalls, erosion of road fill materials, and damage to tunnel entrances to enhance the safety of roads against extreme weather events. This will involve establishing barriers and net systems against mass movements, strengthening road infrastructure, and using materials that are resistant to wear. Furthermore, reinforcement works will be carried out at tunnel entrances to prevent potential damages, and drainage systems in these areas will be improved.

Strategy 2. Reducing Vulnerability Levels to Ensure Transportation and Passenger Safety

To reduce the vulnerability levels of passengers and transportation activities by mitigating the effects of climate hazards, various engineering measures, along with nature-based "green" solutions, will be implemented to ensure passenger safety and provide uninterrupted services in transportation.

In urban settlements, permeable paving materials will be used on the hard surfaces of roads, sidewalks, squares, and parking areas, provided they do not adversely affect road stabilization conditions.

To protect against heatwaves, tree-lined and sheltered pathways will be constructed for vehicles, pedestrians, and cyclists. Safe and shaded areas will be created at intersections and crossings where cyclists and pedestrians can wait, as well as at public transport stops, utilizing materials that incorporate natural landscape elements and green roof features.

Strategy 3. Improving Accessibility and Evacuation Options in Disasters and Emergencies, and Enhancing Response Capacity

To enhance disaster and emergency management and response capacity during climate change-related disasters, a flexible transportation system will be developed, providing infrastructure for various modes of transport, along with the implementation of multimodal transportation.

By improving the diversity of transport modes and intermodal integration opportunities in urban areas, the capacity for intervention and evacuation in emergencies will be increased, making emergency traffic management more effective and efficient.

Transportation infrastructure will be made suitable for the evacuation of vulnerable groups (such as people with disabilities, the elderly, children, and pregnant women), and early warning systems will be designed to be comprehensible to all user groups. Particularly in the face of climate hazards such as heatwaves, rail systems that offer relatively healthier transportation options and a high level of service will be planned and implemented, supported by urban transport demand forecasts.

In addition to rail systems, dedicated bus lanes and bus corridors will be promoted as quick and effective alternatives in urban transportation during emergencies. Bicycle transportation infrastructure will be developed and integrated with public transport in all cities, while also ensuring the integration of private vehicles with public transport.

In coastal settlements, alternatives for maritime transportation will be developed as part of urban transportation. Maritime transport will be integrated with terrestrial public transport systems and micromobility options, such as bicycles and e-scooters.

Taking transportation and communication infrastructure into account, early warning and information systems for climate hazards will be developed. Long-term (15-day), medium-term (weekly), and short-term (daily/hourly) weather forecasts will be differentiated to create early warning and information systems for all types of climate hazards.

As part of enhancing early warning capacity, the deployment of wind and other climate sensors along critical transportation routes will be ensured.

Smart City Applications and Intelligent Transportation Systems will also serve as important tools for early warning and information. Applications related to travel routes and options will be developed to include climate hazards and emergency information, featuring functionalities to direct travel requests accordingly.

4.3.6.Biodiversity and Ecosystem Services

Türkiye, named after three phytogeographic regions—Euro-Siberian, Mediterranean, and Iran-Turan—serves as a bridge between two continents and features rapidly changing climatic and geographical characteristics. As a result, it possesses a rich biodiversity across various ecosystems, including forests, mountains, steppes, wetlands, coastal areas, and marine ecosystems, with different forms and combinations. Additionally, Türkiye hosts a wide range of species due to its ecosystem diversity. These ecosystems provide numerous services, including food, water, and timber raw materials. They also contribute to society through supporting ecosystem services such as carbon storage and climate regulation, as well as cultural ecosystem services like tourism, recreation, and pastoralism.

There is a strong connection between biodiversity, ecosystem services, and climate change. While biodiversity acts as a natural buffer against climate change, climate change threatens biodiversity and the services provided by ecosystems.

Therefore, biodiversity and ecosystem services play a vital role in combating climate change. Protecting biodiversity is crucial for sustainable environments and human well-being in the fight against climate change.

In this context, efforts are underway to ensure the conservation of protected areas in line with national and international commitments, primarily the Convention on Biological Diversity, to which Türkiye is a party. These efforts are based on ecosystem-based scientific studies aimed at increasing the number of protected areas to the targeted levels.

As part of these efforts, the number of protected areas, which are important carbon sink areas, has been steadily increasing, reaching 12.87% of the country's total land area. This aims to reduce biodiversity loss, combat the effects of climate change, and ensure that ecosystem services provide benefits at both global and local levels, while maintaining a balance between conservation and use.

It is projected that Türkiye's population will reach approximately 94 million by 2053 [71]. The housing, income, food, and water needs of this population may exert pressure on ecosystems. Land-use change is a significant source of emissions, leading to 2.5 million tons of CO_2 emissions annually [24].

4.3.6.1. Strategies for Biodiversity and Ecosystem Services within the Scope of Adaptation Goals for 2053

Strategy 1. Reducing the Pressure of Factors Threatening Biodiversity and Ecosystem Services, Such as Habitat Fragmentation and Alteration, Pollution, and Overexploitation

Climate change is expected to negatively impact all ecosystems, particularly forest ecosystems. This includes an anticipated increase in forest and marsh fires, tree falls due to storm damage in forests, and potential biomass losses in forest and agricultural ecosystems as harmful species proliferate with rising temperatures.

Sustainable forest management will be planned to determine the optimal level of wood raw material production, taking into account issues such as forest maintenance, regeneration, and protection against fires, as well as the forest products sector. This transition will be aligned with a circular bio-economy approach.

Strategy 2. Increasing the Area of Protected Lands, Expanding Carbon Sink Areas, and Restoring Ecosystems

In order to achieve the United Nations Convention on Biological Diversity's target of "protecting 30% of land, inland waters, and marine areas" by 2030, efforts will be made to increase potential natural site areas through Ecological-Based Scientific Research Projects and Special Environmental Protection Areas. This will involve ensuring the sustainable management of ecosystems, increasing the area of marine and terrestrial protected lands, and restoring ecosystems.

As part of Türkiye's National Land Degradation Neutrality Targets, activities will focus on protection (planning and management activities aimed at prevention), management (sustainable land management (SLM), sustainable forest management (SFM), etc.), and restoration (restoration and rehabilitation aimed at reversing degradation). Monitoring systems will be developed to identify sensitive areas regarding desertification and land degradation, as well as to enhance soil organic carbon and promote land-based climate adaptation through Basin-Based Action Plans for Combating Desertification.

4.3.7.Energy Sector

The primary objective of the adaptation strategies in the energy sector is to ensure energy supply by balancing production and consumption across time and space.

Extreme climate events resulting from changes in temperature and precipitation patterns can lead to alterations in river flow and ecosystems, causing damages and disruptions within the energy sector. The following adaptation strategies aim to enhance the resilience of energy infrastructure against the impacts of climate change.

4.3.7.1. Energy Sector Strategies within the Scope of Adaptation Goals for 2053

Strategy 1. Considering Climate Change Adaptation in Electric Power Systems

Hydropower plants (HPPs) without dams or water storage reservoirs are more vulnerable to floods and erosion. Therefore, various discharge systems and alternative routes will be planned and implemented to mitigate the negative effects of flooding.

To enhance the transmission system's equipment against extreme weather events, power lines will be rerouted along open areas or roads, vegetation will be regularly maintained at safe distances, and storm/hurricane forecasting and prevention tools will be developed. Additionally, cables will be placed underground in suitable locations.

4.3.8.Manufacturing Industry Sector

In the manufacturing industry, the inability to achieve net-zero emission targets with existing production techniques necessitates structural transformation within the sector. Additionally, due to the manufacturing industry's locomotive role in the economy, any negative impacts from climate change will resonate throughout the entire economy, making it essential to prioritize adaptation activities in this sector. Adapting to the effects of climate change in the industrial sector will significantly contribute to both the sustainability of the sector and sustainable development.

Severe rainfall and drought are emerging as significant threats to the manufacturing industry. To minimize the adverse effects of these hazards, it is crucial to assess industrial facilities for climate hazards and strengthen industrial infrastructure. Innovative technologies and practices must be adopted to make the manufacturing industry infrastructure resilient to climate change.

4.3.8.1. Manufacturing Industry Sector Strategies within the Scope of Adaptation Goals for 2053

Strategy 1. Transitioning to Higher-Tech and Climate-Friendly Products in the Manufacturing Industry to Reduce Vulnerability and Enhance Adaptation Capacity

The selection and use of raw materials, technology, site location, and energy and logistics planning are critical for strengthening the adaptation capacity of the manufacturing sector. In the context of adapting to the effects of climate change, the goal is to enhance adaptation capacity by undergoing a structural transformation towards high-tech profiles in the manufacturing industry, focusing on products with low carbon intensity during both production and use phases.

Strategy 2. Planning for the Protection of Production Facilities from Disasters, Prioritizing Strategic, Large-Scale Facilities at High Risk of Major Industrial Accidents

Establishing early warning and forecasting systems is crucial for making production facilities and infrastructure resilient to climate change risks. Additionally, to minimize business interruptions and associated economic losses, processes will be planned by considering the potential impacts of climate change on the intensity and frequency of extreme weather events, thereby reducing losses and damages to a minimum.

Strategy 3. Strengthening Adaptation Capacity through Voluntary Initiatives, Sector Representative Organizations, and Professional Associations in the Manufacturing Industry

Enhancing the adaptation capacity of industrial enterprises to the effects of climate change and sustaining it requires significant financial resources and institutional capacity. The widespread adoption of green procurement in the industrial sector will be promoted, and efforts will be made to ensure that sectoral NGOs, professional organizations, chambers of industry, and organizations such as organized industrial zone (OIZ) management play a leading role in introducing and disseminating technology-based adaptation solutions.

Elements of adaptation will be included in mandatory and voluntary sustainability reporting, a sectoral database will be developed for adaptation, and monitoring and reporting capacity will be enhanced to closely track the adaptation process.

Strategy 4. Strengthening Technical Knowledge Capacity for Adaptation in Industrial Enterprises, Primarily for SMEs

Networks will be established to support SMEs in accessing sector-specific adaptation information and collaborating with other businesses to assess climate-related risks and opportunities. These networks will facilitate the dissemination of knowledge and raise awareness regarding adaptation strategies.

Strategy 5. Developing a Risk Analysis Tool for Assessing Physical Climate Risks Across the Manufacturing Industry

After the completion of vulnerability analyses, which will serve as the foundation for planning adaptation actions at the national and local levels in the industrial sector by 2030, a tool for analyzing climate risks will be developed. This tool will facilitate the implementation of measures to minimize the impacts of climate change and ensure resource efficiency.

Strategy 6. Adopting Water Efficiency Practices in the Manufacturing Industry

The adoption of water efficiency practices in the manufacturing industry is critical for sustainability and cost savings. Under the Water Efficiency Strategy Document and Action Plan (2023-2033) within the Framework for Climate Change Adaptation, it is anticipated that water savings of up to 50% can be achieved by increasing water use efficiency in the industrial sector. In this context, the measures outlined in the industrial water efficiency guideline documents prepared for 152 NACE codes will be implemented by industry representatives, and inter-institutional cooperation and incentive mechanisms will be developed to facilitate the implementation of these measures.

4.3.9.Tourism Sector

Climate hazards and risks will lead to changes in suitable areas and seasons for tourism activities in Türkiye, just as they do worldwide, making it increasingly challenging to ensure the sustainability of existing forms of tourism in certain destinations. The rising demand for new infrastructure and the emergence of new suitable destinations for some types of tourism will increase the need for facilities, consequently raising demands for financial and natural resources.

For the tourism sector in Türkiye to achieve its strategic objectives and contribute effectively to the national economy, it must adapt early to climate change and maintain its competitive position on a global scale.

The increasing intensity and frequency of climate hazards pose sectoral risks to tourism in Türkiye, negatively affecting tourist satisfaction and leading to a decrease in both visitor numbers and tourism revenue. Therefore, it is essential to assess the current and future vulnerability of the tourism value chain to climate hazards and develop adaptation actions to ensure the sustainable development of the sector.

Tourism facilities are expected to be affected by climate hazards at different levels based on their location, the types of tourism they serve, tourist profiles, and business types. With climate change, it is anticipated that accommodation facilities will face challenges in adapting to competitive conditions due to increasing energy demands and costs, food prices, and labor costs.

4.3.9.1. Tourism Sector Strategies within the Scope of Adaptation Goals for 2053

Strategy 1. Enhancing the Climate Change Adaptation Capacity of Tourism Investments and Operations through Infrastructure Improvements

Technical guidelines will be developed to address climate hazards expected to affect tourism businesses, and spatial arrangements will be made to determine the physical needs and standards necessary for strengthening facilities. Design guidelines that consider sustainable tourism principles will be developed for new spaces and facility buildings. Support mechanisms will be established to address the deficiencies of existing tourism facilities in adapting to climate change and to promote the adoption of the standards outlined in the guidelines.

In regions with high tourism activity, climate-adaptive planning efforts will be undertaken that take climate risks into account, particularly directing large investments in this direction. Early warning systems will be established in tourism areas to prepare for extreme weather events that could cause loss and damage, and search and rescue teams will be strengthened.

To minimize the vulnerability of movable and immovable cultural heritage elements and heritage sites to climate change, potential climate hazards will be identified at a regional scale, and impact assessments and risk analyses will be conducted in heritage areas.

Strategy 2. Raising Awareness to Enhance Resilience Against the Effects of Climate Change in the Tourism Sector

Training and awareness programs will be established to educate public, civil society, and private sector actors involved in the tourism value chain about the level of impact of climate change on the tourism sector, the necessity of adaptation actions, and the steps that need to be taken.

Joint awareness campaigns will be organized in collaboration with the Ministry of National Education and the Council of Higher Education (CoHE) to address the effects of climate change on tourism and adaptation actions in schools that provide tourism education. Additionally, training programs will be organized for tourism employees, along with on-the-job training initiatives.

Destination Management Organizations (DMOs) will be established to foster local ownership, promote collective action, and facilitate collaboration among stakeholders, thereby enhancing the capacity to adapt to climate change.

Sustainable climate-adaptive planning efforts will be conducted in regions with high tourism activity, taking climate risks into consideration.

The identification and mitigation of the vulnerabilities of cultural heritage to climate hazards will be coordinated through local, national, and international collaborations involving responsible public institutions.

Strategy 3. Considering Climate Change Adaptation in Strategic and Spatial Decisions Related to Tourism and Cultural Heritage, and Ensuring Coordination Among Relevant Authorities

To ensure sustainable land use in existing and new tourism areas, the local and national coordination structure will be strengthened in the preparation, implementation, and oversight of spatial plans.

Vulnerability and risk analyses will be conducted, and based on the results of these analyses, spatial planning efforts will be carried out. Policies and strategies aimed at enhancing resilience to climate change will be developed.

Strategy 4. Adopting Water Efficiency Practices in the Tourism Sector

Under the Water Efficiency Strategy Document and Action Plan (2023-2033) within the Framework for Climate Change Adaptation, it is anticipated that water savings of up to 40% can be achieved by increasing water use efficiency in the tourism sector. In this context, the measures outlined in the "Water Efficiency Guide for the Tourism Sector" will be implemented by industry representatives, and inter-institutional cooperation and incentive mechanisms will be developed to facilitate the implementation of these measures.

4.3.10. Agriculture Sector

Türkiye's diverse climate and natural resources allow for the cultivation of a wide range of agricultural products. However, this diversity also brings various risks, options, and scenarios regarding the effects of climate change and adaptation within the agricultural sector. A significant portion of Türkiye is under the influence of semi-arid climate conditions. Consequently, changes in the amount and distribution of rainfall, which are crucial for both water resources and dry farming, have significant impacts on the agricultural sector. These impacts will have broad repercussions in areas such as production, consumption, trade, employment, and food security.

The most significant impact of climate change on Türkiye's agricultural sector is the decrease in crop yields (the amount of product harvested per unit area). By 2080, it is expected that changes in temperature and precipitation will significantly reduce the yields of key crops such as wheat, barley, rye, oats, corn, sunflower, legumes, rice, sugar beet, and cotton. Additionally, the increasing frequency and intensity of extreme climate events will exacerbate yield and production losses.

Changes in temperature, precipitation, climatic cycles, and other climate parameters, along with the rise of climate hazards such as droughts, agricultural frost, floods, and storms, directly affect agriculture. These impacts will ripple through production, consumption, trade, employment, and food security.

The physical effects of climate change on agriculture can cause damage to natural assets, including supply chains and ecosystems, both in the short and long term. Agricultural infrastructure and food chains can also be affected by these impacts. Therefore, enhancing resilience and adapting to climate change in agriculture is of paramount importance.

4.3.10.1. Agriculture Sector Strategies within the Scope of Adaptation Goals for 2053

Strategy 1. Developing Policies and Legal Frameworks for Climate Change Adaptation in the Agricultural Sector, Enhancing Institutional Capacity, and Strengthening Collaboration and Awareness

To enhance resilience and adaptation to the potential adverse effects of climate change in agriculture, the development of policies and legal frameworks will be prioritized. Efforts will be intensified to strengthen institutional capacity, collaboration, and awareness.

Strategy 2. Ensuring the Protection, Development, and Sustainable Use of Ecosystems and Natural Resources in Agricultural Production

To reduce the negative impacts of agricultural activities on soil, water resources, and biodiversity, efforts will be made to determine appropriate crop patterns, including crop rotation and livestock systems, that can ensure effective use of soil and water resources and the protection of biodiversity at the provincial and/or district level. Guides will be prepared to assist farmers in this regard.

The conservation of agricultural lands, the quality of pastures, and rural landscapes will be ensured, with increased monitoring of pasture capacities and yields. Efforts will be intensified to identify and implement options that contribute to water balance in pastures and enhance productivity.

Work will continue on traditional and natural methods that are environmentally friendly and increase climate change adaptation capacity. The number of farmers practicing organic farming and good agricultural practices across Türkiye will be increased, with measures taken to disseminate these practices in all provinces. Practices such as conservation agriculture, protective and restorative agricultural practices, rainwater harvesting, permaculture, and live windbreaks will be promoted.

A national guide to nature-based solutions for agricultural activities will be developed, and an ecosystem-focused food production model will be implemented and disseminated.

Strategy 3. Increasing R&D Efforts on the Effects of Climate Change and Adaptation in Agriculture, Promoting Database Development, Information Technologies, and Innovation Practices, and Conducting Agricultural Activities Accordingly

Research and development (R&D) efforts focused on the effects of climate change and adaptation in the agricultural sector will be supported and enhanced. The use of rapidly advancing global technologies, such as satellite-based and sensor-driven early warning and monitoring technologies, as well as integrated agricultural application technologies, will be widely promoted.

Systems for combating and adapting to the increasing impacts of drought, flooding, hail, and inundation in Türkiye will be developed and implemented to mitigate their effects on agriculture.

To ensure the reliability of information provided to decision-makers, the capacity for information generation among public and private organizations in the agricultural sector will be improved. The breadth and depth of research conducted by research institutions on climate impacts and adaptation in agriculture will be expanded, and the ability to incorporate existing scientific research and data into decision-making processes will be enhanced.

Development of a database for agriculture, as well as information technologies and innovation practices, will be ensured, and agricultural activities will be conducted accordingly.

The development of plant species and animal breeds that are relatively less sensitive to climate will be promoted, along with the conservation, support, and dissemination of local breeds with high adaptation capacity. Efforts will be made to reduce losses and damages to critical infrastructures (such as irrigation, cold chain, modern storage, transportation infrastructure, etc.), and the insurance system will be developed with consideration of the impacts of climate change.

4.3.11. Urban

Cities, which are home to more than half of the world's population and responsible for approximately 70% of global greenhouse gas emissions, are at the center of adaptation policies

aimed at combating climate change, as they are among the areas most affected by its adverse impacts.

In Türkiye, our cities have developed a vulnerable structure against the negative effects of climate change due to rapid growth and expansion.

The approach within the strategies for Turkish cities focuses on conducting urban risk analyses based on new research and data, making planning processes climate-sensitive, transforming the carbon-intensive urbanization model characterized by rapid growth, sprawl, and unintended land uses, and ensuring sustainable and resilient urbanization. In this context, three main strategies have been defined for urban areas, and the necessary actions have been summarized under these strategies.

4.3.11.1. Urban Sector Strategies within the Scope of the 2053 Adaptation Goals for 2053

Strategy 1. Adapting to Climate Change by Increasing the Resilience of Cities

Initially, areas in cities that are at risk of floods and inundations will be improved. Based on flood calculations conducted according to scenarios with varying precipitation levels and the prepared maps, risky locations will be analyzed, and appropriate transformation models will be determined. Risky urban areas and structures will be identified and improved with consideration for the needs of groups requiring special policies, such as women, children, the elderly, disabled individuals, and low-income populations. In this context, evacuation corridors will be created, covered stream channels will be reopened, and protective zones will be established around riverbeds.

To increase the resilience of urban infrastructure against flood and inundation risks, smart information systems related to infrastructure capacities and severe precipitation scenarios will be strengthened. Infrastructure will be enhanced through the reconfiguration of drainage systems, separation of combined sewer (rainwater and wastewater) systems, changes in surface coatings, and capacity increases where needed. Standards for locally suitable materials that improve the resilience of buildings' roofs and facades against extreme weather events and prevent urban heat increase will be established to ensure their effective use.

Urban heat islands, green space requirements, and wind corridors will be identified, and accessible, densely green areas and ecological corridors with natural surfaces will be created within urban structures.

Rainwater management will be implemented in urban and peripheral areas by establishing rain gardens, sponge city elements, rain ditches, and natural water surfaces; public spaces will be transformed into designs that capture water during heavy rains and transfer it to storage systems.

Through xerophytic landscaping practices, drought-resistant and aesthetically pleasing urban areas will be created. Additionally, educational and awareness-raising efforts will promote a shift in water use habits, fostering a culture of water efficiency and adopting a water-efficient city approach.

Strategy 2. Ensuring Climate Change Adaptation in Spatial Planning

The processes of spatial plan development will be reconsidered within the scope of climate change adaptation. Guiding manuals will be developed that address issues such as site selection, prevailing wind direction, passive ventilation and solar exposure, development, and implementation. These manuals will incorporate local climate data and consider urban landscape and green spaces as an integrated system in spatial planning and urban design.

Using spatial data, risk maps will be created for urban areas. Digital twins of cities will be developed to facilitate risk analyses through this infrastructure.

4.3.12. Health

To understand the impacts of climate change on public health, it is essential to identify climate-sensitive populations and the threats they face, establish early warning systems, and develop rapid and effective response mechanisms. The following strategies have been developed to manage climate-related events and ensure that communities can maintain healthy and safe lives.

4.3.12.1. Health Sector Strategies within the Scope of 2053 Adaptation Goals

Strategy 1. Strengthening Evidence-Based Analysis, Assessment, and Reporting Infrastructure Related to Climate Change in the Health Sector

To facilitate the health sector's adaptation to climate change, evidence-based scientific research will be prioritized, and the outcomes of these studies will be considered in climate and health adaptation planning. Planned studies will integrate data on individuals, health, all determinants of health, living environments, and climate indicators to build a robust evidence pool.

All adaptation policies will be incorporated into the Health Impact Assessment (HIA) process to reduce the health impacts of climate change. Awareness efforts will be conducted to inform the public about protection from dust and polluted air, especially considering the increase in allergy cases due to dust transport.

Strategy 2. Increasing Awareness, Capacity, and Collaboration on Climate Change and Health

By integrating health considerations into sectoral adaptation plans and policy development, the potential impacts (both positive and negative) of these sectors' adaptation activities on the health sector will be assessed. Planning based on health impact chains will be carried out to support adaptation to the health effects of climate change. Climate-compatible health monitoring and surveillance systems will be established, and early warning and rapid response mechanisms for climate-sensitive diseases will be developed.

Awareness will be raised among vulnerable groups—such as individuals with disabilities, women, the elderly, children, pregnant individuals, and low-income populations—about common climate-related events. Preparedness for potential climate-related incidents and mental health issues will also be encouraged. A detailed list of climate-sensitive diseases specific to Türkiye will be compiled, and the links between climate risks and diseases will be thoroughly analyzed.

The impacts of climate change on worker health (including outdoor workers in sectors such as agriculture, forestry, fisheries, security, archaeology, excavation and construction, geology, as well as indoor workers in industries like baking, steel, glass, food, and office environments) will also be evaluated.

In response to climate signals, academic and institutional analyses will examine the movement of people, animals, and biodiversity from high-risk neighborhoods, cities, and regions to lower-risk areas. Preparations will be made for potential epidemics, endemics, and pandemics that may arise due to an increase in disease agents, vectors, and sources associated with rising displacement rates.

Strategy 3. Strengthening City and Environmental Health Services with an Integrated Approach to Reduce Mortality Risks from Climate Change

Health risks associated with climate-related deaths, expected to increase between 2030 and 2050 according to the World Health Organization, will be identified. In this context, a list of climate-sensitive diseases will be prepared for each city, and vulnerable groups will be made ready based on these lists. Local governments and institutions responsible for public and environmental health will collaborate closely.

4.3.13. Social Development

The effects of climate change have reached a level that profoundly impacts all areas of social development. Groups that require special policies, such as people with disabilities, women, the elderly, children, and low-income individuals, are among the most affected by the consequences of climate change, particularly in the face of extreme weather events like floods, droughts, and extreme temperatures.

In the fight against climate change, it is crucial to ensure inclusivity, strengthen social protection systems, and raise awareness and adaptation capacity, particularly among these vulnerable groups, to reduce social vulnerability and enhance resilience. It is also important to address the sectors affected by climate change not only from an economic development perspective but also from a social development perspective.

4.3.13.1. Social Development Strategies within the Scope of Adaptation Goals for 2053

Strategy 1. Enhancing Community Participation in the Fight Against Climate Change

To effectively combat climate change, participatory processes will be established to develop more effective and sustainable solutions at the local level, taking into account the needs and opinions of local communities. National policies in the area of combating climate change will be shaped by considering the needs and views of the local population.

Strategy 2. Enhancing Family Resilience to Disasters and Emergencies Through Family-Sensitive Environmental Policies and Raising Awareness in the Fight Against Climate Change

Family-sensitive environmental policies will be developed to enhance families' resilience against climate change and natural disasters. Efforts will be made to raise awareness among families regarding natural disasters, the effects of climate change, and emergencies, promoting the adoption of environmentally conscious individual and community behavior models.

Strategy 3. Strengthening Social Protection Systems and Aligning Them with Climate Change Strategies

Social protection systems will be restructured to adapt to climate change and meet the needs of vulnerable groups, based on research and current data.

Efforts will be made to ensure that national and local social protection systems are aligned with climate change strategies, fostering collaboration among stakeholders.

Strategy 4. Raising Awareness on Climate Change Adaptation, Particularly Among Vulnerable Groups

Awareness of climate change adaptation will be increased within the community, particularly among vulnerable groups. Additionally, efforts will be made to enhance the awareness of

personnel working in institutions and organizations that provide services in this area. Initiatives will be implemented to translate this awareness into action.

Strategy 5. Enhancing the Resilience of Vulnerable Groups Such as Women, the Elderly, Children, People with Disabilities, and Low-Income Individuals, Who Are Significantly Affected by Climate Change

Vulnerable groups require special policies, as they are more susceptible to the impacts of climate change. Therefore, it is essential to minimize the effects of climate change on these groups. In this context, studies will be conducted to assess the physical, physiological, psychological, social, and economic impacts of climate change and global warming on women, children, people with disabilities, the elderly, and low-income individuals.

In disaster situations caused by climate change, women, children, the elderly, people with disabilities, and low-income individuals represent the highest-risk group and require special measures regarding issues such as nutrition and shelter, accessibility for family members, and access to medications. Consequently, specific policies will be developed in disaster management for these groups. Additionally, awareness will be raised regarding the actions these groups need to take during disasters.

4.3.14. Disaster Risk Reduction

Türkiye aims to establish resilient communities and safe living spaces at both national and local levels to prevent or minimize losses caused by disasters resulting from climate change.

4.3.14.1. Disaster Risk Reduction Strategies within the Scope of Adaptation Goals for 2053

Strategy 1. Ensuring the Resilience of Critical Infrastructure Against the Effects of Climate Change

To enhance the resilience of critical infrastructure (such as energy systems, water and wastewater management, communication and information systems, health infrastructure, and transportation) against climate-related hazards, necessary measures will be implemented during the planning, construction, and operational phases, considering long-term disaster risks.

Investments aimed at reducing disaster risk will be made to establish resilient infrastructure systems, thereby ensuring resilience against disasters.

Strategy 2. Reducing Climate Change-Related Disaster Risks in Alignment with the Priorities and Goals of the Sendai Framework for Disaster Risk Reduction

Comprehensive disaster databases will be established to better analyze and monitor disaster hazards and risks, as well as to identify exposure and vulnerabilities, focusing primarily on disaster-related losses, and efforts will be made to ensure the continuity of this data.

Mechanisms will be developed to identify hazards and risks, enabling effective management of risks arising from climate change. In this context, investments will be made in scientific research and innovative technologies to identify and minimize disaster risks.

To reduce climate change risks, infrastructure for preparing, developing, updating, and sustaining hazard and risk maps will be established for all relevant sectors.

Awareness and effectiveness regarding all phases of disaster management—before, during, and after disasters—will be increased for all segments of society, particularly vulnerable groups such as the elderly, people with disabilities, children, and women. Local governments' capacities for disaster risk reduction and response will be strengthened.

Community participation in disaster management will be encouraged, with an emphasis on volunteer-based efforts. Active community involvement in disaster preparedness, response, and recovery processes will be facilitated through collaboration between local governments and civil society organizations.

Strategy 3. Developing Early Warning and Forecasting Systems for Multiple Disaster Hazards

Early warning and forecasting systems will be developed using innovative technologies, ensuring that these systems comply with international standards. Necessary collaborations will be established to integrate the systems into global warning networks.

Local governments will be supported in establishing early warning and forecasting systems.

Awareness campaigns and training programs will be implemented to inform the public about how early warning systems work and the measures that need to be taken.

4.4. Initiatives for Climate Finance

4.4.1. Carbon Pricing

Türkiye has implemented various policy instruments to reduce greenhouse gas emissions, and carbon pricing instruments are among the most effective tools developed in this context. In this context, the main strategy is to establish the necessary infrastructure to ensure the effective use of carbon pricing tools.

Strategy 1. Ensuring the Effective Use of Carbon Pricing Instruments

In line with Türkiye's Nationally Determined Contribution and 2053 net zero emission targets, reduction activities will be supported by utilizing various carbon markets in both ETS and non-ETS sectors.

As of 2025, the total emission amount that sectors and facilities within the scope of the ETS can emit during certain periods constitutes the upper limit of the ETS. This upper limit is planned to be determined in a manner that aligns with the current status of emission-intensive sectors, reduction targets, international agreements, and our country's 2053 net zero emission target, contributing to emission reduction.

The free allocations foreseen in the ETS will be gradually phased out in a manner consistent with the 2053 net zero emission target. The sectoral scope of the ETS will also be gradually expanded over time. As a result of a carbon pricing policy to be implemented with ETS in our country, it is of great importance for producers in sectors with high carbon intensity and a high risk of carbon leakage to undergo a green transformation and maintain their market power to ensure their competitiveness. With the revenues obtained within the framework of the ETS, investments aimed at supporting the decarbonization of sectors, including their green and technological transformation, will be supported as part of the fight against climate change. In the future, the global competitiveness of sectors within the scope of the ETS will be supported.

The voluntary carbon market in Türkiye has been actively operating since the early 2000s through projects provided by private actors. With the issuance of the Voluntary Carbon Market Project Registration Communiqué in 2013, the procedures and principles for registering projects developed in Türkiye for greenhouse gas emission reduction and obtaining carbon certificates were established. In the upcoming periods, it is aimed to establish a national carbon crediting system due to the importance of reduction outputs occurring within the country for the Nationally Determined Contribution and the 2053 net zero target, as outlined in Article 6 of the Paris Agreement. At this point, finally, the issue of utilizing international carbon markets to

cost-effectively achieve Türkiye's long-term reduction targets will be evaluated, and necessary steps will be taken as deemed appropriate.

Türkiye's participation in Article 6 of the Paris Agreement will be evaluated, taking into account the potential to transfer low-carbon technologies such as renewable energy and electric vehicles to relevant countries through established collaborations, as well as the transfer of high technologies and products not available in our country. If a decision to join is made, it is aimed to carry out the necessary strategic studies.

4.4.2. Taxonomy and Climate Finance Strategy

Strategy 1. Preparation of the National Green Taxonomy

One of the most important tools in meeting the need for large-scale investments in mitigation and adaptation is climate finance.

Türkiye has adopted the goal of developing and implementing a national green taxonomy, which will play an important role in directing projects that support the efforts against climate change. Taxonomies establish clear principles and criteria for investment areas and activities related to issues such as climate change mitigation, climate change adaptation, efficient resource use, and pollution prevention, thereby providing guidance for activities. Taxonomies also serve as a framework that categorizes economic activities and investments based on their contributions to environmental goals.

Turkish Green Taxonomy is planned to include six environmental objectives. These can be listed as the mitigation of greenhouse gas emissions, adaptation to climate change, sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention and control, and protection and restoration of biodiversity and ecosystems. An economic activity that is compliant with the taxonomy must contribute to at least one of these objectives and not cause significant harm to the other objectives. The conditions for contributing and not causing significant harm will be determined by the technical screening criteria within the legislation.

Strategy 2. Preparation of the Climate Finance Strategy

A Climate Finance Strategy will be prepared to provide clear and predictable guidance on climate policies, transform these into investment goals, provide clear signals to potential investors, and create a enabling environment for increasing sustainable climate investments and supporting existing plans and strategies.

To achieve the necessary goals, priority areas and concrete actions will be identified, special measures will be defined with corresponding timelines (short-term, long-term), and responsibilities in Türkiye's public (national and local) and private sectors will be determined to facilitate access to climate finance and increase flows.

To achieve the 2053 net zero emissions target, investment needs of the sectors will be analyzed in detail, and a study will be conducted to establish the required financial instruments, time scales, and sources of finance.

Thus, climate finance will be directed towards necessary investments to reduce greenhouse gas emissions and adapt to the impacts of climate change, the participation of the private sector in climate-friendly investments will be encouraged, risks to economic stability and development will be reduced, and a sustainable development path will be followed.

4.5. Technology Development

Climate technologies are critical tools for achieving the 1.5°C target specified in the Paris Agreement and ensuring the effective implementation of NDCs and LTSs. These technologies stand out as significant and comprehensive intervention tools in both mitigation and adaptation strategies in the fight against climate change, due to their great capacity to transform economies, societies, and cultures worldwide. In this context, Türkiye places great importance on the development and dissemination of technology to achieve its climate goals.

In 2022, the Science and Technology Commission of the Climate Council established long-term, technology-based policies aimed at gaining momentum in groundbreaking technologies that will create opportunities in the fight against and adaptation to climate change. However, R&D and innovation studies specifically targeted for each policy have been prepared. These long-term technology policies have been grouped into 5 themes:

- **Climate Change, Environment, and Biodiversity:** Climate models and risk management strategies aim to enhance the resilience of ecosystems and infrastructure by integrating digital technologies.
- **Clean and Circular Economy:** Bioenergy and waste management technologies are at the forefront. Integrated biorefineries and processes based on circular economy principles are being developed, and recycling and zero waste technologies are being promoted. Additionally, sensor technologies and CCUS systems are coming to the forefront.
- **Clean, Accessible, and Safe Energy Supply:** Renewable energy, hydrogen technologies, and energy storage systems are being developed, with the aim of widespread adoption of wind and solar energy systems.
- **Green and Sustainable Agriculture:** Smart farming technologies and environmentally friendly agricultural machinery are being developed; innovations aimed at converting agricultural waste into biofertilizers and bioactive substances are being encouraged.
- **Sustainable Smart Transportation:** Autonomous and eco-friendly transportation systems, green hydrogen-fueled engines, and next-generation transportation technologies are being developed, and efforts are underway for smart energy management and data-based charging systems.

In line with our country's green growth goals, a "Green Growth Technology Roadmap" has been prepared for critical carbon emission sectors such as iron-steel, aluminum, cement, chemicals, plastics, and fertilizers to determine the technological needs of the industrial sectors. Technologies needed by these sectors for combating and adapting to climate change, which will be directed by R&D-innovation support, are listed below:

- **Energy Efficiency and Renewable Energy:** In energy-intensive sectors such as aluminum, cement, and iron-steel, new furnace, electrolysis, and recycling technologies are being developed, with a focus on carbon capture and energy savings.
- **Waste Management and Recycling:** Sensor-based sorting technologies and new chemical recycling processes aim to recover valuable elements.
- **Process Optimization and Advanced Materials:** Production processes are optimized using process simulations and data analytics, and innovative casting technologies and green chemicals are being developed.
- **Carbon Capture, Utilization, and Storage (CCUS):** In sectors with high carbon emissions, innovations that reduce carbon release are being integrated with CCUS technologies.

- **Biotechnology and Biochemistry:** Biomass-based production processes are being developed in the chemical industry, and environmentally friendly bio-based products are being produced from renewable sources.

Türkiye is making significant strides in the field of electric vehicle technologies, contributing to global climate goals. Türkiye's Automobile Initiative Group (TOGG) is a pioneering initiative in this field as Türkiye's first domestic and electric passenger vehicle. Türkiye also has commercialized products in electric tractor, electric bus, and hydrogen bus technologies.

As an alternative to existing commercial CO_2 capture processes and methods, studies have been initiated to develop a process and methods that are cost-effective, more advantageous in terms of installation and operation, innovative, and open to technological development. Energy storage, development of photovoltaic (PV) panels and their use on different surfaces, and R&D projects on hydrogen technologies and applications are being carried out. Hydrogen technologies play an important role in Türkiye's energy transition. The projects on hydrogen and fuel cell technologies have taken significant steps towards the use of hydrogen in vehicles. For example, range-extending projects developed with boron-based fuel cells support the use of electric vehicles. Additionally, projects aimed at the storage and transportation of hydrogen produced from renewable energy sources hold a critical place in green hydrogen production. In line with Türkiye's hydrogen goals, it is planned to achieve an electrolysis capacity of 5 GW by 2035 and 70 GW by 2053 with the South Marmara Hydrogen Valley Project, which will be implemented in Western Türkiye; and to reduce hydrogen production costs to $2.4 per kilogram by 2035 and $1.2 per kilogram by 2053.

Projects like the South Marmara Hydrogen Shore Project, covering the years 2023-2026, aim to increase the use of hydrogen technologies in industry and their application in emergency power generation systems. On the other hand, work on Small Modular Reactors (SMR) has been ongoing since 2016.

Studies are also being conducted on sensor and system technologies aimed at more efficient use of renewable energy sources such as solar energy and R&D studies on the development and use of photovoltaic panels. Additionally, the development and widespread adoption of carbon capture technologies have been targeted. Research on hybrid solutions in carbon capture and storage systems offers innovative methods aimed at reducing the costs of existing systems.

In line with greenhouse gas emission reduction targets, Türkiye is conducting research on artificial intelligence-supported air quality monitoring systems. These systems aim to closely monitor the effects of climate change by specifically tracking air pollution levels in urban areas. NO2, O3, and PM2.Projects aimed at detecting harmful substances such as NO2, O3, and PM2.5 strengthen Türkiye's technological infrastructure in its fight against climate change.

4.5.1. Strategies for the Technology Development within the Scope of the 2053 Net Zero Emission Target

The following strategies have been determined to develop Türkiye's technological capabilities and scientific research infrastructure to contribute to the fight against climate change. For the technology areas specified below, basic/applied research, technology development, and innovation projects focused on technology and innovation, aimed at developing practical solutions and systems, will be supported.

Strategy 1. Development of domestic technologies and critical products for the decarbonization of the energy sector, and enhancement of the performance of existing technologies and products

Domestic and national technologies will be developed to support the momentum in the use of renewable energy sources. In this context, the development of photovoltaic panels and their use on different surfaces, concentrated solar power systems, and thermal energy storage technologies will be prioritized. The development and integration of offshore wind turbines will be supported. Hydrogen technologies will be developed and integrated into energy systems, and system subcomponents will be developed for the localization of electrolyzer technology. In energy storage and battery technologies, solid-state batteries, Li-Metal, Li-Sulfur, Li-Air, sodium-ion, and magnesium-sulfur batteries will be developed and their efficiency will be increased. Innovative solutions and high-efficiency battery management systems that will increase energy efficiency in the industry will be developed.

Strategy 2. Development of Carbon Capture, Utilization, and Storage Technologies

The effectiveness of carbon capture technologies will be increased, alternative carbon capture technologies (BECCS, DACCS) will be developed, cost-effective solutions for the use of carbon and its conversion into useful products will be developed, and safe and sustainable carbon storage solutions will be developed. On the carbon storage side, the establishment of appropriate infrastructure will be supported; the widespread implementation of clustering practices where organizations that cause carbon emissions can collaborate with organizations that can use carbon as a raw material in their processes will be encouraged.

Strategy 3. Development of smart city applications

The development of smart city infrastructures will be ensured, innovative applications aimed at supporting the development of electric vehicle technologies and charging infrastructure for sustainable and smart transportation solutions will be supported, and smart traffic management systems will be improved. Within the scope of sustainable and smart transportation solutions, innovative technologies such as connected, cooperative, and fully autonomous mobility systems, Hyperloop, and maglev will be developed.

Strategy 4. Development of smart agriculture and food Technologies

Digital transformation in agriculture and big data-based decision support systems will be developed. Unmanned agricultural vehicles (UAVs), autonomous agricultural robots, and the use of advanced technology eco-friendly agricultural machinery will be promoted. Databases will be created to determine the chemical composition of food industry waste, and sustainable food production methods will be developed. Technologies will be developed to convert agricultural and food sector waste into biofertilizers, proteins, dietary fibers, and bioactive substances, and innovative solutions that will increase water and energy efficiency in agricultural production and reduce the use of chemical fertilizers will be supported.

Strategy 5. Development of integrated ecosystem-focused Technologies

Under the blue economy platforms, multi-use offshore systems and underwater and above-water biomass farms will be developed. Technologies for harvesting micro and macro algae, as well as technologies for preventing water pollution, will be supported. Solutions will be developed to enhance the resilience of marine, transitional waters, freshwater, and terrestrial ecosystems against climate change in an integrated manner. Advanced systems will be used for monitoring and managing greenhouse gas emissions, and global and regional climate modeling and scenario approaches with advanced features in terms of resolution and complexity levels will be developed.

Strategy 6. Development of technology and innovation-focused solutions to prevent and minimize the risks, damages, and losses that may arise from disaster types caused by extreme climate events

Risk maps and decision support systems will be developed to prevent and minimize the risks, damages, and losses that may arise before, during, and after disasters. Early warning systems will be established for monitoring extreme climate events, and the resilience of human life, ecosystems, natural resources, and critical infrastructure against climate change will be enhanced through the integration of digital technology.

Strategy 7. Development of resource efficiency-focused technologies and improvement of waste management

Within the scope of waste management and recycling technologies, smart waste collection systems, fill-level detection sensors, near-infrared optical sorters, and robotic technologies will be developed for waste sorting systems. Innovative solutions will be created for process optimization in the industry, circular economy practices will be supported in all sectors, and industrial and household waste management technologies will be developed. Online data entry and monitoring systems will be developed in every area of waste management. Technologies for upgrading biogas and producing biomethane from biodegradable waste will be supported, and technologies for biodegradable and compostable plastics will be developed. Technologies for generating energy from waste, such as producing green hydrogen from plastic waste, will be worked on. Wastewater treatment and recovery technologies will be developed, and process optimization will be achieved with advanced sensor technologies and artificial intelligence applications. Wastewater treatment plants operating on the biorefinery principle will be designed, and technological solutions aimed at reducing greenhouse gas emissions in the waste sector will be developed. Advanced sensor technologies, artificial intelligence, and remote sensing applications will be developed for the optimization of waste and wastewater management processes and energy efficiency, and efforts will be made to promote their widespread use.

4.6. Just Transition

It is expected that the measures to be taken in the fight against climate change will have significant impacts on society, especially on employees and groups requiring special policies. However, it is anticipated that the green transition process will also bring various opportunities in terms of social welfare. Therefore, it is important to develop just transition policies to manage the efforts aimed at minimizing the negative impacts of the process and maximizing its opportunities with an approach that leaves no one behind.

In efforts towards a just transition, it is planned to prioritize increasing the resilience of groups highly vulnerable to climate change, such as women, youth, the elderly, people with disabilities, workers at high risk of job loss, and SMEs, while promoting inclusive employment and social cohesion. With this approach, a just transition is addressed across a wide range of policy areas, from national development plans to thematic and sectoral strategy documents.

In this context, it is essential that the risks and opportunities arising from the economic transition required by climate change are managed together and shared justly by broad segments of society, with the understanding that no one is left behind by creating decent and green job opportunities.

Strategy 1. Developing data/information capacity to enable the development of evidence-based and holistic just transition policies

It is important to manage the reflections of efforts to promote climate-sensitive clean production practices in carbon-intensive and resource-intensive sectors on skill needs and labor demand, in order to avoid significant job losses and related social issues during this process. The condition for the just transition policies aimed at the effective management of the process to be

results-oriented is that these policies are developed based on evidence and in a mutually supportive manner. With this approach, efforts will be made to strengthen the data/information capacity of all relevant parties, especially policymakers and practitioners, regarding the direction of the transition, its scope, the anticipated skills gap, the risks and opportunities of the process, and its multifaceted social impacts.

Strategy 2. Determining just transition policies at the national, regional, and sectoral levels and ensuring their effective governance

Evidence-based just transition policies will be developed, focusing on risk and opportunity management in areas such as education, employment, social protection, occupational health and safety, social inclusion, and migration within the context of climate change and green transition. A national just transition strategy will be prepared and implemented through effective mechanisms. In this context, the skills ecosystem will be strengthened by taking into account the requirements of green and digital transformation, and efforts will be made to enhance the institutional capacities of ecosystem stakeholders operating at all levels, support collaborations, and improve inter-institutional coordination. Considering practical experiences, governance and financing models for a just transition will be developed in our country. Measures will be taken to enhance social dialogue and ensure participation in order to strengthen the peace of work and social welfare throughout the process.

Strategy 3. Implementing measures to identify early-stage changes in skill demand during the green transition process and to adapt educational programs and skill development and acquisition programs to new needs

During the green transition, labor markets will be regularly analyzed in terms of supply and demand, and efforts will be made to reduce skill mismatches in the labor market. Vocational education, higher education, lifelong learning, and active labor market programs will be organized in accordance with the skill needs of the sectors undergoing green transtion. Efforts will be made to increase flexibility and adaptability at all levels of the education system to sustainably provide a workforce with green skills.

Strategy 4. Ensuring the adaptation of labor markets to the green and digital transformation by strengthening gender equality and inclusivity in labor markets under the most just conditions for everyone

Efforts will be made to equip the workforce with the skills required by climate change mitigation and adaptation measures through vocational training, skill acquisition, and skill development programs. To manage the impacts of mitigation and adaptation policies that could lead to the exclusion of vulnerable groups requiring special policies, such as women, youth, and people with disabilities, from the labor market, and to enhance the inclusivity of employment in our country and ensure the transition to a green economy occurs under the most equitable conditions for everyone, efforts to ensure skill alignment will be carried out in accordance with inclusivity principles.

Strategy 5. Creation of green job sectors and increasing green employment

The development of green jobs that provide decent full social protection and also have a greenhouse gas emission reduction effect will be supported. Measures will be taken to strengthen SMEs involved in the green economy value chains by popularizing practices that support social entrepreneurship in green jobs.

Especially, employment-supportive policies will be implemented, such as planning the necessary vocational training and capacity development programs for workers in the energy

sector to adapt to the job opportunities arising from green energy technologies within the framework of the 2053 net zero target.

4.7. Capacity Development

4.7.1. Climate Envoy

The Climate Envoy Project is being implemented to strengthen efforts to combat climate change through national green transformation and to enhance the effectiveness of our younger generations in the development and implementation of climate policies. Currently, as of 2024, there are 175 climate ambassadors from 208 universities. The vision of the Climate Envoy movement is to involve young people in decision-making processes alongside Climate Envoy youth in the fight against Climate Change and to raise public awareness. The primary mission of the Climate Envoy is for the universities they represent to have green and climate-friendly campuses and to take the lead in this.

The Climate Envoy first held the Youth Session at the Climate Council in Konya in 2022, where the Youth Declaration prepared by approximately 200 young people was presented. During the two-year period, Climate Envoy received Policy Dialogue Training, organized the Climate Envoy Youth Camp and the Local Conference of Youth (LCOY), completed the institutionalization process of Climate Envoy, and participated in COP27 and COP28 with the selected Climate Envoy Türkiye Delegation. Additionally, the Climate Envoy have contributed to the preparation of Türkiye's 8th National Communication within the framework of the UNFCCC reporting processes.

With the Climate Envoy initiative, the aim is to strengthen youth participation in climate change mitigation and adaptation efforts in Türkiye in line with the country's 2053 net zero emissions and green development goals.

4.7.2. Education and Capacity Development

Strategy 1. Increasing Climate Change Awareness

Education and capacity building in the fight against climate change hold a central position in Türkiye's long-term strategy. In this context, various programs are being designed to raise social awareness, enhance technical knowledge and skills, and ensure cooperation between the public and private sectors. Training programs aim to actively involve both institutions and individuals in the processes of climate change adaptation and mitigation. At the same time, it is aimed to produce stronger and more effective solutions in combating climate change by enhancing the competencies of technical personnel through capacity-building efforts.

In addition to raising social awareness, the development of technical and scientific capacity will enable Türkiye to achieve its climate goals at both national and international levels. The efforts in the field of education and capacity building will ensure the permanence of the steps taken towards sustainable development and guarantee the participation of new generations in this process. Education and awareness programs tailored to specific sectors will contribute to the development of more effective and sustainable solutions at both national and local levels. The content of the training programs will be expanded to include innovative and science-based approaches. These programs will cater to a wide range of audiences, from individuals to institutions, and will create educational modules aimed at professionals in various sectors, local governments, and academic circles. In this process, Türkiye's capacity to combat climate change will be developed, and broader participation in climate-friendly practices will be ensured.

Ensuring the effective participation of women in the planning, budgeting, and implementation of climate policies in a gender-sensitive manner has been identified as a critical priority. Additionally, raising awareness in society about the risks that women, girls and girls may face due to climate change and promoting awareness-raising activities will be a fundamental tool in enhancing social resilience.

Türkiye addresses capacity-building efforts for climate change with a multifaceted approach. In addition to short- and medium-term sectoral awareness and training efforts, the development of technical infrastructure is also a priority. For example, in the field of NDCs, the aim is to train technical personnel for greenhouse gas emission calculations and reporting, and to enhance scientific, human, and technical capacity against forest losses. Additionally, efforts will be focused on the dissemination of climate-friendly practices in the agricultural sector, training on good agricultural practices and organic farming activities, and training for local administrations on climate actions. In the industrial sector, it is anticipated that the capacities of businesses, especially SMEs, will be strengthened in terms of GHG reduction and climate change adaptation processes. In this context, by focusing on issues such as energy use and carbon management, new skills needed in the green transformation process will be provided. Especially for the sectors that will be included in the ETS, a comprehensive capacity development and training program will be planned simultaneously with legislation and administrative regulations, ensuring that the capacity for adaptation is strengthened throughout the value chain. Additionally, aligning educational curricula with climate change and sustainable development goals will ensure that the future workforce is equipped with knowledge and skills in these areas. Based on the critical importance of renewable energy and energy efficiency in combating climate change, emphasis will be placed on education and training programs to raise awareness across all segments of society. With the development of social dialogue during the just transition process, the participation of women and groups requiring special policies is encouraged, and vocational training programs are provided to ensure these groups benefit effectively.

4.8. Key Targets Summary of Long-Term Climate Strategy

Sector			Target
MITIGATION	Energy	2030	Primary energy consumption will be reduced by 16%, preventing 100 million tons of CO_2 emissions
			Nuclear energy installed capacity will be increased to 4.8 GW
			Electrolyzer capacity will be increased to 2 GW
			Battery capacity will be increased to 2.1 GW
		2035	Energy intensity will be reduced by 35%
			Installed capacity of solar and wind energy will be increased fourfold
			Nuclear energy installed capacity will be increased to 7.2 GW
			Electrolyzer capacity will be increase
		2053	The share of renewable energy in primary energy will be increased from 17% to 50%
			Electrolyzer capacity will be increased to 70 GW
	Industry	2040	20% emission reduction in the iron and steel sector
			30% emission reduction in the cement sector
			53% emission reduction in the aluminum sector
		2045	80% reduction in HFC consumption will be achieved
		2053	93% emission reduction in the cement sector
			99% emission reduction in the iron and steel sector
			75% emission reduction in the aluminum sector
			100% emission reduction in the fertilizer sector
	Buildings	2025	New buildings with a usable area of 2000 m² and above will be required to meet Nearly Zero Energy Building (nZEB) standards
		2030	30% energy savings will be achieved in public buildings
		2033	All new buildings will be required to have an Energy Performance Certificate (EPC) Class A rating
		2043	All new buildings will be constructed as Net Zero Operational Carbon Buildings
		2053	Emissions in the buildings sector will be reduced to near zero
			2 billion tons of CO_2-equivalent emissions will be prevented over 30 years
	Transportation	2035	The number of electric vehicles will be increased to 4.2 million

Sector			Target
			347,000 charging stations will be established
			A 75% localization rate for electric vehicles will be achieved
		2053	Electrification of railways will be completed
			7,000 km of High-Speed Train (HST) and Fast Train (FT) lines will be constructed
			The share of railways in logistics will increase from 5% to 22%
	Waste	2030	The reuse rate of treated wastewater will be increased to 15%
			The population coverage for wastewater treatment services will be increased to 100%
		2035	Waste intake at uncontrolled dumping sites will be terminated
		2053	The recovery rate of municipal waste will be increased to 70%
			Sending waste to landfills without segregation will be eliminated
			The reuse rate of treated wastewater will be increased to 20%
	Agriculture	2030	Planned animal production will be completed according to recommended reports on animal types, breeds, and systems suitable for each geographical region
		2053	Consolidation of all fragmented lands will be completed
			At least 10% of agricultural land will be used for organic farming
			Irrigation efficiency rate will be increased to 65%
			Emissions from livestock will be reduced by optimizing feed rations and feed variety
			Biogas facilities will be expanded
	LULUCF	2030	Project funding for strengthening R&D and innovation in the sector will be doubled compared to 2020 levels
		2053	Ecosystems will be protected through proactive restoration and conservation
			The proportion of woody green areas in settlements will be increased
			Mechanisms similar to and compatible with the EU Carbon Removal Certification regulations will be developed
			Circular economy components will be implemented in forests, reducing the raw wood material demand of the forest products industry
ADA	General Targets		A climate projection for Türkiye with a 3 km resolution will be developed up to the year 2100

Sector		Target
		Vulnerability analyses will be conducted in each sector
		Protection of critical infrastructure from climate hazards and enhancement of resilience will be ensured in each sector
	Water Resources Management	A Water Law and a Flood Law will be enacted
		River Basin Management Plans, Drinking Water Safety Plans, and Sectoral Water Allocation Plans will be prepared
		A Smart Water Management System will be implemented
		The rate of water loss in cities will be reduced to 25% by 2033
		Per capita daily water consumption will be reduced to 120 liters by 2030 and to 100 liters by 2050
		Agricultural irrigation efficiency will be increased to 60% by 2030 and to 65% by 2050
		Up to 50% water efficiency in industry by 2030
		Up to 40% water efficiency will be achieved in the tourism sector by 2030
	Transportation	The resilience of critical infrastructure will be enhanced
		Transportation and passenger health will be safeguarded by reducing vulnerability levels
		Accessibility and evacuation capabilities during disasters and emergencies will be improved, and response capacity will be increased
	Biodiversity and Ecosystem Services	Basin-Based Action Plans for Combating Desertification will be developed
		Within the framework of sustainable forest management, the optimal wood raw material production level will be determined in line with the transition to a circular bio-economy
	Energy	Climate change adaptation will be integrated into electrical energy systems
		The infrastructure of existing fossil fuel-based facilities will be reviewed
	Manufacturing Industry	The shift towards manufacturing higher technology and climate-friendly products will reduce vulnerability while increasing adaptation capacity
		Planning efforts will be undertaken to protect production facilities from disasters, prioritizing strategic, large-scale facilities and those at risk of major industrial accidents
		Voluntary initiatives in the manufacturing industry, along with efforts led by sector

Sector		Target
		representative organizations and professional associations, will strengthen adaptation capacity.
		A risk analysis tool will be developed to assess physical climate risks
	Urban	Risk maps for urban areas will be created using spatial data
		Flood calculations and maps will be created based on precipitation scenarios to analyze flood-prone areas, and appropriate transformation models will be determined
		Standards for locally appropriate materials that enhance the resilience of building roofs and facades against extreme weather events and prevent urban heat increase will be established and promoted
		Drainage systems will be restructured, combined sewer systems (stormwater and wastewater) will be separated, and the use of permeable surface materials and green corridors will be promoted
		Spatial planning processes will be reconsidered within the scope of climate change adaptation, and drought-resistant and aesthetically pleasing urban areas will be created
		Evacuation escape corridors will be established, enclosed stream channels will be opened, and buffer zones will be created around stream beds
	Tourism and Cultural Heritage	The Sustainable Tourism Program will be expanded in scope and to new regions
		Impact assessments and risk analyses will be conducted in cultural heritage sites, and protective measures will be implemented
		Spatial planning studies will be carried out based on the results of vulnerability and risk analyses
		Policies and strategies aimed at enhancing resilience to climate change will be established and implemented
	Agriculture	The preservation of the quality of agricultural lands and pastures will be ensured
		Efforts will be intensified on traditional and natural methods that are environmentally friendly and enhance climate change adaptation capacity
		The number of farmers engaged in organic farming and good agricultural practices across Türkiye will be increased
		No-till farming, conservation and regenerative agricultural practices, rainwater harvesting, permaculture, and the use of living windbreaks will be promoted

Sector		Target
		The implementation and promotion of an ecosystem-based food production model using nature-based solutions will be ensured
		Mitigation and adaptation systems will be developed and implemented to reduce the impacts of drought, flooding, hail, and inundation on agriculture
		The development of plant species and animal breeds that are relatively less sensitive to climate, as well as the preservation, support, and promotion of local breeds with high adaptation capacity, will be ensured
		An insurance system will be developed to reduce losses and damages related to critical infrastructure (such as irrigation, cold chain, modern storage, transportation infrastructure, etc.).
	Health	All adaptation policies will be included in the Health Impact Assessment (HIA) process to reduce the health effects of climate change
		Climate change-adapted health monitoring and surveillance systems will be established
		Early warning and rapid response mechanisms, along with intervention plans for climate-sensitive diseases, will be developed
		Preparations will be made against the expected increase in climate-related mortality events between 2030 and 2050, according to the World Health Organization
	Disaster Risk Reduction	Resilient infrastructure systems will be created through investments aimed at reducing disaster risk to ensure resilience against disasters
		Early warning and forecasting systems will be developed using innovative technologies, ensuring that these systems comply with international standards
	Social Development	Policies sensitive to family needs will be developed to enhance the resilience of families in the face of climate change and natural disasters
		Social protection systems and climate change strategies will be aligned at national and local levels
		Public awareness on climate change adaptation will be increased, especially among vulnerable groups
	Disaster Risk Reduction	Investments will be made to reduce disaster risk and build resilient infrastructure systems to enhance resilience against disasters

Sector		Target
		Early warning and forecasting systems will be developed using innovative technologies, ensuring their alignment with international standards
CROSS-CUTTING	Technology Development	Within the scope of green transformation, technologies related to hydrogen, carbon capture, utilization and storage, smart cities, smart agriculture, and food technologies will be developed alongside integrated ecosystem-focused technologies
	Just Transition	Just transition policies will be implemented at national, regional, and sectoral levels
	Climate Finance	The Emissions Trading System will be implemented starting from 2025
	Capacity Building	Capacity building processes will be conducted for each stakeholder, focusing on climate change mitigation and adaptation in every sector.

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