MERSİN

GREENHOUSE GAS EMISSIONS

INVENTORY

2023

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MAYOR’S FOREWORD

Due to the progress of industry and the consumption of fossil fuel, greenhouse gas emissions resulting from human activity are increasing at rates faster than ocean and forest areas can hold. Our country is in a geographical area that will be most affected by climate change, as there will certainly be disasters related to climate change and the efforts to fight it. This issue is one of the most important for us to solve.

Day by day, local governments are developing and implementing strategies for confronting climate change. Mersin is one of the most developed provinces of Türkiye. With its fertile soil and growth of agricultural products, it stands out against the rest of the country. Mersin is also advanced in technology, as it has rich natural and underground resources, as well as port activities and an oil refinery. Due to its international port and adjacent free zone, Mersin provides global trade connections to many provinces, especially in eastern and central Anatolia.

Our increasingly growing city is also one of the most affected by climate change, which will have a negative impact on our agriculture and industry. As people’s welfare increases, so do new lifestyles and new technologies, which can affect not only the environment of our province, but also our country and the rest of the world. Actions conducted by local governments to reduce greenhouse gas emissions and climate change adaptation efforts are vital.

Cities with high population, production, and consumption also have elevated levels of pollutants which trigger and worsen climate change. The greenhouse gas emission inventory includes all significant greenhouse gas emissions occurring within the geopolitical and operational boundaries of local governments. Therefore, the role of local governments in the fight against climate change increases day by day. The Mersin Metropolitan Municipality has shown our determination in this fight by becoming members of international organizations such as ICLEI (Local Governments for Sustainability) and GCoM (Global Covenant of Mayors for Climate and Energy).

In order to quantify the greenhouse gas emissions occurring within the borders of Mersin, the Mersin Metropolitan Municipality Department of Climate Change and Zero Waste worked with TÜBİTAK Marmara Research Center, Vice Presidency of Climate Change and Sustainability and prepared a "Greenhouse Gas Inventory Report" in accordance with international standards and protocols. Our city has taken a key step in adapting to climate change by conducting joint work with the "Sustainable Energy and Climate Action Plan", which includes reducing greenhouse gas emission and climate change adaptation activities.

For an environmentally friendly world and a better future, we must reduce carbon emissions in the fields of transportation, energy, services, and construction. We must also focus our efforts on activities that are in accordance with environmental standards and actions that reduce the impact of climate change. I hope and wish that this study will contribute to national, regional, and urban climate change policies and aid in meeting our goals for a sustainable future.

Vahap SEÇER

Mayor of Mersin Metropolitan Municipality

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LIST OF ABBREVIATIONS

WWTP	Wastewater Treatment Plant
AFOLU	Agriculture, Forestry and Other Land Use
UNFCCC	United Nations Framework Convention on Climate Change
COP	Conference of the Parties
CORINE	Coordination of Information on the Environment
C40	C40 Cities Climate Leadership Group
MoEUCC	Republic of Türkiye Ministry of Environment, Urbanization and Climate Change
EMRA	Republic of Türkiye Energy Market Regulatory Authority
GCoM	Global Covenant of Mayors for Climate and Energy
GPC	Global Protocol for Community - Scale Greenhouse Gas Emission Inventories
GDP	Gross Domestic Product
ICLEI	Local Governments for Sustainability
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
KGM	Republic of Türkiye General Directorate of Highways
NDC	Nationally Determined Contribution
OECD	Organization for Economic Co-operation and Development
GHG	Greenhouse Gas
TÜBİTAK MAM	Scientific and Technological Research Council of Türkiye - Marmara Research Center
TURKSTAT	Turkish Statistical Institute
TSMS	Turkish State Meteorological Service
WRI	World Resources Institute

1. INTRODUCTION

Climate change, which is considered one of the most important problems facing our planet in the 21st century, is triggered by the accumulation of greenhouse gases in the atmosphere caused in part by various human activities such as the use of fossil fuels and land use changes. As a result of the researches carried out by the scientific community, it is foreseen that if the global warming process continues at the current rate, many severe disasters such as extreme weather events, floods, widespread and severe drought events and forest fires will arise in the climate zone including our country.

Furthermore, it is known that approximately 60% of greenhouse gas emissions worldwide are generated within cities mainly due to energy consumption. Therefore, it is predicted that efforts conducted at the city level will contribute significantly to combating global climate change, leading to an intensified focus on such endeavors. Cities, due to the activities taking place within their boundaries, make substantial contributions to the process of climate change. Conversely, the events expected to occur as a result of climate change threaten the existence of the systems that make up cities. At the urban scale, especially in areas such as infrastructure, public health, and water resource management, higher vulnerabilities to the impacts of climate change are expected. For these reasons, it is acknowledged that local climate change action plans should contain objectives aimed at both rapidly and fairly reducing the city's contributions (i.e. greenhouse gas emissions) to climate change and enhancing the city's capacity to adapt to climate change.

Many municipalities in our country are currently preparing climate change action plans and in this context, they are also members of various international voluntary initiatives. Mersin Metropolitan Municipality became a member of the Global Covenant of Mayors for Climate and Energy (GCoM) in 2021, one of the most important of these initiatives. GCoM has been signed by 50 municipalities from our country, 15 of which are metropolitan municipalities. This initiative, which was first launched in 2008 within the European Commission, aims to support local governments in achieving climate and energy targets and to bring together many cities and regions that want to implement the targets set within the framework of the Covenant. Municipalities that are parties to the GCoM are obliged to prepare action plans containing the measures they plan to implement in terms of greenhouse gas emission reduction and adaptation to climate change. Therefore, the role of local governments in combating climate change is increasing day by day.

1.1. Purpose

Within the scope of the project, it was aimed to prepare emission inventories of the main sources of greenhouse gas emissions within the provincial borders of the Mersin Metropolitan Municipality, to establish the baseline scenario for the greenhouse gas emissions, to calculate the greenhouse gas emission reduction levels for the set-targets, to conduct a general assessment in three areas that will be most affected by climate change impacts, to identify adaptation measures, and to prepare the climate change action plan based on thorough evaluations. The project also includes reporting all the conducted studies and presenting them as the "Mersin Sustainable Energy and Climate Action Plan".

1.2. Scope

Within the scope of the study:

- Information on factors affecting greenhouse gas emissions and climate change in Mersin was collected.
- Stakeholders who will contribute to the preparation of the Action Plan were determined, and evaluation meetings were organized.
- An emission inventory has been created for the Mersin province using emission factors accepted in national/international standards, and a "Greenhouse Gas Emission Inventory Report" has been prepared.
- In addition to the baseline scenario, GHG emission mitigation scenarios were designed in line with the opinions and suggestions of relevant stakeholders, taking into account the existing plans and policies of Mersin province, and GHG emission mitigation amounts were calculated on the basis of 2 (two) scenarios.
- A general assessment was made within the scope of adaptation to climate change and adaptation measures were identified in priority sectors for Mersin.
- Incorporating all the obtained outputs, the "Mersin Sustainable Energy and Climate Action Plan" was prepared.

Greenhouse gas emissions include carbon dioxide (CO_2); methane (CH_4) and nitrous oxide (N_2O) emissions. Hydrofluorocarbons (HFCs); F-gases such as perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), etc. could not be included in the system due to lack of data. The institutions and organizations included in the preparation of the action plan are given in Table 1.1. It is envisaged that the stakeholders will contribute towards both in providing data specific to Mersin and determining the actions regarding with reduction of GHG emissions and improving adaptive capacity to climate change. Approximately 40 people representing the project stakeholders participated in the opening meeting held on September 6, 2022, and the project team presented the scope of the project including detailed information about the data needs and sources, the expectations from the stakeholders and the steps to be followed.

Table 1.1: Institutions and organizations involved in the project

Public institutions and organizations	Representatives of the private sector, Universities, NGOs
Mersin Metropolitan Municipality	Mersin Chamber of Commerce and Industry (MTSO)
- Directorate of Climate Change and Zero Waste	Mersin-Tarsus Agricultural Product Processing Specialization Organized Industrial Zone (TÜİOSB)
- Directorate of Environmental Protection and Control	Mersin Tarsus Organized Industrial Zone
- Directorate of Studies and Projects	Mersin Chamber of Agricultural Engineers
- Directorate of Technical Works	Mediterranean Chamber of Agriculture
- Directorate of Housing and Urbanization	Mut Chamber of Agriculture
- Directorate of Parks and Gardens	Chamber of Environmental Engineers
- Directorate of Transportation	Chamber of Civil Engineers
- Directorate of Agricultural Services	Chamber of Urban Planners
Mersin Water and Sewerage Administration (MESKİ)	Chamber of Forest Engineers
Akdeniz Municipality	Chamber of Electrical Engineers
Anamur Municipality	Mersin Chamber of Maritime Commerce
Bozyazi Municipality	Chamber of Landscape Architects
Mersin Yenişehir Municipality	Aksa Natural Gas Çukurova General Directorate
Mezitli Municipality	Kalde Energy Electricity Generation Co. Inc.
Mut Municipality	ŞİŞECAM - Soda, Glass Packaging and Flat Glass Production Facilities
Silifke Municipality	Eren Holding - Medcem Cement
Tarsus Municipality	ÇİMSA - Mersin Factory
Toroslar Municipality	İZOCAM - Glass Wool and Foamboard Production Facilities
Erdemli Municipality	Tarsus University
Aydıncık Municipality	Mersin University
Çamlıyayla Municipality	Toros University
Gülnar Municipality	Çağ University
Mersin Governorship	Agriculture and Rural Development Support Agency (TKDK)
Mersin Provincial Directorate of Industry and Technology	Mersin Tourism Operators Association (MERTİD)
Mersin Provincial Directorate of Environment, Urbanization and Climate Change	Entrepreneurial Business Women's Association (GIŞKAD)
Mersin Provincial Directorate of Agriculture and Forestry	Çukurova Development Agency
Mersin Regional Directorate of Forestry	Mersin Investor Business People Association (MERYAD)
Mersin Provincial Directorate of National Education	Toroslar Electricity Distribution Co. Inc.
SSI Mersin Provincial Directorate	Mersin International Port Management (MIP)
Mersin Provincial Directorate of Culture and Tourism	Akdeniz Clean Air Center
Mersin Provincial Directorate of Disaster and Emergency	TEMA Foundation
Meteorology 6. Regional Office	MENKOBIRLİK
Anamur, Mersin and Silifke Meteorological Directorates	Yenişehir Clean Environment Inc.
Directorate of Highways Mersin 5. Regional Office	
6. Regional Directorate of Turkish State Railways	
TURKSTAT Adana Regional Office	
6. Regional Directorate of State Hydraulic Works	

In order to obtain the necessary data for the GHG emission inventory and develop actions for mitigation and adaptation, TÜBİTAK MAM and Mersin Metropolitan Municipality project teams organized series of one-on-one meetings on 26-27 October 2022 with the officials of Mersin Metropolitan Municipality, Directorate of Environmental Protection and Control, Directorate of Climate Change and Zero Waste, Directorate of Reconstruction and Urbanization and Directorate of Transportation and officials of Mersin Regional Directorate of Forestry, Mersin Agriculture and Forestry Directorate, Mersin Environment, Urbanization and Climate Change Directorate, Mersin Industry and Technology Directorate and Mersin Chamber of Commerce and Industry (MTSO).

Finally, 8 sectoral meetings were held between 2-5 May 2023 in order to determine the actions applicable to reduction of GHG emissions and increase the capacity to adapt to climate change. Within 8 online meetings organized for different areas (e.g. buildings and infrastructure, transportation, industry and energy, waste and wastewater management, agriculture and livestock, forestry and water resources, tourism and cultural heritage and coastal areas and fishery), general information about the Mersin GHG emissions inventory and the details of the calculations made for the relevant sectors were shared, and the opinions and suggestions of the participants were obtained. In addition, mitigation and adaptation measures for the relevant areas were discussed and potential strategies were presented to evaluation of participants through online surveys.

Finally, stakeholders came together to clarify the actions that can be implemented in Mersin to reduce greenhouse gas emissions and increase the capacity to adapt to climate change. 8 sector-based roundtable meetings were held physically at the Mersin Metropolitan Municipality meeting hall. Approximately 90 people representing the relevant departments of Mersin Metropolitan Municipality, district municipalities and all other stakeholders participated in the meetings. During the meetings, the current situation assessment, sub-actions, responsible and related institutions/units, implementation period, performance indicators and performance targets of the actions determined for each sector were discussed. Prior to the 4 parallel sessions, short informative speeches were made on behalf of Mersin Metropolitan Municipality and TÜBİTAK MAM teams, and the action tables created on the basis of the relevant sector were explained to the participants with TÜBİTAK MAM representatives as table moderators, and their opinions and suggestions were received. The action tables were updated by taking into account the issues communicated within the framework of the meeting. Afterwards, the tables were finalized by taking the written opinions and suggestions of the stakeholders on the actions.

2. COMBATING CLIMATE CHANGE AND ITS IMPACTS

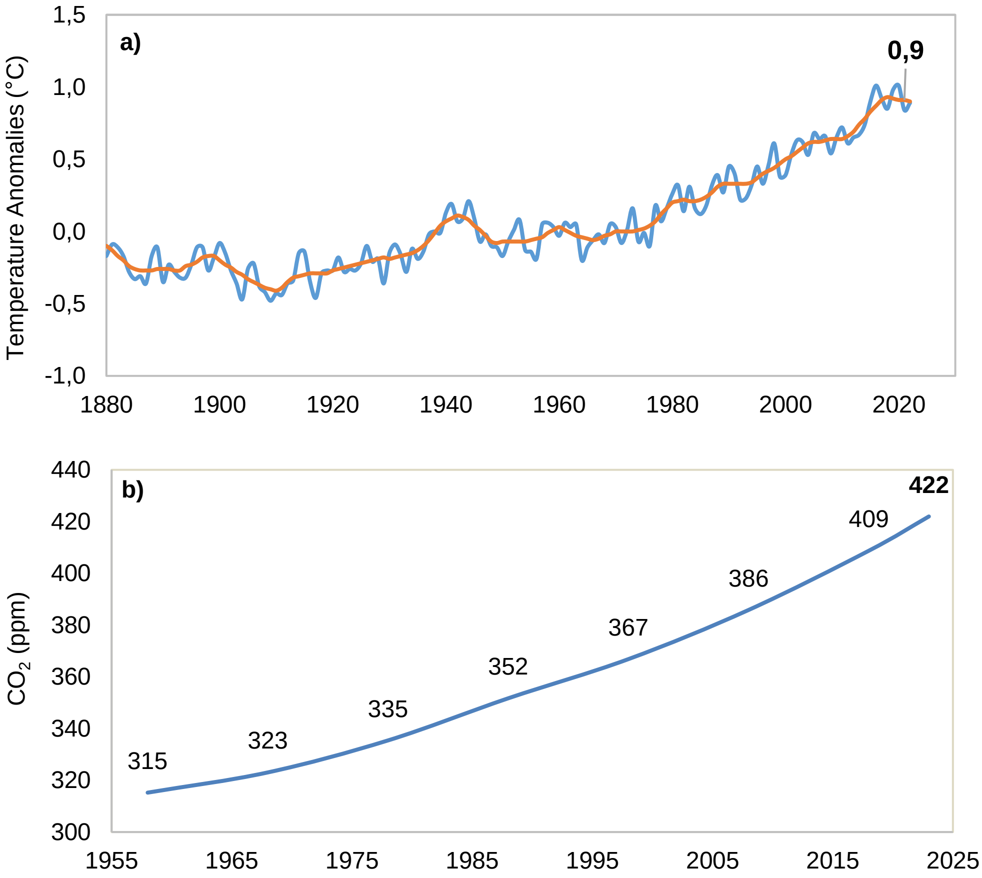
2.1. Climate Change

Climate change is defined as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (UNFCCC, 1992). The increase in extreme weather events and changes in vegetation cover in recent years are among the significant consequences of climate change. The rise in average temperatures, noticeable changes in precipitation regimes and amounts, heatwaves, droughts, excessive rainfall, and increased occurrences of floods, hailstorms, storms, and tornadoes have a substantial impact on various sectors and daily life, particularly in agriculture, health, and energy sectors. Severe weather events categorized as *"Heat Waves", "Extreme Rainfall", "Flood", "Meteorological and Hydrological Drought", "Ecological and Agricultural Drought", "Tropical Cyclones/Winter Storms and Storms", "Hurricane", "Hail", "Lightning", "Extreme Winds"* and *"Fire Weather"* have shown visible changes associated with climate change. These changes are ***identified*** in the high and medium confidence range to be ***linked*** to human activities, as stated in the latest assessment report prepared by the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2021).

According to the IPCC 6th Assessment Report published in 2022, the Mediterranean Basin, which includes our country, is projected to be among the most affected regions by climate change. It is estimated that the agriculture, forestry and water resources, as well as the energy, health, transportation, and tourism sectors, will experience significant impacts due to climate change in our country with its semi-arid climate. Given our country's semi-arid climate, the increase in temperatures will lead to increased evaporation rates, decreased rainfall and soil moisture in a large part of our country, and a rise in severe weather events and associated disasters. This will have a severe impact on the agricultural sector, while the competition for water resources between the agriculture, tourism, textile manufacturing, and drinking/utility water sectors, already under water stress, will further intensify (IPCC, 2021).

The increase in global temperature and atmospheric carbon dioxide concentration, as observed since the pre-industrial era, is primarily attributed to the changes and variability in the absorption, transmission, and reflection-scattering of solar radiation by the atmosphere (including clouds, aerosols, and air molecules) and the Earth's surface (such as water bodies like oceans, seas, and lakes, snow surfaces, ice caps, vegetation, etc.). This increase in temperature is influenced by natural factors such as the Earth's precession and the El Niño phenomenon, as well as anthropogenic (human-induced) factors including rapid population growth, increased consumption patterns, industrialization, energy production, and the use of fossil fuels.

Human activities, particularly the combustion of fossil fuels, have significantly contributed to the rise in global surface temperature (Figure 2.1a) and atmospheric carbon dioxide concentration (Figure 2.1b), and these trends continue to persist.



Source: (NASA, 2023)

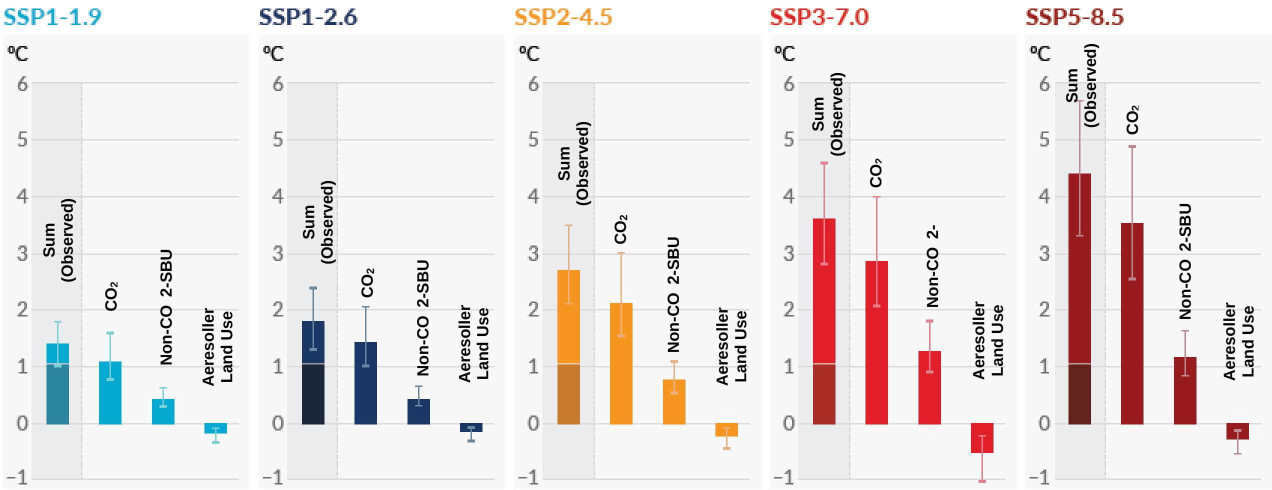
Figure 2.1 a) Change of global surface temperature, b) Change of atmospheric carbon dioxide concentration

Since the pre-industrial era, the global average surface temperature has increased by approximately 1°C. This number is increasing by 0.2 every 10 years, and the current warming trend is advancing at an unprecedented pace.

Today's atmospheric concentration of CO_2 has risen to 50% above the pre-industrial levels. The concentration, measured as 280 ppm in 1850, reached to 422 ppm by mid-2023, and the 350 ppm safety limit has already been exceeded. For this reason, negotiations are being carried out at the international level and various steps are being taken to limit the countries' GHG emissions.

The IPCC 6th Assessment Report emphasizes the need for these efforts to be faster and more effective. It states that the evidence attributing changes observed in extreme events such as heatwaves, heavy rainfall, droughts, and tropical cyclones to human influence has strengthened since the 5th Assessment Report. The link between increased greenhouse gas concentrations resulting from human activities and climate change has been consistently expressed with increasing confidence starting from the 2nd Assessment Report to the latest, the 6th Assessment Report. The IPCC 1st Assessment Report (1990) stated that human activities significantly increased greenhouse gas concentrations in the atmosphere. The 2nd Assessment Report noted the distinction between signals of human-induced climate change and natural variability, highlighting the visible impacts of human activities on the global climate. The 3rd Assessment Report pointed to new and strong evidence indicating that a significant portion of the warming over the past 50 years is due to human activities. The 4th and 5th Assessment Reports strongly emphasized that climate change is most likely caused by human activities.

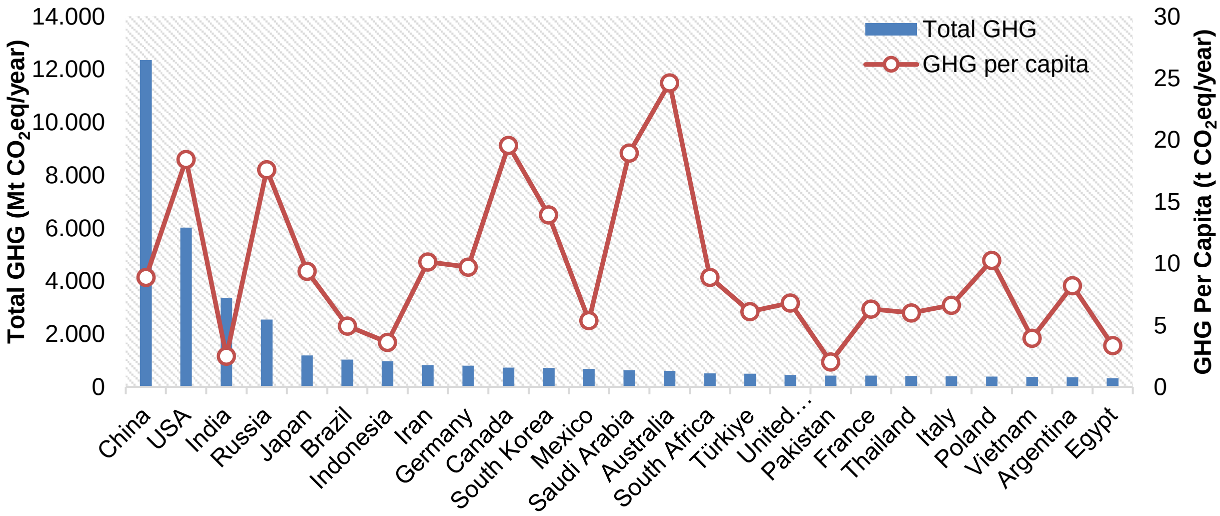
In the 6th Assessment Report, five new emission scenarios covering the future developments of anthropogenic factors related to climate change are considered for the near-term (2021-2040), mid-term (2041-2060), and long-term (2081-2100) periods, relative to the period of 1850-1900. According to the scenario results (Figure 2.2), global surface temperature will continue to increase at least until the middle of the century under all emission scenarios. If there is no reduction in CO_2 and other greenhouse gas emissions in coming years, the targets of 1.5°C and 2°C will be exceeded in the 21st century (IPCC, 2021). Therefore, in order to achieve the targets, countries need to make significant improvements in addition to their current plans and policies.



Source: (IPCC, 2021)

Figure 2.2: Change in global surface temperature in 2081–2100 (ºC)

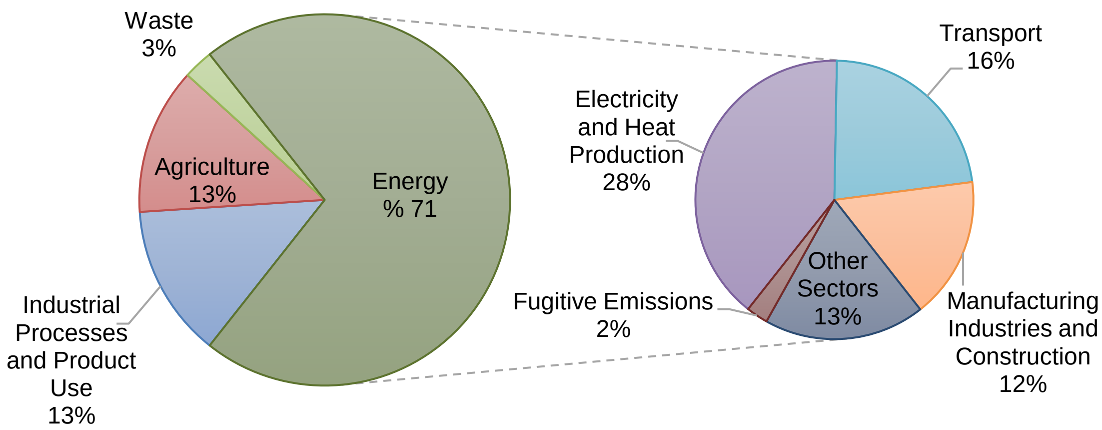
Türkiye ranks 16th among the 25 countries with the highest greenhouse gas emissions in 2019 (Figure 2.3). China is the world's top greenhouse gas emitter with a rate of 26.4%. China is followed by the United States with 12.5% and India with 7.1%. The U.S. reduced its per capita greenhouse gas emissions from 23.4 t/year in 1990 to 18.2 t/year by 2019, while China increased its greenhouse gas emissions from 2.8 t/year to 9 t/year, and China increased its GHG from 1.4 t/year to 2.5 t/year. Türkiye, as a developing country, currently causes 1% of global greenhouse gas emissions and ranks 16th. Its' 3.8 t/year per capita greenhouse gas emissions in 1990 reached 5.9 t/year by 2019.



Source: (CW, 2019; WB, 2019)

Figure 2.3: Greenhouse gas emissions by country

Türkiye's total greenhouse gas emissions in 2021 is 564 Mton CO_2e. With 402 Mton CO_2e, the energy sector accounts for 71% of total emissions. The agricultural sector has a rate of 12.7% with 72 Mton CO_2e, industrial processes and product use have a rate of 13.3% with 66.7 Mton CO_2e and the waste sector has a rate of 3% with 15 Mton CO_2e (Figure 2.4).



Source: (TURKSTAT, 2023)

Figure 2.4: Distribution of GHG by sector

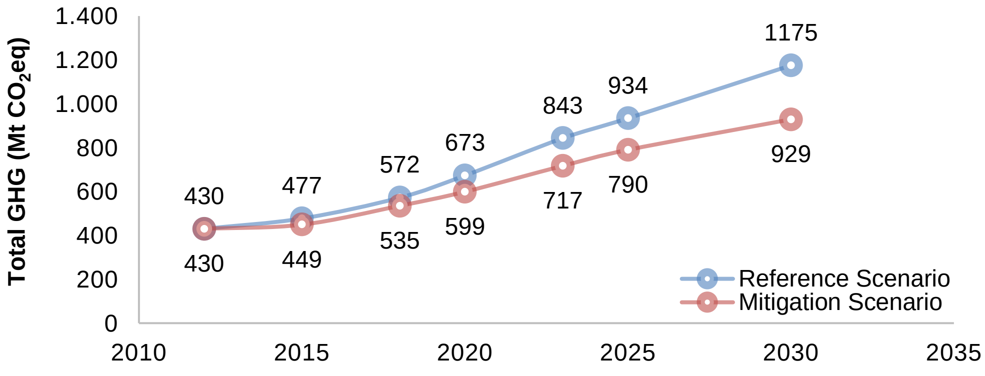
2.2. International Negotiation Processes and Türkiye's Position

The first and most significant step taken at the international level to address the impacts of global warming caused by human activities was the United Nations Framework Convention on Climate Change (UNFCCC), which was opened for signature at the United Nations Conference on Environment and Development (the Rio Earth Summit) in 1992. At the time of the Convention's opening for signature, Türkiye was included in Annex I (industrialized countries and countries in transition to a market economy) and Annex II (industrialized countries) lists, and it continued to remain in Annex I by being granted special conditions at the 7th Conference of the Parties held in 2001. Türkiye became a Party to the Convention on 24 May 2004, which entered into force on 21 March 1994, becoming the 189th Party.

On the other hand, the Kyoto Protocol, which was signed at the 3rd Conference of the Parties in 1997 and entered into force on 16 February 2005, sets quantified emission limits or reduction commitments for the Annex I Parties of the Convention listed under Annex B. However, Türkiye, which became a Party to the Protocol on 26 August 2009, was not included in Annex B as it had not become a Party to the Convention when the Protocol was adopted, and therefore, it did not have any quantified emission limitation or reduction obligations (MoEUCC, 2021).

Countries that are Parties to the UNFCCC are represented at the Conference of the Parties (COP), which is the highest decision-making body of the Convention, and all Parties come together annually to continue negotiations on climate change. The 21st Conference of the Parties (COP21), held in Paris in November 2015, was a significant turning point as the legally binding international Paris Agreement was adopted to strengthen the global response to the threat of climate change.

The Paris Agreement aims to limit global warming to well below 2 °C, preferably to 1.5 °C, compared to pre-industrial levels. It also emphasizes the need for Parties to make their "nationally determined contributions" (NDCs), demonstrating their best efforts and enhancing these efforts in coming years, accelerating the provision of financial resources, technology transfer, and capacity-building support from developed country Parties to developing countries, particularly Small Island Developing States, and undertaking absolute emission reduction targets (UNFCCC, 2015). The Agreement entered into force on 4 November 2016, requiring the approval of 55 countries representing at least 55% of global emissions. Türkiye, which signed the Agreement on 22 April 2016, ratified it in the Turkish Grand National Assembly as of 6 October 2021. The "Law on the Approval of the Paris Agreement" was published and entered into force in the Official Gazette numbered 31621 on 7 October 2021. Prior to the adoption of the Paris Agreement at COP21, countries submitted their intended nationally determined contributions (INDCs) regarding greenhouse gas emission reductions to the UNFCCC Secretariat. Türkiye, in its national contribution submitted to the Secretariat on 30 September 2015, declared its aim to achieve a 21% reduction in greenhouse gas emissions by 2030 compared to projected levels (Figure 2.5).



Source: (MoEU, 2015)

Figure 2.5: Nationally Determined Contribution of Türkiye

In order to achieve the set reduction target, various plans and policies have been determined, including increasing electricity generation capacity from solar and wind energy, commissioning one nuclear power plant, reducing the rate of energy losses, reducing fuel consumption from road transportation, phasing out old vehicles, improving the energy efficiency of new and existing buildings, supporting good agricultural practices, promoting waste recycling and energy recovery from waste, increasing carbon sinks, conducting forest rehabilitation and pasture improvement projects (MoEU, 2015). Prior to the COP21, national commitments on mitigation and adaptation were prepared as intended nationally determined contributions (INDCs), which were later formalized as Nationally Determined Contributions (NDCs) and submitted to the Secretariat after the approval of the Paris Agreement. In Türkiye, efforts to update the NDC were carried out in 2022, and it was announced that the reduction target for 2030 was raised to 41% and emissions are expected to peak in 2038, as reported during COP27.

2.3. Local Climate Change Policies

Local governments play a significant role in both reducing greenhouse gas emissions and adapting to climate change. Urban activities account for approximately 60% of global greenhouse gas emissions and 78% of energy use (UN, 2021). In the global ranking of cities' carbon footprints, Istanbul ranks 26th, while Ankara ranks 80th, with Seoul, Guangzhou, and New York City being in the top three (GGMCF, 2021). Cities also harbor vulnerable structures in the face of climate change impacts such as anticipated temperature increases, sea-level rise, and altered precipitation patterns. Therefore, efforts by local governments to reduce greenhouse gas emissions and enhance climate change adaptation are of great importance, and such initiatives have gained momentum in our country.

Climate change action plans to be prepared by local governments should include targets to reduce the city's contributions to climate change (i.e. greenhouse gas emissions) quickly and fairly and to increase the city's capacity to adapt to climate change impacts. In this context, it was aimed to prepare local climate change action plans in 30 Metropolitan Municipalities in our country by 2024. In line with this goal, efforts are underway to support local governments to prepare their climate change action plans. Currently, studies are being carried out within the provincial and district municipalities for the preparation of Local Climate Change Action Plans (LCCAP). In this context, there are various voluntary initiatives in the international arena, and one of the most important of these is the Global Covenant of Mayors for Climate and Energy (GCoM), which has been signed in our country by 50 municipalities, 15 of which are metropolitan cities. This initiative, which was first launched in 2008 within the European Commission, aims to support local governments in achieving climate and energy targets and to bring together many cities and regions that want to implement the targets set within the framework of the convention. Municipalities that are parties to the Convention are obliged to prepare action plans containing the measures they plan to implement in terms of greenhouse gas emission reduction and adaptation to climate change (GCoM, 2022). Another initiative established by local governments to combat climate change at the international level is the Local Governments for Sustainability (ICLEI). This association, whose main purpose is to increase capacity building and cooperation of local governments under the theme of sustainability, has over 2,500 members, 8 of which are from our country (ICLEI, 2021).

There are many studies already completed or ongoing by local governments, especially metropolitan municipalities, for the preparation of greenhouse gas emission inventories and climate change action plans. Mitigation and adaptation actions that can be generally implemented by local authorities are given in Table 2.1.

Table 2.1: Mitigation and adaptation actions that can be implemented by local authorities

Sector	Mtitigation	Adaptation
Energy	• Reducing fossil fuel use • Renewable energy use • Efficient street lighting	• Strengthening the electricity transmission and distribution infrastructure • Increasing the resilience of grids to climate change
Industry	• Improvement of processes, identification of the best available techniques • Reduction of fuel and electricity consumption	• Determination of climate resistance, preparation of action plans
Buildings/Housing	• Increasing energy efficiency • Thermal insulation • Energy-efficient design during the construction phase and completion of energy identity documents • Green roof applications • Awareness-raising activities	• Disaster management • Awareness-raising activities • Strengthening infrastructure in buildings
Transportation	• Low-carbon emission network • Increasing the use of electric and hybrid vehicles • Saving energy and fuel with efficient technologies	• Improvement of traffic signaling systems

Sector	Mtitigation	Adaptation
	• Dissemination of intelligent transportation systems • Enabling public transport • Encouraging pedestrian access • Expansion of bicycle paths	
Waste and Wastewater	• Obtaining energy from landfill gas • Reduction of emissions from storage • Ensuring solid waste and wastewater recovery • Reducing water losses in drinking water supply and distribution systems in order to protect existing water resources	• Reducing industrial waste and ensuring recycling • Creation of waste collection points • Positioning of containers in such a way that they are not affected by weather conditions • Ensuring that the treated water is reused • Taking measures to save water in car washes
Agriculture	• Reduction of the use of chemical fertilizers • Installation of solar energy for use in agricultural activities • Realization of animal and plant production suitable for the region • Modification and alteration of tillage practices • Carrying out afforestation works on the edges of agricultural areas	• Expansion of systems to reduce water consumption • Determination of drought resistant plant pattern • Improving food safety • Encouraging urban agriculture
Other (Water resources, food security, public health, heat island, land use, AFOLU etc.)	• Obtaining agricultural fertilizer from animal waste • Land consolidation • Use of organic fertilizers • Reduction of heating, cooling and electricity consumption in health institutions	• Establishment of early warning systems in response to flash floods and floods • Rainwater collection • Agricultural drought management • Combating water and foodborne diseases • Being prepared for epidemic diseases • Switching to natural soil floor in parks and gardens • Increasing carbon sink sources

3. MERSIN IN GENERAL

3.1. The Importance of Mersin

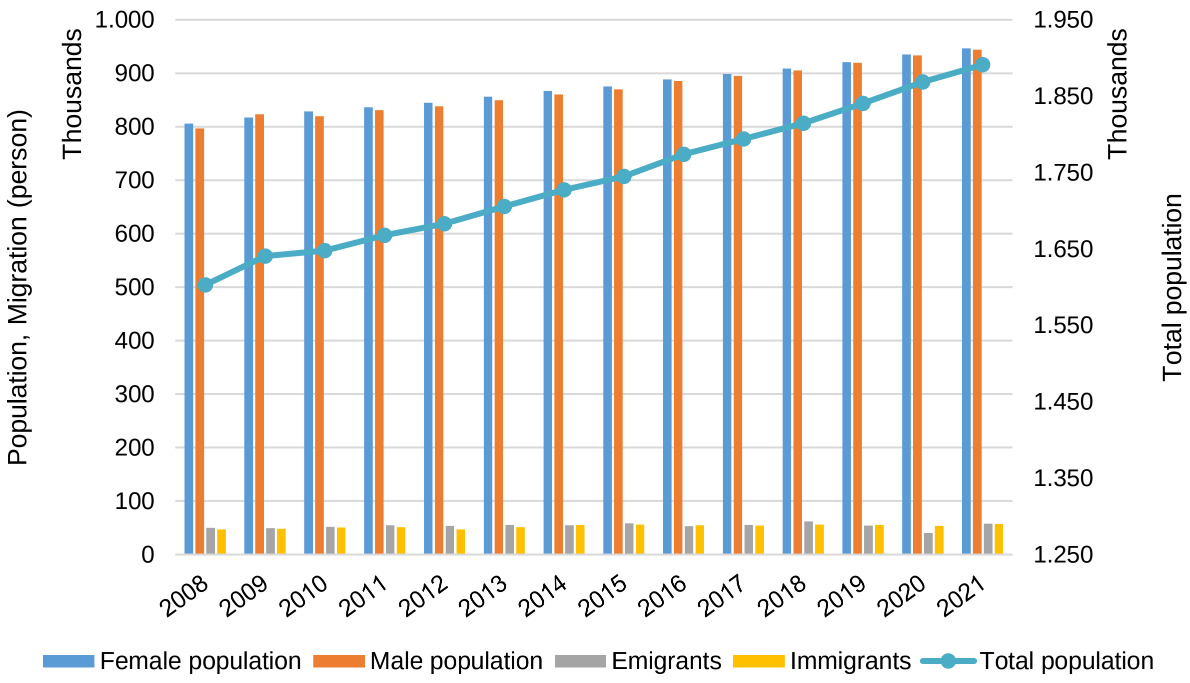
Mersin, which was known as Cilicia in classical times, is located in a region that has hosted different civilizations, ranging from the Hittites to the Persians, from the Macedonians to the Byzantines. As the 9th largest province in terms of areal coverage in Türkiye, Mersin encompasses significant tourist attractions such as the Cennet-Cehennem Cave, Aya Thekla Church, and the Temple of Zeus. With its 321 km long coastline, Mersin is also one of the important residential areas for summer tourism in our country. In addition to the central districts of Akdeniz, Mezitli, Yenişehir, and Toroslar, it has a total of 13 districts including Anamur, Aydıncık, Bozyazı, Silifke, Tarsus, Çamlıyayla, Erdemli, Gülnar, and Mut. The international port and adjacent free zone in Mersin provide a connection for global trade, particularly for many provinces located in Eastern Anatolia and Central Anatolia regions (GM, 2022).

Source: (GM, 2022; AA, 2014; MMM, 2022)

Figure 3.1: Photos of Mersin

3.2. Population

The population of 1,488,755 of the Mersin province in 2000 has increased by approximately 27% in the last 21 years and reached 1,891,145 in 2021. Mersin is the 11th largest province in Türkiye. As shown in Figure 3.2, the female and male populations are very close to each other. The majority of population lives in urban areas, and between 1990 and 2000, the urban population increased by 23.67% and the rural population by 30.92%. Mersin province received 57,213 immigrants in 2021 and 57,930 migrated. Between 2016 and 2019, Mersin province received migration from outside of Türkiye, approximately 81% of which were foreign nationals, while 17,401 people, 59% of whom were foreign nationals, migrated from Mersin in the same time period. On the other hand, there has not been a steady increase or decrease in migration inwards or outwards over the years. The difference between the migration received and the migration given in 2021 is 717 people. While 10% of the immigration received was from Adana, 12% of the migration given was to Istanbul (TURKSTAT, 2023).

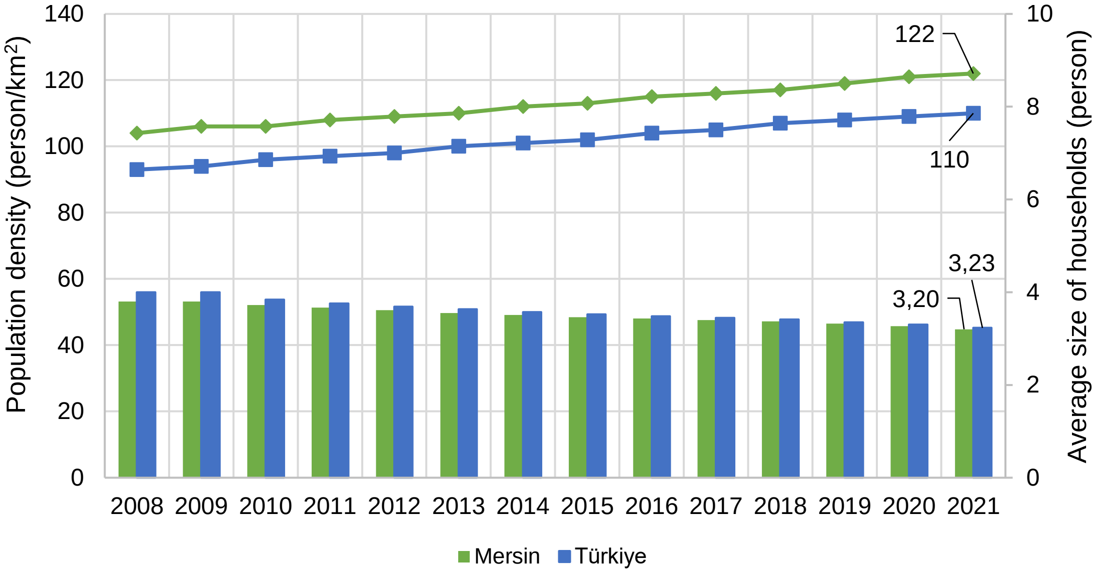


Source: (TURKSTAT, 2023)

Figure 3.2: Population and migration change in Mersin province (2008-2021)

The average household size of 3.7 in 2010 showed a decreasing trend and decreased to 3.2 people in 2021. This number is 3.23 for the average of Türkiye. The number of illiterates decreased from

36,077 in 2017 to 28,917 in 2021. As can be seen in Figure 3.3, as of 2021, the area of the province is 15,853 km^2 and the population density is approximately 122 people/km^2 (TURKSTAT, 2023).



Source: (TURKSTAT, 2023)

Figure 3.3: Change in population density and household size in Mersin (2008-2021)

3.3. Geography

In terms of surface area of Mersin province, 53% is covered with forest and nursery, 21% is covered with agricultural land, 22% is comprising non-agricultural land, and around 4% is covered by meadows and pastures. Geographically, the province is located between the latitudes of 36-37° North and the longitudes of 33-35° East. With an area of 15,853 km^2, Mersin has a coastline of 321 km and a land border of 608 km. It is bordered by the provinces of Konya, Karaman, and Niğde to the north, Antalya to the west, Adana to the east, and the Mediterranean Sea to the south. Mersin is divided into 13 districts.

Figure 3.4: Map of Mersin Province

Mersin province is predominantly composed of high, rugged, rocky Western and Central Taurus Mountains. The plains and gently sloping areas are developed in the central parts of the province, as well as in areas such as the provincial capital, Tarsus and Silifke, where these mountains extend towards the sea. In the northern part of the province, between the mountains or in the higher regions, there are flat or gently sloping areas. Mersin province is not rich in rivers. The most important rivers in the province are the Göksu and Berdan rivers.

3.4. Climate Conditions

Mersin province's coastal areas have a typical Mediterranean climate, with hot and dry summers and mild and rainy winters. As you move inland from the coast, a continental climate is observed. In the higher regions of the province, summers are cool and dry, while winters are cold and snowy. According to the climate statistics for Mersin province from 1940 to 2021 provided by the Turkish State Meteorological Service (MGM), the lowest average temperatures are around - 6.5°C in January and February, and the average temperatures during the hottest months, from June to September, are around 39.9°C. The annual average temperature is 19.2°C. The average daily sunshine duration is 7.5 hours, and the annual average number of cloudy days is 40.7 days. The average number of rainy days is approximately 57 days. The average sea water temperature in this region is measured to be 20.8°C.

Based on the data from 1940 to 2021, the annual average precipitation in Mersin province is 613.9 mm. The highest rainfall occurs in November (average 76.9 mm), December (average

138.5 mm), January (average 119.9 mm), February (average 85.2 mm), and March (average 56.4 mm). Precipitation measurements at the MGM's stations indicate that rainfall is higher in mountainous areas. In the coastal regions, the prevailing wind directions are southwest to west. The annual average wind speed in the city is about 2.1 m/s. The relative humidity is on average 64.1% over the past 30 years. Throughout the year, these values range between 60.0% and 66.6% (MGM, 2022).

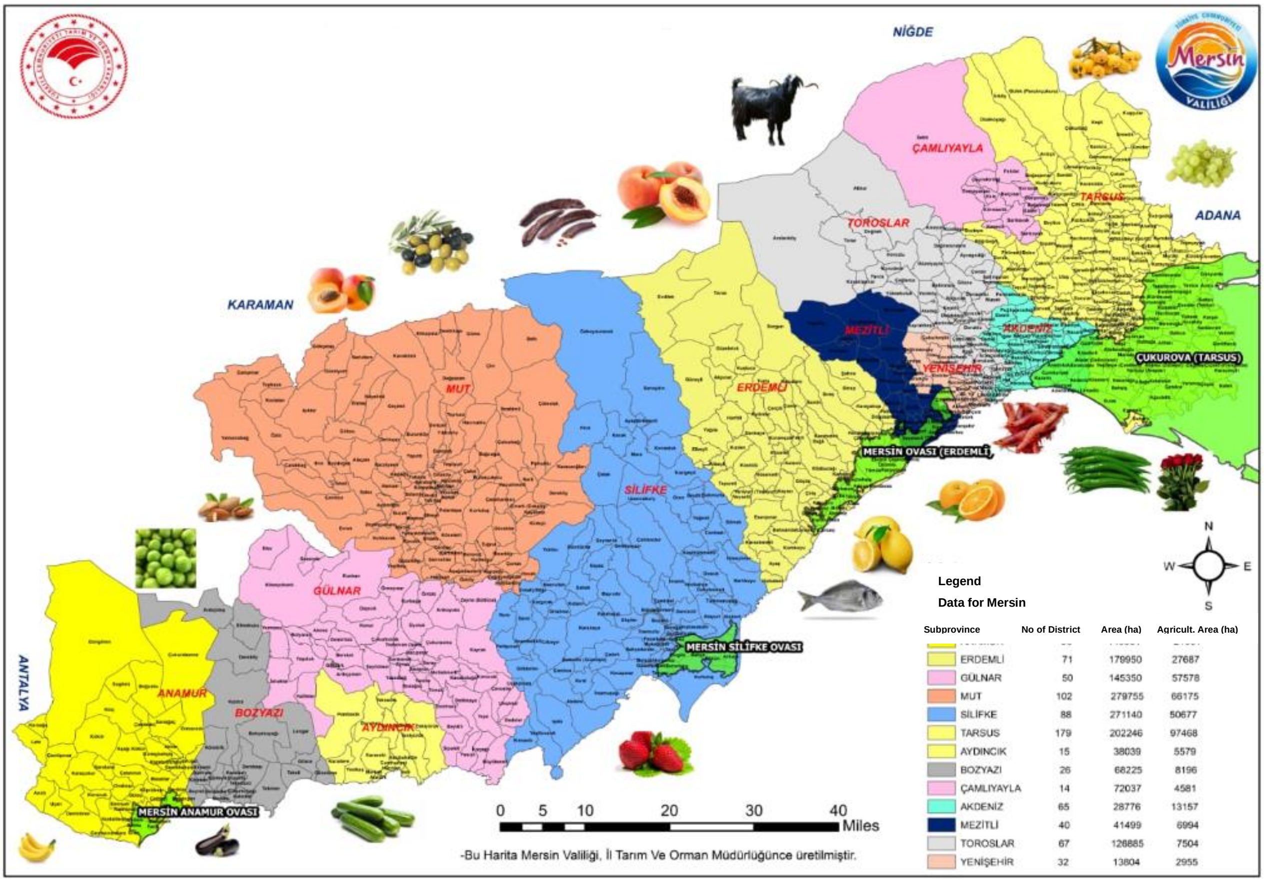
3.5. Economics

Mersin is one of the most developed provinces in Türkiye in many aspects. Its fertile land, advanced industrial sector, rich natural and underground resources, the presence of port activities, and the Mersin oil refinery are among the main reasons for this development. Approximately 40% of the income comes from the industrial sector, 30% from agriculture, and 10% from the trade sector.

In Mersin province, around 32% of the working population, which amounts to 517,000 people, is employed in the agricultural sector. With an area of 1,585,300 hectares, Mersin constitutes approximately 2% of the total area of Türkiye and agricultural production is realized in 21% of the provincial area (PDEUCC, 2022). Mersin ranks 28th with 816.3 million TL in terms of the value of animal products in 2020, 24th with approximately 3.5 billion TL in terms of the value of livestock in 2021 and 2nd after Konya and Antalya with 17 billion TL in terms of the value of crop production in 2021 (TURKSTAT, 2023)

According to the 2021 Report of Mersin Chamber of Commerce and Industry (MTSO), a total of 177,000 hectares of agricultural land is cultivated in the province. Mersin ranks 2nd in Türkiye in terms of vegetable production with a share of 7.5% and 1st in fruit production with a share of 16%. Mersin is the 3rd largest province in Türkiye in terms of the value of crop production, and the annual production value has expanded by 31%. The area planted with ornamental plants has increased by 32% compared to the previous year, reaching 1,054,606 m^2, while the production quantity has increased by 17% to reach 31,991,610 units. Mersin accounts for 2% of Türkiye's ornamental plant production and ranks 10th among the provinces that produce ornamental plants. Mersin is also the top exporter of fresh fruits and vegetables in Türkiye, covering 21% of the country's total exports in that category. In terms of greenhouse cultivation, the areas have expanded by approximately 19% to reach 223,893 decares, constituting 37% of Türkiye's total and placing Mersin in the 1st position (MTSO, 2022).

A wide variety of agricultural products are grown in Mersin. The agricultural data map of Mersin province is given in Figure 3.5. According to the data from 2022 on the amount of production, some of the main grain products are the followings: wheat, corn, soybeans, barley, rye, rice, chickpeas, pods and lentils. Peanuts and sesame also play a major role in the agricultural sector of Mersin. Almost all kinds of vegetables are planted in the province. Tomato, pepper, eggplant, beans, zucchini, fresh pods, peas, okra, cucumbers, broccoli, spinach, cabbage, lettuce, leeks, onions and cauliflower are the main vegetables grown. Mersin is also quite advanced with its greenhouse cultivation sector, and ranks as the 2nd province with biggest greenhouse area after Antalya. Citrus fruits grow in abundance, while banana, grape, strawberry, apricot, peach, carob, olive, pomegranate, apple, fig, plum, almond and cherry are other fruits grown (TURKSTAT, 2023). Mersin is one of Türkiye's grain, fruit and vegetable warehouses. Early grown and fresh fruits and vegetables go all over Türkiye, from Mersin, therefore it is defined not only as a cotton warehouse but also as a vegetable and fruit warehouse. According to the Mediterranean Exporters' Associations (AKİB) export of fresh fruits and vegetables from Mersin has increased from a total of $ 639,988,782 in 2020 to $ 655,911,594 in 2021.



Source: (GM, 2022; MİTOM, 2023)

Figure 3.5: Agricultural data map of Mersin province

Within the scope of the Basin Based Support Model proposed by the former Ministry of Food, Agriculture and Livestock, support mechanisms have been carried out since 2017. Annually, product lists are created to determine the products to be supported in the Agricultural Basins. In addition, products that cannot benefit from Diesel-Fertilizer Support, Difference Payments Support for the product they sell and Certified Seed Use support for the seed they use have also been identified for the parcel they produce. The products determined in this context should be evaluated within the scope of determining climate change adaptation activities in terms of agricultural basins. List of products supported by agricultural basins in Mersin districts in the 2021 production season is given in Table 3.1.

Table 3.1: Products supported in Mediterranean water basins

Districts	Products Supported within the Scope of Turkish Agricultural Basins Production and Support Model
Akdeniz	Barley, Wheat, Corn (Dane), Soybean, Fodder Crops, Olive-Olive Oil
Anamur	Barley, Wheat, Chickpeas, Fodder Crops, Olive-Olive Oil
Aydıncık	Barley, Wheat, Chickpeas, Fodder Crops, Olive-Olive Oil
Bozyazı	Barley, Wheat, Chickpeas, Fodder Crops, Olive-Olive Oil
Camliyayla	Barley, Wheat, Chickpeas, Sunflower (Oily), Fodder Crops, Olive-Olive Oil
Erdemli	Barley, Wheat, Chickpeas, Fodder Crops, Olive-Olive Oil
Gülnar	Barley, Wheat, Dried Beans, Chickpeas, Fodder Crops, Olive-Olive Oil
Mezitli	Wheat, Fodder Crops, Olive-Olive Oil
Mut	Barley, Wheat, Chickpeas, Fodder Crops, Olive-Olive Oil, Potatoes
Silifke	Barley, Wheat, Paddy, Corn (Dane), Chickpeas, Fodder Crops, Olive-Olive Oil
Tarsus	Barley, Wheat, Paddy, Corn (Grain), Cotton (Pulp), Soybean, Sunflower (Oily), Fodder Crops, Olive-Olive Oil, Potato, Onion (Dry)
Toroslar	Barley, Wheat, Corn (Dane), Chickpeas, Fodder Crops, Olive-Olive Oil
Yenisehir	Barley, Wheat, Corn (Dane), Fodder Crops, Olive-Olive Oil

Source: (BUGEM, 2022)

The livestock sector is carried out in mountainous regions and highlands. The total proportion of non-agricultural land, meadows and pastures in the province is about 26%. The beekeeping sector has developed in the province. Although the province has extensive coasts in the Mediterranean region, fish production is about 28,800 tons (TURKSTAT, 2023). There are 20 sea bream-sea bass production facilities with a total capacity of 49.8 thousand tons per year, one trout production facility with a capacity of 287 tons per year, three blackfish production facilities with a capacity of 170 tons per year, and four sea bass production facilities with a capacity of 70 tons per year. Apart from sea bream-sea bass production, the other fish farming facilities are land-based. The rivers of Tarsus, Berdan, and Tragon are abundant with freshwater fish. Mersin, which is rich in forest areas, has the third-largest forest cover in Türkiye, occupying 53% of its land area. The coastline from Anamur to Tarsus is covered with maquis vegetation. Among the maquis vegetation, there are wild olive and stone pine trees called "Delice". While dense forests are found up to an altitude of 2,200 meters from the maquis zone, dwarf and sparse forests are present in higher regions. Oak, mastic, sandalwood, myrtle, and juniper trees are found in forested areas up to an altitude of 600 meters. Various types of pine trees, fir trees, and cedar trees are found in higher elevations. The forested and maquis areas cover 785,000 and 100,000 hectares, respectively. Every year, 3,500 tons of resin and 250,000 m^3 of industrial timber are obtained from these forests.

According to industrial registration records, the manufacturing industry accounts for 89% of the enterprises operating in the industrial sector in Mersin province. Among the sub-sectors of the manufacturing industry, food product manufacturing constitutes 32%, followed by machinery and equipment manufacturing, rubber and plastic product manufacturing, fabricated metal product manufacturing, mineral product manufacturing, clothing manufacturing, chemical and chemical product manufacturing, and wood, wood product, and mushroom product manufacturing with percentages of 11%, 8%, 8%, 7%, 7%, 5%, and 5%, respectively. Developments in foreign trade volume in 2021 were parallel to the national trends. Mersin experienced a 31% increase in export volume and a 39% increase in import volume compared to 2020. The manufacturing industry played a determining role in this, while the agricultural sector also made a contribution. Mersin companies conducted exports worth $4.2 billion and imports worth $3.9 billion in 2021 (MoIT, 2021).

Mersin province is among the rich provinces in terms of minerals. The General Directorate of Mineral Research and Exploration has carried out studies in Mersin and its surrounding areas, resulting in the identification of metallic minerals such as chromium, as well as iron, copper-lead-zinc deposits, and industrial raw material sources including primarily dolomite and barite, as well as cement raw materials, phosphate, limestone, and magnesite beds and formations. Chrome, copper, iron, quartzite, aluminum, barite, and dolomite are extracted in this province, and some of these minerals are exported to foreign countries through the Port of Mersin.

Mersin Free Zone with an area of 860,076 m^2 opened in 1987 and is the first free zone of our country. In 2020, $2,520,963,199 trade occurred. There are a total of 406 companies in the region with 293 domestic, 79 foreign and 34 domestic-foreign partnerships. Mersin Port is among the top 92 in the world with its container volume, and ranks 1st in Türkiye with its 2.6 million TEU container business volume. Freight traffic handled increased by 10% annually to 36.4 million tons. Mersin ranks 4th in Türkiye in terms of the number of ships calling at ports for operations. Mersin Technology

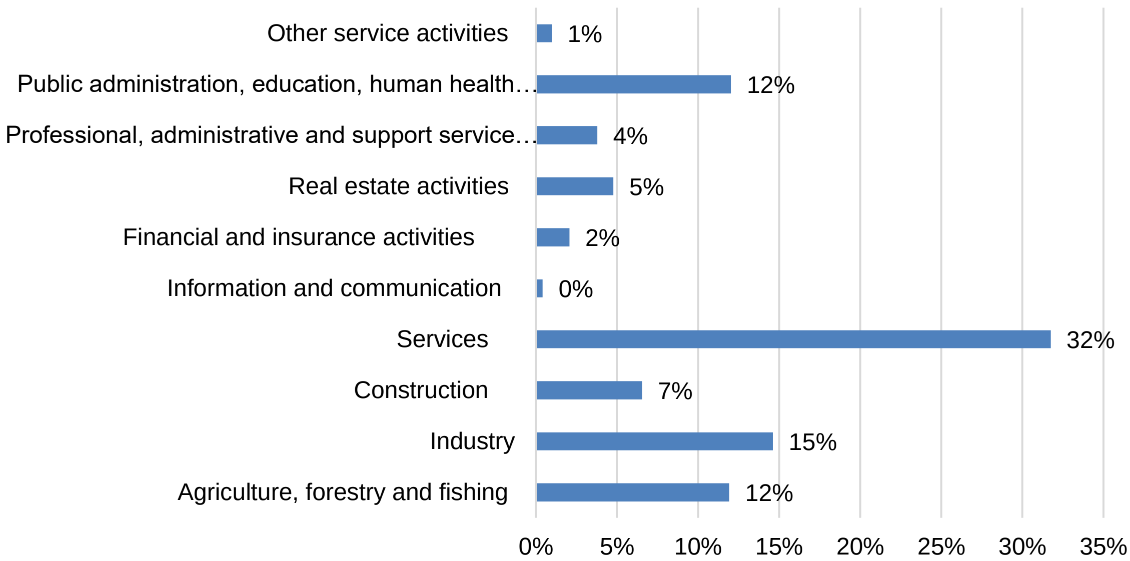
Development Zone (Mersin TEKNOPARK) was established in 2006 and 86 companies operate within.

Mersin, due to its geographical location; covers a significant part of the Eastern Mediterranean Basin to the west of the Çukurova part of the Mediterranean Region. With 321 km long coastline, it has one of the longest coastlines in Türkiye. From Tarsus to Anamur, Mersin has a great potential in terms of tourism with its ancient cities, historical and natural values. According to the data of 2021 (Ministry of Culture and Tourism), the total bed capacity of the accommodation facilities that have received a tourism operation certificate in the province is 9,449 (MoCT, 2022).

The region consisting of natural beaches and 108 km of sandy coastline, is also very rich in terms of historical and cultural values. Mersin, which has been a settlement since the Neolithic period, has many archaeological and historical artifacts from the Chalcolithic, Hittite, Roman, Byzantine and Ottoman civilizations. There are two centers that are the most important in terms of faith tourism in the province. First, the House and Well of St. Paul, one of Jesus' Apostles, in Tarsus were declared a place of pilgrimage by the Vatican. The other is St. Aya Tekla (Meryemlik), in Silifke/Başucu which is important for the Muslim and Christian world and is accepted as a place of pilgrimage in the early Christian period, are the most important religious visiting centers. In addition, the Ashabı Kehf Cave of Tarsus is also located within the borders of the province.

In order to shift the yacht tourism to the Eastern Mediterranean, marina projects in accordance with international standards are being developed and Mersin Main Marina with a capacity of 500 yachts has been built. Yacht Basen with a capacity of 300-350 yachts operates in Mersin Çamlıbel region in which blue cruise, daily tour and moonlight tours are also made. There are also healing water springs in the region, highlanding, suportive activities, paragliding, sailing sports, underwater diving, rafting, water skiing activities can be done. A significant number of people in the region migrate to the cooler Taurus plateaus in the summer months and revive the highland tourism.

The per capita gross domestic product (GDP) value of Mersin province increased from 15,207 TL in 2011 to 74,343 TL in 2021. Mersin is the 10th largest province with a share of 1.9% in Türkiye's GDP (TURKSTAT, 2023). According to the 2019 data, TURKSTAT ranked Mersin 4th among the provinces that contributed the most to the 0.9% increase of the annual GDP compared to the previous year with the chained volume index (Figure 3.6).



Source: (TURKSTAT, 2023)

Figure 3.6: Distribution of Mersin gross domestic product according to economic activity (2020)

3.6. Transportation

Road Transportation

Mersin province has a total road length of 1,492 km, including 155 km of highways, 488 km of state roads, and 849 km of provincial roads (MoTI, 2023).

There are three important transportation axes connecting the province to other regions. First, it connects the province to the Central Anatolia and Marmara regions via Aksaray. After Mersin, this road extends from Adana to Hatay and the Syrian border, and the Pozantı-Tarsus-Adana-Toprakkale-Gaziantep highway, which connects to this road, continues until Mersin. Mersin Province is connected to Southeastern Anatolia by this route. Another important axis connects the province to Izmir via Antalya-Muğla-Aydın along the Mediterranean and to Çanakkale along the Aegean. The third important axis of the province is the road that connects the province to the Central Aegean via Silifke-Karaman-Konya-Afyon and again to Central Anatolia on Silifke-Karaman-Konya.

Railway

The current conventional railway network of Mersin is 136 km long. In 2022, a total of 2,602,372 passengers were transported within Mersin province (MoTI, 2023).

Mersin province is connected to the country's railway network through a 43.4 km line starting from Yenice. The railway extends eastward through Adana to Southeastern Anatolia and Syria, while it terminates at Mersin Port in the west. Mersin Gar Directorate, under the administration of Adana 6th Regional Directorate, provides passenger and freight transportation services with a double-track length of 55.21 km within the boundaries of Mersin. There are railway connections of 250 meters to Mersin Port. Daily reciprocal train services operate between Mersin and Adana, as well as train services between Mersin and İskenderun. Additionally, reciprocal services are available between Mersin and İslahiye. Connections from Yenice to Ankara, Eskişehir, Afyon, and Haydarpaşa are also available, and transportation to all cities with connections through Adana is possible. There are daily reciprocal train services between Mersin and Ankara (Papatya & Mehmet Nedim, 2019).

Aviation

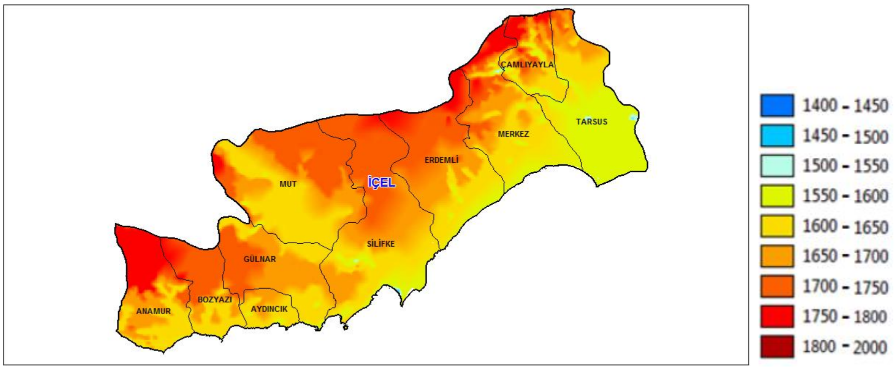
There is no airport within the boundaries of Mersin province. The nearest airport to Mersin is Adana Şakirpaşa Airport and it is open to domestic and international flights. There are daily flights from Ankara, Istanbul and Izmir to Adana and the annual passenger capacity of Adana Şakirpaşa Airport is 5,000,000 passengers/year. In Tarsus district, the construction of Çukurova Regional Airport is continuing in order to serve Mersin and Adana provinces and Çukurova Region.

Waterborne Navigation

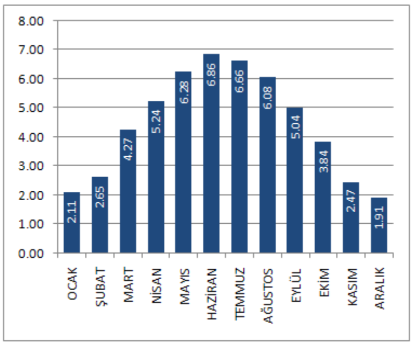
Mersin has the largest cargo port in Türkiye, making it one of the important gateways for import and export to the world. Mersin International Port offers regular voyages and commercial connections to numerous ports in continents such as America, Europe, Africa, Asia, and Australia, including destinations like Tunisia, Sydney, Abidjan, Liverpool, Panama, and Odessa. While Mersin International Port is primarily used for cargo transportation, it also serves passenger ships, especially during the summer months. In addition to Mersin International Port, there are other facilities in Mersin Province, such as Taşucu Port, which provides passenger bus and ferry services between Girne and Mersin, as well as Anamur Pier, Bozyazı, Yeşilovacık, and Karaduvar Fishing Harbors. Taşucu SEKA Port, which is privatized, is currently used for bulk cargo transportation. The construction of Mersin Yacht Port with a capacity of 1,000 yachts and Erdemli-Kumkuyu Yacht Port with a capacity of 450 yachts has been completed (MoTI, 2023)

3.7. Renewable Energy Sources

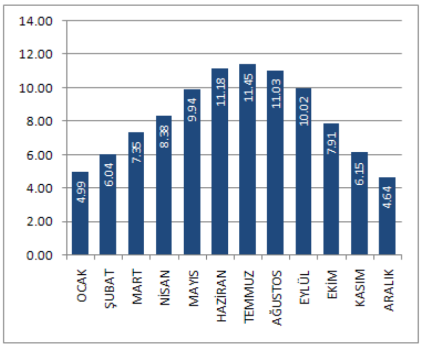
Currently, the installed capacity of unlicensed solar energy-based power plants in Mersin is at the level of 143 MW. As shown in Figure 3.7, according to the Solar Energy Potential Atlas prepared by the General Directorate of Renewable Energy on a provincial basis, it was determined that the average daily sunshine duration in Mersin was 8.2 hours-day and the total daily solar radiation was 4.4 kWh/m^2-day (GEPA, 2022). On the other hand, according to the Wind Energy Potential Atlas prepared by the General Directorate of Renewable Energy on a provincial basis, especially Mut, Silifke and Erdemli districts of Mersin have a physical geography that meets the minimum wind speed and capacity factor requirements needed for a feasible wind power plant investment (Figure 3.8) (REPA, 2022).



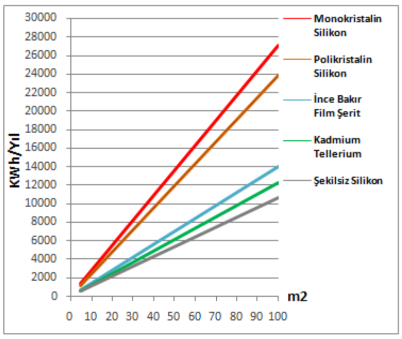
Total solar irradiation (KWh/m^2-year)



Global solar irradiation (KWh/m^2-gün)



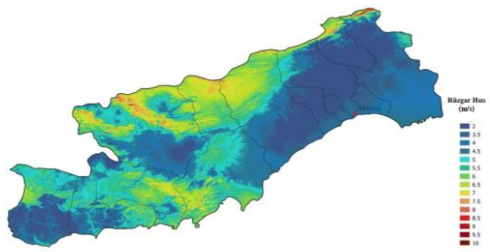
Sunshine duration (hours)



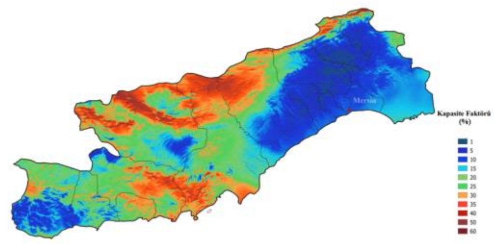
PV type-area-energy that can be produced (KWh-Year)

Source: (GEPA, 2022)

Figure 3.7: Solar energy potential of Mersin province



Annual average wind speed distribution (m/s) – 100 meters



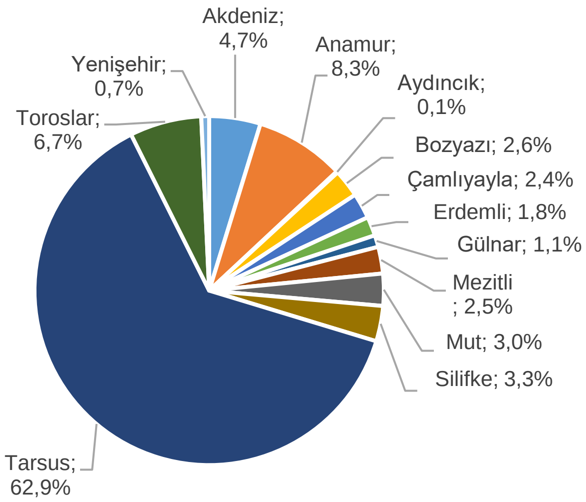
Capacity factor distribution (%) – 100 meters

It has been prepared by taking into account the technical values of a wind turbine with a power of 3 MW.

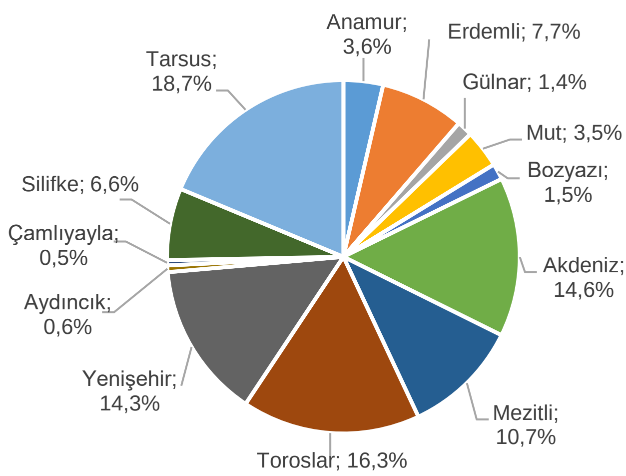
Source: (REPA, 2022)

Figure 3.8: Mersin province wind energy potential

According to the Biomass Energy Potential Atlas prepared by the General Directorate of Renewable Energy on a provincial basis, the economically achievable energy potential that can be obtained by evaluating the wastes generated in animal and plant production in Mersin through biomethanization and incineration facilities is on the order of 82 thousand TOE/year. In terms of municipal waste, there is a potential of approximately 1,922 TOE/year and the breakdown of this potential by districts is given Figure 3.9 (BEPA, 2022).



Energy equivalent of animal and vegetable wastes (TOE/year)



Energy equivalent of municipal waste (TOE/year)

Source: (BEPA, 2022)

Figure 3.9: Distribution of biomass energy potential for animal, vegetable and urban wastes in Mersin districts (%)

4. MERSİN GREENHOUSE GAS EMISSION INVENTORY

4.1. Methodology

The greenhouse gas emission inventory for the province of Mersin has been prepared in accordance with the criteria set forth by the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), which was published in 2014. The GPC, developed through a collaborative effort by the C40 Cities Climate Leadership Group, the International Council for Local Environmental Initiatives (ICLEI), and the World Resources Institute (WRI), is based on the IPCC National Greenhouse Gas Inventory Guidelines. It provides the necessary standards and tools for identifying total emissions and major emission sources, setting emission reduction targets, planning effective reduction strategies, and monitoring progress.

Within the scope of the GPC, an inventory boundary needs to be defined, which encompasses the geographical area, time interval, gases, and emission sources covered by the GHG inventory. Depending on the purpose of the inventory, the boundary would be aligned with the administrative boundary of a local government, a neighborhood or district within a city, a combination of administrative divisions, a metropolitan area, or any other geographically defined entity.

Greenhouse gas emissions resulting from city activities are assessed under the main sectors of:

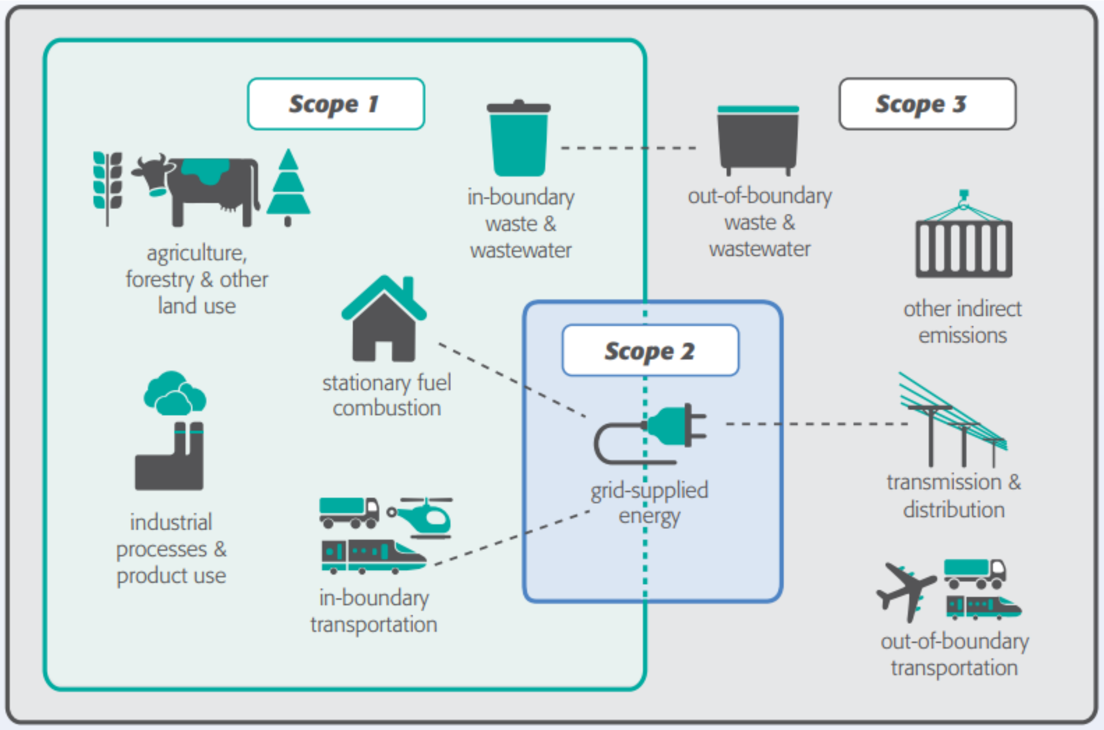
- Stationary energy
- Transportation
- Waste
- Industrial processes and product use (IPPU)
- Agriculture, forestry, and other land use (AFOLU)

These sectors are further divided into sub-sectors and subsequently into sub-categories. The sub-sectors represent components of a sector, such as waste treatment methods or modes of transportation like road transport. The sub-categories offer opportunities for using disaggregated data, improving inventory details, and facilitating the identification of mitigation actions and policies. They are used to specify an additional level of categorization, such as vehicle types within each transportation mode or building types within the energy sector. Table 4.2 provides details on the sectors covered in this study.

The main greenhouse gases considered in GPC-based inventories and defined in the Kyoto Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

On the other hand, emissions are classified into three categories according to whether they occur within or outside the city boundaries:

- Scope 1: GHG emissions from sources located within the city boundaries.
- Scope 2: GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundaries.
- Scope 3: All other greenhouse gas emissions that occur outside the city boundaries as a result of activities taking place within the city boundaries.



Source: (GPC, 2014)

Figure 4.1: Sources and boundaries of greenhouse gas emissions

In the protocol, the calculation and reporting of greenhouse gas emissions are based on the principles of relevance, completeness, consistency, transparency and accuracy to represent a real and impartial emission account, and these principles have been taken into account in the calculation and reporting processes of the greenhouse gas emission inventory prepared within the scope of this study.

To ensure transparency, it is necessary to provide references to all data sources and assumptions used in the creation of the greenhouse gas emission inventory. The "tier" approach used by the IPCC emphasizes increasing accuracy, which requires more detailed and high-quality data. In the GPC, references to the relevant IPCC methodologies, tiers, and methods are provided in each section of emission source categories. The quality of activity data and emission factors used in the calculation of emissions are assessed as high, medium, or low (Table 4.1) (GPC, 2014).

Table 4.1: Data quality assessment criteria

Data Quality	Activity Data	Emission Factor
High (H)	Detailed activity data	Specific emission factors (Local)
Medium (M)	Modeled activity data using robust assumptions	More general emission factors (National)
Low (L)	Highly-modeled or uncertain activity data	Default emission factors (International)

Within the scope of this study, all data and emission factors have been obtained from official statistics and the 2022 National Inventory Report to the maximum extent possible. The aim was to ensure high quality and consistency with national reports. An assessment of data quality is provided in Section 4.4.

4.2. Greenhouse Gas Emission Calculation

Inventory Boundaries and Greenhouse Gases

The inventory boundaries covers all emission sources within the administrative boundaries of Mersin province, under the authority and responsibility of Mersin Metropolitan Municipality. The inventory focuses on three greenhouse gases: CO_2, CH_4, and N_2O. For the calculation of CH_4 and N_2O emissions in terms of carbon dioxide equivalent, global warming potentials provided in the IPCC Fourth Assessment Report (AR4) are used to ensure compatibility with the National Greenhouse Gas Inventory. Accordingly, the global warming potentials for CH_4 and N_2O are 25 and 298, respectively. However, due to data limitations, emissions from F-gases (HFCs, PFCs, SF_6, etc.) could not be calculated and thus, were not included in the inventory.

Greenhouse Gas Emissions

The inventory calculations were based on the BASIC level approach, which covers emission sources commonly found in almost all cities (Stationary Energy, In-City Transportation, and In-City Waste) and utilizes readily available calculation methodologies and data. Additionally, the BASIC+ level approach, which includes more comprehensive emission sources and involves more challenging data collection and calculation procedures, was partially considered. The inclusion status, indicators, and reasons for the inclusion or exclusion of Scope 1, Scope 2, and Scope 3 emissions in the inventory are shown in Table 4.2.

Table 4.2: Greenhouse gas emissions included in the inventory

GPC Ref No	Scope	GHG Supply	Application	Indicator/Justification
I		**STATIONARY ENERGY**		
I.1		Residential Buildings		
I.1.1	1	Direct Emissions	Included	
I.1.2	2	Indirect Emissions	Included	
I.2		Commercial/Institutional Buildings		
I.2.1	1	Direct Emissions	Included	
I.2.2	2	Indirect Emissions	Included	
I.3		Manufacturing Industries and Construction		
I.3.1	1	Direct Emissions	Included	
I.3.2	2	Indirect Emissions	Included	
I.4		Energy Industries		
I.4.1	1	Direct Emissions	Not calculated	NE : Due to data inadequacy
I.4.2	2	Indirect Emissions	Not calculated	NE : Due to data inadequacy
I.5		Agriculture, Forestry and Fishing Activities		
I.5.1	1	Direct Emissions	Included	
I.5.2	2	Indirect Emissions	Included	
I.6		Non-specified Sources		
I.6.1	1	Direct Emissions		
I.6.2	2	Indirect Emissions		
I.7		Fugitive emissions from mining, processing, storage, and transportation of coal		
I.7.1	1	Direct Emissions	Not calculated	NE : Due to data inadequacy
I.8		Fugitive emissions from oil and natural gas systems		
I.8.1	1	Direct Emissions	Not calculated	NE : Due to data inadequacy
II		**TRANSPORTATION**		
II.1		Road Transportation		
II.1.1	1	Direct Emissions	Included	
II.1.2	2	Indirect Emissions	Included	IE: Considered under I.2.

GPC Ref No	Scope	GHG Supply	Application	Indicator/Justification
II.2		Railways		
II.2.1	1	Direct Emissions	Not calculated	NE : Due to data inadequacy
II.2.2	2	Indirect Emissions	Not calculated	NE : Due to data inadequacy
II.3		Waterborne Navigation		
II.3.1	1	Direct Emissions	Included	
II.3.2	2	Indirect Emissions	Included	IE: Considered under I.2.
II.4		Aviation		
II.4.1	1	Direct Emissions	Not calculated	NO: No activity
II.4.2	2	Indirect Emissions	Not calculated	NO: No activity
II.5		Off-road Transportation		
II.5.1	1	Direct Emissions	Included	IE: Considered under II.1.
II.5.2	2	Indirect Emissions	Included	IE: Considered under I.5.
III		**WASTE**		
III.1		Solid Waste Disposal		
III.1.1	1	Direct Emissions	Included	
III.2		Biological Treatment of Wastes		
III.2.1	1	Direct Emissions	Included	IE: Considered under III.1.
III.3		Incineration and Open Burning		
III.3.1	1	Direct Emissions	Not calculated	NO: No activity
III.4		Wastewater Treatment and Discharge		
III.4.1	1	Direct Emissions	Included	
IV		**INDUSTRIAL PROCESSES AND PRODUCT USE**		
IV.1	1	Direct emissions from industrial processes	Included	
IV.2	1	Direct emissions from product use	Not calculated	NE: Due to data inadequacy
In		**AGRICULTURE, FORESTRY AND OTHER LAND USE**		
V.1	1	Direct emissions from livestock	Included	
V.2	1	Direct emissions and sinks from land use and land use change	Included	
V.3	1	Non-CO_2 emissions from agricultural land	Included	
IE - Included Elsewhere NE - Not Estimated NO - Not Occurring C - Confidential				

Data Sources and Key Stakeholders

In order to create the greenhouse gas emissions inventory, an initial open data search was conducted, resulting in access to various data at the provincial and district levels. Key data sources include the Central Distribution System of the Turkish Statistical Institute, Provincial Environmental Status Reports, Provincial Industrial Status Reports, Agricultural Briefing Reports, Traffic and Transportation Statistics, Maritime and Air Transportation Statistics from Ministry of Transport and Infrastructure, Energy Market Regulatory Authority (EMRA) Sector Reports, and EMRA Electricity Generation License Statistics. In addition, data was obtained through various stakeholders identified at the provincial level. Table 4.3 provides information on the key stakeholders who supported data acquisition for the greenhouse gas emissions inventory and the information obtained through these stakeholders.

Table 4.3: Data provided through key stakeholders

Key Stakeholder	Data acquired within the scope of the inventory study
Mersin Metropolitan Municipality and relevant sub-units	Wastewater and solid waste statistics, industrial facilities process information, transportation statistics (bicycle path, pedestrian path, public transportation, transportation master plan current status data), master plan, environmental plan
Provincial Directorate of Environment, Urbanization and Climate Change	Number of buildings with energy identity certificate, industrial wastewater treatment plant statistics, waste characterization
Provincial Directorate of Industry and Technology	Sectoral energy consumption statistics, soda, glass and cement production statistics
Provincial Directorate of Agriculture and Forestry	Fertilizer consumption statistics, disaster statistics, district-based animal numbers, fruit, vegetable, ornamental plant and field products production statistics
Regional Directorate of Forestry	Fire statistics, forest areas and production statistics
General Directorate of Meteorology and 1.Regional Office	Historical meteorological data
TURKSTAT Adana Regional Office	Building permit statistics, motor vehicle statistics

In the process of obtaining the data, on 26-27 October 2022, a series of one-on-one meetings on 26-27 October 2022 with the officials of Mersin Metropolitan Municipality, Directorate of Environmental Protection and Control, Directorate of Climate Change and Zero Waste, Directorate of Reconstruction and Urbanization and Directorate of Transportation and officials of Mersin Regional Directorate of Forestry, Mersin Agriculture and Forestry Directorate, Mersin Environment, Urbanization and Climate Change Directorate, Mersin Industry and Technology Directorate and Mersin Chamber of Commerce and Industry.

Base Year

Ensuring data quality and maximum accessibility to data is of great importance in order to maximize the accuracy and minimize the uncertainty of the greenhouse gas emissions inventory. Both greenhouse gas emissions inventory and other statistics such as consumption data lag behind the period in which the study is conducted. Furthermore, the Covid-19 pandemic in 2020 and 2021 led to significant changes in sectoral consumption patterns. Therefore, in order to exclude the effects of the pandemic from the inventory and to conduct the study with the maximum available data, the base year for the greenhouse gas emissions inventory has been set as 2019. However, emission quantities for the years 2020 and 2021 have also been calculated wherever data is available.

4.2.1 Stationary Energy

Stationary energy emissions generally include the residential and commercial buildings, manufacturing and construction industries, energy production, and agriculture, forestry, and fishing sectors associated with fuel consumption and/or production. All emission factors used to determine stationary source emissions have been obtained from the 2022 National Greenhouse Gas Emission Inventory Report.

I.1 Residential Sector

Greenhouse gas emissions from the consumption of fuels in residential buildings within the boundaries of Mersin are obtained by multiplying the fuel consumption within the province by the emission factor corresponding to the fuel type. The total fuel consumption of Mersin in 2019, 2020, and 2021 is provided in Table 4.4. Additionally, as of 2021, the number of residential subscribers using natural gas in Mersin is 131,116 (EMRA_a, 2022).

Table 4.4: Amount of fuel consumed in residential buildings of Mersin

Fuel Type	Amount of Consumption 2019	Amount of Consumption 2020	Amount of Consumption 2021	Unit
Natural gas	67.6	75.9	77.0	Million Sm^3
Kerosene	66	81	78	Tone
LPG	10,356	10,759	10,733	Tone
Domestic coal	37,000	35,340	37,062	Tone
Imported coal	55,500	53,010	55,594	Tone
Wood/biomass	-	-	-	-
Electricity	844,290	846,566	815,061	MWh

Source: (TURKSTAT, 2023; EMRA_a, 2022; PDEUCC, 2022)

According to the GPC, fuel consumptions that occur within the city boundaries should be considered under Scope 1. For this reason, greenhouse gas emissions calculated for natural gas, kerosene, LPG and coal consumption in residential buildings are evaluated under Scope 1 *(I.1.1).* Greenhouse gas emissions from electricity consumption in residential buildings are considered under Scope 2 *(I.1.2)*.

Assumptions and Presumptions

- It was assumed that the fuel sale amounts obtained on a provincial basis from the annual sector reports of EMRA were utilized within the territorial boundaries of Mersin. The assumption is made that around 35% of the consumption attributed to the "LPG (Cylinder)" category in the EMRA reports occurs in the residential sector.
- Greenhouse gas emissions arising from transmission and distribution losses due to grid supplied energy consumption, which are evaluated under Scope 3 (I.1.3), have not been included in the inventory due to the lack of available data.
- In the process of making projections, various factors have been taken into account: For natural gas and coal consumption, factors considered include the number of residential subscribers using natural gas, the total number of residential units, and the mid-year total population. As for electricity consumption, the mid-year total population and per capita GDP have been taken into consideration. Furthermore, for LPG and kerosene consumption, the trend observed between 2015 and 2021, as well as electricity consumption, have been utilized.

I.2 Commercial/Institutional Buildings

The greenhouse gas emissions resulting from fuel consumption in commercial and institutional buildings within the boundaries of Mersin are obtained by multiplying the fuel consumption within the province by the corresponding emission factor for each fuel type. The total fuel consumption for the years 2019, 2020, and 2021 within the boundaries of Mersin is provided in Table 4.5.

Table 4.5: Amount of fuel consumed in commercial/institutional buildings of Mersin

Fuel Type	Amount of Consumption 2019	Amount of Consumption 2020	Amount of Consumption 2021	Unit
Natural gas	15.2	17.5	17.0	Million Sm^3
Fuel oil	3,438	2,996	3,979	Tone
LPG	19,433	20,558	20,508	Tone
Electricity	1,220,176	1,249,113	1,297,755	MWh

Source: (TURKSTAT, 2023; EMRA_a, 2022)

According to the GPC, fuel consumptions that occur within the city boundaries should be considered under Scope 1. Therefore, greenhouse gas emissions calculated for natural gas, fuel oil, and LPG consumption in commercial/institutional buildings are evaluated under Scope 1 (I.2.1). Greenhouse gas emissions resulting from electricity consumption in commercial/institutional buildings are addressed under Scope 2 (I.2.2).

Assumptions and Presumptions

- It was assumed that the fuel sale amounts obtained on a provincial basis from the annual sector reports of EMRA were utilized within the territorial boundaries of Mersin. In the EMRA reports, it is assumed that 6.5% of the consumption specified under the "Cylinder" item for LPG consumption is realized in the service sector.
- Since there is no data on the amount of fuel oil consumed in the service sector in the city, the total fuel oil consumption specified in the dealer delivery category in the reports of EMRA is considered under *I.2 Commercial/Institutional Buildings* sector. In the national energy balance tables, it is noticed that most of the total fuel oil consumption is occurred in the service sectors.
- The sum of electricity consumption from governmental buildings, commercial buildings and street lighting has been accepted as the total electricity consumption of the service sector.

- Greenhouse gas emissions arising from transmission and distribution losses due to grid supplied energy consumption, which are evaluated under Scope 3 (I.1.3), have not been included in the inventory due to the lack of available data.
- When making projections, for natural gas and electricity consumption; gross domestic product and the total population in the middle of the year, LPG and fuel oil consumption trend between 2015-2021 and natural gas consumption were taken into account.

I.3 Manufacturing Industry and Construction

The greenhouse gas emissions resulting from fuel consumption in manufacturing and construction activities within the boundaries of Mersin are calculated by multiplying the fuel type-specific emission factor with the total fuel consumption within the province. The total fuel consumption in Mersin for the years 2019, 2020, and 2021 is provided in Table 4.6.

Table 4.6: Amount of fuel consumption manufacturing and construction industries of Mersin

Fuel Type	Amount of Consumption 2019	Amount of Consumption 2020	Amount of Consumption 2021	Unit
Natural gas	567.7	581.5	723.2	Million Sm^3
Imported coal	591,073	755,108	671,731	Tone
Anthracite	143,181	380,911	147,539	Tone
Petroleum coke	260,839	441,617	247,941	Tone
LPG	1,180	934	1,168	Tone
Fuel oil	163	134	115	Tone
Diesel	14,629	11,042	10,671	Tone
Electricity	2,154,954	2,427,722	2,600,343	MWh

Source: (TURKSTAT, 2023; EMRA_a, 2022; PDEUCC, 2022)

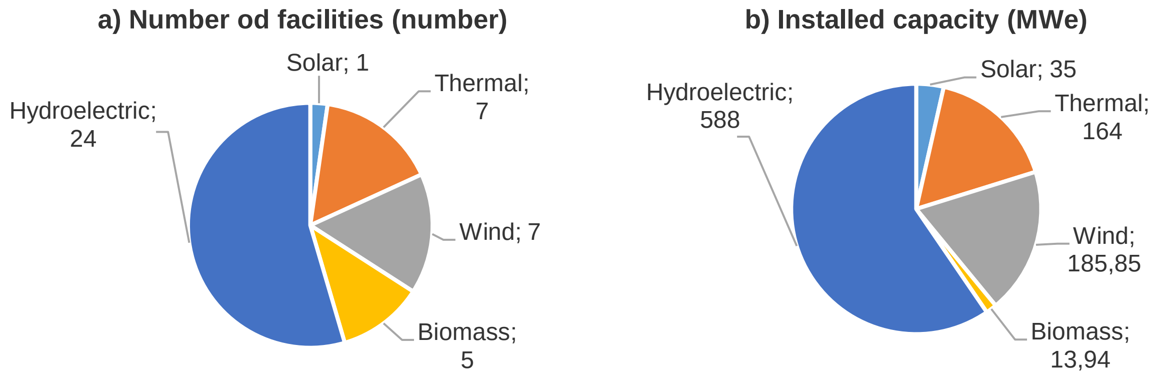
According to the GPC, fuel consumptions that occur within the city boundaries should be considered under Scope 1. Therefore, the greenhouse gas emissions resulting from natural gas, coal, and fuel oil, diesel, and LPG consumption in the manufacturing and construction sectors are evaluated under Scope 1 (I.3.1). The emissions resulting from electricity consumption in these sectors are addressed under Scope 2 (I.3.2).

Assumptions and Presumptions

- It was assumed that the fuel sale amounts obtained on a provincial basis from the annual sector reports of EMRA were utilized within the territorial boundaries of Mersin. For LPG consumption, it is assumed that the entire amount specified under the "Bulk" category in the EMRA reports is attributed to the industrial sector.
- Due to the lack of data on fuel oil consumption in the service sector, the total fuel oil consumption specified in the EMRA reports under the "Free User Delivery" category is considered under Scope 1 of the manufacturing and construction industries (I.3). National energy balance tables also indicate that the majority of total consumption occurs in the service sectors.
- Due to the lack of data on diesel consumption in the industrial sector, 1% to 3% of the total diesel consumption specified in the EMRA reports is considered under Scope 1 of the manufacturing and construction industries (I.3). National energy balance tables also indicate that only a limited portion of total consumption occurs in the industrial sectors.
- The electricity consumption for industrial purposes is considered as the total electricity consumption of the manufacturing and construction industries (I.3).
- Greenhouse gas emissions arising from transmission and distribution losses due to grid supplied energy consumption, which are evaluated under Scope 3 (I.1.3), have not been included in the inventory due to the lack of available data.
- Projections are made taking into account gross domestic product (GDP) for natural gas and diesel consumption, GDP and mid-year total population for electricity consumption, and trends from 2015 to 2021 for solid fuels, LPG, fuel oil consumption, and electricity consumption.

I.4 Energy generation

As of the end of 2022, there are 44 licensed power generation facilities within the boundaries of Mersin, operating for the purpose of electricity production (EMRA_b, 2022). Figure 4.2 provides the number of facilities and their total capacities categorized by facility types.



Source: (EMRA_b, 2022)

Figure 4.2: Number and capacity information of electricity generation plant

Under the category of fossil fuel-based energy generation facilities, there are 4 natural gas-fired thermal power plants with a total capacity of 142.8 MW and 1 naphtha-fired thermal power plant with a capacity of 12.1 MW in Mersin. Additionally, there is a thermal power plant with a capacity of approximately 9.6 MW operating at the ÇİMSA facilities, which generates electricity using process waste heat.

According to the GPC, greenhouse gas emissions from electricity generation activities within the city boundaries are considered out of scope (I.4.4). Similar to other sectors, emissions from the energy generation are calculated by multiplying the fuel consumption of thermal power plants by the emission factor by fuel type. Accordingly, in 2019, 2020, and 2021, the total amount of natural gas consumed in the conversion and cycle sector in Mersin was 140.5 million m^3, 37.3 million m^3, and 50.7 million m^3, respectively. The corresponding CO_2e emissions for the natural gas consumptions were 271.4 kton, 72.1 kton, and 98.0 kton CO_2e, per year, respectively.

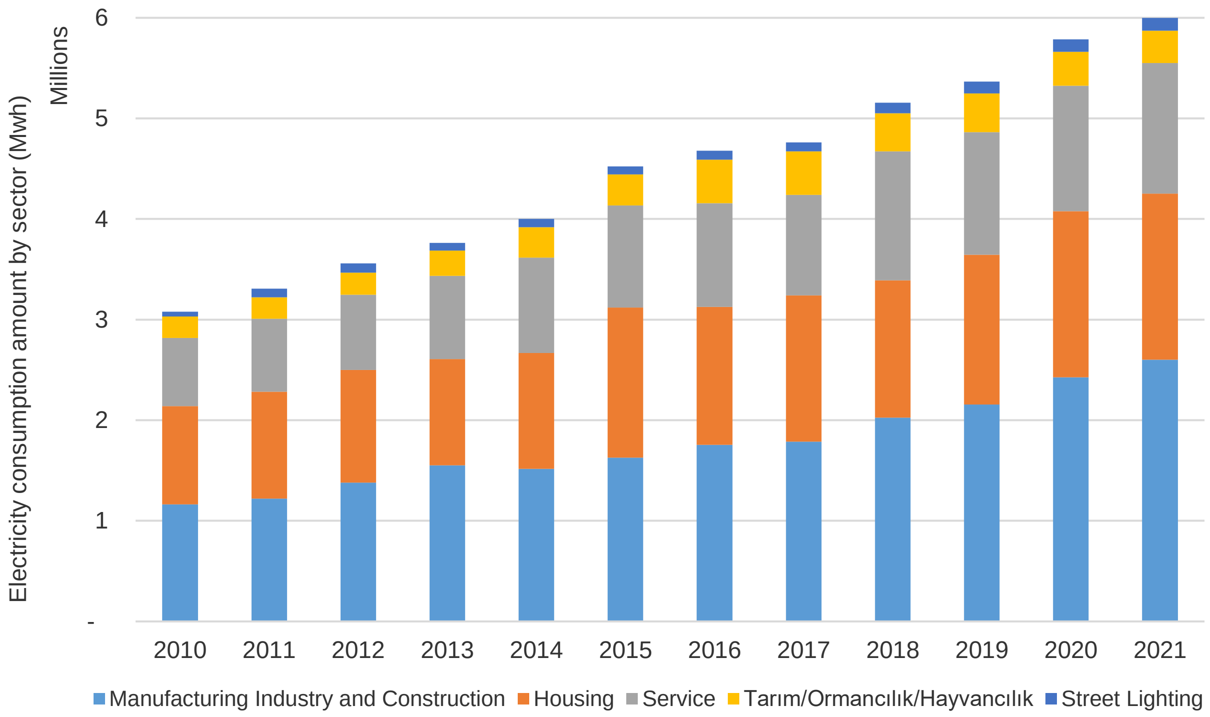
The Provincial Environmental Status Report, prepared annually by the Mersin Provincial Directorate of Environment, Urbanization, and Climate Change, states that the amount of coal consumed in the thermal power plants was 265,543 tons in 2020 and 224,707 tons in 2021. Due to the lack of consumption data for previous years and the absence of a coal-fired thermal power plant operating in the province, the coal consumption data was not included in the inventory calculations.

According to the GPC, fuel consumptions that occur within the city boundaries should be considered under Scope 1. However, when considering fuel consumption information for low-capacity power generation plants, especially those operating within the industrial sectors, it is addressed under the manufacturing and construction industries (Scope 3 - I.3). Therefore, emissions under Scope 1 (I.4.1) are not calculated under this category.

Assumptions and Presumptions

- As for the installed power distribution, capacity and facility information in operation by the end of 2022 and capacity and facility information commissioned between 2014-2021 were evaluated based on Electricity Market License Statistics.
- Greenhouse gas emissions arising from transmission and distribution losses due to grid supplied energy consumption, which are evaluated under Scope 3 (I.1.3), have not been included in the inventory due to the lack of available data.

Finally, the total amount of electricity consumed between 2010 and 2021 on the basis of sectors is given in Figure 4.3.



Source: (EMRA_a, 2022)

Figure 4.3: Total electricity consumption by sectors (Mwh)

I.5 Agriculture, Forestry and Fishing Activities

Greenhouse gas emissions from fuel consumption in the agriculture, forestry, and fishing activities within the boundaries of Mersin were calculated by multiplying the amount of fuel consumed within the province by the emission factor specific to each fuel type. The total fuel consumption within the boundaries of Mersin in 2019, 2020, and 2021 is presented in Table 4.7.

Table 4.7: Amount of fuel consumed in the agricultural activities in Mersin

Fuel Type	Amount of Consumption 2019	Amount of Consumption 2020	Amount of Consumption 2021	Unit
Natural gas	1.40	1.78	2.93	Million Sm^3
Electricity	386,192	336,668	319,800	MWh

Source: (TURKSTAT, 2023; EMRA_a, 2022)

It is also known that coal consumption is being used for heating purposes in greenhouses during agricultural production, and no information has been obtained on the amount of its consumption in Mersin. However, the amount of greenhouse gas emissions related to the total coal consumed in the city is included under the residential sector *(I.1)*.

According to the GPC, fuel consumptions that occur within the city boundaries should be considered under Scope 1. For this reason, greenhouse gas emissions calculated for natural gas consumption in the agriculture, forestry and fishery activities are evaluated under Scope 1 *(*I.5.1*).* Greenhouse gas emissions from electricity consumption in these sectors are considered in Scope 2 *(I.5.2)*.

Assumptions and Presumptions

- Since there is no data on the amount of diesel consumed by the vehicles used in the agricultural sector (off-road vehicles) in the city, the relevant consumption is considered under *the Transport sector II.*
- The amount of electricity consumed in agricultural irrigation and other activities is included under Agriculture, Forestry and Fishing Activities.
- Greenhouse gas emissions arising from transmission and distribution losses due to grid supplied energy consumption, which are evaluated under Scope 3 (I.1.3), have not been included in the inventory due to the lack of available data.
- When making projections for natural gas and electricity consumption, gross domestic product and the trend between 2010-2021 were taken into account.

4.2.2 Transportation

The greenhouse gas emissions due to the transportation sector are considered under five sub-sectors: road, railway, waterborne navigation, aviation, and off-road. All emission factors used to determine emissions from the transportation sector are obtained from the 2022 National Greenhouse Gas Emission Inventory Report.

II.1 Road Transportation

In the GPC, due to differences in data availability, a specific method is not recommended for calculating road emissions. The methodologies used to determine emissions are generally categorized as top-down and bottom-up approaches. The top-down approach computes the emission amount by multiplying the total fuel sold with the greenhouse gas emission factor, while the bottom-up approach requires detailed activity data.

Greenhouse gas emissions from road transportation in Mersin are derived by multiplying the amount of fuel sold within the city's boundaries by the emission factor specific to the fuel type. The fuel consumption data for Mersin in the years 2019, 2020, and 2021 are provided in Table 4.8.

Table 4.8: The amount of fuel consumed within the scope of road transportation in Mersin

Fuel Type	Amount of Consumption 2019	Amount of Consumption 2020	Amount of Consumption 2021	Unit
Gasoline	50,487	52,025	67,029	Tone
Diesel	797,361	785,246	775,395	Tone
LPG	87,016	83,349	82,793	Tone
CNG	681	5	1,564	Bin Sm^3

Source: (EMRA_a, 2022)

The amount of diesel fuel sold within the province of Mersin has been evaluated in terms of consumption under the sub-category of road transport, excluding the consumption in manufacturing industry, railway, and waterborne navigation. This ratio corresponds to an average of 97%, including vehicles such as tractors that fall under the off-road category. In order to distribute the total fuel sales according to the sub-category of road vehicles, it is necessary to allocate them based on vehicle classes. The number of vehicles determined by fuel types within the boundaries of Mersin province for the year 2019 is presented in Table 4.9. The total number of vehicles for the year 2019 is 619,418.

Table 4.9: Number of motor vehicles by fuel type in 2019

Fuel Type	Truck	Truck	Minibus	Motorcycle	Bus	Car	Special Purpose	Tractor
Gasoline	116	2,157	157	148,448	22	54,304	45	715
Diesel	32,732	101,877	8,975	184	5,316	98,203	1,282	34,860
LPG	2	2,916	5	10	1	125,838	1	1
CNG	-	-	-	2	-	-	-	-
Diesel-Electric	-	-	-	-	-	22	-	-
Gasoline-Electric	-	-	-	-	-	149	-	-
Electricity	-	-	-	1.069	-	8	-	-
TOTAL	**32,850**	**106,950**	**9,137**	**149,714**	**5,339**	**278,524**	**1,328**	**35,576**

Source: (TURKSTAT, 2023)

According to the GPC, even if fuel purchases are made for cross-border travels, all domestic fuel sales should be considered under Scope 1. Therefore, the greenhouse gas emissions calculated for vehicles powered by gasoline, diesel, and LPG fuels are evaluated under Scope 1 (II.1.1). The calculations related to transit travels included in Scope 1 emissions are based on highway transit data found in the 2019, 2020, and 2021 Traffic and Transportation Information Reports prepared by the General Directorate of Highways.

Assumptions and Presumptions

- It was assumed that the fuel sale amounts obtained on a provincial basis from the annual sector reports of EMRA were utilized within the territorial boundaries of Mersin.
- It was assumed that all of the gasoline consumed within the province is used in the road subcategory of the transport sector.
- The consumption rates of diesel for the manufacturing industry, railway and maritime transportation were determined by using the Energy Balance Tables.
- Scope 2 *(II.1.2)* emissions from the consumption of electrically powered vehicles are included in the inventory under stationary energy.
- Emissions from cross-border travel outside the city, which are considered under Scope 3, and transmission and distribution losses due to grid-supplied energy for electric vehicle use, are not included in the inventory due to the lack of fuel consumption data.
- When projections were computed to estimate the number of vehicles per 1,000 people, a regression analysis was used using the data of workable population aged between 15 and 64 year and GDP per capita in the last 15 years.
- Calculations for transit for the road are also included in the inventory.

II.2 Railway

There is no urban rail transportation system used for intra-city transportation within the boundaries of Mersin province. The length of the Mersin-Yenice railway line, which is used for intercity transportation, and train-kilometer data were obtained from the TCDD (Turkish State Railways) 2017-2021 Statistical Yearbook. The greenhouse gas emissions resulting from railway transportation in Mersin are calculated by multiplying the amount of fuel sold within the provincial boundaries by the emission factor corresponding to the fuel type. The amount of diesel fuel consumed for railways in Mersin is calculated as 2,163 tons, 1,039 tons, and 1,854 tons for the years 2019, 2020, and 2021, respectively (EMRA_a, 2022). Scope 1 emissions include the emissions resulting from the direct combustion of fossil fuels during the railway transit time within the city boundaries of stationary railway lines. The greenhouse gas emissions calculated for diesel consumption are evaluated under Scope 1 (II.2.1).

Assumptions and Presumptions

- The entire railway line operating within the boundaries of Mersin province is assumed to be diesel-powered.
- It is assumed that the fuel sales quantities obtained from the annual sector reports of EMRA are used within the boundaries of Mersin.
- The consumption rates of diesel for railway transportation are determined based on the National Inventory Report CRF tables and train-kilometer statistics, assuming that it will account for approximately 0.3% of the total consumption.
- Since there is no electricity provided from the grid to power rail transportation systems, Scope 2 (II.2.2) emissions are not included in the inventory.
- Emissions related to trips outside the city boundaries, which are evaluated under Scope 3, are not included in the inventory due to unavailable data.

II.3 Waterborne Navigation

Waterborne navigation encompasses ships, ferries, and other vessels operating within the city boundaries, as well as sea vehicles whose journeys commence or conclude at ports within the city boundaries but have destinations outside the city.

The greenhouse gas emissions attributed to waterborne navigation in Mersin have been obtained by multiplying the quantity of fuel sold within the provincial boundaries by the emission factor corresponding to the fuel type. The fuel consumption amount within the Mersin province in 2019 is provided in Table 4.10.

Table 4.10: The amount of fuel consumed within the scope of waterborne navigation in Mersin

Fuel Type	Amount of Consumption 2019	Amount of Consumption 2020	Amount of Consumption 2021	Unit
Fuel-Oil Marine Fuel	649	0	0	Tone
Diesel	12,889	13,741	10,724	Tone

Source: (EMRA_a, 2022)

Greenhouse gas emissions from waterborne navigation in Mersin have been calculated based on the fuel consumption data obtained from the EMRA Sector Reports, considering fuel-oil as the maritime fuel. Furthermore, diesel fuel consumption has been included in waterborne navigation to a certain extent.

Scope 1 emissions encompass the emissions resulting from the direct combustion of fossil fuels for all journeys that begin and end within the city boundaries. The greenhouse gas emissions calculated for diesel fuel and fuel oil consumption are evaluated under Scope 1 (II.3.1).

Assumptions and Presumptions

- The assumption is made that the fuel sales quantities obtained from annual sector reports of EMRA are used within the boundaries of Mersin.
- The consumption rates of diesel fuel for sea transportation are determined based on Energy Balance Tables, assuming that it accounts for approximately 1.6% of the total consumption.
- Scope 2 emissions, which originate from any grid-supplied energy consumed by marine vessels typically at piers or ports, are included in the inventory under Scope 2 (II.3.2) emissions in the stationary sources category.
- Emissions associated with journeys outside the city, evaluated under Scope 3, are not included in the inventory due to the unavailability of fuel consumption data.

II.4 Aviation

There is no airport within the borders of Mersin province.

II.5 Off-road

Greenhouse gas emissions of this category, which typically includes off-road vehicles, landscaping and construction equipment, tractors, bulldozers, snowmobiles and other off-road vehicles, are assessed under *II.1 Road Transportation* and Scope 1 (*II.1.1).*

4.2.3 Waste and Wastewater

The waste sector is covered under four subcategories in the GPC: solid waste disposal, biological treatment of waste, waste incineration (including open burning), and wastewater treatment and discharge. All emission factors, as well as other factors and coefficients used to determine emissions from the waste sector, are obtained from the 2022 National Greenhouse Gas Emission Inventory Report.

III.1 Solid Waste Disposal

Within the scope of solid waste disposal, CH_4 emissions arising from the storage of domestic (municipal) and industrial wastes are handled. In the calculation of CH_4 emissions, the sanitary landfills were classified as managed waste disposal sites, while applications such as municipal dumps and burial practices are classified as unmanaged waste disposal sites. The calculations rely on municipal waste indicators published on a provincial basis by TURKSTAT, data provided by the Mersin Metropolitan Municipality, and the Provincial Environmental Status Report (PDEUCC, 2022; TURKSTAT, 2021).

Methane emissions released from landfill areas continue for several decades (and sometimes even centuries) after waste disposal. Waste disposed of in a specific year contributes to greenhouse gas emissions in that year and subsequent years. The same applies to unmanaged landfill areas other than sanitary landfills. Therefore, the first-order decay (FOD) method, which is one of the widely accepted approaches to estimate methane emissions from solid waste disposal, has been preferred.

$$CH_4 = \{\sum_x \left[MSW_x \; x \; L_0(x) \; x \; \left(\left(1-e^{-k}\right) x \;\; e^{-k(t-x)}\right)\right] - R(t)\} \; x \; (1-OX)$$

Given in equality;

***CH_4* :** *Total CH_4 emissions intonnes*

x: *Landfill opening year or earliest year of historical data available*

t: *Inventory year*

***MSW_x*:** *Total municipal solid waste disposed at SWDS* in year x *in tonnes*

R: *Methane recovered in inventory year, tons*

L_o: *Methane generation potential (* $L_0 = MCF\ x\ DOC\ x\ DOC_F\ x\ F\ x\ 16/12$*)*

k: *Methane generation rate constant*

OX: *Oxidation factor*

MCF: *Methane correction factor based on type of landfill site for the year of deposition*

DOC: *Degradable organic carbon in year of deposition, fraction (tonnes C/tonnes waste)*

DOC_F: *Fraction of DOC that is ultimately degraded*

F: *Fraction of methane in landfill gas*

Within the scope of solid waste disposal, the data on the amount of municipal waste produced and sent to landfill in Mersin for the years 2019, 2020 and 2021 are given in Table 4.11 Apart from the amount of waste send off for disposal, 116, 167 and 171 kt of waste were sent to recovery for 2019, 2020 and 2021, respectively.

Table 4.11: Quantities of municipal waste produced in Mersin and send off for disposal sites

AtıkTürü	Amount of Waste 2019	Amount of Waste 2020	Amount of Waste 2021	Unit
Municipal Solid Waste	763	819	839	kt/year
Waste Per Capita	1.15	1.2	1.1	ton/year. person
Amount of waste sent to managed disposal sites	577	597	613	kt/year
Amount of waste sent to unmanaged disposal sites	70	54	56	kt/year

Since the disposal of solid wastes is carried out within the boundaries of Mersin province, the calculated emissions are evaluated under Scope 1 *(III.1.1).*

Assumptions and Presumptions

- Waste composition data was provided by Mersin Metropolitan Municipality, and missing historical data ws completed based on the Turkish national average.
- The amount of methane gas recovered from the Merkez, Silifke, and Tarsus solid waste disposal sites (sanitary landfills) has been taken into account in the in the calculations.
- Sludge sent to the disposal facilities was also included in the calculations.

- Medical wastes generated within the provincial boundaries are sterilized at the Medical Waste Sterilization Facility in Mersin and then disposed off at the sanitary landfill under the administration of Mersin Metropolitan Municipality. It is assumed that all medical wastes are disposed of in the sanitary landfills.
- It is assumed that approximately 2% of currently generated industrial wastes are sent to disposal sites, and all of them are disposed of in unmanaged disposalsites. This percentage is derived from calculations in the National Inventory Report of Türkiye.
- Emissions from solid waste generated within the city boundary but disposed in landfills or open dumps outside the city boundary are not included in the inventory due to lack of data.

III.2 Biological Treatment of Wastes

Biological treatment of wastes includes the composting and anaerobic digestion of food waste, garden and park waste, sludge, and other organic wastes. The biological treatment of solid wastes reduces the total waste volume and the toxicity of the waste for final disposal (landfilling or incineration). In cases where wastes are biologically treated (e.g., composting), the associated emissions of CH_4, N_2O, and non-biogenic CO_2 resulting from the biological processing of the waste are calculated (GPC, 2014). The amount of methane recovered at the Karaduvar and Mezitli Anaerobic Digestion Plants is reported under the III.4 *Wastewater Treatment and Discharge* section..

III.3 Incineration of Waste

Incineration is a controlled and industrial process that allows for energy recovery and where inputs and emissions can be measured, making it a reliable method. In contrast, open burning is an uncontrolled and usually illegal process. When calculating emissions, different data should be used for incineration and open burning. Emissions from incineration include CH_4, N_2O, and non-biogenic CO_2 (GPC, 2014). However, since open burning is not practiced in Mersin, it is not included in the inventory calculations.

III.4 Wastewater Treatment and Discharge

Wastewater can be categorized as domestic and industrial wastewater, and as a result of the treatment of wastewater, CH_4 and N_2O emissions are released. In the calculation of CH_4 emissions from domestic and industrial wastewater, data such as the amount of rural and urban population, organic content of wastewater are needed. In this context, municipal wastewater statistics published by TURKSTAT and the Provincial Environmental Status Report published by TURKSTAT were used for the data needed in the calculations (PDEUCC, 2022; TURKSTAT, 2021)

$$CH_4 = \sum_i [(TOW_i \, x \, S_i)EF_i - R_i] \, x \, 10^{-3}$$

Given in equality;

***CH_4* :** *Total CH_4 emissions in metric tonnes*

***TOW_i*:** *Organic content in the wastewater (kg BOD/year for domestic wastewater, kg COD/year for industrial wastewater)* $TOW_i = P \, x \, BOİ \, x \, I \, x \, 365$

***EF_i*:** *Emission factor (*kg CH_4/ kgBOD for domestic wastewater, kg *CH_4/ kgCOD for industrial wastewater)*

$$EF_j = B_o \, x \, MCF_j \, x \, U_i \, x \, T_{i,j}$$

***S_i*:** *Organic component removed as sludge in inventory year (kg BOD/year for domestic wastewater, kg COD/year for industrial wastewater)*

***R_i*:** *Amount of CH_4 recovered in inventory year, kg CH_4/year*

***i*:** *Income group*

***P*:** *City population in inventory year*

***BOD*:** *City-specific per capita BOD in inventory year, g BOI /person/day*

***I*:** *Correction factor for additional industrial BOD discharged into sewers*

***B_o*:** Maximum *CH_4*, kg CH_4/kg *BOD or kg CH_4/kg COD*

***MCF_j*:** *Methane correction factor (fraction)*

***U_i*:** *Fraction of population in income group i in inventory year*

***$T_{i,j}$*:** *Degree of utilization (ratio) of treatment/discharge pathway or system, j,for each income group fraction i in inventory year*

N_2O emissions can arise as direct emissions from treatment processes in wastewater treatment plants or as indirect emissions due to the discharge of wastewater into receiving bodies. Although direct emissions from nitrification and denitrification processes in wastewater treatment plants are considered to be a minor source, they have been considered in the calculations.

$$N_2O = [(P \, x \, Protein \, x \, F_{NPR} x \, F_{NON-COM} \, x \, F_{IND-COM}) - N_{SLUDGE}] \; EF_{EFFLUENT} \, x \, \frac{44}{28} x \, 10^{-3}$$

The terms given in equation

N_2O: *Total* N_2O emissions in tonnes

P: *The total population served by the treatment plant*

Protein: *Annual per capita protein consumption,, kg/person/year*

$F_{NON\text{-}COM}$: Factor to adjust for non-consumed protein

F_{NPR}: *Nitrogen fraction in protein*

$F_{IND\text{-}COM}$: *Factor for industrial and commercial co-discharged protein into the sewer system*

N_{SLUDGE}: *Nitrogen removed with sludge, kg N/year*

$EF_{EFFLUENT}$: Emission factor for N_2O emissions from discharged to wastewater kg *N_2O-N/kg N_2*O

The industrial wastewater amount in Mersin for 2019, 2020 and 2021 is 15,405, 15,180 and 17,196 thousand m^3/year, respectively (PDEUCC, 2022; TURKSTAT, 2021). Since wastewater treatment and discharge are carried out within the boundaries of Mersin province, the calculated emissions are evaluated under Scope 1 *(III.4.1).*

Assumptions and Presumptions

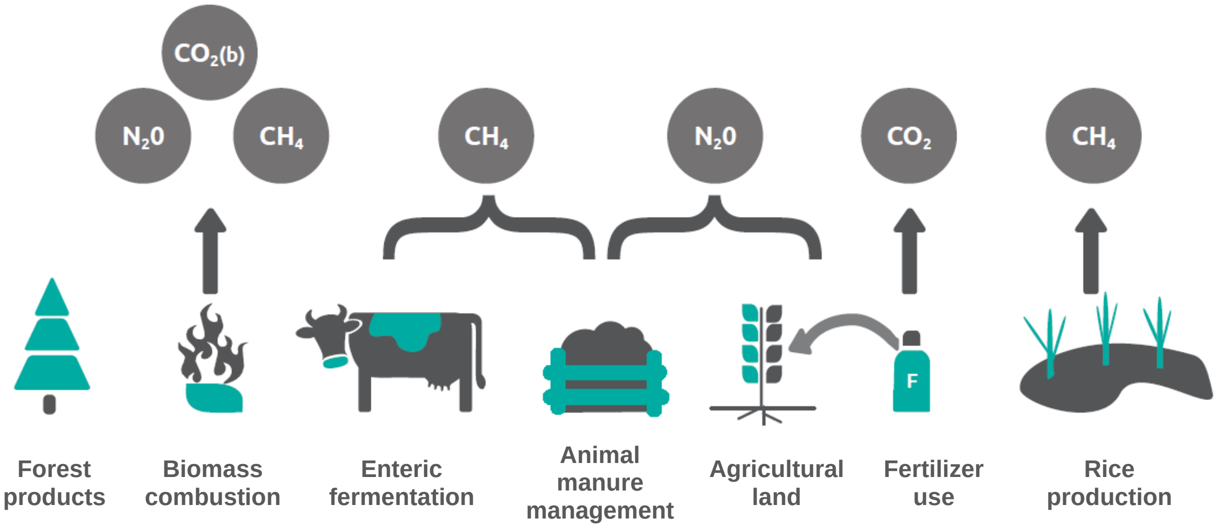
- The emission factors and other factors used in the calculations (e.g., FNON-COM, I, Bo vb.) were obtained from the National Greenhouse Gas Inventory, and it is assumed that they are the same for Mersin.
- Data on wastewater generated within the city boundary but treated outside of the city boundary is not available; therefore, Scope 3 emissions were not included in the inventory.
- Methane emissions from sludge recovery at Karaduvar and Mezitli Wastewater Treatment Plants were included in the calculations.

4.2.4 Industrial Processes and Product Use

All greenhouse gas emissions arising from industrial processes, product use and non-energy uses of fossil fuels are evaluated under this scope. Emissions from two cement plants, three glass plants, and one soda production facility operating in Mersin province have been calculated using activity data and greenhouse gas emission reports obtained from these facilities. Due to insufficient data, emissions related to product use are currently not included in the inventory.

4.2.5 Agriculture, Forestry and Other Land Use

Emissions/sinks from agriculture, forestry, and other land use are classified into three subcategories in the GPC: Livestock emissions, emissions and sinks from land use and land-use change, and emissions from agricultural lands (Figure 4.4). All emission factors used in determining emissions/sinks from agriculture, forestry, and other land use are derived from the 2022 National Greenhouse Gas Emission Inventory Report.



Source: (GPC, 2014)

Figure 4.4: Distribution of emissions/sinks from agriculture, forestry and other land use

V.1 Emissions from livestock

Under this section, CH_4 emissions from enteric fermentation and CH_4 and N_2O emissions from animal manure processing are investigated. In the calculations, livestock statistics published by TURKSTAT on a province-specific basis were used (TURKSTAT, 2021).

The amount of CH_4 emissions generated as a result of enteric fermentation is obtained by multiplying the number of animals by the emission factors specific to the animal type. Data on the number of animals used in the calculations were retrieved from TURKSTAT statistics. As for the emission factor, the values specified in the IPCC 2006 guidelines for Western Europe and Asia are used.

$$CH_4 = N_T \ x \ EF_{enteric,T} \ x \ 10^6$$

The terms given in the above equation are explained as

CH_4 4: Total *CH_4* emissions *per year (kt)*

***T:** Animal species*

***N_T:** Total number of animals per year (head)*

***$EF_{enteric,\ T}$** fermentation emission factor* for animal species *(kg CH_4/head/year)*

The amount of CH_4 emissions generated as a result of the use of animal manure is obtained by multiplying the number of animals by the emission factors specific to the animal type. The amount of N_2O emission resulting from the use of animal manure is obtained by multiplying the number of animals by the emission factors specific to the animal type and the rate related to the manure management system. Data on the number of animals used in the calculations were retrieved from TURKSTAT statistics. Emission factors including the effect of animal type and manure management system together are taken from the National Greenhouse Gas Emission Inventory Report for 2022 years.

$$CH_4\ /\ N_2O = N_T\ x\ EF_{manure,T}\ x\ 10^{-6}$$

The terms given in the above equation are explained as:

***CH_4 / N_2O:** Total annual CH_4 / N_2O emissions (kt)*

***T:** Animal species*

***N_T:** Total number of animals per year (head)*

***$EF_{manure,T}$:** Fertilizer management emission factor for T* animal species *(kg CH_4/head/year – kg N_2O/head/year)*

V.2 Emissions/sinks from land use and land-use change

In this section, land uses are classified under 6 categories in accordance with the IPCC: forest land, cropland, grassland, wetland, settlement and other land. GPC recommends a simplified approach that consists of multiplying the net annual carbon stock change by surface area for different categories of land use (and land use change). The total change in carbon stock is calculated by the equation given below.

$$\Delta C_{AFOLU} = \Delta C_{FL} + \Delta C_{CL} + \Delta C_{GL} + \Delta C_{WL} + \Delta C_{SL} + \Delta C_{OL}$$

The terms in the above equation are explained as:

***Δ:** Carbon stock change*

***AFOLU:** Agriculture, Forestry and Other Land Use*

FL: *Forest land*, **CL** *Cropland*, **GL**: *Grassland*, ***WL***: *Wetland,* ***SL***: *Settlements* and ***OL:*** *Other land*

Land use data for Mersin were obtained from CORİNE (Coordination of Information on the Environment Inventory) and classified according to the categories described above (CORINE, 2018). The land use distribution of the province in 2018 is given in Figure 4.5.

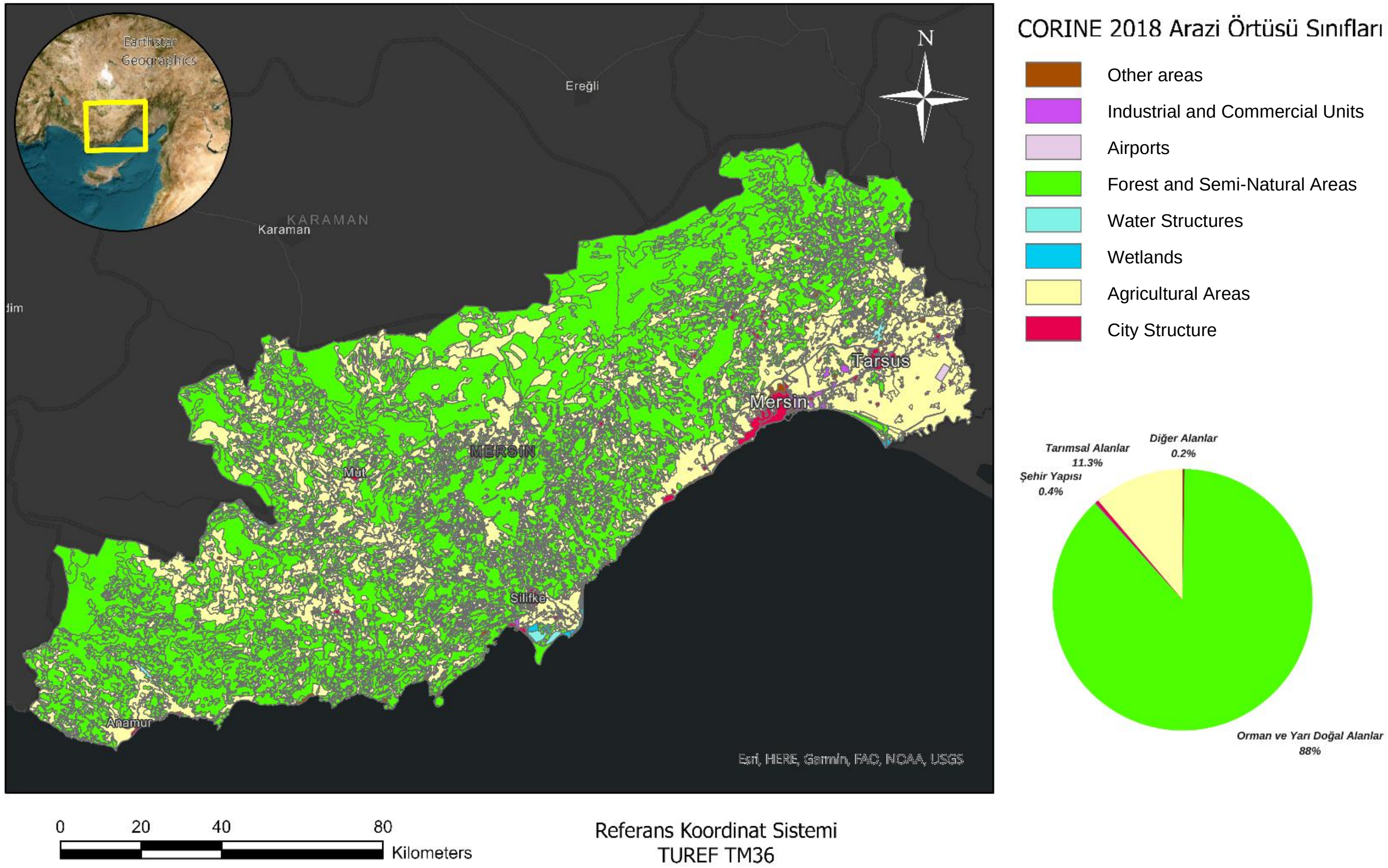


Figure 4.5: Land use distribution of Mersin in 2018

Land use changes were evaluated using the CORİNE database and emissions due to land use changes were included in the inventory. In this context, the amount of areal changes between 1990 and 2018 is given in Table 4.12. The amount of emissions and sinks caused by this change is indicated in Table 4.13.

Table 4.12: The amount of land exchange in Mersin (1990-2018) (ha)

Intended use of land		2018					
		Forest land	Cropland	Grassland	Wetlands	Settlements	Other land
1990	Forest land		13,791	84,943	167	938	327
	Cropland	8,382		31,711	1,381	15,613	657
	Grassland	98,589	141,880		360	3,068	39,147
	Wetlands	35	950	708		103	368
	Settlements	-	-	-	-		-
	Other land	2,313	485	10,116	76	39	

Source: (CORINE, 2018)

Table 4.13: Emissions and sinks from Mersin due to land use changes

Intended use of land	Area changed between 1990-2018 (ha)	Total net emissions ($t_{,CO2,e}$)	Net emissions on an annual basis ($t_{CO2}e$)
Forest land	100,165	1,377,335	49,191
Cropland	57,744	101,838	3,637
Grassland	283,044	-252,995	-9,036
Wetlands	2,163	850	30
Settlements	3,606	95	3
Other land	13,029	-64,808	-2,315

V.3 Emissions from agricultural land

The following emission sources are considered under this category:

1. CO_2 emissions from the application of urea fertilizers.
2. N_2O emissions from the application of synthetic fertilizers.
3. N_2O emissions from the application of animal manure to the soil.
4. N_2O emissions from urine and dung deposited by grazing animals.
5. CH_4 emissions from rice production.

In addition to these, CH_4 and N_2O emissions from the burning of agricultural residues and N_2O emissions from composting are not included in the inventory due to a lack of information on the occurrence of these activities in the region and the fact that these categories are not considered key categories in the 2022 National Greenhouse Gas Emission Inventory Report. N_2O emissions from agricultural residues, organic matter loss/gain in soil, atmospheric deposition, and leaching/surface runoff have also not been included in the inventory.

1. The amount of CO_2 emissions resulting from the use of urea fertilizers is calculated by multiplying the amount of fertilizer used by the corresponding emission factor. The physical consumption of fertilizers used in the calculations is obtained from the Mersin Provincial Directorate of Agriculture and Forestry.

$$CO_2 = M \, x \, EF \, x \, \frac{44}{12} \, x \, 10^{-3}$$

The terms given in the above equation are expressed as:

CO_2: *Total annual CO_2 emissions (kt)*

M: *Total annual urea fertilizer consumption (t)*

EF: *Emission factor (0.2 t CO_2-C / t urea fertilizer)*

2. The amount of N_2O emissions resulting from the use of synthetic fertilizers is calculated by multiplying the nitrogen content in the fertilizer by the corresponding emission factor. The equivalent amount of fertilizer used in the calculations is determined using the physical consumption values of nitrogen-based fertilizers provided by the Mersin Provincial Directorate of Agriculture and Forestry.

$$N_2O = M \, x \, 0{,}21 \, x \, EF \, x \, \frac{44}{28} \, x \, 10^{-3}$$

The terms given in the above equation are expressed as:

N_2O: *Total annual N_2Oemission (kt)*

M: *Total annual consumption of nitrogen fertilizer (t)*

EF: *Emission factor (0.1 kg N_2O-N / kg N)*

3. The amount of N_2O emissions resulting from the application of animal manure to the soil is calculated by multiplying the livestock population values by the nitrogen conversion rates specific to each animal type, the rates related to the manure management system, and the corresponding emission factor. The livestock population data used in the calculations is obtained from the TURKSTAT statistics. The emission factors that incorporate both the animal type and the manure management system are obtained from the 2022 National Greenhouse Gas Emission Inventory Report.

$$N_2O = N_T \; x \; EF_{soilmanure,\; T} \; x \; (1 - \; Frac_{other}) \; x \; EF \; x \; \frac{44}{28} \; x \; 10^{-6}$$

The terms given in the above equation are expressed as:

N_2O: *Total annual N_2O emission (kt)*

T: *Animal species*

N_T: *Total number of animals per year (head)*

$EF_{soil\ fertilizer,\ T}$: *Emission* factor for T animal species *(kg N/head/year)*

$Frac_{other}$: *Proportion of use of animal manure in other applications (%)*

EF: *Emission factor (0.1* kg N_2O*-N / kg N)*

4. The amount of N_2O emissions generated from the excrement of grazing animals is calculated by multiplying the livestock population values by the nitrogen conversion rates specific to each animal type, the rates related to the manure management system, and the corresponding emission factor. In this context, factors related to pasture lands have been chosen for the selection of manure management system factors. The livestock population data used in the calculations is obtained from the TURKSTAT statistics. The emission factors that incorporate both the animal type and the manure management system, taking into account their combined effect, are obtained from the 2022 National Greenhouse Gas Emission Inventory Report.

$$N_2O = N_T \ x \ EF_{pasturemanure, \ T} \ x \ EF \ x \ \frac{44}{28} \ x \ 10^{-6}$$

The terms given in the above equation are expressed as:

N_2O: *Total annual N_2O emissions (kt)*

T: *Animal species*

N_T: *Total number of animals per year (head)*

$EF_{pasturemanure, T}$: *Emission* factor for T animal species *(kg N/head/year)*

EF: *Emission factor (0.1 kg N_2O-N / kg N)*

5. The amount of CH_4 emissions generated from rice production is obtained by multiplying the area of rice cultivation by the corresponding emission factor. The data on rice cultivation area used in the calculations is obtained from the TURKSTAT statistics. The emission factors are obtained from the relevant 2022 National Greenhouse Gas Emission Inventory Report. The determination of emission factors takes into account the irrigation regime (continuously flooded, intermittently flooded-single aeration, and intermittently flooded-multiple aeration), and it is assumed that the practice in Mersin is compatible with the national practices.

$$CH_4 = M \ x \ EF_{irrigation, \ T} \ x \ 10^{-6}$$

The terms given in the above equation are expressed as:

CH_4 : *Total annual CH_4 emission (kt)*

M: *Area planted with rice (decares/year)*

$EF_{irrigation}$: Emission factor for T irrigation type *(g CH_4 / m^2)*

4.3. Total Greenhouse Gas Emission

The amounts of greenhouse gas emissions for 2019 as the inventory base year, and 2020 and 2021 realized on the basis of sectors within the borders of Mersin province are given in Table 4.14 and Table 4.15with the units of CO_2e. The distribution of emissions among the main sectors is shown in Figure 4.6, Figure 4.7 and Figure 4.8. Accordingly, the largest share is taken by stationary energy with an average of 44%, followed by the transportation sector with 24%. The total net emissions calculated for the whole province of Mersin for 2019, 2020 and 2021 are 15,593 Mtons, 18,097 Mtons and 17,310 Mtons of CO_2e, respectively. With these values, the total greenhouse gas emissions in Mersin constitute approximately 3.1% of the total greenhouse gas emissions of Türkiye.

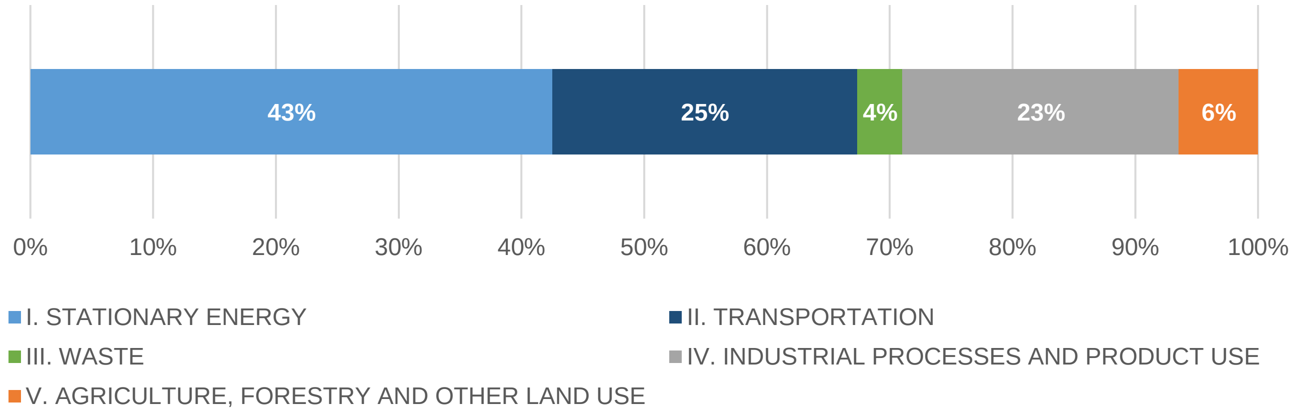


Figure 4.6: Sectoral distribution of total greenhouse gas emissions in 2019 (%)

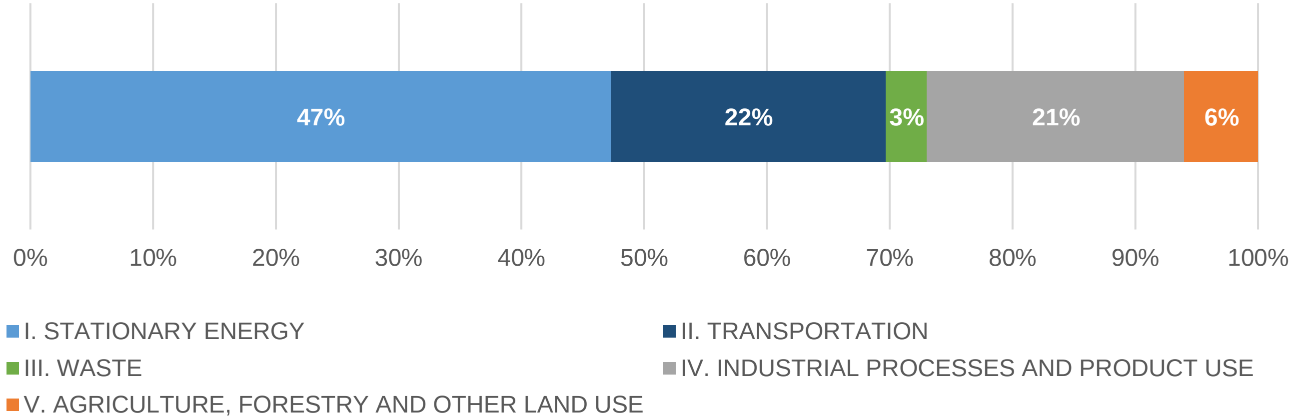


Figure 4.7: Sectoral distribution of total greenhouse gas emissions in 2020 (%)

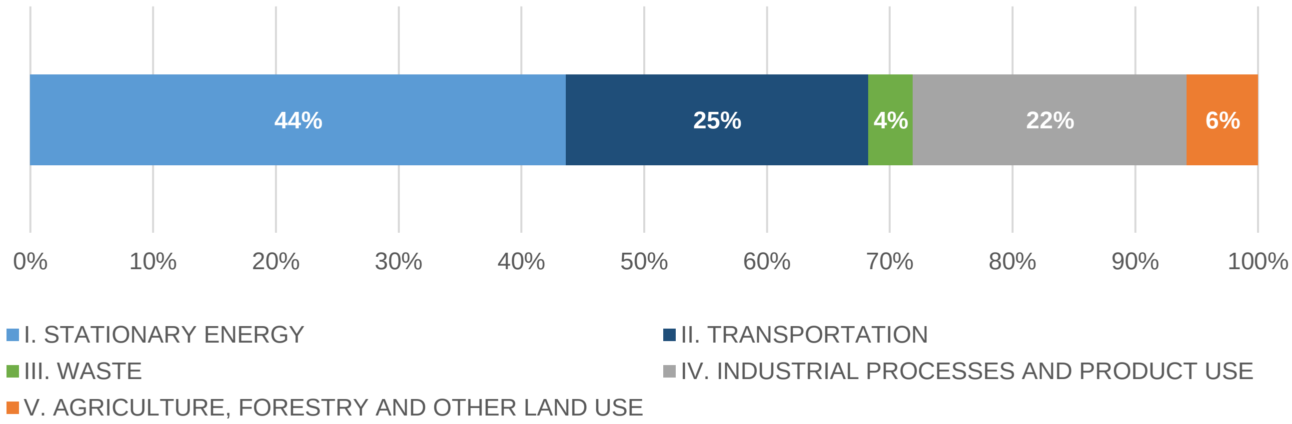


Figure 4.8: Sectoral distribution of total greenhouse gas emissions in 2021 (%)

When an evaluation is made in terms of emissions per capita, it is seen that the three-year average for Mersin province is 9.1 kg CO_2e/person (Figure 4.9). This value is 30% higher compared to the Turkish average level of 6.35 kg CO_2 e/person.

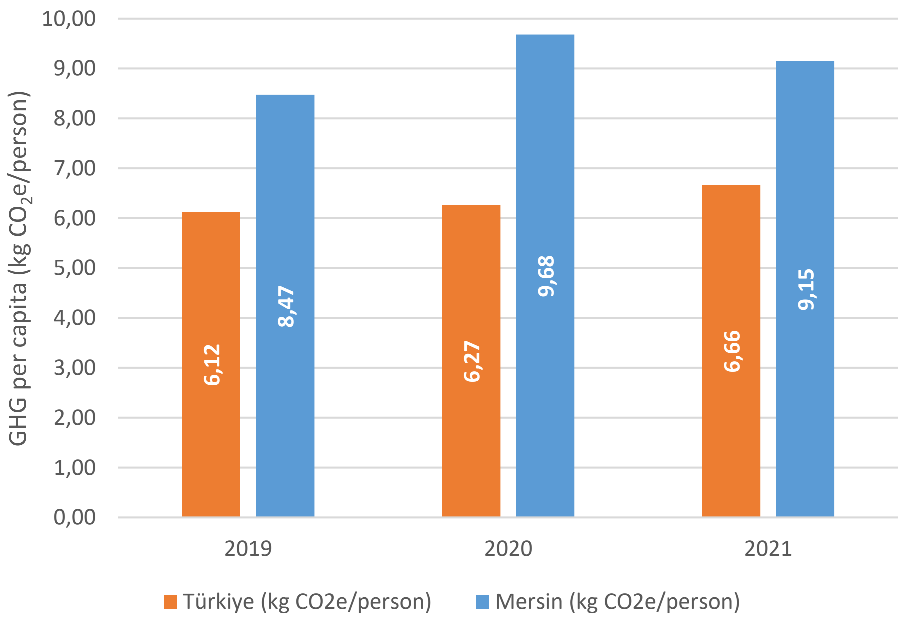


Figure 4.9: Amount of greenhouse gas emissions per capita (kg CO_2e/person)

Table 4.14: Total emissions by greenhouse gas type (kt CO_2e)

Sector	GHG (kt CO_2e)								
	2019			2020			2021		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
I. STATIONARY ENERGY	**6,597.5**	**21.5**	**11.6**	**8,515.1**	**24.0**	**17.2**	**7,514.0**	**22.7**	**12.6**
I.1 Residential buildings	1,005.3	13.3	0.9	1,130.9	12.7	0.8	1,142.1	13.3	0.9
I.2 Commercial/Institutional buildings and facilities	711.2	0.2	0.1	767.1	0.2	0.1	796.2	0.2	0.1
I.3 Manufacturing Industries and construction	4,701.3	8.0	10.7	6,450.6	11.0	16.3	5,415.4	9.1	11.7
I.4 Energy industries	269.5	0.5	1.4	71.6	0.1	0.4	97.3	0.2	0.5
I.5 Agriculture, forestry and fishing activities	179.7	-	-	166.4	-	-	160.3	-	-
I.6 Non-specified sources	-	-	-	-	-	-	-	-	-
I.7 Fugitive emissions from mining, processing, storage, and transportation of coal	-	-	-	-	-	-	-	-	-
I.8 Fugitive emissions from oil and natural gas systems	-	-	-	-	-	-	-	-	-
II. TRANSPORTATION	**3,791.9**	**15.1**	**60.3**	**3,974.5**	**15.8**	**62.6**	**4,179.1**	**18.4**	**66.4**
II.1 Road transportation	3,741.4	15.0	59.0	3,928.2	15.7	61.9	4,139.7	18.3	65.4
II.2 Railways	8.2	-	1.0	3.3	-	0.4	5.8	-	0.7
II.3 Waterborne navigation	42.4	0.1	0.3	43.0	0.1	0.4	33.6	0.1	0.3
II.4 Aviation	-	-	-	-	-	-	-	-	-
II.5 Off-road transportation	-	-	-	-	-	-	-	-	-
III. WASTE	**16.4**	**405.9**	**157.7**	**14.9**	**431.2**	**159.8**	**14.6**	**452.1**	**161.8**
III.1 Solid waste disposal	16.4	319.2	-	14.9	344.5	-	14.6	362.4	-
III.2 Biological treatment of wastes	-	-	-	-	-	-	-	-	-
III.3 Incineration and open burning	-	-	-	-	-	-	-	-	-
III.4 Wastewater treatment and discharge	-	86.7	157.7	0.0	86.7	159.8	-	89.7	161.8
IV. INDUSTRIAL PROCESSES AND PRODUCT USES	**3,508.80**			**3,797.70**			**3,863.50**		
V. AGRICULTURE, FORESTRY AND OTHER LAND USE	**56.3**	**502.3**	**447.4**	**62.8**	**529.2**	**491.8**	**58.3**	**482.7**	**463.8**
V.1 Livestock	-	499.4	62.0	-	526.3	66.2	0.0	479.7	62.1
V.2 Land use and land use change	41.5	-	-	41.5	0.0	-	41.5	-	-
V.3 Agricultural land	14.8	2.8	385.4	21.3	2.9	425.6	16.8	3.1	401.7

Table 4.15: Total greenhouse gas emissions for 2019, 2020 and 2021 (kt CO_2e)

Scope / Sector		GHG (kt CO_2e)		
		2019	2020	2021
I. STATIONARY ENERGY		**6,630.6**	**8,556.3**	**7,549.4**
	I.1 Residential buildings	1,019.4	1,144.5	1,156.4
Scope 1	I.1.1 Emissions from fuel combustion within the city boundary	336.7	345.5	355.8
Scope 2	I.1.2 Emissions from grid-supplied energy consumed within the city boundary	682.7	799.0	800.6
Scope 3	I.1.3 Emissions from transmission and distribution losses from grid supplied energy consumption	-	-	-
	I.2 Commercial/Institutional buildings and facilities	711.5	767.4	796.5
Scope 1	I.2.1 Emissions from fuel combustion within the city boundary	98.1	103.3	105.2
Scope 2	I.2.2 Emissions from grid-supplied energy consumed within the city boundary	613.4	664.1	691.3
Scope 3	I.2.3 Emissions from transmission and distribution losses from grid supplied energy consumption	-	-	-
	I.3 Manufacturing Industries and construction	4,720.0	6,478.0	5,436,2
Scope 1	I.3.1 Emissions from fuel combustion within the city boundary	3,731.6	5,301,9	4,176.5
Scope 2	I.3.2 Emissions from grid-supplied energy consumed within the city boundary	988.4	1,176.1	1,259.7
Scope 3	I.3.3 Emissions from transmission and distribution losses from grid supplied energy consumption	-	-	-
	I.4 Energy industries	-	-	-
Scope 1	I.4.1 Emissions from energy used in power plant auxiliary operations within the city boundary	-	-	-
Scope 2	I.4.2 Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary	-	-	-
Scope 3	I.4.3 Emissions from transmission and distribution losses from grid supplied energy consumption in power plant auxiliary operations	-	-	-
Out of scope	I.4.4 Emissions from energy generation supplied to the grid	271.4	72.1	98
	I.5 Agriculture, forestry and fishing activities	179.7	166.4	160.4
Scope 1	I.5.1 Emissions from fuel combustion within the city boundary	2.6	3.3	5.4
Scope 2	I.5.2 Emissions from grid-supplied energy consumed within the city boundary	177.1	163.1	154.9
Scope 3	I.5.3 Emissions from transmission and distribution losses from grid supplied energy consumption	-	-	-
	I.6 Non-specified sources	-	-	-
Scope 1	I.6.1 Emissions from fuel combustion within the city boundary	-	-	-
Scope 2	I.6.2 Emissions from grid-supplied energy consumed within the city boundary	-	-	-
Scope 3	I.6.3 Emissions from transmission and distribution losses from grid supplied energy consumption	-	-	-
	I.7 Fugitive emissions from mining, processing, storage, and transportation of coal	-	-	-
Scope 1	I.7.1 Emissions from fugitive emissions within the city boundary	-	-	-
	I.8 Fugitive emissions from oil and natural gas systems	-	-	-
Scope 1	I.8.1 Emissions from fugitive emissions within the city boundary	-	-	-

Scope / Sector		GHG (kt CO_2e)		
		2019	2020	2021
II. TRANSPORTATION		**3,867.4**	**4,052.9**	**4,263.9**
	II.1 Road transportation	3,815.4	4,005.8	4,223.5
Scope 1	II.1.1 Emissions from fuel combustion for on-road transportation occurring within the city boundary	3,815.4	4,005.8	4,223.5
Scope 2	II.1.2 Emissions from grid-supplied energy consumed within the city boundary for on-road transportation	-	-	-
Scope 3	II.1.3 Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	-	-	-
	II.2 Railways	9.2	3.6	6.5
Scope 1	II.2.1 Emissions from fuel combustion for railway transportation occurring within the city boundary	9.2	3.6	6.5
Scope 2	II.2.2 Emissions from grid-supplied energy consumed within the city boundary for railways	-	-	-
Scope 3	II.2.3 Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	-	-	-
	II.3 Waterborne navigation	42.8	43.5	33.9
Scope 1	II.3.1 Emissions from fuel combustion for waterborne navigation occurring within the city boundary	42.8	43.5	33.9
Scope 2	II.3.2 Emissions from grid-supplied energy consumed within the city boundary for waterborne navigation	-	-	-
Scope 3	II.3.3 Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	-	-	-
	II.4 Aviation	-	-	-
Scope 1	II.4.1 Emissions from fuel combustion for aviation occurring within the city boundary	-	-	-
Scope 2	II.4.2 Emissions from grid-supplied energy consumed within the city boundary for aviation	-	-	-
Scope 3	II.4.3 Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	-	-	-
	II.5 Off-road transportation	-	-	-
Scope 1	II.5.1 Emissions from fuel combustion for off-road transportation occurring within the city boundary	-	-	-
Scope 2	II.5.2 Emissions from grid-supplied energy consumed within the city boundary for off-road transportation	-	-	-
III. WASTE		**580.0**	**605.9**	**628.5**
	III.1 Solid waste disposal	335.6	359.4	377.0
Scope 1	III.1.1 Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary	335.6	359.4	377.0
Scope 3	III.1.2 Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary	-	-	-
	III.2 Biological treatment of wastes	-	-	-
Scope 1	III.2.1 Emissions from solid waste generated within the city boundary that is treated biologically within the city boundary	-	-	-
Scope 3	III.2.2 Emissions from waste generated outside the city boundary but treated biologically within the city boundary	-	-	-
	III.3 Incineration and open burning	-	-	-

Scope / Sector		GHG (kt CO_2e)		
		2019	2020	2021
Scope 1	III.3.1 Emissions from solid waste generated and treated within the city boundary	-	-	-
Scope 3	III.3.2 Emissions from waste generated outside the city boundary but treated within the city boundary			
	III.4 Wastewater treatment and discharge	244.5	246.6	251.4
Scope 1	III.4.1 Emissions from wastewater generated and treated within the city boundary	244.5	246.6	251.4
Scope 3	III.4.2 Emissions from wastewater generated outside the city boundary but treated within the city boundary	-	-	-
IV. INDUSTRIAL PROCESSES AND PRODUCT USES		**3,508.8**	**3,797.7**	**3,863.5**
Scope 1	IV.1 Emissions from industrial processes occurring within the city boundary	3,508.8	3,797.7	3,863.5
Scope 1	IV.1 Emissions from product use occurring within the city boundary			
V. AGRICULTURE, FORESTRY AND OTHER LAND USE		**1,006.0**	**1,083.9**	**1,004.8**
	V.1 Livestock	561.4	592.6	541.8
Scope 1	V.1.1 CH_4 emissions from enteric fermentation	439.4	462.8	421.6
Scope 1	V.1.2 CH_4 and N_2O emissions from animal manure processing	122.1	129.8	120.2
	V.2 Land use and land use change	41.5	41.5	41.5
	V.3 Agricultural land	403.1	449.8	421.5
Scope 1	V.3.1 CO_2 emissions from the application of urea fertilizers	14.8	21.3	16.8
Scope 1	V.3.2 N_2Oemissions from the application of synthetic fertilizers	105.6	124.0	113.2
Scope 1	V.3.3 N_2O emissions from the application of animal manure to the soil	109.4	118.1	113.6
Scope 1	V.3.3 N_2O emissions from urine and dung deposited by grazing animals	170.4	183.5	174.9
Scope 1	V.3.3 CH_4 emissions from rice production	2.8	2.9	3.1

4.4. Monitoring and Evaluation

The greenhouse gas emission inventories are created for various reasons such as identifying hotspots of emissions in terms of sectors/activities, determining policies for emission reductions, comparison between cities/regions, and raising public awareness. A reliable inventory should be prepared in accordance with the principles of relevance, completeness, consistency, transparency and accuracy. Particularly, in line with the transparency principle, all the accepted assumptions related to the data used during the calculations are provided under the relevant chapters. The quality of the collected data has been evaluated based on the criteria listed in Table 4.1, and the results have been shared in Table 4.16.

Table 4.16: Evaluation of data quality

GPC Ref No	GHG Source / Data Coverage	Data source	Activity data	Emission factor
I	**STATIONARY ENERGY**			
I.1	Residential Buildings			
	Natural gas consumption	(EMRA_a, 2022)	High	Low
	Kerosene oil consumption	(EMRA_a, 2022)	High	Low
	LPG consumption	(EMRA_a, 2022)	High	Low
	Domestic coal consumption	(PDEUCC, 2022)	Low	Middle
	Imported coal consumption	(PDEUCC, 2022)	Low	Middle
	Electricity consumption	(TURKSTAT, 2023)	High	High
I.2	Commercial/Institutional Buildings			
	Natural gas consumption	(EMRA_a, 2022)	High	Low
	Fuel oil consumption	(EMRA_a, 2022; EIGM, 2022)	Middle	Low
	LPG consumption	(EMRA_a, 2022)	Middle	Low
	Electricity consumption	(TURKSTAT, 2023)	High	High
I.3	Manufacturing and Construction Industries			
	Natural gas consumption	(EMRA_a, 2022)	High	Low
	Imported coal consumption	(PDEUCC, 2022)	High	Middle
	Anthracite consumption	(PDEUCC, 2022)	High	Middle
	Petroleum coke consumption	(PDEUCC, 2022)	High	Middle
	LPG consumption	(EMRA_a, 2022)	Middle	Low
	Fuel oil consumption	(EMRA_a, 2022; EIGM, 2022)	Middle	Low
	Diesel consumption	(EMRA_a, 2022; EIGM, 2022)	Middle	Low
	Electricity consumption	(TURKSTAT, 2023)	High	High
I.4	Energy Industries			
	Natural gas consumption	(EMRA_a, 2022)	High	Low

GPC Ref No	GHG Source / Data Coverage	Data source	Activity data	Emission factor
I.5	Agriculture, Forestry and Fishing Activities			
	Natural gas consumption	(EMRA_a, 2022)	High	Low
	Electricity consumption	(TURKSTAT, 2023)	High	High
I.6	Non-specified Sources		Not calculated	
I.7	Fugitive Emissions from Mining, Processing, Storage, and Transportation of Coal		Not calculated	
I.8	Fugitive Emissions from Oil and Natural Gas Systems		Not calculated	
II	**TRANSPORTATION**			
II.1	Road Transportation			
	Gasoline consumption	(EMRA_a, 2022)	High	Low
	Diesel consumption	(EMRA_a, 2022; EIGM, 2022)	Middle	Low
	LPG consumption	(EMRA_a, 2022)	High	Low
II.2	Railways			
	Diesel consumption	(EMRA_a, 2022; EIGM, 2022)	Middle	Low
	Train line length and km statistics	(TURKSTAT, 2023; TCDD, 2021)	Middle	
II.3	Waterborne Navigation			
	Fuel oil consumption	(EMRA_a, 2022)	High	Low
	Diesel consumption	(EMRA_a, 2022; EIGM, 2022)	Middle	Low
II.4	Aviation		Not calculated	
II.5	Off-road Transportation		Included under II.1 and I.5	
III	**WASTE**			
III.1	Solid Waste Disposal			
	Amount of household waste produced	(TURKSTAT, 2023)	High	Low
	Composition of household waste	Mersin Metropolitan Municipality	High	Low
	Amount of industrial waste produced	(MBB; TÜİK,2022)	Middle	Low
	Amount of medical waste	Mersin Metropolitan Municipality	High	Low
	Methane recovery quantity	Mersin Metropolitan Municipality	Middle	Low
III.2	Biological Treatment of Wastes		Included under III.4	
III.3	Incineration and Open Burning		Not available	
III.4	Wastewater Treatment and Discharge			
	Mid-year population	(TURKSTAT, 2023)	High	
	Gross domestic product	(TURKSTAT, 2023)	High	
	Amount of industrial wastewater	Provincial Directorate of Environment, Urbanization and Climate Change	High	Low
	Methane recovery quantity	MESKI	High	

GPC Ref No	GHG Source / Data Coverage	Data source	Activity data	Emission factor
IV	**INDUSTRIAL PROCESSES AND PRODUCT USE**			
	Direct emissions from industrial processes			
	Process emissions for cement production	Industrial plants	Middle	Middle
	Process emissions for glass production	Industrial plants	High	Middle
	Process emissions for soda production	Industrial plants	High	Middle
	Direct emissions from product use		Not calculated	
In	**AGRICULTURE, FORESTRY AND OTHER LAND USE**			
V.1	Direct emissions from livestock			
	Number of animals	(TURKSTAT, 2021)	High	Middle
V.2	Direct emissions and sinks from land use and land use change			
	Land use changes	(CORINE, 2018)	Middle	Middle
V.3	Non-CO_2 emissions from agricultural land			
	Number of animals	(TURKSTAT, 2021)	High	Middle
	Amount of chemical fertilizer consumption	(MİTOM, 2023)	Middle	Middle
	Rice planted area	(TURKSTAT, 2021)	High	Middle

In order to successfully carry out the inventory preparation process, it is recommended to establish a coordination team to manage the data flow between municipal units and other stakeholders operating within the province and to collect the necessary data for annual updates of the inventory. It is beneficial for the coordination team to be led by the Directorate of Climate Change and Zero Waste of Mersin Metropolitan Municipality, with the participation of the following institutions:

- Mersin Metropolitan Municipality Directorate of Environmental Protection and Control
- Mersin Metropolitan Municipality Directorate of Transportation
- Mersin Metropolitan Municipality Directorate of Agricultural Services
- Mersin Water and Sewerage Administration (MESKİ)
- Mersin Provincial Directorate of Industry and Technology
- Mersin Provincial Directorate of Environment, Urbanization and Climate Change
- Mersin Provincial Directorate of Agriculture and Forestry
- TURKSTAT Adana Regional Office
- Mersin Chamber of Commerce and Industry (MTSO)
- ŞİŞECAM - Soda, Glass Packaging and Flat Glass Production Facilities
- Eren Holding - Medcem Cement
- ÇİMSA - Mersin Factory

- İZOCAM - Glass Wool and Foamboard Production Facilities
- Aksa Natural Gas Çukurova General Directorate
- Kalde Energy Electricity Generation Co. Inc.

Finally, there is no obligation to verify inventory reports prepared on the basis of cities. However, it is considered useful for a team consisting of officials who are not involved in inventory preparation within the Directorate of Climate Change and Zero Waste of Mersin Metropolitan Municipality to review the inventory prepared as a 3rd party.

5. MERSİN METROPOLITAN MUNICIPALITY GREENHOUSE GAS EMISSION INVENTORY

In addition to the greenhouse gas emission inventory created for the entire Mersin province within the scope of the project, a separate greenhouse gas emission inventory has been established for areas directly related to the activities of Mersin Metropolitan Municipality. In this context, data regarding the total fuel consumption (natural gas) in municipal buildings, electricity consumption in buildings and street lighting, fuel consumption in transportation vehicles (diesel, gasoline, and CNG), solid waste and wastewater generation, and refrigerant gas consumption for the years 2019, 2020, and 2021 have been provided by Mersin Metropolitan Municipality officials. The emissions calculations follow the same methodology, emission factors, and assumptions as those used for the overall calculations in Mersin. The ratio of emissions calculated for areas under the responsibility of Mersin Metropolitan Municipality to the total greenhouse gas emissions calculated for the Mersin province is 1.28%, 1.27%, and 1.23% for the years 2019, 2020, and 2021, respectively (Table 5.1).

Table 5.1: Mersin Metropolitan Municipality total greenhouse gas emissions (t CO_2e)

Scope / Sector		GHG (t CO_2e)		
		2019	2020	2021
I. STATIONARY ENERGY				
	I.2 Commercial/Institutional Buildings	**19,406**	**21,268**	**21,864**
Scope 1	I.2.1 Emissions from fuel combustion within the city boundary	4,021	4,307	6,302
Scope 2	I.2.2 Emissions from grid-supplied energy consumed within the city boundary[1]	15,385	16,962	15,562
II. TRANSPORTATION				
	II.1 Road Transportation	**45,714**	**47,167**	**47,566**
Scope 1	II.1.1 Emissions from fuel combustion for on-road transportation occurring within the city boundary	45,714	47,167	47,566
Scope 2	II.1.2 Emissions from grid-supplied energy consumed within the city boundary for on-road transportation	-	-	-
III. ATIK				
	III.1 Solid Waste Disposal	**64**	**77**	**53**
Scope 1	III.1.1 Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary	64	77	53
	III.4 Wastewater Treatment and Discharge	**324**	**328**	**332**
Scope 1	III.4.1 Emissions from wastewater generated and treated within the city boundary	324	328	332
IV. INDUSTRIAL PROCESSES AND PRODUCT USE				
Scope 1	IV.1 Emissions from industrial processes occurring within the city boundary	1.20	1.20	1.37
	SUM	**65,509**	**68,841**	**69,816**

[1] The amount of electricity consumption in 2019 has been obtained by proportioning the consumption amount of commercial/institutional buildings in Mersin province in 2020 and 2021 to the consumption amount of Mersin Metropolitan Municipality.
[2] The amount of refrigerant gas consumption for 2019 and 2020 has been obtained by averaging the data for 2021 and 2022.

6. OTHER COMPLETED WORKS

Following the completion of the greenhouse gas emission inventory, in the next period of the project work, the 2055 greenhouse gas emission projections, which were prepared by taking into account the data of TURKSTAT, OECD and Türkiye's general projections, were revised by taking the opinions of the stakeholders. In calculating sectoral projections, a number of additional data sets such as the number of residences, the number of subscribers using natural gas, rural and urban population situations, vehicle and fuel types, the rate of population benefiting from waste services, the amount of waste per capita were used and trend analyzes were carried out. TherReference (base) scenario GHG projections were calculated taking into account stationary energy (residential/commercial buildings, agriculture, forestry, and fisheries, manufacturing and construction) as well as the transportation, waste, and agriculture and livestock sectors..

After the baseline scenario (base GHG projections) was finalized, GHG mitigation analyses were conducted. In this framework, a "workshop" was organized to diversify and prioritize mitigation actions and stakeholders' opinions and suggestions were received. Sectoral mitigation scenarios were made by considering two alternative emission mitigation scenarios and were based on measures such as fuel production/consumption, renewable energy applications in the context of " stationary energy", expansion of electric vehicles in the context of "transportation", reduction in car ownership as a result of the expansion of public transportation, and measures such as methane recovery applications, waste recovery, reduction of waste generation in the context of "waste and wastewater".

After calculating sector-based GHG mitigation amounts over alternative scenarios, stakeholder opinions and previous strategy and planning documents were taken into consideration in the determination of "mitigation actions". Actions, sub-actions, responsible institutions/organizations, implementation periods, performance indicators, risks and opportunities that may arise in implementation were identified.

In the section on climate change adaptation, a methodology defined by the EU Climate Adaptation Platform (Climate-ADAPT) was followed. Within this framework, risk and vulnerability assessments were conducted against climate change impacts. The current situation was analyzed by taking into account the climatological data, meteorological and hydrological events of the past period, and the climate projections carried out by the General Directorate of Water Management and the General Directorate of Meteorology and made specifically for our country were used in climate-related threats and vulnerability analyses. Changes in extreme climate parameters (climate indices) were determined with reference to these climate projection studies. A survey was conducted to assess the areas expected to be affected and the measures that can be implemented within the scope of adaptation, adaptation measures were determined, prioritization studies were carried out and monitoring and evaluation methodology was put forward. In this context, areas such as energy and industry, transportation infrastructure, agriculture and animal husbandry, solid waste and wastewater management, water resources, forest areas, coastal areas, fisheries, tourism and cultural heritage were taken into consideration. Existing "plans" (such as Basin Management Plans, Spatial Plan decisions, Environmental Plans prepared in the region) were evaluated in terms of adaptation to climate change, and finally, priority actions and sub-actions determined sectorally within the scope of adaptation were identified, implementation, monitoring and reporting methods were determined and the final report was prepared.

ANNEXES

Annex 1 - Greenhouse Gas Emission Factors

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ANNEX 1

Greenhouse Gas Emission Factors

EMISSION FACTORS*						
STATIONARY ENERGY						
Sector/Area	**Sub-sector**	**Fuel type**	**Unit**	**Emission factors**		
				CO_2	**CH_4**	**N_2O**
Manufacturing and Construction Industries, Residentail and Commercial Buildings, Agriculture, Livestock and Fishing Activities	General	Domestic coal	kg/TJ	106,620	0.7	0.5
		Hardcoal	kg/TJ	96,890	0.7	0.5
		Imported coal	kg/TJ	94,580	0.7	0.5
		Natural gas	kg/TJ	53,670	5	0.1
		Fuel oil	kg/TJ	76,970	10	0.6
		Diesel	kg/TJ	72,280	10	0.6
		Gasoline	kg/TJ	69,300	10	0.6
		LPG	kg/TJ	63,070	5	0.1
		Wood	kg/TJ	111,800	300	4
		Kerosene	kg/TJ	72,280	10	0.6
		Biyofuels	kg/TJ	54,630	-	-
Electricity and Heat Production	General	Hardcoal - Pulverised	kg/TJ	96,890	0.7	0.5
		Imported coal - Pulverised	kg/TJ	94,580	0.7	0.5
		Hardcoal - Fluidized bed	kg/TJ	96,890	1	61
		Imported coal - Fluidized bed	kg/TJ	94,580	1	61
		Natural gas	kg/TJ	55,500	4	1
		Fuel oil	kg/TJ	76,970	0.8	0.3
		Diesel	kg/TJ	72,280	0.9	0.4
TRANSPORTATION						
Sector	**Sub-Sector**	**Fuel Type**	**Unit**	**Emission Factors**		
				CO_2	**CH_4**	**N_2O**
Transportation	Aviation	Jet Fuel	kg/TJ	70,657	1.2	2.4
	Road Transport	Gasoline	kg/TJ	69,300	25	8.0
		Diesel	kg/TJ	72,278	3.9	3.9
		LPG	kg/TJ	63,067	62	0.2
		CNG	kg/TJ	53,671	92	3.0
	Water-Borne Navigation	Fuel-Oil	kg/TJ	76,970	7	2
		Diesel	kg/TJ	72,278	7	2

AGRICULTURE AND LIVESTOCK						
Sub categories	**Type**		**Unit**	**Emission factors**		
				CO_2	**CH_4**	**N_2O**
Enteric Fermantation	Cattle	General	kg/head/year		60.7	
		Dairy cattle	kg/head/year		83.3	
		Non-dairy cattle	kg/head/year		47.3	
	Sheep	General	kg/head/year		5.1	
		Domestic	kg/head/year		5.0	
		Merino	kg/head/year		6.5	
	Swine	Swine	kg/head/year		1	
	Other Livestock	General	kg/head/year		0.2	
		Buffalo	kg/head/year		55.0	
		Camels	kg/head/year		46.0	
		Goats	kg/head/year		5.0	
		Horses	kg/head/year		18.0	
		Mules and Asses	kg/head/year		10.0	
		Poultry	kg/head/year		-	
Manure Management	Cattle	General	kg/head/year		7.9	0.4
		Dairy cattle	kg/head/year		19.6	1
		Non-dairy cattle	kg/head/year		1.0	0.2
	Sheep	General	kg/head/year		0.1	0.1
		Domestic	kg/head/year		0.1	0.1
		Merino	kg/head/year		0.2	0.1
	Swine	Swine	kg/head/year		3.8	
	Other Livestock	General	kg/head/year		0.0	0.0
		Buffalo	kg/head/year		1.5	0
		Camels	kg/head/year		1.9	0.1
		Goats	kg/head/year		0.1	0.1
		Horses	kg/head/year		1.4	0.3
		Mules and Asses	kg/head/year		0.7	0.1
		Poultry	kg/head/year		0.016	0.001
Rice Cultivation	Irrigated	Continuously Flooded	g/m^2		11.6	
		Intermitently Flooded – Single Aeration	g/m^2		7.1	
		Intermitently Flooded – Multiple Aeration	g/m^2		6.3	
Direc and indirect N_2O emissions from agricultural lands	Direct N_2O Emissions	Inorganic – N Fertilizer	kg N_2O-N/kg N			0.010
		Organic – Animal Manure	kg N_2O-N/kg N			0.010

		Organic– Sewage sludge	kg N_2O-N/kg N			0.010
		Organic – Other	kg N_2O-N/kg N			0.010
		Urine and dung	kg N_2O-N/kg N			0.013
		Loss of soil organic matter	kg N_2O-N/kg N			0.010
		Cultivation of organic soil	kg N_2O-N/kg N			8.000
	Indirect N_2O emissions	Atmospheric depositin	kg N_2O-N/kg N			0.010
		Nitrogen leaching	kg N_2O-N/kg N			0.008
	Fractions	$Frac_{GASF}$	-			0.100
		$Frac_{GASM}$	-			0.200
		$Frac_{LEACH-(H)}$	-			0.015
Biomass burning	Cereals	Wheat	g/kg		2.7	0.07
		Barley	g/kg		2.7	0.07
		Corn	g/kg		2.7	0.07
		Other	g/kg		2.7	0.07
		Rice	g/kg		2.7	0.07
	Yanma Faktörü, C_f	Wheat	-		0,9	0,9
		Barley	-		0,9	0,9
		Corn	-		0.8	0,8
		Rice	-		0.8	0.8
CO_2 emissions from carbon-containing fertilizers	Application of urea fertilizers		t CO_2-C/t	0.2		
WASTE AND WASTEWATER						
Sub-Category	**Type**		**Unit**	**Emission factors**		
				CO_2	**CH_4**	**N_2O**
Wastewater Treatment	Domestic Wastewater		kg/kg DC		0.07	
			kg N_2O-N/kg N			0.01
	Industrial Wastewater		kg/kg DC		0.01	
	Other parameters	Protein Consumption			40.4	
		Nitrogen fraction of protein	kg/person/yr		0.2	
		$F_{NON-CON}$			1.4	
		$F_{IND-COM}$			1.3	
		T_{PLANT}			42.1	

*: Emission factors are compiled from National Greenhouse Gas Emission Inventory Report of Türkiye.