ANKARA CLIMATE CHANGE ACTION PLAN

Dear Ankara residents,

As a result of increasing human activities with the industrial revolution, the accumulation of greenhouse gases in the atmosphere has increased rapidly. The warming of the earth caused by the greenhouse effect, which has increased as a result of the accumulation of greenhouse gases in the atmosphere, has brought about climate changes. Climate change causes significant changes, whether on a global or regional scale. Climate change is making its effects felt increasingly in our country as well as in the rest of the world.

Although Turkey is located in the Mediterranean Basin, one of the regions in the world that is expected to be most affected by climate change, our city is also among the regions that are expected to be most affected by climate change in the models prepared by scientists. The increasing climate crisis threatens our living spaces as well as our nature. The natural disasters that have occurred as a result of climate change on our doorstep have brought to light the need for us to be more sensitive and prepared for climate change. Most of the natural disasters we experience today are due to climate changes in our region. We, the societies living in big cities, both create the causes of climate change and experience the negativities experienced as a result of climate change. As Ankara Metropolitan Municipality, our aim is to strive to protect the ecological balance with the understanding of being a capital city in harmony with nature. For the first time in our capital, steps are taken to combat climate change and to combat and adapt to the negativities that will occur as a result of climate change. In our Ankara Province local climate change action plan that we have prepared, information about our current situation has been obtained by creating the greenhouse gas emission inventory of our city. By making models in the light of the information we have obtained, we have determined various actions in order to be more resistant to natural events awaiting our city in the future and to reduce our greenhouse gas emissions.

In order to leave a more livable, nature-friendly and ecological city legacy to our future generations, I hope that our Ankara Local Climate Change Action Plan, which will serve as a guide in the fight against climate change of Ankara in the coming years, will bring good luck to all our people. I sincerely thank all our stakeholders who contributed to the preparation of our Local Climate Change Action Plan and all my colleagues who made efforts in the relevant units of our Municipality.

Mansur Yavaş,

The Mayor of Ankara

Content

1. INTRODUCTION: CLIMATE CHANGE AND CITIES

Climate is the whole of the patterns that emerge by long-term monitoring and observation of all weather conditions and their frequency of occurrence anywhere on the earth. Climate change, on the other hand, is defined as "change in climate as a result of human activities that directly or indirectly degrade the composition of the global atmosphere, in addition to natural climate change observed over comparable time periods"[1].

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), established by the United Nations Environment Program and the World Meteorological Organization in 1988, states that the global warming experienced since the mid-20th century is mostly due to the increase in greenhouse gas concentrations as a result of human activities[2]. Anthropogenic greenhouse gases emissions have been rising since the industrial era, with economic growth and population growth, and there is now more greenhouse gases in the atmosphere than ever before. Throughout the World, while the annual total greenhouse gas emission amount was 38 Gt CO2e in 1990, it increased by 29% in 2017 and reached to 53,5 Gt CO2e[3].

The global effects of climate change are seen today due to increase in greenhouse gases consisting of carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and fluorinated gases observed in the atmosphere as a result of activities such as fossil fuel use, destruction of forest areas and sinks, industrialization and agriculture and livestock. Climate change is an important change process that is experienced on a global scale but has effects even on a local scale, and it causes changes in many different issues, both in the environmental, economic and social context.

In recent years, numerous disasters have been encountered in many parts of the world due to climate change. Urban areas, where millions of people live, were the areas that suffered the most from these disasters. On the one hand, cities, where economic development takes place, but on the other hand, are responsible for 75% of natural resource consumption and 80% of global greenhouse gas emissions that endanger the extinction of humans and other living species[4].

Today, 55% of the world's population lives in urban areas, a proportion that is expected to increase to 70% by 2050[5]. Depending on the population growth in cities, it is estimated that the amount of built up area will increase three times in developing countries and 2.5 times in developed countries until 2030.

[1] UNFCCC (2006), United Nations Framework Convention on Climate Change: Handbook. Bonn, Germany: Climate Change Secretariat.

[2] IPCC, (2014). Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment, Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[3] IPCC. (2018). Emissions Gap Report (2018). https://www.ipcc.ch/site/assets/uploads/2018/12/UNEP-1.pdf

[4] UNEP (2014). Cities and Buildings. Sustainable Buildings and Climate Initiative, France. https://www.unep.org/SBCI/pdfs/Cities_and_Buildings-UNEP_DTIE_Initiatives_and_projects_hd.pdf

[5] UN-DESA (United Nations, Department of Economic and Social Affairs- Population Division) (2018). World Urbanization Prospects: The 2018 Revision.

According to the IPCC 5th Assessment Report, problems such as drought, increase in precipitation, floods and overflows and related erosion, difficulty in water supply and air pollution caused by climate change in and around urban areas have been increasing. As a result, it is expected to show the negative effects of climate change on urban infrastructure systems, public services and ecosystem services.

As a result of the negative effects of climate change, national and international centres around the world have started work on setting new targets for the amount of greenhouse gas emissions. Within the efforts to combat climate change, the authorities who came together in Paris (COP21) in December 2015, agreed with the Paris Agreement, which is the most comprehensive international agreement in history, primarily on the importance of the participation of all countries in the most comprehensive possible cooperation and an effective and appropriate international response to accelerate the reduction of global greenhouse gas emissions[6]. The 197 countries that signed the agreement also committed to limit the global temperature rise to 1.5°C by reducing greenhouse gas emissions. Turkey signed the Paris Agreement on April 22nd, 2016 but has not yet ratified[7]. It is expected that the total greenhouse gas emission amount of Turkey by 2030 will be 1.175 million tons of CO2e, if no measures are taken for combating climate change. Through the measures to be taken and adaptation studies within the framework of the national target to be presented as a contribution to the Paris Agreement, it is foreseen that the greenhouse gas emission value of 2030 can be kept at 929 million tons of CO2e (246 million tons of reduction, a 21% reduction)[8].

In Turkey, which has 30 metropolitan cities, 51 provinces and 1399 district municipalities and a population of 82 million 3 thousand 882, the proportion of those residing in metropolitan, provincial and district centres has become 92.5%[9]. The ratio of metropolitan municipalities to the total municipal population is over 80%. Based on these data, it is seen that the majority of the population lives in cities. Cities, which are the areas that focus on the causes and consequences of climate change, therefore, have to be the centre of climate action, both to combat climate change and to be resilient to climate change.

Cities are the main cause of climate change but can also offer a part of the solution to reducing greenhouses gases. Under these conditions, on one hand, existing built-up areas of cities should be made resilient against the effects of climate change, on the other hand, new residential areas should be selected considering the effects of climate change and projections, and both adaptation and mitigation processes should be integrated into the development of cities.

Especially local governments have important responsibilities in reducing the effects of climate change and increasing adaptation capacity. For this reason, today, local

[6] UN (2015). United Nations Summit on Sustainable Development 2015 Informal summary. United Nations Headquarters, New York. https://sustainabledevelopment.un.org/content/documents/8521Informal%20Summary%20-%20UN%20Summit%20on%20Sustainable%20Development%202015.pdf

[7] Republic of Turkey Ministry of Environment and Urbanization. (2018). https://iklim.csb.gov.tr/paris-anlasmasi-i-98587

[8] Republic of Turkey Ministry of Environment and Urbanization. (2018). https://iklim.csb.gov.tr/paris-anlasmasi-i-98587

[9] Turkish Statistical Institute (TÜİK) (2019). The population of province/district centres and towns/villages and annual population growth rate by province.

governments have become stakeholders that play a key role in sustainable and low-carbon development, as well as being structures that establish and maintain the economic, social and environmental infrastructure in cities. Beyond the policies and studies accounted by countries against the current and potential impacts of climate change, cities can take effective and rapid steps to reduce greenhouse gas emissions and take measures against possible impacts.

While New York, one of the major metropolitans of the world, committed 80%[10] greenhouse gas emission reduction by 2050 and London 60%[11] by 2040, South Korea's capital, Seoul, with a population of 10 million, has committed to reduce 25%[12] by 2020. European cities have demonstrated that small-scale cities, as well as large cities, can contribute greatly to combating climate change. Copenhagen, a medium-sized city, aims to reduce greenhouse gas emissions by 100% by 2025[13].

Some of the provincial and district municipalities, especially the metropolitan municipalities, in Turkey have started to combat climate change by becoming members of international networks related to local governments. The prominent ones among the mentioned international networks are; The EU Covenant of Mayors (COMs) are the renewed “Global Covenant of Mayors for Climate & Energy”, C40, ICLEI and Eurocities networks. As of December 2019, 14 of the 30 Metropolitan Municipalities carrying out activities in this scope have greenhouse gas inventory. Nine of these cities have prepared a Greenhouse Gas Reduction Target and a Local Climate Change Action Plan (LCCAP), while five have both a Mitigation Action Plan and Adaptation Action Plan.

1.1. Climate Change and Ankara

Ankara, located in the Central Anatolia Region, which is dominated by plains formed by Kızılırmak and Sakarya Rivers, is the capital of the Republic of Turkey. It is the third-largest city in Turkey with an area of 25,437 km2 and the second most populous city with a population of 5,639,076 people[14].

Contrary to its large lands, the majority of the population is concentrated in the centre. At the same time, in addition to the intensive agricultural activities in the surrounding districts, thermal tourism and cultural tourism also have stood out as activities that have developed significantly in recent years. The centre of Ankara is an area where universities, technoparks, industrial zones, strong sector clusters, high-level bureaucracy, international institutions and non-governmental organizations are concentrated. All these features make the capital Ankara a region with economic, social, human and intellectual capital.

[10] Mayor of New York. (2014). New York City's Roadmap to 2050. https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/New%20York%20City's%20Roadmap%20to%2080%20x%2050_Final.pdf

[11] Mayor of London. (2018). Zero Carbon London. https://www.london.gov.uk/sites/default/files/1.5c_compatible_plan.pdf

[12] Seul Climate Action Plan. (2015, 10 30). Seoul - Citizens Shape Climate Action. C40 Cities: https://www.c40.org/case_studies/cities100-seoul-citizens-shape-climate-action

[13] Kopenhagen Climate Action Plan. (2009). Copenhagen Climate Plan. https://www.energycommunity.org/documents/copenhagen.pdf

[14] Turkish Statistical Institute (TÜİK) (2019). Address Based Population Registration System (ABPRS) Database Ankara Population.

According to 2014 data, Ankara is the second province after Istanbul with the highest share in the gross domestic product (GDP) with 187 Billion TL. In terms of foreign trade, it has a 5% share of our country. In Turkey, 7% of the population in the labour force is employed in Ankara. When the sectoral components of Ankara's economy are examined, it is seen that an economic structure is formed with service and industry sectors, and the share of agriculture, which constitutes the economic activities of the rural sector, is quite limited. In Ankara, 73% of the total population in employment is in services, 24% in industry and 3% in agriculture. Considering the technology usage situation in the manufacturing industry, it is seen that the share of medium and medium-high technologies is higher than in other regions. Although the share of agriculture in the general economic structure is low, it is one of the prominent provinces of Turkey in terms of the added value it produces and the size of arable agricultural land.

Ankara, which consists of 25 districts, generally has a continental climate and widespread vegetation is steppe. It is possible to see climatic changes since it is located in a large land. In addition to the steppe climate, which is the climate of Central Anatolia, temperate and rainy climate characteristics are observed in the northern regions from the Black Sea climate characteristics. In continental regions, winters are cold and summers are hot[15].

In accordance with both Ankara's precipitation data along with the changes in temperature values, and national and global scale predictions about climate change, Ankara is expected to encounter drought and related problems that will arise due to climate change in the medium term. In the scenario of the IPCC, it has been specified that if necessary measures are not taken, the annual average temperatures in Turkey will rise by 2.5 - 4^{o}C until 2050[16]. It has been stated that the south of Turkey will face a serious drought threat, while the risk of flooding will increase in the northern regions. Ankara is also listed among the provinces that will be exposed to drought.

Indicators on climate change in Ankara show that some changes have occurred in the long term. Annual average temperature changes show parallelism with the global temperature increase trend. In addition, considering the data on Ankara according to the results of the TURKSTAT's liveability index in the provinces (2015) [17], it is seen that both air and noise pollution are issues that need to be taken precautions for Ankara.

Studies indicate that the vulnerability of Ankara to climate change impacts is high[18]. In this context, Ankara Metropolitan Municipality has established the 'Climate Change and Adaptation Branch Directorate' to leave a livable world for future generations and carry out studies to reduce greenhouse gas emissions in the fight against climate change. It is aimed to increase the capacity of combating and adapting to climate change and to raise

[15] http://www.ankara.gov.tr/sehrimiz

[16] IPCC, (2014). Climate Change 2014: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fifth Assessment, Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[17] Turkish Statistical Institute (TÜİK) (2015). Liveability Index, 2015.

[18] Çobanyılmaz P, Duman Yüksel, Ü (2013). Determination of Vulnerability of Cities to Climate Change: The Case of Ankara, S.D.U Journal of Natural and Applied Science, 17(3), 39-50

awareness at the provincial by preparing the Ankara Province Local Climate Change Action Plan.

2. GREENHOUSE GAS EMISSIONS

2.1. Overview of 2019 Greenhouse Gas Emissions

The 2019 Greenhouse Gas Inventory, prepared within the scope of the climate change action plan studies carried out by the Ankara Metropolitan Municipality, has been prepared in accordance with the criteria of the Global Protocol for Community Scale Greenhouse Gas Emission Inventories, which is an international standard.

In the preparation of the Greenhouse Gas Inventory, greenhouse gas emissions originating from residences, industry, transportation, solid waste and waste management, electricity distribution and transmission line losses, fertilizer use in agriculture, livestock activities, changes in land use, cooler gases, cement and lime production have been calculated using the data collected at the provincial level and the national greenhouse gas inventory data prepared by the Ministry of Environment and Urbanization.

In the calculations made within the scope of the main categories of the GPC standard (GPC Basic), the greenhouse gas emissions caused in Ankara Province in 2019 have been calculated as approximately 22.9 million tons. According to the results of the 2019 Address Based Population Registration System (ABPRS) by TURKSTAT, the population of Ankara is 5,639,076 people. Therefore, emissions per capita were calculated as 4.05 tons. This value is calculated as 6.1 tons per person in Turkey. When livestock, cement process emissions, electricity losses, refrigerant gases, chemical fertilizers and land use, which are not included in the GPC main category, are included, the total emissions are approximately 27.3 million tons.

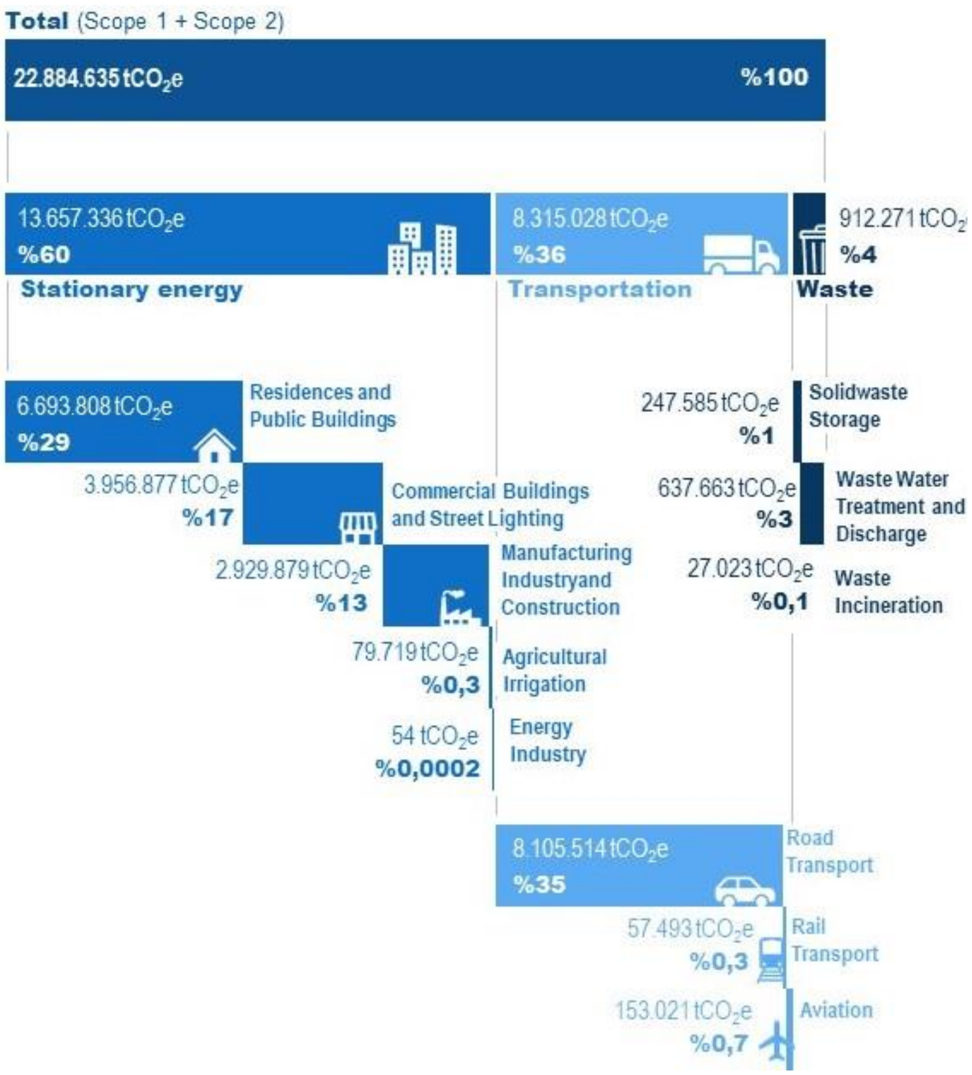


Figure 2.1. **Greenhouse gas emissions under GPC Basic**

2.2. Greenhouse Gas Emissions Accounting Method

This greenhouse gas inventory and report has been prepared in accordance with the latest version of the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC), the world's most important joint initiative at the municipal level to reduce greenhouse gas emissions, monitor progress/developments and prepare for the effects of climate change. The GPC standard is the result of a collaborative effort between World Resources Institute (WRI), C40 Cities Climate Leadership Group (C40), and ICLEI—Local Governments for Sustainability (ICLEI). Within the scope of the study, the CIRIS-City Inventory Reporting and Information System tool was used to calculate and evaluate city-scale greenhouse gas emissions. CIRIS is a software tool that enables the categories of emission sources for metropolitan areas to be prepared in accordance with the GPC format.

2.3. Boundary Setting and Gases

The boundaries of the inventory include Scope 1 and Scope 2 emissions within the administrative borders of Ankara Province, which are under the authority and responsibility of Ankara Metropolitan Municipality.

Within the scope of the inventory, greenhouse gases such as carbon dioxide (CO2), methane (CH4), nitrogen oxide (N2O), and hydro fluoride carbons (HF) exist. The effect of greenhouse gas types on global warming is expressed in terms of carbon dioxide equivalent (tCO2e). The global warming potentials specified in the IPCC 5th Assessment Report (AR5) were used in the calculation of the carbon dioxide equivalent.

2.4. Greenhouse Gas Emissions Inventory Base Year

The first greenhouse gas inventory for Ankara prepared in accordance with GPC standards belongs to 2019. Therefore, 2019 is expressed as the base year.

2.5. Analysis of Greenhouse Gas Emissions Inventory Results

Total greenhouse gas emissions of Ankara calculated according to the GPC BASIC approach are found as 22.884.636 tCO_2e for 2019. As shown in Figure 2.2, 72% of the emissions originate from "Scope 1- Direct Emissions" and 28% from "Scope 2-Indirect Emissions".

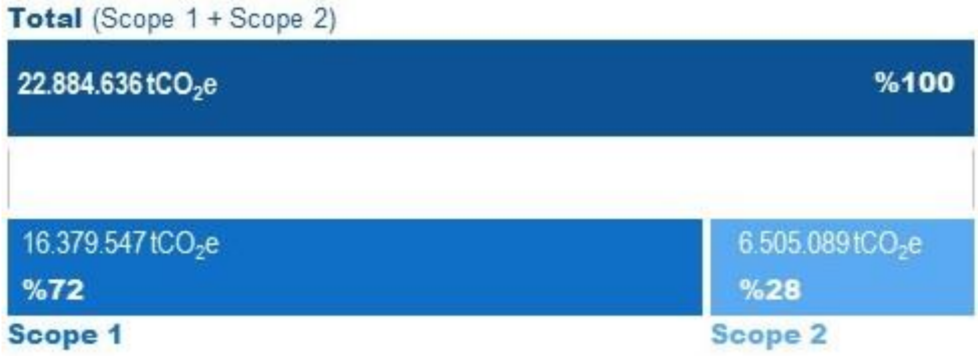


Figure 2.2. Distribution of Ankara 2019 Total Greenhouse Gas Emissions according to Scope 1 and Scope 2 emissions according to the "GPC BASIC" approach

2.5.1. Greenhouse Gas Emissions Based on Source Categories

Greenhouse gas emission distribution based on source categories emerges as residential institutional and commercial buildings and street lighting, manufacturing industry and construction, energy industry and transportation. Numerical expressions of greenhouse gas emissions based on fuel, electricity and waste management and their weights in the category are expressed in tables and graphs presented in this section.

Emissions from the use of natural gas, electricity, electricity loss, domestic coal and imported coal, LPG and wood for residences and public buildings are respectively; %50.7 %27.3, %1.6, %1.4, %17.6, %1.1 ve %0.4 (Figure 2.3).

Figure 2.3. Distribution of emissions from residences and public buildings by type of fuel

In the commercial buildings and street lighting category, emissions from natural gas and electricity use are 34.1% and 62.3% , respectively (Figure 2.4).

Figure 2.4. Distribution of emissions from commercial buildings and street lighting by fuel type

In the manufacturing industry and construction category, emissions from natural gas, electricity and electricity loss, fuel-oil, LPG and gas oil are 51.1%, 42.7%, 2.5%, 2.6%, 0.6% and 0.04%, respectively (Figure 2.5).

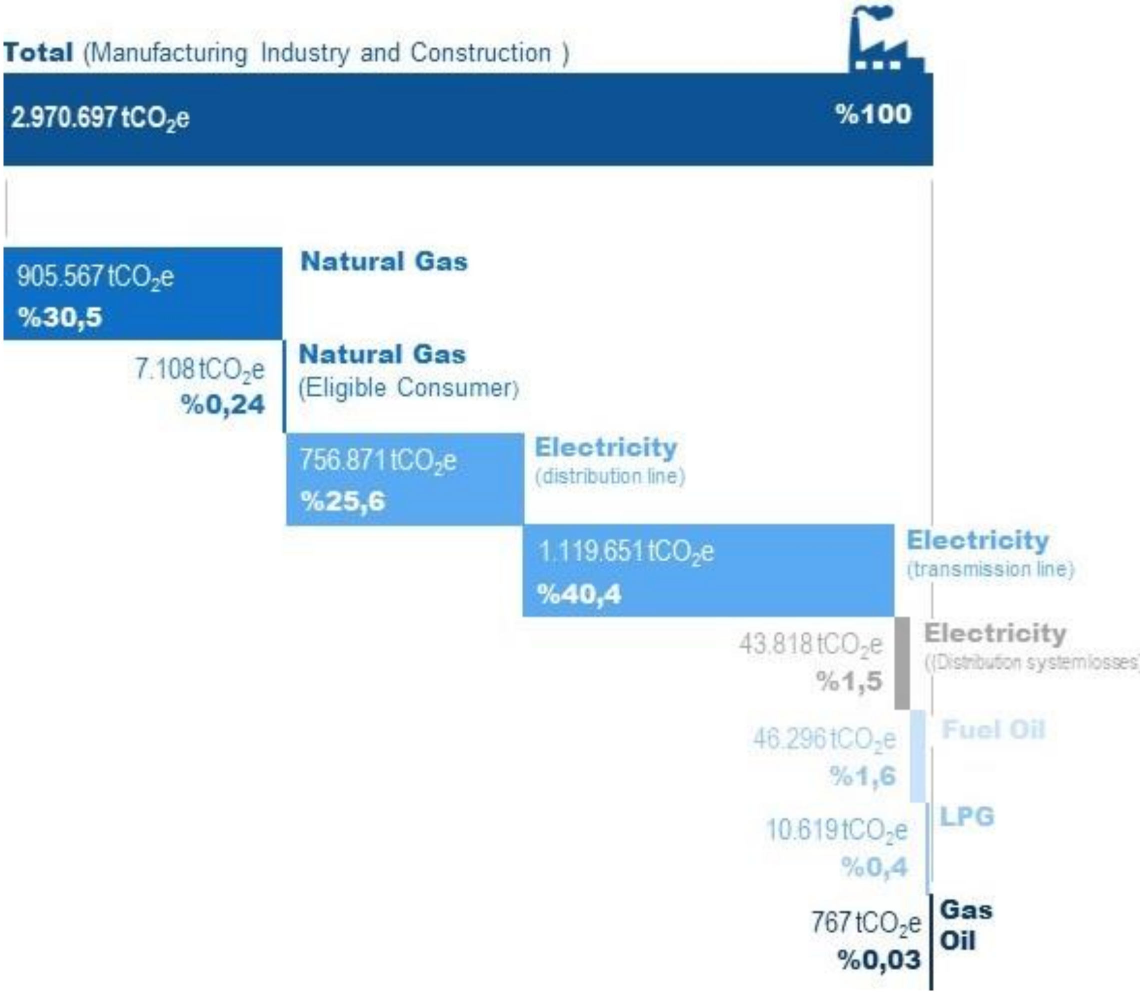


Figure 2.5. Distribution of emissions from manufacturing industry and construction by fuel type

As mentioned in the previous sections, emissions originating from all electricity consumption based on invoice are included in the inventory for 2019. In this case, the inclusion of emissions from fossil fuel use of electricity generation plants in the inventory will cause duplicate counting. Therefore, in this inventory study, fossil fuels (natural gas, coal, etc.) used by the cross-border power generation facilities feeding the national electricity grid for electricity generation are not included in the scope. Yet, the use of natural gas and emissions from electricity generation within the provincial borders are expressed in the table and the graph below.

Emissions from the use of fossil fuels by electricity generation plants are not included in the inventory, however, in Table 2.1, emissions originating from the activities of all thermal power plants operating with natural gas and feeding the national electricity grid are expressed in Ankara Province. In addition, emissions from natural gas used in blast furnaces, CHP and heat plants and included in the inventory calculations are also shown in Table 2.1.

Table 2.1. Distribution of emissions from the energy industry by fuel type

Fuel Type	Greenhouse Gas Emission (tCO2e)	Perc. in Source Category (%)
Natural gas (Electricity generation facilities)	1.288.405	%99,006
Natural gas (Natural gas consumed as fuel in clast furnaces and electricity, CHP and heat plants)	54	%0,004
Total	**1.288.459**	**%100**

Emissions from electricity consumption in agricultural irrigation activities are expressed in Table 2.2. In addition, emissions from electricity loss/leakage in agricultural activities are also shared in the table below. Detailed information on the mentioned electricity transmission line losses is explained in detail in Section 3 of this document.

Table 2.2. Emissions from electricity consumption in agricultural irrigation

Fuel Type	Greenhouse Gas Emission (tCO2e)	Perc. in Source Category (%)
Electricity (Electricity consumption based on invoice)	79.719	%95
Electricity (Losses due to the transmission system)	4.615	%5
Total	84.334	**%100**

When the emissions originating from on-road transportation are examined in detail, it is understood that the emissions from diesel consumption make the biggest contribution with 76.6%. The emissions from diesel consumption are followed by LPG with 13.7% and gasoline consumption with 8.1% (Figure 2.6).

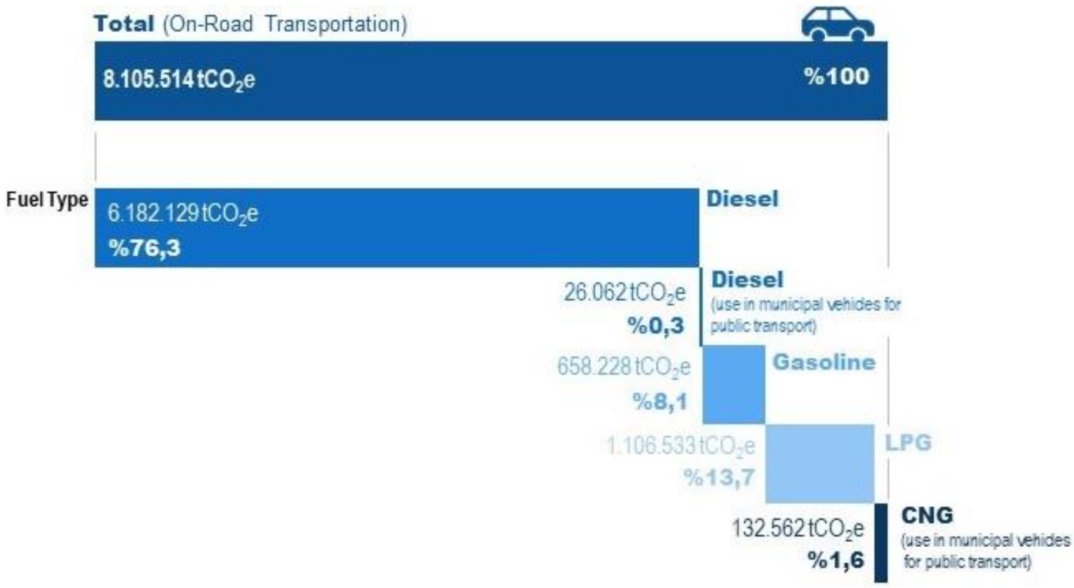


Figure 2.6. Distribution of emissions from road transport by fuel type and usage

In the calendar year 2019, greenhouse gas emissions related to domestic and international aviation activities within the borders of Ankara are 108,673 tCO_2e and 43,348 tCO_2e, respectively (Table 2.3).

Table 2.3. Emissions from Domestic and International Flights in Ankara

Fuel Type	Greenhouse Gas Emission (tCO2e)	Perc. in Source Category (%)
Domestic Flights	**108.673**	%71
International Flights	**43.348**	%29
Total	**152.021**	**%100**

When the emissions originating from railway are examined in detail, the emissions from the use of electricity among the Metro, Ankaray and Cable Car lines have shares of 15%, 83% and 2%, respectively (Figure 2.7).

Figure 2.7. Emissions from rail transport and transportation

Among the emissions arising on the basis of waste management, emissions arising from managed and unmanaged landfills and domestic wastewater treatment have 27.1% and 69.9%, respectively (

Figure **2.8**). Detailed information on this resource category is detailed in

Figure **2.8** below.

Figure 2.8. Distribution of emissions from domestic solid waste, wastewater management and waste incineration

2.5.2. Greenhouse Gas Emissions Based on Electricity and Natural Gas

When the GPC BASIC greenhouse gas emission distribution is analyzed on the basis of fuel and electricity, emissions from manufacturing industry and construction, commercial buildings, agricultural irrigation and electricity consumption in residential buildings stand out within the framework of emissions from electricity consumption (43%, 33% and 13.5%, respectively). The emission values resulting from the electricity consumption of these categories are expressed in detail in Figure 2.9.

Figure 2.9. Distribution of emissions from electricity consumption based on source categories

Residential and instutional buildings emitted 60% of emissions from the use of natural gas. Natural gas emissions used in the manufacturing industry and commercial buildings have the rates of 24% and 16%, respectively, within the total emissions from natural gas use (Figure 2.10).

Figure 2.10. Distribution of emissions from natural gas consumption based on source categories

2.6. Greenhouse Gas Emissions Excepted By GPC Basic

In the part of the inventory studies reported up to this point, the emission categories within the scope of GPC Basic and the results of the related emission calculations are shared. In the table below (Table 2.6), the greenhouse gas emissions that are outside the scope of GPC Basic and emerged within the boundaries of Ankara in 2019 are expressed.

- Cement/Clinker production
- Lime production
- Livestock activities
- Use of refrigerants, foams or aerosol cans (HFCs)
- Application of nitrogen based fertilizer (urea)
- Land-use change emissions

Emissions from cement and clinker production activities within the borders of Ankara in the 2019 calendar year are 1,471,465 tCO_2e and are detailed in Figure 2.11.

* According to the data shared from Çimsa Ankara Cement Factory and Limak Ankara Cement Factory, no production activities were carried out in both facilities in 2019. Therefore, no greenhouse gas emissions originating from these facilities have emerged.

Figure 2.11. Emissions from Cement/Clinker Production within Ankara Province Boundaries

Detailed information on the emissions from livestock activities within the borders of Ankara within the 2019 calendar year is given in Table 2.4 in detail. In summary, greenhouse gas emissions from cattle and ovine breeding activities are 1,663,780 tCO_2e and 330,047 tCO_2e, respectively.

Table 2.4. Emissions from Cattle and Ovine Breeding Activities in Ankara in 2019

Livestock activities		Emissions from enteric fermentation ($tCO_2e/year$)	Emissions from Animal Manure Management-CH4 ($tCO_2e/year$)	Emissions from Animal Manure Management-NO2 ($tCO_2e/year$)	Total ($tCO_2e/year$)
Cattle	Cattle (Culture)	402.560	94.873	24.864	**1.663.780 (%83)**
	Cattle (Cross-breed)	739.665	174.320	45.685	
	Cattle (Domestic)	134.778	31.764	8.324	
	Buffalo	5.355	1.262	331	
Ovine	Sheep (Domestic)	112.856	2.742	14.336	**330.047 (%17)**
	Sheep (Merino)	118.147	3.028	11.959	
	Goat (Hair and Angora Total)	55.951	1.666	9.362	
Total					**1.993.827 (%100)**

* Since NO2 emissions originating from animal manure management per domestic and merino sheep are not included in the national inventory calculations, they are not included in this study. **Since the emission factors for hair and angora goats are considered the same in the national emission inventory, the same emission factor has been used for both goat species within the scope of this study.

Within the scope of inventory studies, land cover/use data of the CORINE database, which is a project of the Ministry of Agriculture and Forestry and carried out together with the European Environment Agency, was used in order to calculate emissions from land use. Greenhouse gas emissions from the change in land cover between 2000 and 2018 are expressed in Table 2.5.

Table 2.5. Greenhouse Gas Emissions from the Changes in Land Cover between 2000 and 2018 in Ankara

Land use categories	Change Between 2000-2018 (ha)	Greenhouse Gas Emissions Between 2000-2018 (tCO_2e)	Greenhouse Gas Emissions for a Year (tCO_2e)
Agricultural Areas	-23.346	120.110	6.673
Forest and Semi-Natural Areas	-4.589	54.632	3.035
Wetlands	+2.102	2.285	127
Toplam	**-25.883**	**177.027**	**9.835**

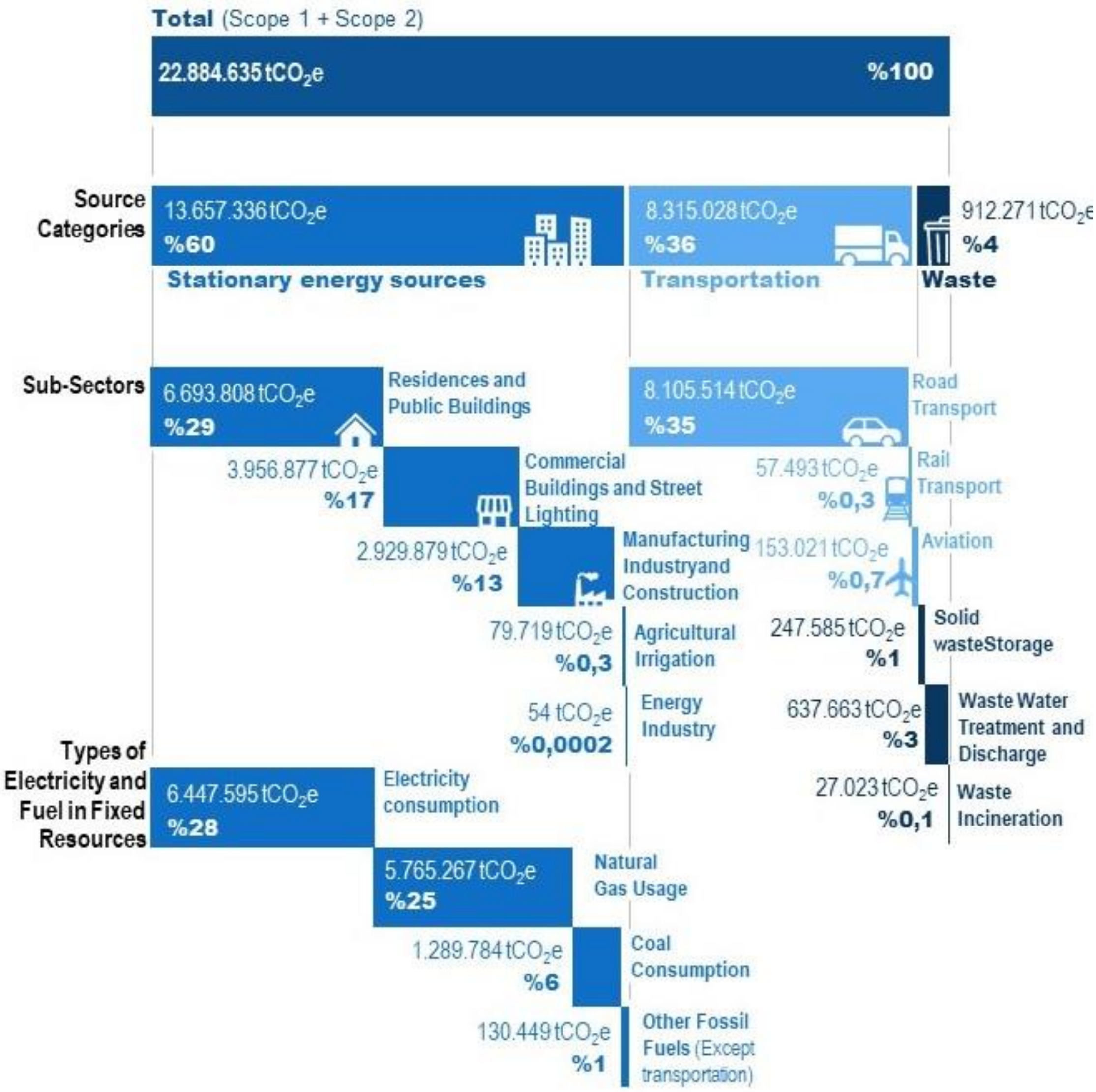
Calculated as a result of scaling of country-wide emissions from refrigerant gases using gross domestic product data on a city basis in accordance with the method suggested by the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories. Turkey's 2019 National Inventory Statement stated that HFC emissions as greenhouse gas was 6.063.970 tons CO_2equivalent for the whole country. On the other hand, proportion of the Ankara GDP over Turkey GDP was 9.2% fo the year 2019. Therefore, the total greenhouse gas emissions from cooling gases (HFCs) within the boundaries of Ankara Province in 2019 are expressed as 557.885 tons of CO2 equivalent.

Table 2.6. Emission distribution of source categories other than GPC BASIC (Basic +)

Source Category	GHG Emission (tCO_2e)
Emissions due to electrical losses	303.823
Emissions from cement production	1.471.465
Emissions from lime production	24.242
Emissions due to HFCs release	557.885
Emissions due to commercial fertilizer usage (urea)	26.299
Emissions from land use change	9.835
Emissions from livestock activities	1.993.827
Total (Excluding GPC BASIC Emissions)	**4.387.376**

2.7. Greenhouse Gas Emissions Inventory Results

When total emissions are analyzed on the basis of upper source categories (Figure 2.12), stationary energy sources have the largest share in total greenhouse gas emissions with 59%. Emissions from stationary energy sources are followed by transportation with 39% and waste management with 2%.



a: Since emissions from energy production are included in the inventory within the electricity consumption of fixed resources, data are not shown in this line.

b: The emission calculation of waste water collected from solid waste landfills is stored in the storage and biological treatment of solid wastes. For this reason, the data of the emission source in question is not included in the "waste water treatment and discharge" emission value.

Figure 2.12. GPC BASIC- Distribution by source categories (Scope 1+Scope 2)

When the emissions are analyzed in detail on the basis of the sub-headings of the source categories (Figure 2.12), residences and public buildings, road transport and transportation activities, commercial buildings and street lighting are the highest among the greenhouse gas emissions of Ankara in 2019 with 31%, 38% and 19%, respectively. These 3 categories constitute 89% of the total emissions.

Greenhouse gas emissions within the scope of GPC Basic and greenhouse gas emissions within the scope of GPC Basic +, together with the greenhouse gas emission inventory results of as of 2019 calendar year of Ankara Province are expressed in Table 2.7.

Table 2.7. Emissions under GPC BASIC and Basic +

Source Category	GHG Emission (tCO2e)
GPC Basic (Scope 1 and scope 2)	22.884.635
Emissions due to electrical losses	303.823
Emissions from cement production	1.472.454
Emissions from lime production	24.242
Emissions due to HFCs release	557.885
Emissions due to commercial fertilizer usage (urea)	26.299
Emissions from land use change	9.835
Emissions from livestock activities	1.993.827
Total (GPC Basic +)	**27.273.000**

According to the results of the 2019 greenhouse gas emission inventory of Ankara Province, the total greenhouse gas emissions within the scope of GPC Basic are 22,884,635 tons of CO_2e. The population of Ankara Province in 2019 is 5,639,076 and therefore, the greenhouse gas emission per capita is 4.05 tons CO_2e according to the scope of GPC Basic. In addition, total greenhouse gas emissions are 27,273,000 tons of CO_2e, with emission sources excepted by the scope of GPC Basic. According to this scope, the greenhouse gas emission per capita is 4.83 tons of CO_2e.

3. GREENHOUSE GAS EMISSION PROJECTION

3.1. Population

Projections for the population of Ankara between 2020-2050 were calculated to be used in the Kaya Identity Model. Reference sources for these projections are prepared by TURKSTAT and listed below.

- Population of provinces by years, 2018-2025
- Population Projections 2018-2080
- 2019-2020 Address-Based Population Registration System

Explanations and numerical values regarding population projections and assumptions in greenhouse gas emission projections calculated over 3 different scenarios are given in Table 3.1, Table 3.2 and Figure 3.1.

Table 3.1 Population values and assumptions used in scenarios 1-2 and 3

Scenarios	Data and Assumptions Used in Population Projection
Scenario 1	The results of the address-based population registration system are based on the 2020 Ankara population.
Scenario 2	For the period between 2020-2025, the annual population projection data calculated for Ankara Province by TURKSTAT is based.
Scenario 3	According to the annual population projections calculated for Turkey and Ankara by TURKSTAT for the period 2020-2025, the annual average population growth rates are 1.14% and 1.69%, respectively. Therefore, it is predicted that Ankara population growth rate will be 32.6% higher than Turkey's population growth rate between 2020-2025. 32.6% more than the population growth rate prepared by TURKSTAT for 2025-2080 Turkey in general has been used for the calculations of Ankara population projection between 2025-2050.

Table 3.2 Turkey and Ankara Province Population Projections (2025-2050)

Population	2025	2030	2040	2050
Turkey	88.844.934	93.328.574	100.331.233	104.749.423
Ankara_Scenario 1,2 ve 3	6.263.201	6.680.781	7.347.481	7.777.284

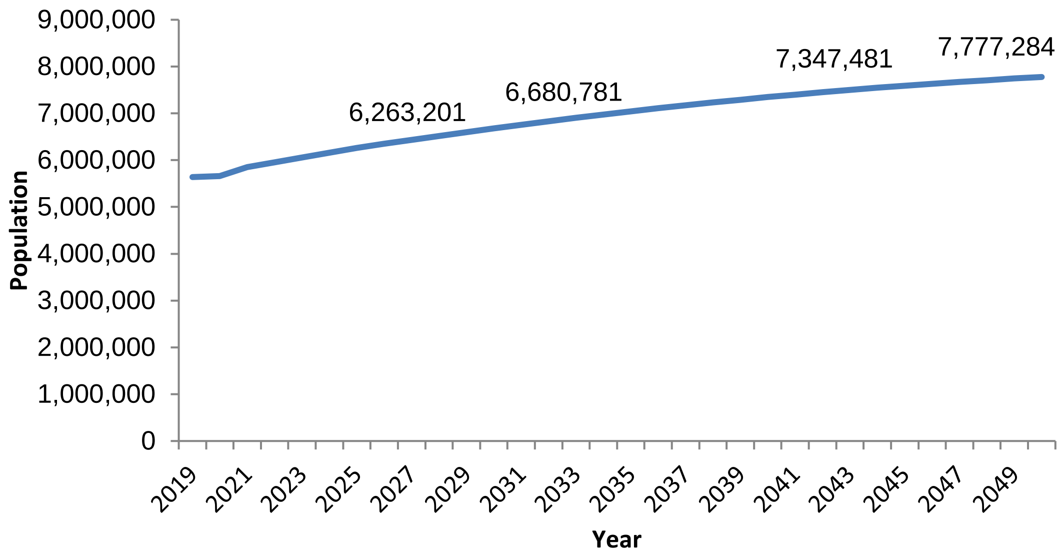


Figure 3.1 Ankara Province Population Projection_Scenario 1, 2 and 3(2019-2050)

3.2. Gross Domestic Product (GDP)

GDP per capita is another factor used in greenhouse gas emission projections. GDP data shared in Turkey's 7th National Communication, "Gross Domestic Product by Province, 2004-2019" statistics published by TURKSTAT and the GDP values predicted in the study titled “Low Carbon Development Pathways and Priorities for Turkey” published in 2015 by the World Wildlife Foundation Turkey (WWF) were evaluated in greenhouse gas emission projection scenarios.

Detailed information about the values used in the scenarios and their references are given in Table 3.3.

Table 3.3 GDP values and assumptions used in scenarios 1-2 and 3

Scenarios	Data and Assumptions Used in GDP
Scenario 1	In the "Gross Domestic Product, 2004-2019" statistics published by TURKSTAT, the GDP per capita for Ankara in US Dollars between 2004-2019 shows an average increase of 1.65% on a yearly basis. From this point of view, in Scenario 1, annual GDP growth of 1.65% for the period 2020-2050 is included in the calculations.
Scenario 2	According to the data shared in Turkey's Seventh National Communication published by the Ministry of Environment and Urbanization of the Republic of Turkey within the scope of the United Nations Framework Convention on Climate Change (UNFCCC); "*According to the Medium Term Program (MTP) 2019-2021 targets, Turkey aims to grow by 2.3%, 3.5% and 5% respectively for the next three years. According to the OECD's forecasts, Turkey has an annual average growth rate of 4.9% in the 2015-2025 period. It will be one of the fastest growing economies*". From this point of view, in Scenario 2, annual GDP growth of 5% for the period 2020-2050 is included in the calculations.
Scenario 3	In the report titled “Low Carbon Development Pathways and Priorities for Turkey” published by World Wildlife Foundation Turkey (WWF) in 2015, an annual GDP increase of 3.3% is predicted for the period until 2030. From this point of view, in Scenario 3, annual GDP growth of 3.33% for the period 2020-2050 is included in the calculations.

3.3. Carbon Intensity of The Economy

The carbon intensity of the economy is defined as the amount of carbon emission per unit of economic activity. It shows the ratio of carbon emissions to Gross Domestic Product (GDP) according to the Purchasing Power Parity (PPP) value (GDP) (CO_2 / GDP). The carbon intensity of the economy is a product of the energy intensity of the economy and the carbon intensity of the energy supply. Seventh National Communication of Turkey on Climate Change pointed out also this factor for projection calculations of greenhouse gas emissions (Ministry of Environment and Urbanization Ministry, 7. National Communication). The factor has also been used in the calculation of the greenhouse gas emission projections of Ankara in this study. Related data was given in Table 3.4 and also visualized in Figure 3.2.

Table 3.4 Carbon Intensity of the Economy in Turkey (ton CO2-eq./1000 USD) (2010 USD)

Carbon Intensity of the Economy	1990	2000	2010	2015	2016
Turkey	0,35	0,34	0,32	0,26	0,27

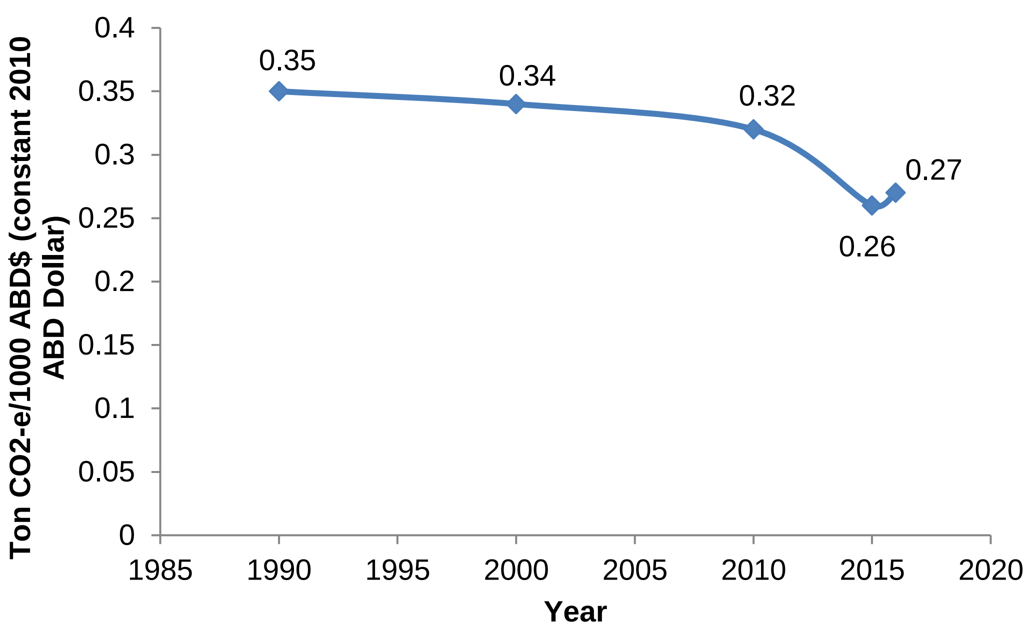


Figure 3.2 Carbon Intensity of the Economy (ton CO2-eq./1000 US$) (1990-2016) (Source: the Seventh National Communication on Climate Change of Turkey, 2018)

In terms of data Carbon Density of Economy for between 2010 and 2016, it was assumed that the value was decreased as 2.6% each year compared to the previous year. From this point of view, it has been assumed that it will continue to decrease by 2.6% every year from 2016 to 2050, and the yearly carbon intensity values of the economy obtained with this assumption are used in the calculations of Ankara Province Greenhouse Gas Emission Projections

3.4. Energy Intensity of The Economy

Energy intensity of the economy is the ratio of primary energy use to Gross Domestic Product (GDP) (TEP / GDP (PPP)) according to the Purchasing Power Parity (PPP). The energy intensity of the economy is a value that reflects both efficiency in energy use and efficiency in the economic structure. Energy intensity shows the economic structure of countries or regions, energy consumption structure, climatic conditions and technical energy efficiency. The energy intensity trend is affected by structural changes in the economy and industry, changes in the energy consumption structure, and the equipment used by end users and efficiencies in the building sector. The energy intensity of the economy was used as another factor in the calculation of the greenhouse gas emission projections of Ankara. Related data was given in Table 3.5 and also visualized in Figure 3.3.

Table 3.5 Energy Intensity of the Economy, Turkey (Toe/1000 US$) (2010 USD)

Energy Intensity of the Economy	**1990**	**2000**	**2010**	**2015**	**2016**
Turkey	0,088	0,093	0,084	0,073	0,074

In terms of data Energy Density of Economy for between 2010 and 2016, it was assumed that the value was decreased as 1.98% each year compared to the previous year. From this point of view, it has been assumed that it will continue to decrease by 1.98% every year from 2016 to 2050, and the yearly carbon intensity values of the economy obtained with this assumption are used in the calculations of the Ankara Province Greenhouse Gas Emission Projections.

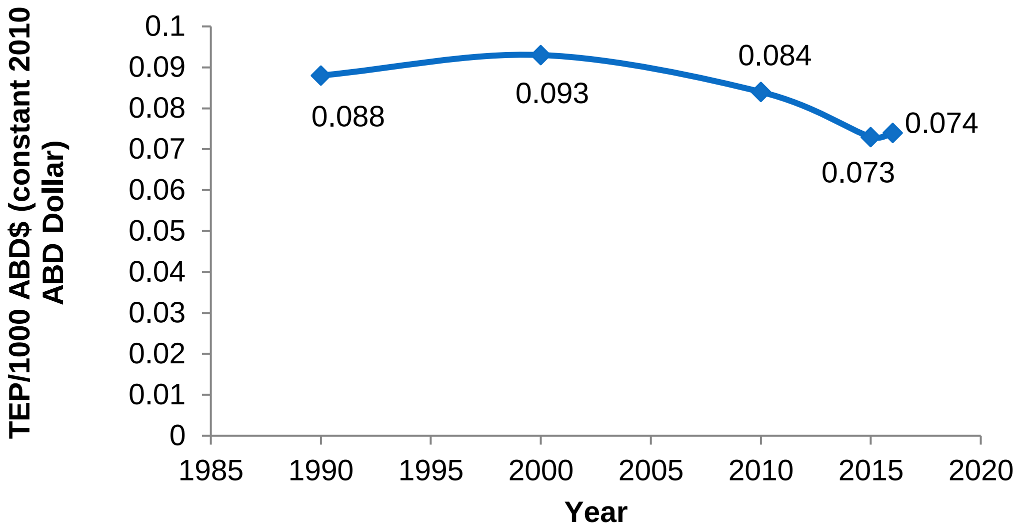


Figure 3.3 Energy Intensity of the Economy (ton CO2-eq./1000 US$) (1990-2016) (Source: the Seventh National Communication on Climate Change of Turkey, 2018)

3.5. Greenhouse Gas Emission Projection Calculations for Ankara Province

After sharing the definitions of the factors used in the projection calculations and the values used in the calculations, the details of the formula used in the calculation and the results are shared in this section.

The following formula is used in calculating the greenhouse gas emissions that can be predicted for a year of activity of a particular region according to Kaya Identity.

CO2equivalent (GHG) emissions = Population × (GDP/Population) × (Energy/GDP) × (CO2/Energy)

It is possible to calculate the "CO2 / Energy" factor in the relevant formula as follows.

CO2/Energy = (Carbon Density of Economy/Energy Density of Economy)

According to the values related to the energy density of the economy and the energy density concepts of the economy, which are expressed in the above sections, the “CO2/Energy” factor has been calculated as "0.994".

While calculating the projections of greenhouse gas emissions for 2020 and beyond, population, energy density of the economy, carbon density of the economy and the increase / decrease rates of per capita GDP values on a yearly basis are used based on the Rock Identity formula. The mathematical formula for the calculation method in question is as follows.

2020 CO2equivalent (GHG) emissions = [2019 CO2equivalent (GHG) emissions × *(2020 Ankara Province Population/2019 Ankara Province Population* × *(2020 GDP Per Capita/ 2019 GDP Per Capita)]* × *(CO2/Energy)*

In this direction, assuming that no energy efficiency studies / greenhouse gas emission mitigation measures were taken between 2019-2050, Ankara Province Greenhouse Gas Emissions values for 2025-2030-2040 and 2050 are given in Tables 3-6, 3-7 and Figures 3-4, 3-5, 3-6, 3-7, 3-8 and 3-9.

Table 3.6 Ankara Province 2025-2030-2040-2050 Greenhouse Gas Emission Projection (GPC Basic)

Greenhouse Gas Emission (ton CO_2e)	2019 (Base Year)	2025	2030	2040	2050
Scenario 1	22.884.635	26.984.826	30.255.654	36.764.599	42.996.326
Scenario 2	22.884.635	29.730.340	36.137.132	51.607.251	70.932.618
Scenario 3	22.884.635	32.789.421	43.244.655	72.707.507	117.653.349

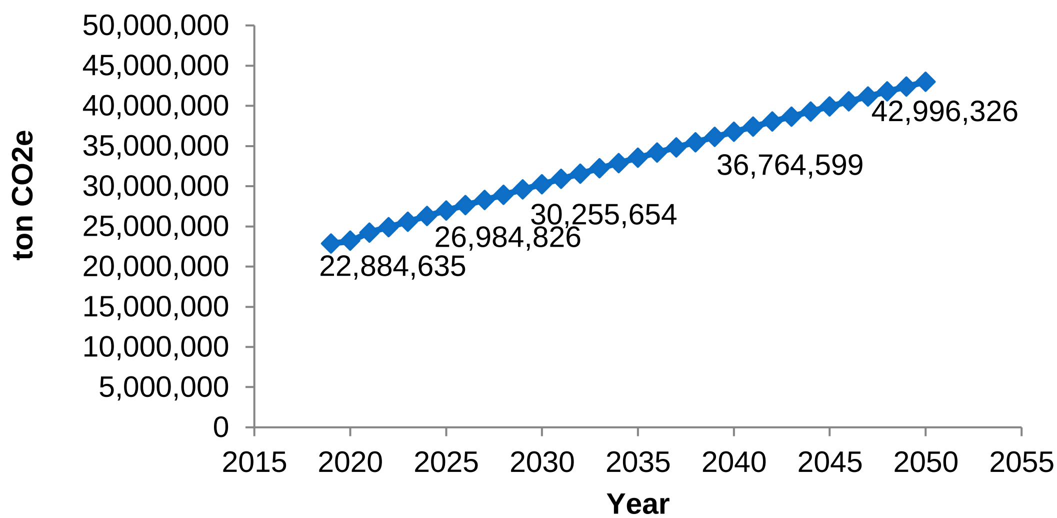


Figure 3.4 Ankara Province 2019-2050 Greenhouse Gas Emission Projection_Scenario 1(GPC Basic)

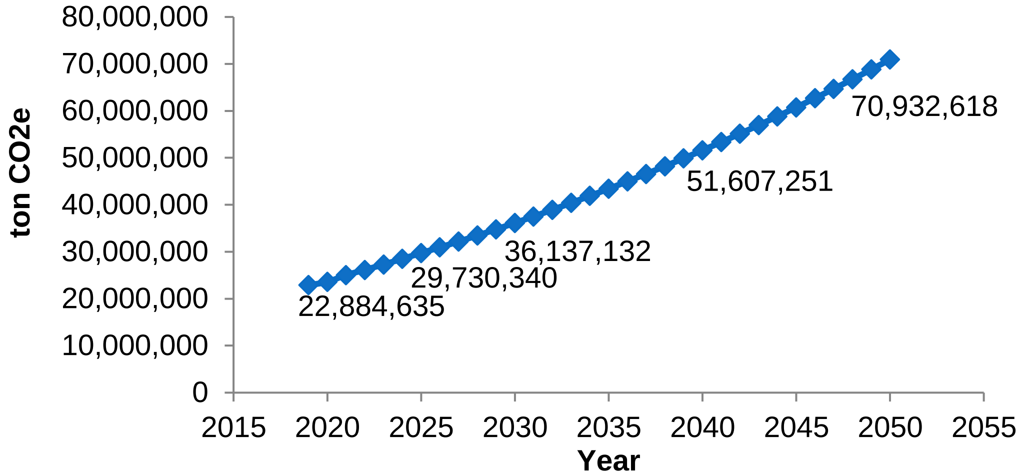


Figure 3.5 Ankara Province 2019-2050 Greenhouse Gas Emission Projection_Scenario 2(GPC Basic)

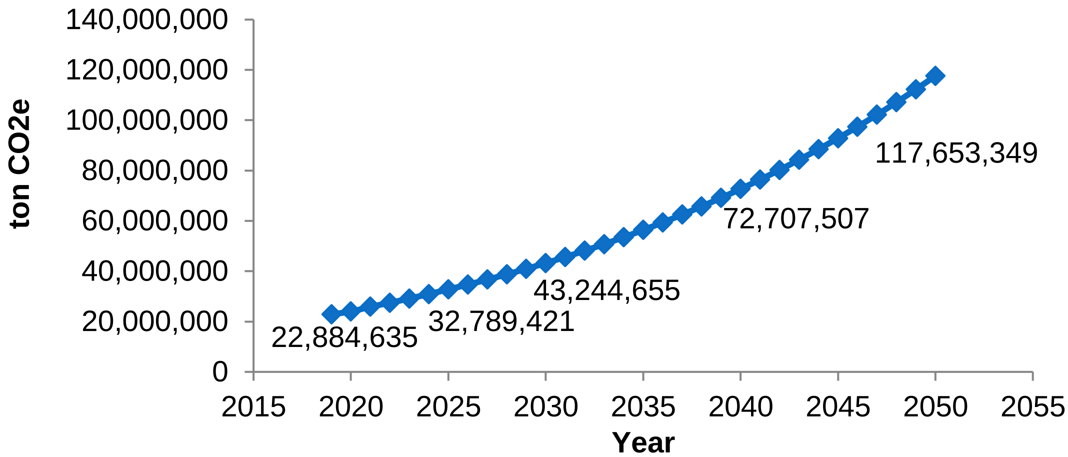


Figure 3.6 Ankara Province 2019-2050 Greenhouse Gas Emission Projection_Scenario 3(GPC Basic)

Table 3.7 Ankara Province 2025-2030-2040-2050 Greenhouse Gas Emission Projection (Projection of Total Emissions Excepting by GPC Basic and Basic Category)

Greenhouse Gas Emission (ton CO_2e)	2019 (Base Year)	2025	2030	2040	2050
Scenario 1	27.273.000	32.159.445	36.057.488	43.814.590	51.241.315
Scenario 2	27.273.000	35.431.440	43.066.800	61.503.474	84.534.680
Scenario 3	27.273.000	39.077.130	51.537.263	86.649.922	140.214.593

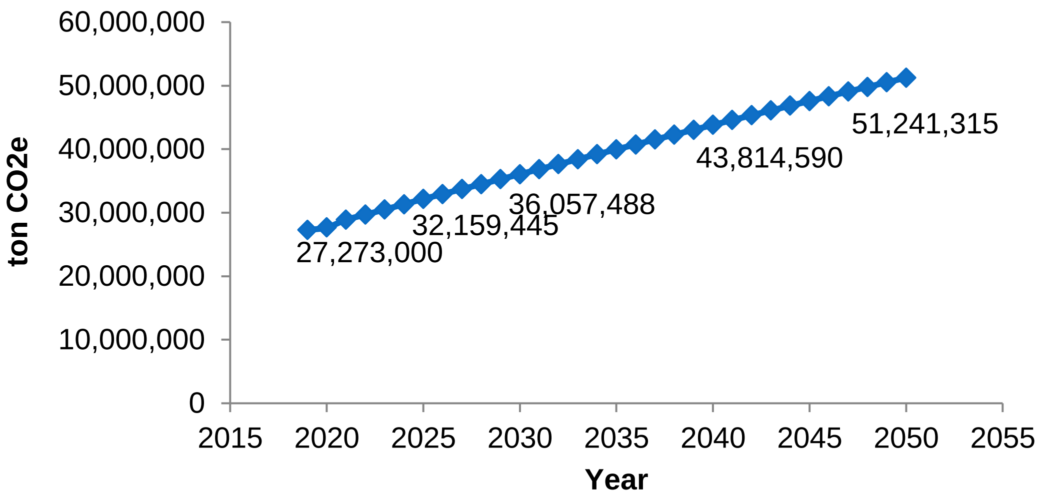


Figure 3.7 Ankara Province 2019-2050 Greenhouse Gas Emission Projection_Scenario 1 (Projection of Total Emissions Excepting by GPC Basic and Basic Category)

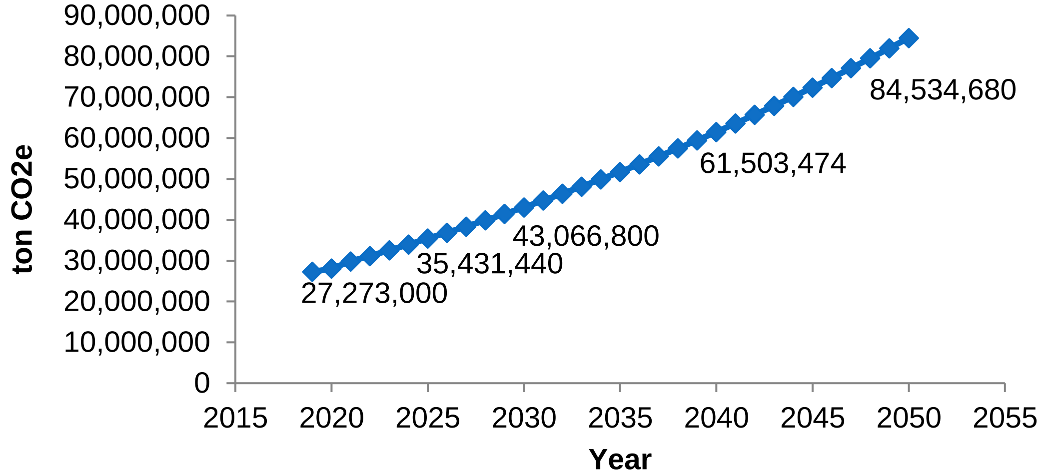


Figure 3.8 Ankara Province 2019-2050 Greenhouse Gas Emission Projection_Scenario 2 (Projection of Total Emissions Excepting by GPC Basic and Basic Category)

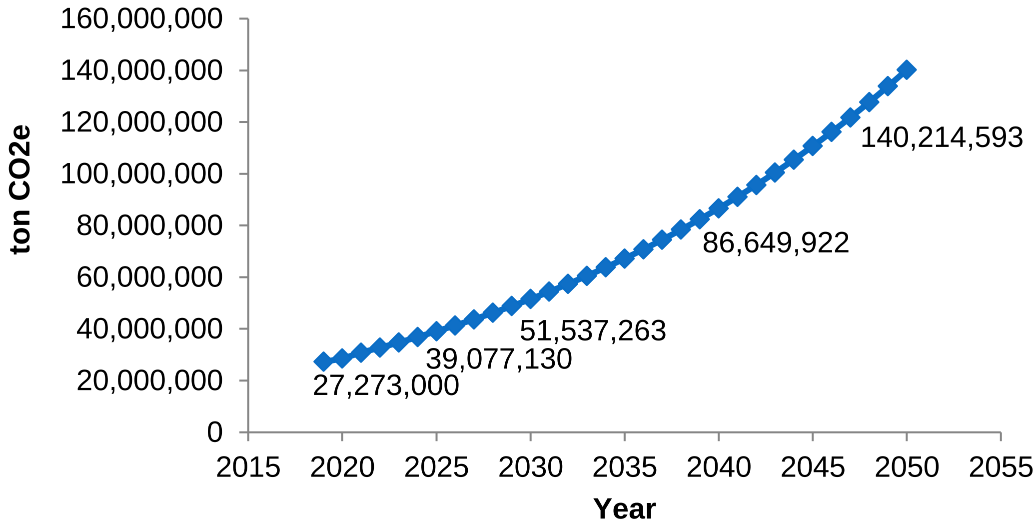


Figure 3.9 Ankara Province 2019-2050 Greenhouse Gas Emission Projection_Scenario 3 (Projection of Total Emissions Excepting by GPC Basic and Basic Category)

Based on the year 2019, the greenhouse gas emission values of Ankara Province are shared in the greenhouse gas emission inventory report on the basis of source categories sub-headings. Since these values are the basic data used in the projections, they are shared again in this study, and the greenhouse gas emission projections on the basis of source category are also expressed in Table 3-8, 3-9 ve 3-10.

Table 3.8 Greenhouse Gas Emission Projections of Ankara Province by Source Category_Scenario 1

Greenhouse Gas Emission (ton CO_2e)	2019(Base Year)	2025	2030	2040	2050
Residences and Public Buildings	6.693.807	7.893.122	8.849.847	10.753.728	12.576.522
Commercial Buildings and Street Lighting	3.956.877	4.665.822	5.231.366	6.356.798	7.434.297
Manufacturing Industry and Construction	2.926.879	3.451.282	3.869.611	4.702.086	5.499.106
Electricity Use in Agricultural Irrigation	79.719	94.002	105.396	128.070	149.778
Energy Industry	54	64	71	87	101
Road Transportation	8.105.514	9.557.761	10.716.257	13.021.662	15.228.878
Rail Transportation	57.493	67.794	76.011	92.364	108.020
Aviation Activities	152.021	179.258	200.986	244.225	285.622
Solid Waste Storage Activities	247.585	291.944	327.331	397.750	465.170
Wastewater Treatment and Discharge	637.663	751.912	843.051	1.024.418	1.198.060
Waste Incineration Activities	27.023	31.865	35.727	43.413	50.772
GPC Basic	22.884.635	26.984.826	30.255.654	36.764.599	42.996.326

Total Excluding GPC Basic Categories	4.388.365	5.174.619	5.801.834	7.049.991	8.244.989
Total	27.273.000	32.159.445	36.057.488	43.814.590	51.241.315

Table 3.9 Greenhouse Gas Emission Projections of Ankara Province by Source Category_Scenario 2

Greenhouse Gas Emission (ton CO2e)	2019(Base Year)	2025	2030	2040	2050
Residences and Public Buildings	6.693.807	8.696.191	10.570.192	15.095.237	20.747.950
Commercial Buildings and Street Lighting	3.956.877	5.140.536	6.248.305	8.923.172	12.264.633
Manufacturing Industry and Construction	2.926.879	3.802.425	4.621.835	6.600.419	9.072.078
Electricity Use in Agricultural Irrigation	79.719	103.566	125.884	179.775	247.095
Energy Industry	54	70	85	122	167
Road Transportation	8.105.514	10.530.196	12.799.419	18.278.784	25.123.640
Rail Transportation	57.493	74.691	90.787	129.653	178.204
Aviation Activities	152.021	197.497	240.056	342.823	471.200
Solid Waste Storage Activities	247.585	321.648	390.962	558.330	767.408
Wastewater Treatment and Discharge Activities	637.663	828.413	1.006.934	1.437.997	1.976.484
Waste Incineration Activities	27.023	35.107	42.672	60.940	83.760

GPC Basic	22.884.635	29.730.340	36.137.132	51.607.251	70.932.618
Total Excluding GPC Basic Categories	4.388.365	5.701.100	6.929.668	9.896.223	13.602.062
Total	27.273.000	35.431.440	43.066.800	61.503.474	84.534.680

Table 3.10 Greenhouse Gas Emission Projections of Ankara Province by Source Category_Scenario 3

Greenhouse Gas Emission (ton CO_2e)	**2019(Base Year)**	**2025**	**2030**	**2040**	**2050**
Residences and Public Buildings	6.693.807	9.590.979	12.649.159	21.267.109	34.413.869
Commercial Buildings and Street Lighting	3.956.877	5.669.468	7.477.234	12.571.521	20.342.899
Manufacturing Industry and	2.926.879	2.474.796	3.263.910	5.487.631	8.879.939
Electricity Use in Agricultural Irrigation	79.719	114.222	150.643	253.278	409.847
Energy Industry	54	77	102	172	278
Road Transportation	8.105.514	11.613.692	15.316.834	25.752.288	41.671.666
Rail Transportation	57.493	82.377	108.643	182.663	295.580
Aviation Activities	152.021	109.142	143.943	242.012	391.617
Solid Waste Storage Activities	247.585	354.743	467.857	786.610	1.272.872
Wastewater Treatment and Discharge Activities	637.663	913.652	1.204.979	2.025.940	3.278.321

Waste Incineration Activities	27.023	38.719	51.065	85.856	138.929
GPC Basic	22.884.635	32.789.420	43.244.654	72.707.506	117.653.348
Total Excluding GPC Basic Categories	4.388.365	6.287.710	8.292.609	13.942.415	22.561.244
Total	27.273.000	39.077.130	51.537.263	86.649.921	140.214.592

4. MITIGATION ACTIONS

4.1. Buildings

According to the 2019 data of the Ministry of Energy and Natural Resources, the entire construction sector, including the residential and non-residential sectors, accounts for approximately 33% of the total final energy consumption in Turkey. Only the residential building stock is expected to grow by more than 50% in total by 2050, as a very fast-growing sector.[19] Along with these statistics, it is unavoidable for cities to be among the sectors that have an important place in climate change action plans due to carbon emissions and other environmental effects of buildings.

According to the results in the Greenhouse Gas Inventory Report, emissions from residences and public buildings in Ankara are calculated as 6,669,568 tCO2e (31% of total emissions) for 2019, while emissions from commercial buildings and street lighting are calculated as 3,956,877 tCO2e (18% of total emissions). When the results are evaluated on the basis of Ankara province, it is seen that a large part of the total emissions results from the building sector. Therefore, the mitigation activities included in the action plan are of great importance.

Within the framework of the Ankara Climate Change Action Plan, 8 actions have been determined to reduce greenhouse gas emissions in buildings.

ACTION		SUB-ACTION	
1	**Improving the Performance of Existing Municipal Buildings**	**1.1**	Conducting building energy efficiency surveys of all existing buildings of the municipality, starting with buildings with high energy density
		1.2	Making building improvements in accordance with the surveys carried out
		1.3	Integration of energy efficient and green systems into buildings
2	**Integration of Green Building Design to All New Buildings to be Built by the Municipality**	**2.1**	Determining the appropriate green building standard for each of the new municipal building projects
		2.2	Regulating the technical specifications of the projects in accordance with the determined green building standard

[19] Energy Efficiency Technology Atlas for Turkey's building sector, 2021

		2.3	Certification of buildings with high energy density and gross area by relevant institutions
3	**Implementing the Urban Transformation Plan & Coal Phase-Out for Heating Purposes**	3.1	Providing the necessary infrastructure to zero the use of coal for heating purposes
		3.2	Zeroing coal for heating in priority areas & heating from natural gas
4	**Coal Phase-Out for Heating Purposes in Other Areas**	4.1	Zeroing the use of coal for heating in unplanned areas outside the urban transformation zone
5	**Developing Financial Incentive and Fund Mechanisms to Improve the Performance of Existing and New Buildings**	5.1	Developing a series of incentive mechanisms to be applied according to the building class to the new buildings to be constructed as EPC class A and B (Accelerating permit process for buildings, discounts in fees and service fees, etc.)
		5.2	Ensuring cooperation with public and private banks in order to provide concessional loans for existing buildings in need of renovation, providing coordination for financing projects
6	**Disseminating Energy Efficient LED Bulb Campaign**	6.1	Developing a LED bulb support plan by Ankara Metropolitan Municipality Social Services Department, starting from residences and low-income groups
		6.2	Distribution of the highest possible number of LED bulbs to the relevant buildings and users in accordance with the plan
		6.3	Encouraging the use of LED bulbs for higher income groups where support cannot be provided and carrying out activities for the dissemination
7	**Making Rainwater Harvesting Mandatory**	7.1	Obligation to install rainwater collection systems in the mechanical installation projects of the buildings to be built on parcels smaller than 2000 m^2
8	**Trainings / Awareness Raising Studies on Water & Energy Efficiency in Buildings and Other Green Concepts**	8.1	Providing the necessary training to the administrative and technical staff of the municipality working on this issue, carrying out activities on increasing the institutional capacity and certifying the employees working in the relevant position
		8.2	Providing necessary training in cooperation with academia, private sector, chambers of commerce and associations to worker groups working in the construction sector

		8.3	Providing trainings on water/energy efficiency and the concept of sustainable building in secondary and high school schools
		8.4	The use of various announcements, public service announcements and social media materials on this subject within the scope of social responsibility activities to be carried out by the municipality; Carrying out studies aiming to inform households in order to reduce consumption in residences

Action 1. Improving the Performanceof Existing Municipal Buildings

Although the applications on energy efficiency in buildings have developed in the traditional sense in the historical process, it has developed in a more scientific direction after the energy crisis in 1973 and has been started be applied methodologically since that date. In the course of time, within the framework of the laws and regulations mentioned before, in order to analyze the conditions of existing buildings and to carry out necessary rehabilitation necessary steps have been taken. However, the applications that increase the performance of the buildings could not be applied to these buildings since there was no legal requirement valid at the time of the construction of many existing buildings, so the performance of the existing building stock remained quite low and it appears as a stock that is decreasing in performance day by day due to the wear and tear that occurs over time.

In the National Action Plan on Climate Change of the Republic of Turkey, there is a statement that "building stock built before 2000 consumes at least twice as much energy compared to today's regulation, even when compared only in terms of current construction standards". "Defining energy saving targets for public buildings", "increasing energy efficiency in municipal services" and "rehabilitation of existing buildings and improving energy efficiency" are among the measures determined for buildings in the National Energy Efficiency Action Plan (NEEAP) published in 2018.

In the light of this information, making all municipal buildings comply with current regulations and standards becomes one of the important actions within the scope of mitigation actions.

Sub-Action 1.1: Conducting building energy efficiency surveys of all existing buildings of the municipality, starting with buildings with high energy density

- Analysis of the compliance of the insulations of these buildings with the TS 825 standard, status analysis of windows, mechanical equipment, lighting, ventilation and installation systems

Sub-Action 1.2: Making building improvements in accordance with the surveys carried out

Sub-Action 1.3: Integration of energy efficient and green systems into buildings

- Widespread use of heat pumps
  - Heat pumps are systems that can transfer the heat they receive from a heat source to another environment at a lower temperature. These systems are increasingly used for heating and cooling purposes in buildings, with their low energy consumption and high coefficient of performance, as well as their environmentally friendly features.
  - According to a pilot study conducted in the Gölbaşı district of Ankara for 2021, a heat pump benefit/cost analysis was made for a house with a 5 kW heating need and important findings were obtained.
  - Accordingly, while the cost of energy consumed by the house under consideration due to a 16 kW electric heater is 22,752 TL per year, the energy cost to be consumed by a water or ground source heat pump of the same power is calculated as 5,881 TL. Considering the figures, it is seen that the cost has decreased to 25%. These values are also valid for emissions.
- Evaluation of landscaping opportunities with the intent to reduce the green roof and heat island effect for suitable buildings.
- Transition to building automation systems and/or smart building systems in buildings with high energy density
- Meeting the energy need in peak hours from renewable energy in buildings with high energy density (installation of solar power plants (SPP) on roofs or suitable areas in the landscape, etc.)

Mitigation Potential: ~ 35-50% in each of the municipal buildings

Action 2. . Integration of Green Building Design to All New Buildings to be Built by the Municipality

Green building certification systems, which emerged in the last quarter of the 21st century and gained popularity due to the accelerating urbanization and the resulting increase in emissions, are one of the best examples developed to reduce emissions from buildings by 30-40%. Therefore, avoiding uniform design and traditional construction practices is of great importance to achieve high greenhouse gas reduction rates. In many parts of the world, there are many green building certification systems (B.E.S.T, LEED, BREAM, DGNB, ESTIMADA, etc.) that have been created based on this idea, both considering local characteristics and adaptive to each country. These systems have gained the feature of being applicable in many parts of the world by applying pilot studies over time. These certificates, which can be seen as the identities of the buildings, both ensure that the design and operation of the building comply with sustainable criteria, and ensure that the concept of sustainable building becomes widespread and visible to the public. Again, the title of "Promoting the certification of sustainable green buildings and settlements" is among the measures determined within the scope of NEEAP.

Ankara is one of the provinces trying to adapt to the developing green building trends in both public, commercial and residential buildings. For example, according to 2020 LEED data, the number of buildings that received LEED green building certificate in Ankara as of the same year is 42. [20] This trend is expected to continue increasing in the coming years.

Ankara Metropolitan Municipality's design and operation of new buildings in accordance with green building certification systems, and even certifying these buildings by applying for certificates from relevant institutions, will contribute to Ankara's being among the exemplary green cities and increase visibility.

Sub-Action 2.1: Determining the appropriate green building standard for each of the new municipal building projects

Sub-Action 2.2: Regulating the technical specifications of the projects in accordance with the determined green building standard

Sub-Action 2.3: Certification of buildings with high energy density and gross area by relevant institutions

Mitigation Potential: ~ 35-50% in each of the municipal buildings

Action 3. Implementing the Urban Transformation Plan & Coal Phase-Out for Heating Purposes

Currently, ongoing urban transformation projects in Ankara cover four regions, namely Mamak, Hıdırlıktepe, Dikmen and Northern Ankara. The building type in these regions before the urban transformation is generally seen as squatter houses. According to the information received from the municipality, 14,000 squatter houses in Mamak, 5,500 in Hıdırlıktepe, 2,500 in Dikmen and around 6,000 in North Ankara have been included in the scope of the urban transformation plan. As it is known, there are no energy efficiency measures in this type of housing (non-insulated) and the use of wood/coal for heating is quite common.

Coal has become one of the widely used fuels for both electricity generation and heating purposes for many years, due to its low cost and superiority over other fossil resources in terms of storage, transportation and use. However, the widespread use of coal also brings many

[20] www.usgbc.org/projects

environmental effects. Gases such as carbon dioxide, carbon monoxide, sulfur oxides, nitrogen oxides, etc. which arise as a result of burning coal, both negatively affect human health and form the basis of the greenhouse gas effect that causes global warming.

The Intergovernmental Panel on Climate Change (IPCC), report published in October 2018, revealed that limiting the global temperature increase to 1.5^{o}C is essential for all of us. It is also stated in the same report that coal consumption should be reduced to zero by 2035 in OECD countries, of which Turkey is also a member, and by 2050 in all other countries. Although what is meant here is investments in coal and coal power plants used mostly for electricity generation, it is important for the national carbon budget to gradually reduce and and eliminate the use of coal for heating purposes in urban scale.

Sub-Action 3.1: Providing the necessary infrastructure to zero the use of coal for heating purposes

Sub-Action 3.2: Zeroing coal for heating in priority areas & heating from natural gas

Mitigation Potential: 1.66% of emissions from heating in all buildings

Table 4.1 Mitigation potential extending to years- Action 3

	2019	2025	2030	2040	2050
Expected emission from heating according to the reference scenario (tCO_2)	6.166.562	7.271.412	8.152.799	9.906.698	11.585.918
Expected emission from heating after mitigation (tCO_2)	-	7.150.425	8.017.127	9.741.846	11.393.144
Difference (ton CO_2)	-	120.987	135.652	164.834	192.774
Difference (%)	-	1,66	1,66	1,66	1,66

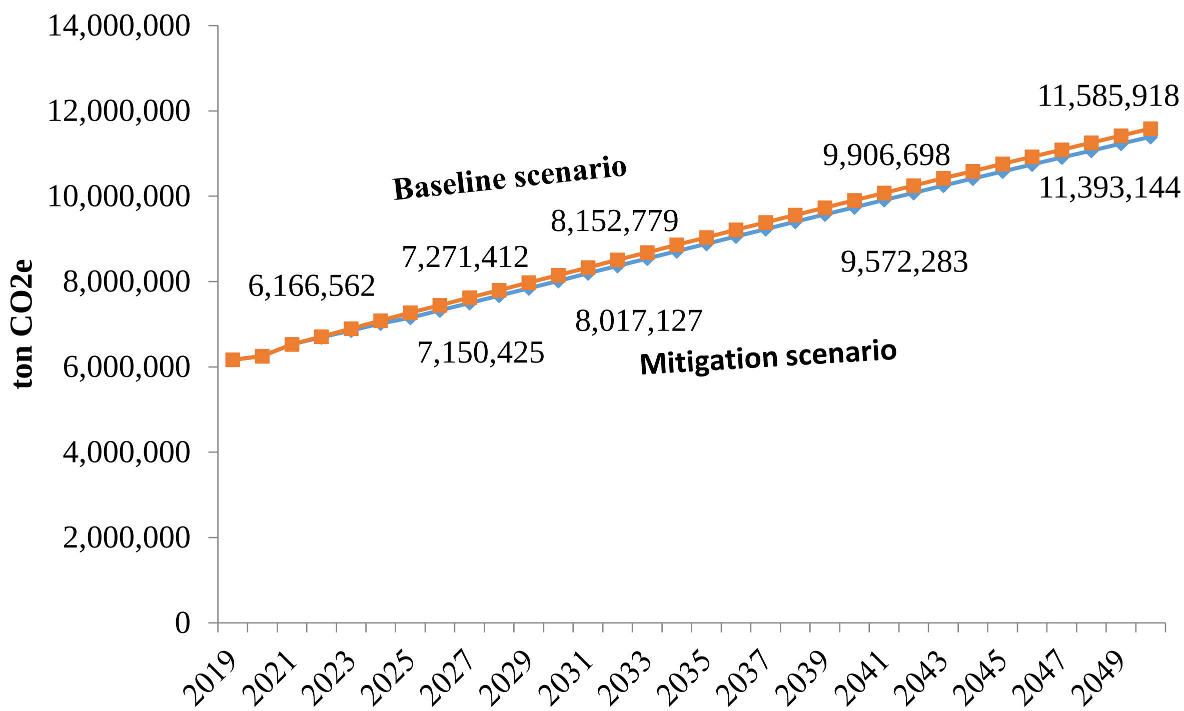


Figure 4.1 Mitigation potential extending to years- Action 3 (Mitigation calculated according to scenario 1)

Action 4. Coal Phase-Out for Heating Purposes in Other Areas

In addition to Action 3, it is important to eliminate the coal consumption for heating purposes in the regions outside the urban transformation zones in Ankara. Considering the total amount of domestic and imported coal distributed for heating purposes in 2019 by Ankara Metropolitan Municipality Social Services Department and Ankara Governorship Social Assistance and Solidarity Foundation, a separate calculation was made for places other than urban transformation zones. Accordingly, the annual 896,763 tons of CO2 emissions caused by the use of coal have been reduced to 274,012 tons of CO2 emissions per year, with the transition to natural gas infrastructure in these regions, and a reduction potential of 622,751 tons of CO2 has been calculated.

Sub-Action 4.1: Zeroing the use of coal for heating in unplanned areas outside the urban transformation zone

Mitigation Potential: 9% of emissions from heating in all buildings

Table 4.2 Mitigation potential extending to years- Action 4

	2019	2025	2030	2040	2050
Expected emission from heating according to the reference scenario (tCO_2)	6.166.562	7.271.412	8.152.799	9.906.698	11.585.918
Expected emission from heating after mitigation (tCO_2)	-	6.381.424	7.154.915	8.694.163	10.167.854
Difference (ton CO_2)	-	622.751	698.235	848.447	992.262
Difference (%)	-	9	9	9	9

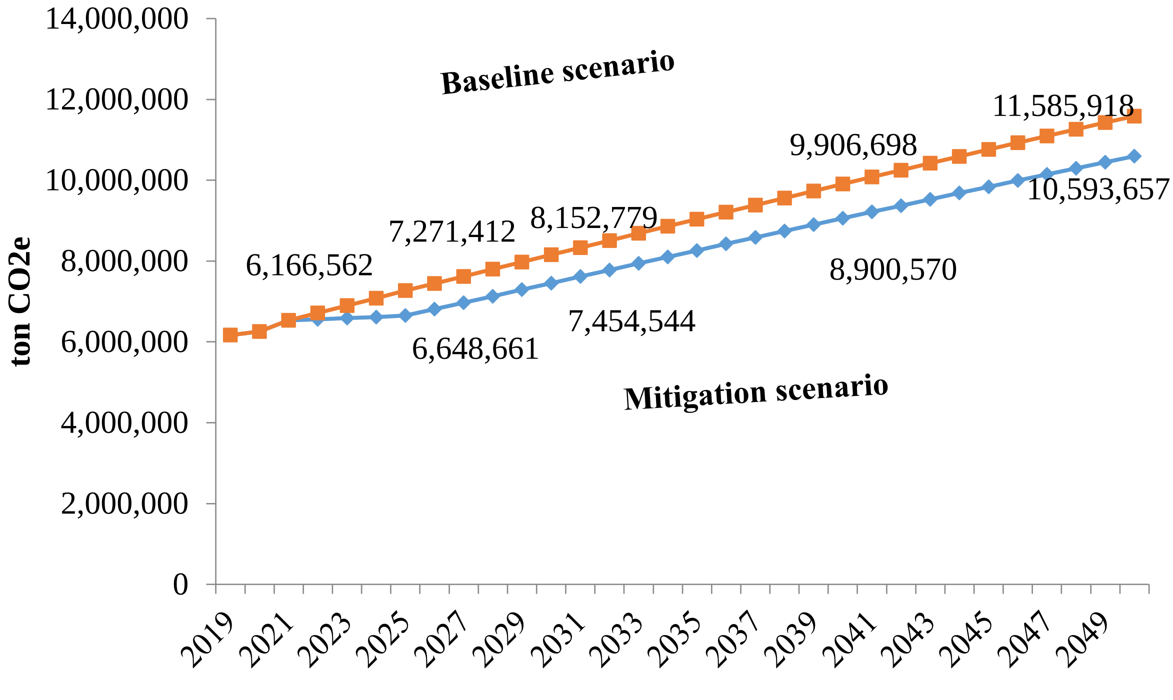


Figure 4.2 Mitigation potential extending to years- Action 4 (Mitigation calculated according to scenario 1)

Action 5. Developing Financial Incentive and Fund Mechanisms to Improve the Performance of Existing and New Buildings

According to the January 2020 data of the Ministry of Environment and Urbanization, 1,000,000 certificates have been received since 2011, when the Energy Performance Certificate (EPC) in Buildings entered in force. Of these buildings, 200,000 are classified as existing and 800,000 as new buildings. When the buildings with EPC are evaluated on a provincial basis, Istanbul ranks first (180,000 buildings with EPC), followed by Ankara with 100,000 buildings. These certificates, which are valid for 10 years, are one of the important documents that show the building performance, as they provide information on the systems, components and insulation that affect the energy consumption of the building, as well as the energy need and energy consumption classification of the building.

It is essential to design and construct new buildings with high performance, and to increase the energy classes of the existing building stock with improvements in existing buildings. Considering that the A-class saves 60%, the B-class 35-50% and the C-class 25-35% energy saving, the mitigation to be achieved is significant. Since the resources of the municipality are limited at this point, the development of some financial incentives and fund mechanisms will help the building sector employees and building owners/users to turn to this issue.

Sub-Action 5.1: Developing a series of incentive mechanisms to be applied according to the building class to the new buildings to be constructed as EPC class A and B (Accelerating permit process for buildings, discounts in fees and service fees, etc.)

Sub-Action 5.2: Ensuring cooperation with public and private banks in order to provide concessional loans for existing buildings in need of renovation, providing coordination for financing projects

Mitigation Potential:

- 20% by upgrading existing buildings (residential, commercial and public) lower than Class C to Class C standards,
- 27% by upgrading existing and new buildings (residential, commercial and public) lower than Class C to Class B standards,
- 40% by upgrading existing and new buildings (residential, commercial and public) below Class C to Class A standards.

Table 4.3 Mitigation potential extending to years- Action 5 (Class C)

	2019	2025	2030	2040	2050
Expected emissions according to the reference scenario (tCO_2)	10.515.544	12.399.591	13.902.545	16.893.420	19.756.913
Expected emission after mitigation (tCO_2)	-	11.998.948	12.927.498	14.565.106	15.872.789
Difference (ton CO_2)	-	400.644	975.047	2.328.314	3.884.124
Difference (%)	-	3	7	14	20

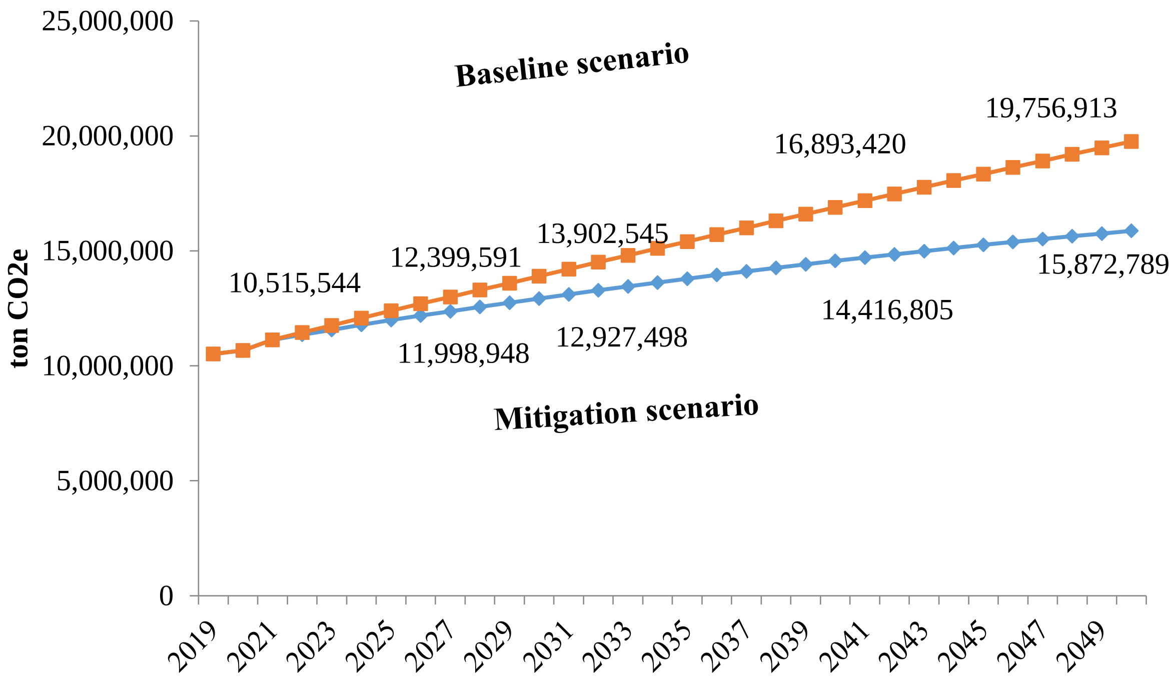


Figure 4.3 Mitigation potential extending to years- Action 5– Class C (Mitigation calculated according to scenario 1)

Table 4.4 Mitigation potential extending to years- Action 5 (B sınıfı)

	2019	2025	2030	2040	2050
Expected emissions according to the reference scenario (tCO_2)	10.515.544	12.399.591	13.902.545	16.893.420	19.756.913
Expected emission after mitigation (tCO_2)	-	11.794.758	12.459.805	13.566.221	14.366.060
Difference (ton CO_2)	-	1.039.846	2.378.746	3.327.200	5.390.853
Difference (%)	-	8	17	20	27

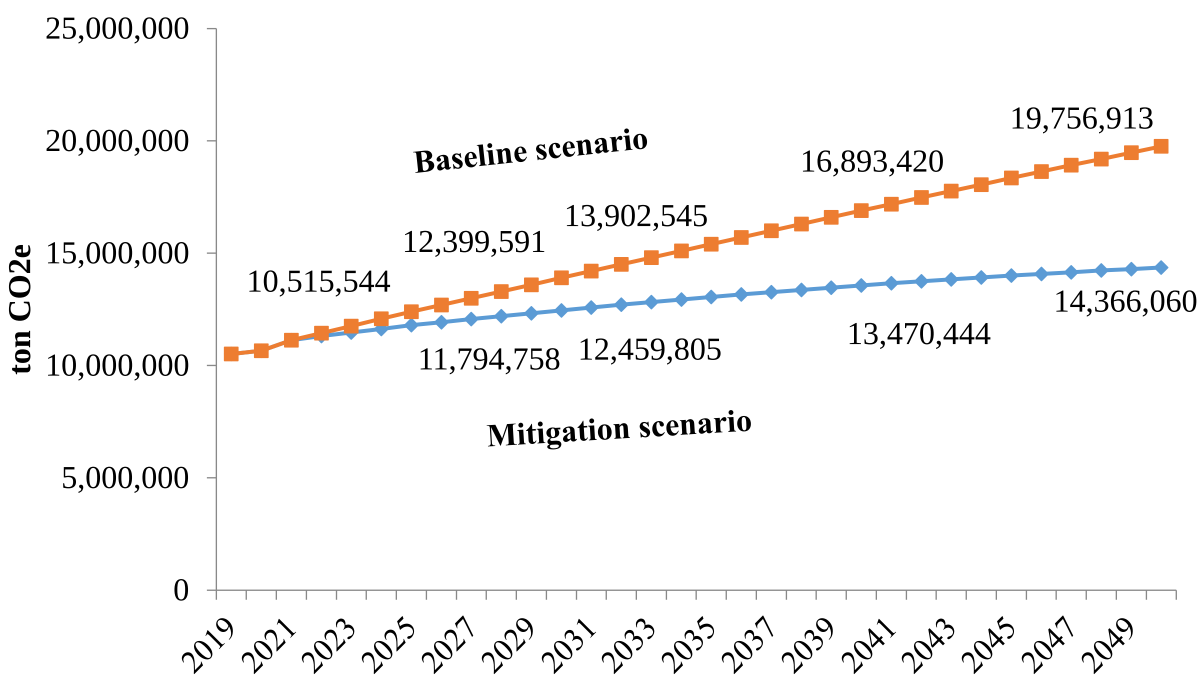


Figure 4.4 Mitigation potential extending to years- Action 5 – Class B (Mitigation calculated according to scenario 1)

Table 4.5 Mitigation potential extending to years- Action 5 (Class A)

	2019	2025	2030	2040	2050
Expected emissions according to the reference scenario (tCO_2)	10.515.544	12.399.591	13.902.545	16.893.420	19.756.913
Expected emission after mitigation (tCO_2)	-	11.359.745	11.523.799	11.761.039	11.852.860
Difference (ton CO_2)	-	1.039.846	2.378.746	5.132.382	7.904.053
Difference (%)	-	8	17	30	40

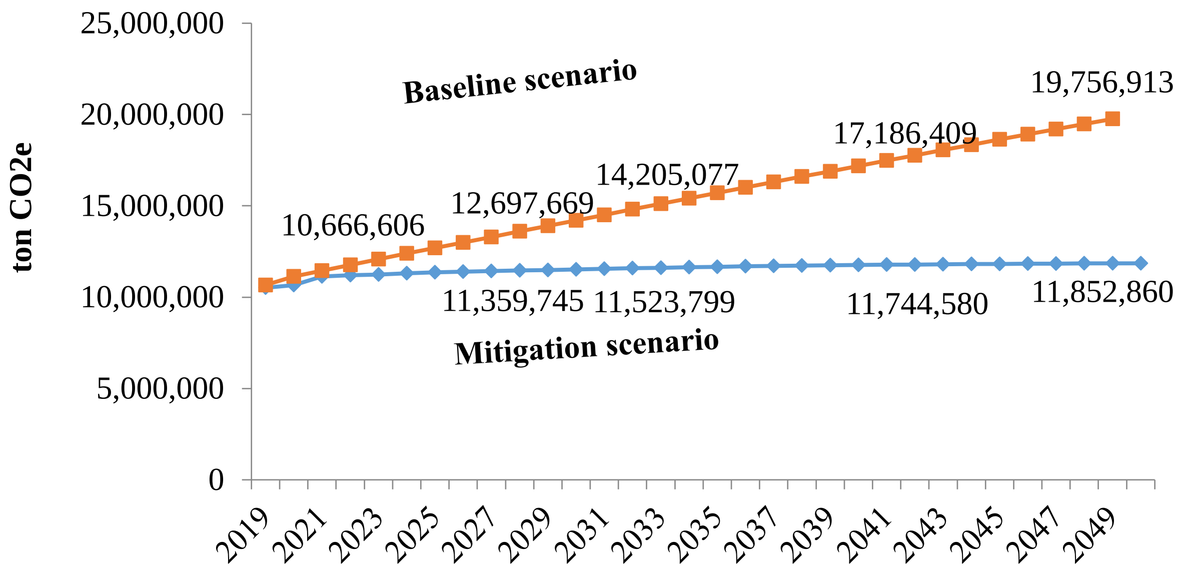


Figure 4.5 Mitigation potential extending to years- Action 5 – Class A (Mitigation calculated according to scenario 1)

Action 6. Disseminating Energy Efficient LED Bulb Campaign

Approximately 12% of electricity consumption in residences is due to lighting.[21] The fact that the technology used in lighting is energy-saving and efficient will not only reduce consumption by up to 90% but also save money by reducing bills. LED bulbs are good investment tools compared to other bulbs. Through their low energy consumption and long service life, they will have a lower environmental impact than traditional incandescent and halogen lamps, and since less bulb replacement will be required, the resulting waste will be reduced.

Considering all these features of LED lighting, the effects of replacing the lighting systems with LED bulbs in all residences in the province over time will be significant. For this, the "Environmentally Friendly Lighting Campaign" to be organized by the Ankara Metropolitan Municipality will increase the lighting efficiency in the residences and will provide both environmental and financial benefits.

Sub-Action 6.1: Developing a LED bulb support plan by Ankara Metropolitan Municipality Social Services Department, starting from residences and low-income groups

Sub-Action 6.2: Distribution of the highest possible number of LED bulbs to the relevant buildings and users in accordance with the plan

Sub-Action 6.3: Encouraging the use of LED bulbs for higher income groups where support cannot be provided and carrying out activities for the dissemination

Mitigation Potential: %17

Table 4.6 Mitigation potential extending to years- Action 6

	2019	2025	2030	2040	2050
Expected emissions from electricity according to the reference scenario (tCO_2)	4.276.215	5.042.375	5.653.561	6.869.820	8.034.279
Expected emissions from electricity after mitigation (tCO_2)	-	4.302.784	4.652.458	5.653.348	6.611.610
Difference (ton CO_2)		739.591	1.001.103	1.216.472	1.422.668
Difference (%)		15	17	17	17

[21] https://www.dunyaenerji.org.tr/wp-content/uploads/2019/11/21112019Sunum.pdf

Action 7. Making Rainwater Harvesting Mandatory

As a result of the amendment made within the scope of the Planned Areas Zoning Regulation dated 03.07.2017, the mechanical installation project in the buildings to be built on parcels larger than 2000 m² has to obey a new rule:

- A rainwater collection system project has also been added in order to collect the rainwater from the roof surface in the rainwater collection tank to be installed under the natural ground, and to filter and reuse it if necessary. The regulation also authorized the relevant administrations to impose obligations on smaller parcels.

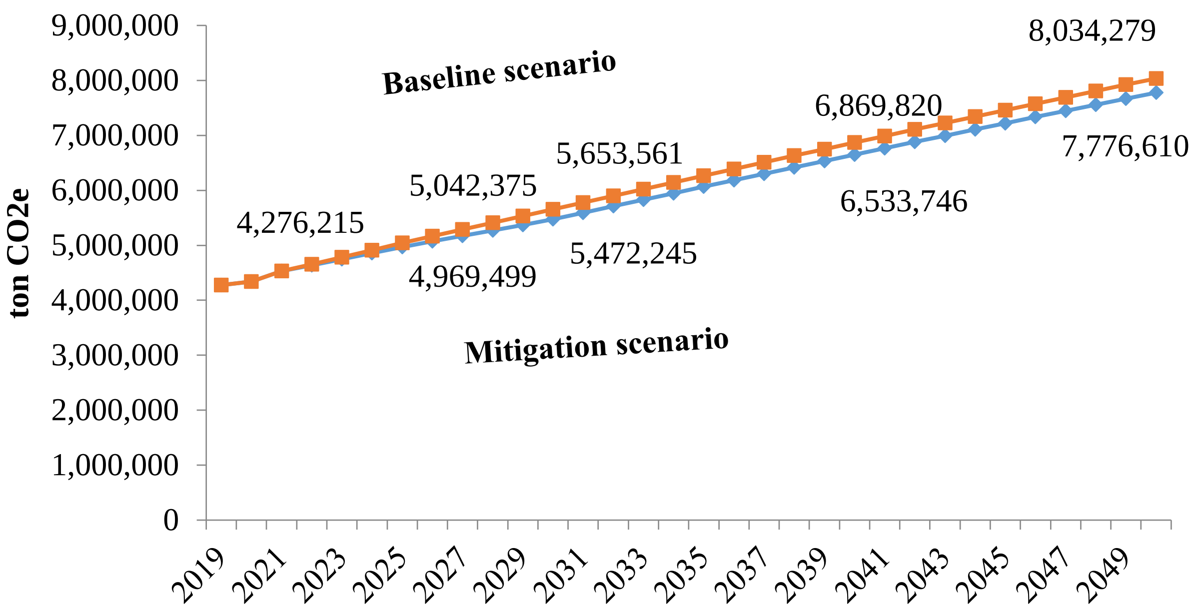


Figure 4.6 Mitigation potential extending to years- Action 6 – (Mitigation calculated according to scenario 1)

In this context, Ankara Metropolitan Municipality announced that rainwater storage areas with a capacity of 20 tons and above will be created in 40 parks in the city. However, when global and even regional conditions are taken into account, it is seen that the importance of water is increasing and how important even the smallest amount of rainwater that can be collected will be. For this reason, Ankara Metropolitan Municipality should impose the obligation to collect rainwater not only for parcels larger than 2000 m2 in the relevant regulation but also for smaller parcels with the authority given by the regulation. Rainwater harvesting is an easy-to-manage and economical system that is very suitable for many building types. It can be easily applied to roofs and open areas.

Sub-Action 7.1: Obligation to install rainwater collection systems in the mechanical installation projects of the buildings to be built on parcels smaller than 2000 m2

Mitigation Potential: -

Action 8. Trainings / Awareness Raising Studies on Water & Energy Efficiency in Buildings and Other Green Concepts

The concept of energy & water efficiency and sustainable building, which has gained momentum in the last few decades in the world and has become more common with new applications and technologies, both provide environmental benefits and create new employment areas. In this sense, it is of great importance that the workforce operating in the construction sector keep up with the developing new technologies and applications. As it is known, it is not enough to design and construct buildings as energy-efficient and sustainable alone. At the same time, their proper operation constitutes an important part of the efficiency to be achieved during the operation phase and the associated emission reductions. For this reason, the employees in the administrative and technical staff of the municipality need to receive the necessary technical training, both in terms of decision-making stages and in terms of the operation of sustainable buildings by their purposes.

From another point of view, these trainings should not be limited to municipal staff only. In order to emphasize the importance of the rapidly developing green construction sector and to provide social awareness on this issue, it is essential to provide necessary training to people from all segments of society. The minimum level of knowledge of both sector workers and building users will facilitate the dissemination and acceptance of such practices.

Sub-Action 8.1: Providing the necessary training to the administrative and technical staff of the municipality working on this issue, carrying out activities on increasing the institutional capacity and certifying the employees working in the relevant position

Sub-Action 8.2: Providing necessary training in cooperation with academia, private sector, chambers of commerce and associations to worker groups working in the construction sector

Sub-Action 8.3: Providing trainings on water/energy efficiency and the concept of sustainable building in secondary and high school schools

Sub-Action 8.4: The use of various announcements, public service announcements and social media materials on this subject within the scope of social responsibility activities to be carried out by the municipality; Carrying out studies aiming to inform households in order to reduce consumption in residences

Table 4.7 Mitigation potential extending to years- Action 8

		2019	2025	2030	2040	2050
Expected emissions from electricity according to the reference scenario (tCO_2)	Setting the thermostat 2.5 - 3 degrees low	6.166.562	7.271.412	8.152.799	9.906.698	11.585.918
	Preferring of energy-efficient electrical appliances	4.276.215	5.042.375	5.653.561	6.869.820	8.034.279
	Not leaving electrical appliances on the standby use mode	4.276.215	5.042.375	5.653.561	6.869.820	8.034.279
Expected emissions from electricity after mitigation (tCO_2)	Setting the thermostat 2.5 - 3 degrees low	-	7.080.076	7.683.677	8.771.516	9.669.940
	Preferring of energy-efficient electrical appliances	-	4.751.219	4.966.518	5.313.572	5.548.602
	Not leaving electrical appliances on the standby use mode	-	4.969.499	5.472.245	6.649.497	7.776.610
Difference (ton CO_2)	Setting the thermostat 2.5 - 3 degrees low	-	191.336	469.102	1.135.182	1.915.978
	Preferring of energy-efficient electrical appliances	-	291.156	687.043	1.556.249	2.485.676
	Not leaving electrical appliances on the standby use mode	-	72.877	181.316	220.323	257.669
Difference (%)	Setting the thermostat 2.5 - 3 degrees low	-	3	6	11	16
	Preferring of energy-efficient electrical appliances	-	6	12	23	31
	Not leaving electrical	-	1.5	3	3	3

	appliances on the standby use mode					

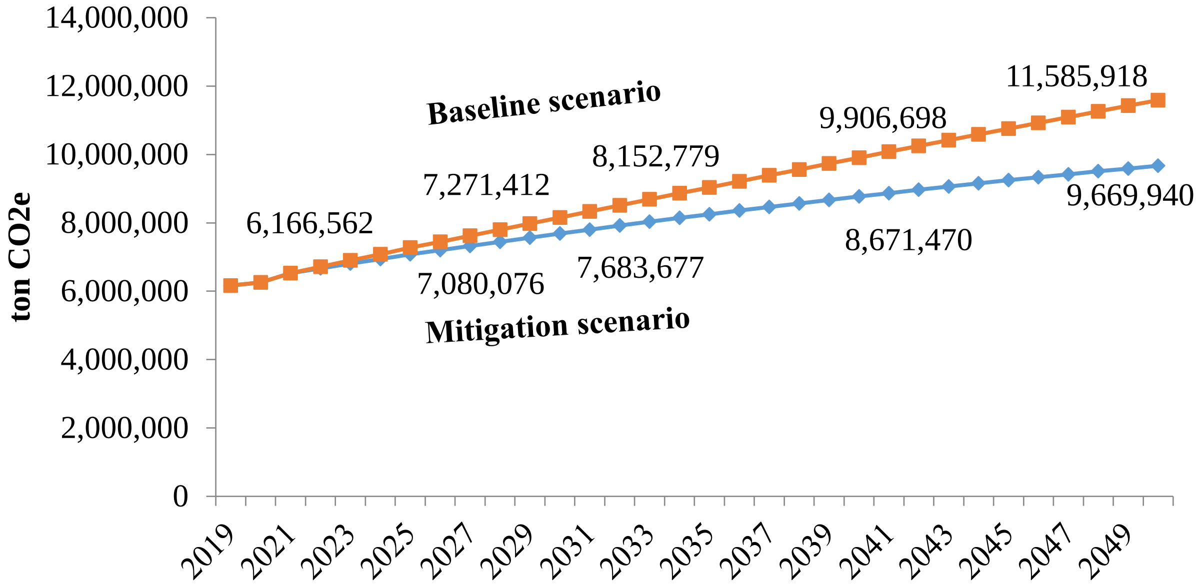


Figure 4.7 Mitigation potential extending to years- Action 8 - Setting the thermostat temperatures (Mitigation calculated according to scenario 1)

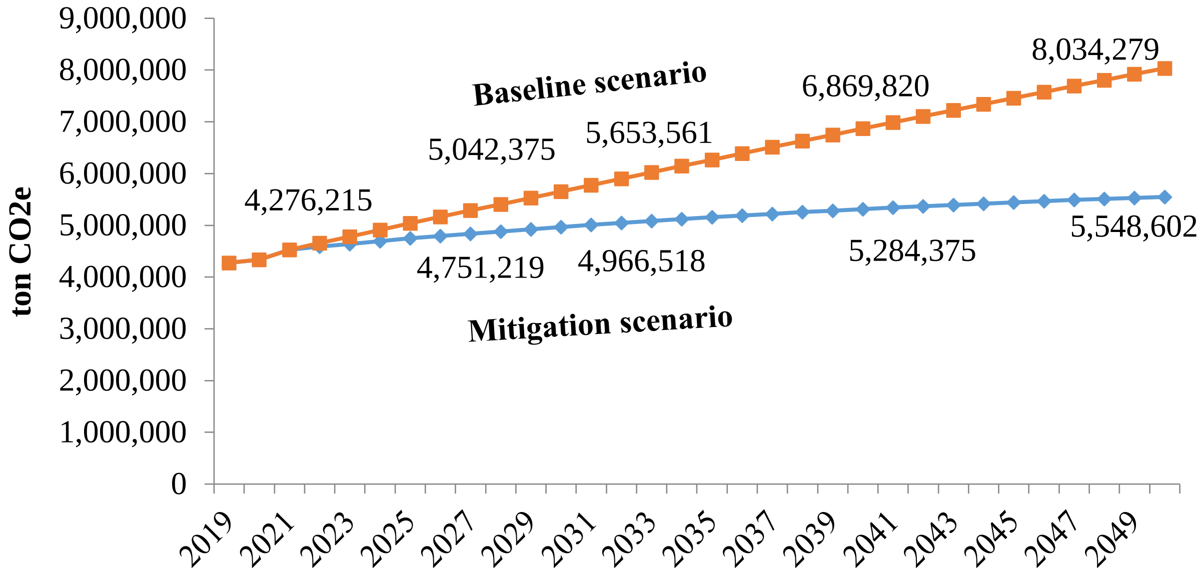


Figure 4.8 Mitigation potential extending to years- Action 8 – Preferring of energy-efficient electrical appliances (Mitigation calculated according to scenario 1)

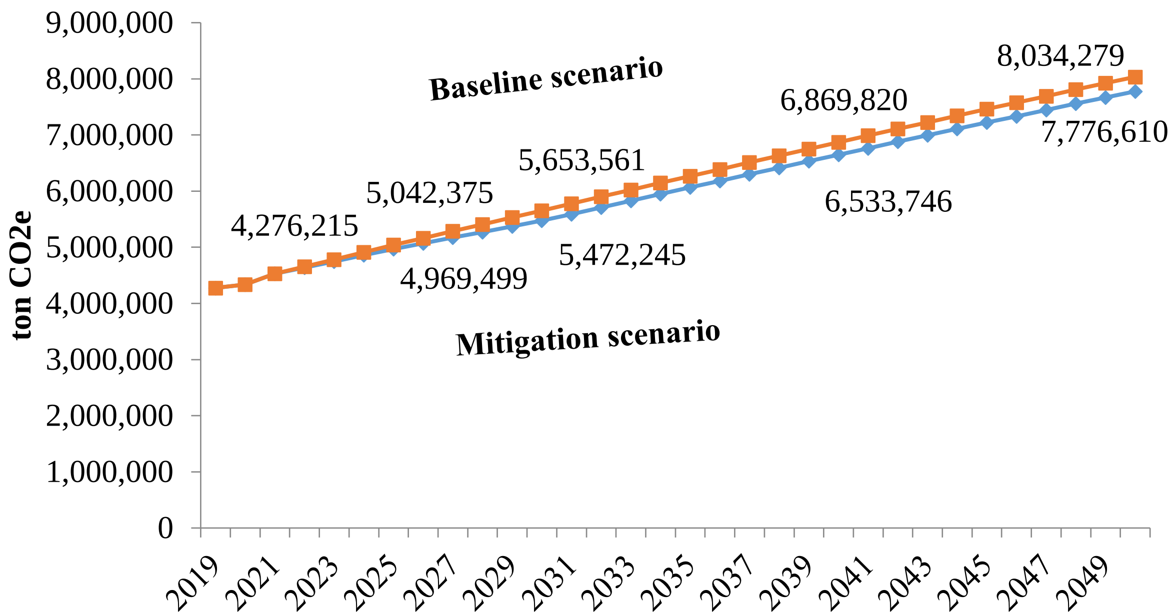


Figure 4.9 Mitigation potential extending to years- Action 8 – Not leaving electrical appliances on the standby use mode (Mitigation calculated according to scenario 1)

4.2. Transportation

According to Ankara Province 2019 Greenhouse Gas Emission Inventory, emissions from on-road transportation activities are given in Figure 4.10 below.

As shown in Figure 4.10, most of the emissions (75.6%) in on-road transportation originate from the use of diesel fuel.

Diesel is used in public transportation vehicles and private vehicles together with CNG within the borders of Ankara Province. The term private vehicles includes light and heavy special vehicles for freight transport as well as passenger vehicles, but it is thought that the vast majority of emissions originate from private passenger vehicles, and an activity-based analysis on this is expressed in the following sections along with the mitigation measures.

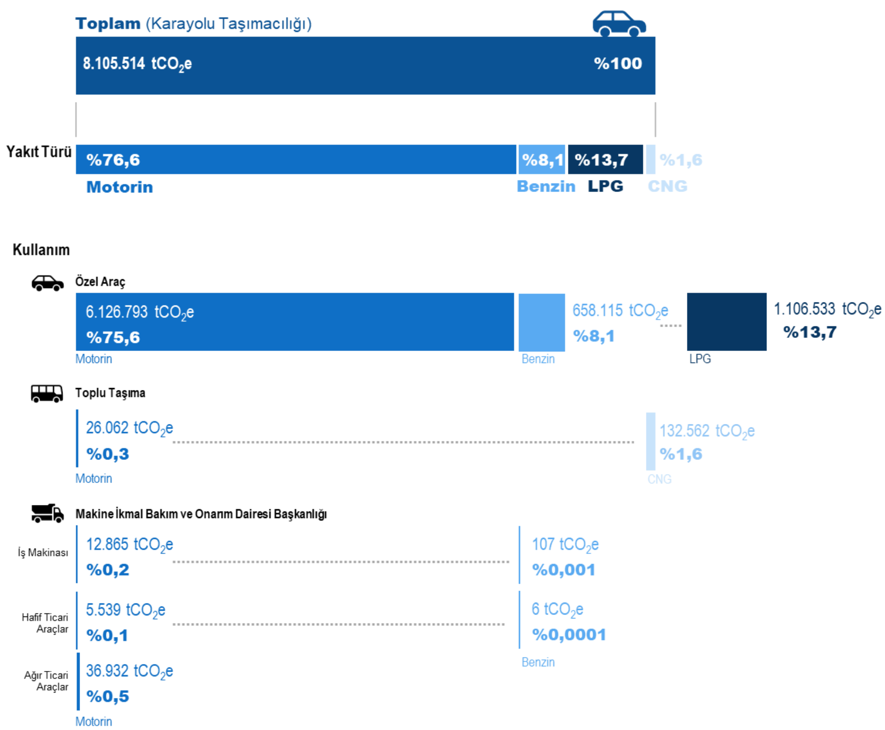


Figure 4.10. Distribution of emissions from on-road transportation by fuel type and use

When the results shared in Figure 4.10 are examined, it is revealed that the issues stated under the following headings should be addressed in order to reduce emissions.

- Substituting the use of diesel in public transport vehicles (Building Electric Bus Fleet)

- Substituting the use of CNG in public transport vehicles (Building Electric Bus Fleet)

- Providing electrical energy needs of electric vehicles from renewable energy sources (for example, solar energy)

- Reducing the activity of private passenger vehicles in traffic by supporting and encouraging the use of public transport as much as possible

- Improving public transportation options and expanding the comfort zone (For example; increasing the rail system lines, expanding the bus fleet with electric buses, separating the lanes that only buses can use during peak hours)

- Planning of systems such as "park – continue" and "congestion charging" in connection with the last two items above

- Developing various incentive mechanisms for electric passenger vehicles

- Expanding and improving bicycle and pedestrian infrastructure

In terms of railway, electricity consumption data and associated emission values in transportation by Metro, Ankaray and Cable Car are given in Figure 4.11 below.

Figure 4.11. Electricity Usage Data in Railways

Figure 4.12. Emissions from railway

Considering the results shared in Figure 4.12, it is revealed that the main issues shared under the following headings should be addressed within the framework of emission reduction.

- Providing electrical energy needs of rail systems from renewable energy sources (for example, solar energy)

Actions for emission reduction in the transportation sector, summarized in this section, are explained in detailed actions in the following sections.

<u>Actions to Improve Public Transportation Options and Expand The Comfort Zone</u>

Action 1: Expanding the Rail System Lines

Current Situation:

The data summarizing the current situation regarding the rail system lines within the provincial borders of Ankara are expressed in the items below. Together with the actions regarding the extension of the rail system lines and the construction of new lines that will provide emission reduction in the coming years are currently among the plans of the Ministry of Transport and the Ankara Metropolitan Municipality, information about the relevant projects has been shared in the activities section.

<u>Metro Lines</u>:

- Batikent-Kızılay line (M1) with a line length of 14,661 m and 12 stations

- Çayyolu-Kızılay line (M2) with a line length of 16,590 m and 11 stations

- Batıkent-Sincan-Törekent line (M3) consisting of 15,360 m line length and 11 stations

- Keçiören-Atatürk Cultural Center (AKM) line with 9,223 m line length and 9 stations (M3)

<u>Ankaray Lines</u>:

- AŞTİ-Dikimevi line (A1) with 8.527 m line length and 9 stations

<u>Cable Car Lines</u>:

- Yenimahalle-Şentepe line (T1) with 3,257 m line length and 4 stations

<u>Başkent Suburban Train Line</u>:

- The Sincan-Kayaş Railway line with 36.000 m line length and 24 stations, are in use.

Activities:

The projects of the Ministry of Transport and the Ankara Metropolitan Municipality to expand the rail systems within the borders of Ankara are given in Table 4.8.

In case the rail systems projects stated in Table 4.8. Rail System Projects are completed, the rail systems line length within the borders of Ankara Province will increase from 95.1 km to 197.5 km. In other words, the rail system line length in urban transportation in Ankara will approximately double. In Table 4.9, activity-based on-road transportation calculations for Ankara Province are shared. The calculations in question were made for the central districts and include only passenger activities, not emissions from freight transport.

Table 4.8. Rail System Projects

	Rail System Projects	Line Lenght	Projected annual number of passengers (person)	Projected annual electricity consumption amount
1	Keçiören Metro (M4) AKM - GAR - KIZILAY Connection Project	3,5 km	114.750.166	1.277.000 kwh/yıl
2	Ankara Keçiören Kuyubaşı Esenboğa Airport Yıldırım Beyazıt University Connection	26,25 km	72.636.101	50.037.011 kwh/yıl
3	Keçiören Kuyubaşı - YHT Station Connection Project	11,24 km	89.425.000	21.631.385 kwh/yıl
4	Esenboğa Çubuk Rail System Connection	16 km	26.914.370	30.792.007 kwh/yıl
5	Dikimevi- Natoyolu Light Rail System Project	7,6 km	275.284.020	17.168.521 kwh/yıl
7	Dikmen – Station	9,19 km	43.476.975	17.686.159 kwh/yıl.

8	Etlik – City Hospital. - Station	8,79 km	56.682.900	16.916.359 kwh/yıl
9	Çayyolu (M2) Sincan (M3) Metro Connection	19,82 km	56.040.586	38.143.598 kwh/yıl
Total		**102,39 km**	**735.210.118**	**193.652.040 kwh/yıl**

Table 4.9. Activity-based on-road transportation and emission calculations (only transportation between central districts, not including freight transportation)

Types of Road Transportation	**Annual Passenger Number**	**Percentage of Total Passengers (%)**	**Average Occupancy (%)**	**Number of Journeys**	**Average Distance (km)**	**Total Distance (km)**	**Total Emission (tCO2)**
EGO Buses	204.864.000	11,1%	78	2.626.462	39,7	104.270.523	122.090
Minibus-Dolmus	336.000.000	18,3%	25	13.440.000	25	336.000.000	131.141
Service Vehicles	224.000.000	12,2%	30	7.466.667	25	186.666.667	72.856
Private Public Bus	80.000.000	4,3%	45	1.777.778	38,2	67.911.111	61.847
Private Public Transport Vehicle	27.904.000	1,5%	30	930.133	102,6	95.431.680	62.078
Private Company Service Vehicle	60.800.000	3,3%	30	2.026.667	25	50.666.667	19.775
Taxi	96.000.000	5,2%	2	48.000.000	12	576.000.000	548.945
Private Car	607.584.000	33,0%	1	607.584.000	12	7.291.008.000	**2.974.731**
Shared Car	202.528.000	11,0%	2	101.264.000	12	1.215.168.000	**495.789**
Private and Shared Car Usage Total	810.112.000	44 %	1,25	648.089.600	12	7.777.075.200	**3.470.520**

In case the rail systems projects stated in Table 4.8 are completed, a total of 735,210,118 passengers are expected to be transported annually. At this point, within the framework of activity-based on-road transportation data, the percentage values of the number of passengers loaded by each type of transportation can be processed with the total number of passengers in the rail systems projects and distributed into categories, and thus, it can be predicted how much greenhouse gas emission reduction will be achieved when the rail systems projects are completed. In Table 4.10 below, the greenhouse gas emission reduction results to be obtained in case of the completion of the projects related to rail systems, within the framework of the calculations for activity-based on-road transportation, are shared.

Table 4.10. Activity-based on-road transportation and emission calculations (only transportation between central districts, not including freight transportation)

Types of Road Transportation	Annual Passenger Number	Percentage of Total Passengers (%)	Distribution of the total passengers to be carried by the rail systems projects within the existing transportation types	Emissions corresponding to passenger distribution by type of transportation (tCO2)
EGO Buses	204.864.000	11,1%	81.871.894	48.792
Minibus-Dolmus	336.000.000	18,3%	134.279.114	52.409
Service Vehicles	224.000.000	12,2%	89.519.409	29.116
Private Public Bus	80.000.000	4,3%	31.971.218	24.716
Private Public Transport Vehicle	27.904.000	1,5%	11.151.561	24.809
Private Company Service Vehicle	60.800.000	3,3%	24.298.125	7.903
Taxi	96.000.000	5,2%	38.365.461	219.381
Private Car	607.584.000	33,0%	242.815.003	1.188.822
Shared Car	202.528.000	11,0%	80.938.334	198.137
Total Passengers	1.839.680.000		735.210.118	**1.794.086**

Table 4.11. The contribution of rail system projects to emission reduction in on-road transportation

Activity-based greenhouse gas emissions **(tCO2)** in on-road transportation	4.489.252
Emission **(tCO2)** corresponding to passenger distribution by mode of transportation	1.794.086
Total emissions from on-road transportation **(tCO2)** according to the greenhouse gas emission inventory	8.105.514
Emission reduction by transportation category **(%)** compared to the baseline scenario	%22
Reduction compared to the total of 2019 Ankara Province greenhouse gas emission inventory GPC Basic category **(%)**	%7,8

As it can be understood from Table 4.11, if all of the rail system projects stated in Table 4.8 are put into practice and the projected passenger transport numbers are reached, the annual greenhouse gas emission reduction is foreseen as 1,794,086 tons of CO2e. This value corresponds to 22% of the emissions originating from transportation activities within the framework of the results of the 2019 greenhouse gas emission inventory of Ankara Province. In other words, if the projects stated in Table 4.8 are realized gradually starting from 2022 and all of them are completed in 2030, emissions from transportation are expected to decrease by 2.75% each year compared to the base emission projection based on the current situation, and a total decrease of 22% in 2030.

<u>Using Electric Energy As Fuel in Public Transport Options</u>

Action 2: Providing Electric Energy Used in Rail System Lines from Renewable Energy Sources

If the rail systems projects, which are stated in “Action 1” and whose estimated electricity consumption is shared in Table 4.8, are evaluated with today's electricity emission factor (0.457 kg CO2e/kWh), the greenhouse gas emissions that will be caused will be 88,500 tons CO2e/year (Table 4.12).

In the future, in case the electricity needs of rail systems lines are met from renewable energy sources, it will be possible to zero the emissions arising from the transportation operations on the subjected lines. In the scenario where the emission consumption values of private passenger cars, which are removed from traffic, will also decrease from the total emissions in on-road transportation, the contribution to the total greenhouse gas emission reduction will be more.

Table 4.12. Contribution to emission reduction in case of using electrical energy in new rail system projects by year of 2030

Emissions **(tCO_2)** that will arise in case the new rail systems are operated due to the current electricity grid and emission factor	88.500
Emission reduction by transportation category **(%)** compared to the baseline scenario	%1
Reduction compared to the total of 2019 Ankara Province greenhouse gas emission inventory GPC Basic category **(%)**	%0,4

Table 4.13. Contribution to emission reduction in case of using electrical energy in existing rail system projects by year of 2030

Emissions (tCO2) from the use of electrical energy by the existing rail systems in 2019	57.493
Emission reduction by transportation category **(%)** compared to the baseline scenario	%0,7
Reduction compared to the total of 2019 Ankara Province greenhouse gas emission inventory GPC Basic category **(%)**	%0,25

Action 3: Replacing Diesel and CNG Buses with Electric Buses in EGO Inventory

Current Situation:

In the current situation, municipal buses are models that run on CNG and Diesel. The number, model and brand information and emissions of the relevant vehicles are given in the tables below.

Table 4.14. Ankara EGO General Directorate Active Bus Fleet (as of 31.12.2018) (Reference: EGO Genel Müdürlüğü stratejik Planı 2020-2024, sayfa 38, https://www.ego.gov.tr/dosya/indir/18705.pdf)

	Vehicle Model	Passenger Capacity	Number
Diesel Buses			
Mercedes SL (Diesel Solo)	1999	100	34
Mercedes (Diesel Articulated)	1999	157	66
Mercedes (Diesel Air-Conditioned Articulated)	2012	152	124
Mercedes (Air Conditioned Articulated)	2013	151	56
CNG Buses			
MAN (CNG-Air Conditioning-Solo)	2007	82	387
MAN (CNG-Air Conditioning-Solo)	2008	82	90
MAN (CNG-Air Conditioning-Solo)	2009	80	348
MAN (CNG-Air Conditioning-Solo)	2010	80	208
MAN (CNG-Air Conditioning-Solo)	2011	80	40
MAN (CNG-Air Conditioning-Articulated)	2012	151	125
MAN (CNG-Air Conditioning-Articulated)	2013	152	75
Total			**1.553**

Following the current situation, if no mitigation action is taken within the framework of public transportation activities by bus in the coming years, the greenhouse gas emission projections that arise are presented in the table in Table 4.16.

Table 4.15. The Distance of the Buses in the Inventory of the General Directorate of EGO in Urban Public Transportation in 2019 Operating Year, the Fuel Used and the Related Greenhouse Gas Emission Data

Public transport buses	Total km	Total fuel	Fuel unit	2019 GHG emissions (tons CO2e)
Bus_CNG	85.024.932	66.236.683	m3	132.562
Bus_Diesel	12.117.567	10.014.707	liter	26.062
Total				**158.624**

Table 4.16. Emissions from transportation in public transportation according to Emission Projection Scenarios 1, 2 and 3

Year	2025	2030	2040	2050
Scenario	**2019 GHG emissions (tons CO2e)**			
Projection of CNG Buses				
Scenario 1	156.313	175.260	212.963	249.061
Scenario 2	172.217	209.329	298.941	410.886
Scenario 3	189.937	250.500	421.167	681.521
Projection of Diesel Buses				
Scenario 1	30.731	34.456	41.869	48.966
Scenario 2	33.858	41.155	58.773	80.781
Scenario 3	37.342	49.249	82.802	133.989
Projection of CNG and Diesel Buses (Total)				
Scenario 1	187.044	209.716	254.832	298.027
Scenario 2	206.075	250.483	357.714	491.667
Scenario 3	227.279	299.749	503.969	815.510

Sub-Action:

It is recommended that all municipal buses running on CNG and diesel fuel be replaced by electric buses by 2030. Various assumptions have been used in the calculations of greenhouse gas emission reductions to be achieved in case of replacing CNG and diesel buses with electric buses.

There are different data in various sources regarding the electrical energy needs of electric buses while traveling 1 km. The reason for this is that the geographical regions in which the buses operate are different from each other. For example, a public transportation vehicle operating in a hilly area needs more electrical energy than a public transportation vehicle operating in a relatively flat area. In the table below, unit values taken from two reference sources are expressed.

Table 4.17. ***Energy need of electric buses***

Energy need of electric buses	kWh/km (Reference source 1)	kWh/km (Reference source 2)	kwh/km (average)
Electric bus (70-80 person capacity)	0,85	1,1	0,975

The electrical energy required by the public transportation vehicles working with CNG and diesel fuel in the case they operate with electricity is calculated based on the distance covered by the vehicles in the 2019 operating year. The relevant results are presented in the table below. In addition, while making the calculations, the electrical energy consumed by a bus carrying 70-80 passengers while traveling 1 km has been accepted as 1.1 kWh/km in order to make a conservative calculation. The subjected value also includes the electrical energy losses experienced during the charging process.

In the current situation, in case of all buses running on CNG and diesel fuel are replaced by buses running on electricity, an emission reduction of approximately 70% is possible. Relevant values are shared in Table 4.18.

Table 4.18. Greenhouse Gas Emissions in the Case of Replacing All Buses Running on CNG and Diesel Fuel with Electric Buses in the Current Situation

	2019 total km	Required electrical energy (kwh) in case of all buses running on CNG and diesel fuel is replaced by buses running on electricity	Electricity Emission factor (Turkey General) (kg CO2e/kwh)	Greenhouse gas emissions (tons CO2e)
CNG Buses	85.024.932	93.527.425	0,457	42.742
Dizel Buses	12.117.567	13.329.324	0,457	6.092

Action 4: Providing Electrical Energy Needs of Electric Buses from Renewable Energy Sources

Table 4.18 shows the emission values obtained as a result of evaluating the electric buses with the emission factor (0.457 kg CO2e/kwh) calculated for Turkey as of 2019. At this point, in the scenario where the electric energy source of electric buses is provided from renewable energy sources, the emissions arising from the use of buses in public transportation will be zero. According to the information received from the Vehicle Maintenance and Repair Department of the EGO General Directorate, there is a construction project within the institution to obtain electrical energy from solar energy. Although the start date of the project in question is stated as 2021, when it will be completed and the exact numbers for how much electrical energy will be obtained have not been pronounced yet. From this point of view, it is recommended to use the subjected energy in electric buses as a result of the activities of obtaining electrical energy from solar energy in the coming years and to zero the emissions arising from the use of buses in public transportation.

In Table 4.19, the emission reduction values obtained when CNG and diesel buses are replaced by electric buses are shared.

Table 4.19. Metro Line 2019 Capacity Usage Data

Rate of CNG and Diesel buses replacing with Electric Buses	Greenhouse Gas Emission Reduction Rate (Electric Emission Factor 0.457 kg CO2e/kWh)	Greenhouse Gas Emission Reduction Rate (Electric Emission Factor 0 kg CO2e/kWh Renewable Energy)
% 100	%69	%100
% 90	%62	%90
% 80	%55	%80
% 70	%48	%70
% 60	%42	%60
% 50	%35	%50
% 40	%28	%40
% 30	%21	%30
% 20	%14	%20
% 10	%7	%10

Mitigation Potential:

At the end of this section, the mitigation potential to be obtained in case the buses used in public transportation from 2022 until 2030 are both replaced by electric buses and the electricity source is renewable energy is expressed. It is assumed that between 2022 and 2030, the same proportion of buses are converted to electric buses every year. The mitigation potential is expressed in comparison to the public transport and transportation category of the reference scenario.

	2019	2025	2030
Reference scenario	158.624	187.044	209.716
Reduced Scenario	-	97.850	0
Difference (tons CO_2)	-	89.193	209.716
Difference (%)	-	%52	%100

Table 4.20. Emission Reduction Rates to be Obtained in the Case of Replacing All CNG & Diesel Fuel Buses Used in Public Transport with Electric Buses by year of 2030

Greenhouse gas emissions calculated activity-based on-road transportation **(tCO_2)**	88.500
Emission reduction by transportation category compared to baseline scenario (**%)**	% 2,6
Reduction compared to the total of 2019 Ankara Province greenhouse gas emission inventory GPC Basic category **(%)**	% 1

Making Connections Between Public Transport Options and Private Vehicles

Action 5: Implementing Congestion Charging System

Urban road pricing systems are implemented in two different ways: financing and regulation. The systems implemented for financing purposes aim to create resources for infrastructure investments without the aim of affecting the transportation habits of the city residents. On the other hand, the main purpose of the congestion charging system, which is applied for regulatory purposes, is to discourage drivers from using cars and to encourage them to use alternative modes of transportation, rather than generating income.

In congestion charging systems, a fee is charged to the user in case of using the roads in a certain area at certain times or all of the day. The travel characteristics of users with a high monetary value of their time will not be affected, other users will stop traveling during these hours and change their route or mode of transportation. In addition, there is the opportunity to create resources for the development of public transportation and related infrastructure projects with the income to be obtained through the congestion charging system. The congestion charging projects, which were implemented in the city centers of Oslo in 1990, Rome in 2001, London in 2003, Stockholm in 2006 and Milan in 2008, resulted in significant gains in terms of reducing traffic density, reducing greenhouse gas emissions and raising funds for the development of transportation systems. . As a result of congestion charging in London in 2004, NOX and PM10 emissions were reduced by approximately 10% and CO2 emissions by 16% in a circular area of 21 km in the city center[22].

Congestion charging systems are an effective method to reduce traffic congestion and reduce greenhouse gas emissions from road transport. However, there is an additional traffic congestion in the border regions of the areas where fees are applied. Therefore, in order for this system to be implemented effectively and acceptable to the residents of the city, public transportation should be made more widespread and accessible. The benefits of congestion charging systems for sustainable urban transportation can be summarized as follows.

- Traffic reduction in the city centre
- Noise reduction. In this way, a more accessible and livable city centre is formed.
- Reduction in fuel consumption and therefore greenhouse gas emissions

The acceptability of road pricing systems by the society is important for the continuity of these systems. Therefore, the success of the application and its effects should be shared with the residents of the city at high access points.

In the study designed by Önder and Kaplan (2017) based on the Kızılay for Ankara Province, it is modelled that the passenger car journey, which is reduced by the charging of the vehicle entrance, is transferred to public transportation through the "park & ride" system, in the seven Traffic Analysis Zones, determined in the city centre of Ankara. In the aforementioned study, 17 “park & ride” transfer stations on the inner cordon line of Kızılay city center were proposed. The average parking capacity at these transfer stations has been determined as 321, taking into account the number of passenger cars. In order to meet the travel demand from each proposal P+R transfer station, shuttle buses with a departure frequency of 6 minutes and a capacity of 80 passengers that will make 10 trips in an hour are designed to serve. As a basic condition of sustainable and integrated transportation, it is envisaged that the ticket system, timetable and shuttle bus system at the P+R car parks and transfer stations will be operated in an integrated manner. According to the modeling carried out within the framework of this fiction, the number of passenger cars in the Kızılay center decreased by 23%, while the amount of public transport trips increased by 26%.

[22] https://www.c40knowledgehub.org/s/article/How-to-design-and-implement-a-clean-air-or-low-emission-zone?language=en_US

Activity-based on-road transportation and emission calculations have been made in order to foreseen how much the congestion charging system will contribute to emission reduction as it moves private vehicles away from the city center Table 4.21

Table 4.21. Activity-based on-road transportation and emission calculations (only transportation between central districts, not including freight transportation)

Types	**Annual Passenger Number**	**Average Occupancy (%)**	**Number of Journeys**	**Average Distance (km)**	**Total Distance (km)**	**Total Emission (tCO2)**
EGO Buses	204.864.000	78	2.626.462	39,7	104.270.523	122.090
Minibus-Dolmus	336.000.000	25	13.440.000	25	336.000.000	131.141
Service Vehicles	224.000.000	30	7.466.667	25	186.666.667	72.856
Private Public Bus	80.000.000	45	1.777.778	38,2	67.911.111	61.847
Private Public Transport Vehicle	27.904.000	30	930.133	102,6	95.431.680	62.078
Private Company Service Vehicle	60.800.000	30	2.026.667	25	50.666.667	19.775
Taxi	96.000.000	2	48.000.000	12	576.000.000	548.945
Private Car	607.584.000	1	607.584.000	12	7.291.008.000	**2.974.731**
Shared Car	202.528.000	2	101.264.000	12	1.215.168.000	**495.789**
Total Cars	810.112.000	1,25	648.089.600	12	7.777.075.200	**3.470.520**

Road pricing systems are a type of action that can provide emission reductions, not alone as in the examples in various cities of the world, but as long as they are carried out together with actions to increase the comfort of "park - ride" and public transportation. However, even if there is a road fee in this way, it is expected that the residents of the city will use public transportation instead of private passenger cars. Therefore, an emission reduction amount and percentage is not pronounced specifically for this action. It is foreseen that the emission reduction amounts to be provided by the congestion charging systems to be built in the city centre and areas close to the city centre are within the emission reduction that will be gained by the next action "park - ride" and the actions aimed at increasing comfort in public transportation in the previous sections.

Action 6: Developing the “Park & Ride” System

“Park - ride” (P+R - Park and Ride, K+R - Kiss and Ride” and “Kiss & Ride) applications are made to important public transportation axes outside the city centers and are operated at low or affordable prices. It is based on the principle that private car users come to these points with their cars and park their cars in these areas and go to the city center by public transportation system.

As a current and successful example on the subject, the "park-and-ride" application, which was carried out in the Stedenbaan region in the south of the Netherlands, has significantly convinced the residents of the city to use public transportation instead of using private cars during their journeys. While the share of train usage as a public transportation vehicle, excluding the Stedenbaan region of the Netherlands, is around 4-5%, the use of trains for public transportation has increased to 13% in the Stedenbaan region, where the infrastructure for the "park-and-ride" application has been created.

Current Situation:

Within the framework of Ankara Metropolitan Municipality's efforts to reduce the traffic density, EGO General Directorate has started the "park - ride" works at the National Library Metro Station on February 12, 2021. With the 430-vehicle car park built next to the National Library Metro Station, the residents of the city, who came to this point with their private vehicles, left their vehicles in the parking lot and continued their journey by metro. Passengers who prefer the metro for transportation benefit from the parking lot where they park their vehicles free of charge. The aforementioned project was completed as a pilot project, and according to the results of the prioritization study carried out by the EGO General Directorate among the rail systems stations throughout Ankara, it is planned to be implemented in 26 different stations in the future.

According to the information shared by the EGO General Directorate on its official home page, a total of 26 stations where the 'Park and Ride' project will be implemented are as follows:

“Akköprü, Yenimahalle, Demetevler, Hospital, Macunköy, Ostim, West Centre, Mesa, Botany, Istanbul Road, Eryaman 1-2, Eryaman 5, Devlet Mahallesi, Wonderland, Fatih, GOP, Törekent, Grove, Çayyolu, Ümitköy, Beytepe, Ministry of Agriculture / Council of State, Bilkent, METU, Söğütözü, National Library.”

Activities:

In addition to the current planning, in case the park-ride system is implemented in all 54 stations by 2030, the prediction of private vehicle fuel consumption savings and emission reduction due to private vehicles is expressed below Table 4.22.

Table 4.22. Gains to be Obtained in the Case of Implementation of the "Park - Ride" System at 54 Points

City Centre	Assumption of Average Distance from Center	Daily Car Circulation at a Station (pieces of cars)	Number of Stations	Annual Greenhouse Gas Reduction by Vehicle (ton CO2e)	Emission Reduction Based on Total Vehicle Usage Compared to Current Situation
Kızılay	10 km	1000	54	160.834	**5%**

One of the important points for the implementation of the “park – ride” application is the gap in the current metro capacity usage. Only in this way can residents of the city park their private cars and use the subway. In Tables 4.23 and 4.24, the capacity usage (occupancy) rates of Metro M1-M2-M3-M4 and Ankaray lines are shared in the 2019 operating year. As can be seen from the relevant tables, the capacity usage rate of Metro and Ankaray lines is 51.4% (M1-M2-M3 Lines), 10.4% (M4) and 58.48% (A1), respectively, as of 2019. Although the capacities of the subjected lines are almost half empty, it is thought that they can easily meet the passenger load brought by the park-and-ride application.

Table 4.23. Metro Line 2019 Capacity Usage Data

	M1-M2-M3 Total Passenger	M1-M2-M3 Total Capacity (passenger)	Capacity Usage Rate	M4 Total Passenger	M4 Total Capacity (passenger)	Capacity Usage Rate
January	8.076.105	16.742.014	48,24%	615.783	6.736.642	9,14%
February	7.717.345	15.174.416	50,86%	600.290	6.103.036	9,84%
March	8.846.738	16.641.696	53,16%	685.235	6.715.507	10,20%
April	8.536.258	16.160.433	52,82%	652.199	6.508.320	10,02%
May	8.411.248	16.742.014	50,24%	643.678	6.736.642	9,55%
June	6.888.807	15.428.362	44,65%	539.574	6.311.970	8,55%
July	7.560.505	15.362.734	49,21%	573.219	5.763.526	9,95%
August	6.495.321	14.879.294	43,65%	510.473	5.712.568	8,94%
Septemb er	7.948.906	14.835.266	53,58%	631.001	5.573.892	11,32%
October	9.444.695	16.742.014	56,41%	751.876	6.736.642	11,16%
Novembe r	9.219.825	16.237.260	56,78%	747.082	6.538.545	11,43%

December	9.390.270	16.742.014	56,09%	770.061	6.736.642	11,43%
TOTAL	98.536.022	191.687.517	51,40%	7.720.471	76.173.932	10,14%

Table 4.24. Ankaray 2019 Capacity Usage Data

2019	**Total Passenger**	**Total Capacity**	**Capacity Usage Rate**
January	3.105.370	5.225.454	59,43%
February	2.929.110	4.922.274	59,51%
March	3.415.142	5.453.328	62,62%
April	3.319.470	5.613.720	59,13%
May	3.084.994	5.624.478	54,85%
June	2.582.357	4.844.034	53,31%
July	2.638.713	4.908.582	53,76%
August	2.030.552	4.895.868	41,47%
September	2.934.197	5.108.094	57,44%
October	3.472.830	5.494.404	63,21%
November	3.583.964	5.326.188	67,29%
December	3.671.381	5.458.218	67,26%
TOTAL	36.768.080	62.874.642	58,48%

As stated in Table 4.8 in the sections above, in case that the rail systems projects for the coming years are implemented, the rail systems line length within the borders of Ankara Province will increase from 95.1 km to 197.5 km. In other words, when the projects in Table 4.8 are completed, the rail system line length in urban transportation in Ankara will nearly double. Therefore, it can be predicted that 54 points, which are the current number of metro stations, will increase approximately 3 times after the completion of the new rail system projects. In Table 4.25, the results of the prediction calculations for the emission reduction that will be achieved in case of integrating the new rail system lines with the “park – continue” system are shared.

Table 4.25. Gains to be Obtained in the Case of Implementation of the "Park - Ride" System on the New Rail System Lines

City Centre	Assumption of Average Distance from Center	Daily Car Circulation at a Station (pieces of cars)	Number of Stations	Annual Greenhouse Gas Reduction by Vehicle (ton CO2e)	Emission Reduction Based on Total Vehicle Usage Compared to Current Situation
Kızılay	10 km	1000	~110	~320.000	**~10%**

Table 4.26. Results of Projected Calculations for Emission Reduction in the Case of Integrating Both Existing Rail System Lines and New Rail System Lines with the "Park – Ride" System by year of 2030

Emission reduction by transportation category compared to baseline scenario **(%)**	~% 6
Reduction compared to the total of 2019 Ankara Province greenhouse gas emission inventory GPC Basic category **(%)**	~% 2,5

Bicycle Lanes

Bicycle road network and suitable cycling infrastructure is a transportation alternative that contributes to a healthy life by increasing the physical activity of the city residents by encouraging the use of bicycles, reducing the negative effects on the environment by reducing the intensity of travel by vehicle, increasing road safety and providing cheap transportation.

Current Situation: Currently, there is a 2.5 km bicycle path between the National Library and Beşevler.

Action 7: Developing Bicycle Rental Systems

Action 8: Extending of Bicycle Lane Network

According to the information received from the Ankara Metropolitan Municipality Department of Transportation Technologies, there are 8 stage new bicycle lane projects, the construction of which has started / will begin in 2021. Information on the route and road lengths of the projects in question are shared in the table below.

In a city such as Ankara, which is built on rough terrain and the distances between central points are relatively long, it is not expected that transportation by bicycle will significantly reduce emissions in transportation by road. Therefore, in the conclusion part of this action, numerical data on greenhouse gas emission reduction are not expressed. However, as mentioned in the introduction, bicycle lane projects are also included in this section, with the thought that they will have positive effects on the physical activity of the city residents and therefore on a healthy life, and that they will create a cheap transportation option for short distances.

Table 4.27. Bicycle Lane Projects Within Ankara Province Boundaries

Stages	Route	Primary responsible Institution	Other Responsible Institution	Project Start Year
Bicycle Lane 2nd Stage	Universities Route (4.75 km)	EGO General Directorate	Department of Transportation Technologies	2021
Bicycle Lane 3rd Stage	Ümitköy-Etimesgut Route (16.95 Km)	EGO General Directorate	Department of Transportation Technologies	2021
Bicycle Lane 4th Stage	Sıhhiye-Cebeci Route (1.68 Km)	EGO General Directorate	Department of Transportation Technologies	2021
Bicycle Lane 5th Stage	TOBB Route (1.87 Km)	EGO General Directorate	Department of Transportation Technologies	2021

Bicycle Lane 6th Stage	Eryaman West Route (6.95 Km)	EGO General Directorate	Department of Transportation Technologies	2021
Bicycle Lane 7th Stage	Eryaman Göksu Route (3.64 km)	EGO General Directorate	Department of Transportation Technologies	2021
Bicycle Lane 8th Stage	Batikent-Ivedik Ostim Route (7.90 Km)	EGO General Directorate	Department of Transportation Technologies	2021
Bicycle Lane 9th Stage	Ankara Metropolitan Municipality- AKM Route (0,840 km)	EGO General Directorate	Department of Transportation Technologies	2021
Total	44,58 km			

Developing Various Incentive Mechanisms for Electric Passenger Vehicles

Incentive mechanisms used around the world on this issue are described as three different actions below.

Action 9: Ensuring priority entry of electric vehicles to certain traffic zones

Action 10: Building of electric charging stations connected to the grid and benefiting from solar energy at points with high solar potential

Action 11: Ensuring cooperation with relevant government institutions and reducing the taxes to be collected from electric vehicles with government incentives (A similar reduction in SCT rates can also be applied to VAT, motor vehicle tax can be reduced, tax burden can be removed completely, or bridge and highway fees can be reduced for electric vehicles. or remove it completely)

In Table 4.10 in the sections above, the results of activity-based on-road transportation and emission calculations (only transportation between central districts, not including freight transportation) are shared. According to the calculation results in question, the annual emission estimate from private passenger vehicles is 3,470,520 tons of CO_2. This value corresponds to 43% of the total emissions from the transportation activities of Ankara Province in 2019. At this point, it can be easily said that mechanisms that encourage the replacement of private passenger cars with electric vehicles will be very important in reducing transportation emissions. The effective implementation of Action 9, Action 10 and Action 11, which have been stated above, and the reflection of the results of the actions on the increase in the number of electric private passenger vehicles, and the passenger vehicles operating within the provincial borders (especially operating in the city center) until 2030. If the number of passenger cars is 20% compared to the total number of passenger vehicles, it will be possible to achieve the emission reduction expressed in Table 4.28.

Table 4.28. Results of the calculations for the emission reduction to be achieved in case all private passenger cars are replaced by electric vehicles by year of 2030

Emission reduction by transportation category compared to baseline scenario **(%)**	~% 8,5
Reduction compared to the total of 2019 Ankara Province greenhouse gas emission inventory GPC Basic category **(%)**	~% 3

Results of Emission Reduction Actions In Transportation

It is foreseen that the emission reduction rates shared in Table 4.29 can be achieved in case the greenhouse gas emission reduction actions in transportation, which have been stated up to this section, are implemented.

Table 4.29. Reduction projections of the results of the proposed emission reduction actions in the transportation category compared to the total of the greenhouse gas emission inventory GPC Basic for 2019

Completion of the rail system lines planned for the future	%7,8
Providing electrical energy needs of rail systems from renewable sources	%0,65
Transitioning to electric buses in municipal public transportation vehicles and using renewable energy as electricity source	%1
“Park – ride” system	%2,5
Increase in the number of electric private passenger cars	%3
Total reduction compared to the total of 2019 greenhouse gas emissions inventory GPC Basic coverage	~%15

5. IMPACT, VULNERABILITY AND RISK ASSESSMENT

Climate change causes the average climate trends to change and extreme events to become more frequent and intensified worldwide. Changes in average temperature and precipitation regimes and an increase in extreme weather events are observed in Turkey. In the last three years, the number of meteorological disasters has broken records consecutively, 984 in 2020, 936 in 2019 and 871 in 2018. [23] Approximately 80% of these disasters are heavy rain, flood, storm and hail events.

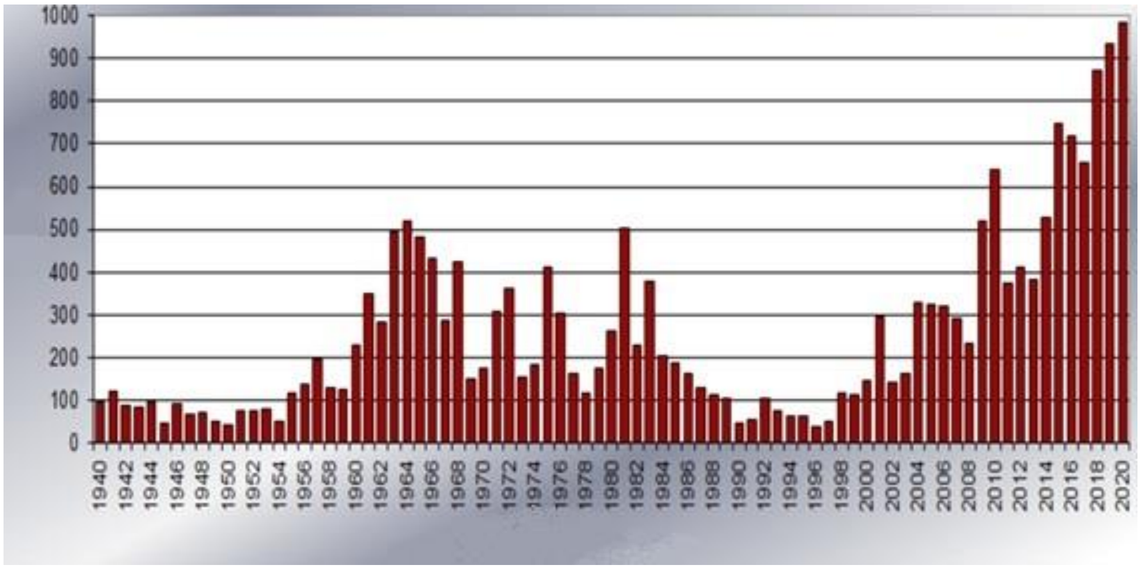


Figure 5.1 Meteorological disasters in Turkey (1940-2020)

Source: Turkish State Meteorological Service 2021

The effects of climate change are more specifically experienced at the local scale. Cities are particularly vulnerable to climate change as areas where people, assets and economic activity are concentrated. Often, also dynamics such as urbanization and ecosystem destruction deepen the vulnerabilities of urban communities, infrastructures and systems.

Responsibility for responding to local vulnerabilities and the impacts of climate change generally falls on local governments. Increasing climatic risks both place additional pressure on the resources and capacities of local governments, which already may be limited, and may also make city services fragile. For this reason, local governments need to carry out comprehensive resilience and climate change adaptation studies at the urban scale.

[23] Turkish State Meteorological Service (2021). Meteorological Disasters Assessment for 2020.

Increasing resilience to climate change in cities begins by identifying current and future climate change risks. This report aims to reveal the climate change trends experienced in Ankara Province to date and examine their effects on the city by presenting climate scenarios for the future.

5.1 Methodology

For climate change projections, scenarios based on factors such as changes in greenhouse gas emissions, population growth, economic growth, increase in energy and food (agricultural) demand, and technological development are used. There are 4 scenarios called RCP (Representative Concentration Pathways) and developed for the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) published in 2013. These scenarios are named as; RCP2.6, RCP4.5, RCP6.0 and RCP8.5 from optimistic to pessimistic. The different effects of these scenarios are determined by integrating the scenario information into a “Global Climate Model” and running the model for the future. Within the scope of IPCC studies, climate projections are made with 40 different global climate models in the CMIP5 (Fifth Coupled Model Intercomparison Project) experiment.

Within the scope of this study, the average of the projections obtained by the RCP2.6, RCP4.5, RCP6.0 and RCP8.5 scenarios and the CMIP5 experiment for Ankara Province was used. Information about the data set used is given in Table 5.1.

Table 5.1 The data set used in the Ankara climate change study

Source	**CMIP5**
Reference Period	1910-2020
Future Period	2020-2100
Scenarios	RCP2.6, RCP4.5, RCP6.0, RCP8.5
Global Climate Models	More than 40 models
Terrestrial Resolution	~100km
Website (URL)	KNMI climate change atlas: https://climexp.knmi.nl

In the analysis of climate models, extreme climate and weather events should be examined as well as temperature and precipitation changes. Different indices have been developed for the analysis of extreme climate parameters by The Expert Team on Climate Change Detection and

Indices (ETCCDI). In addition to the temperature and precipitation changes, the extreme parameter indices that will be examined in this study are presented in Table 5.2.

Table 5.2 Climate indices and definitions

Index	Name	Definition
CDD	Consecutive dry days	maximum number of consecutive days with RR < 1mm
CWD	Consecutive wet days	maximum number of consecutive days with RR ≥ 1mm
CSDI	Cold spell duration index	Annual count of days with at least 6 consecutive days when TN < 10th percentile
DTR	Daily temperature range	Tmax – Tmin
FD	Number of frost days	Annual count of days when TN (daily minimum temperature) < 0°C
GSL	Growth season length	Number of days between the first 6 consecutive days with “T > 5°C” and the first 6 days with “T < 5°C” after 1 July
ID	Number of ice days	Annual count of days when TX (daily maximum temperature) < 0 °C
PRCPTOT	Rainy days precipitation	Annual total precipitation on wet days
R1mm	Days with precipitation 1 mm or more	Number of days with “RR > 1 mm”
R10mm	Days with 10 mm or more precipitation	Number of days with “RR > 10 mm”
R20mm	Days with 20mm or more precipitation	Number of days with “RR > 20 mm”
TXx	Maximum of daily maximum temperatures	Maximum value of daily maximum temperatures

5.2 Historical Climate Analysis

5.2.1 Climatological Analysis

Ankara is 874 m above sea level. In general, continental climate is observed in Ankara. In addition to the steppe climate, which is the climate of Central Anatolia, temperate and rainy climate characteristics are observed from the Black Sea climate characteristics in the northern regions. In winter, there is much more rainfall than in summer. According to Köppen-Geiger, the climate is Csa (Hot Summer Mediterranean Climate). Monthly values of total precipitation, average temperature, maximum temperature and minimum temperature were used for climatological analysis between 1975 and 2020.

The annual average temperature of Ankara is 11.9°C. The annual average rainfall is 393 mm. With 12 mm of precipitation, August is the driest month of the year. With an average of 58 mm precipitation, the highest precipitation is seen in May. With a temperature of 23.4°C, August is the hottest month of the year. The average temperature in January is 0.2°C, which is the lowest average of the year. The amount of precipitation between the driest and wettest months of the year is 49 mm. The average temperature varies around 11°C throughout the year. The number of days with frost is 60-117, and the number of snowy days is 30.5 per year. The highest snow thickness was determined as 30 cm. The months with strong winds are March and April. The highest wind speed detected in Ankara is 29.2 m/s. According to the values measured for many years, the average pressure value of Ankara is 913.1 mb, the highest pressure value detected is 935.0 mb and the lowest pressure value is 891.0 mb.

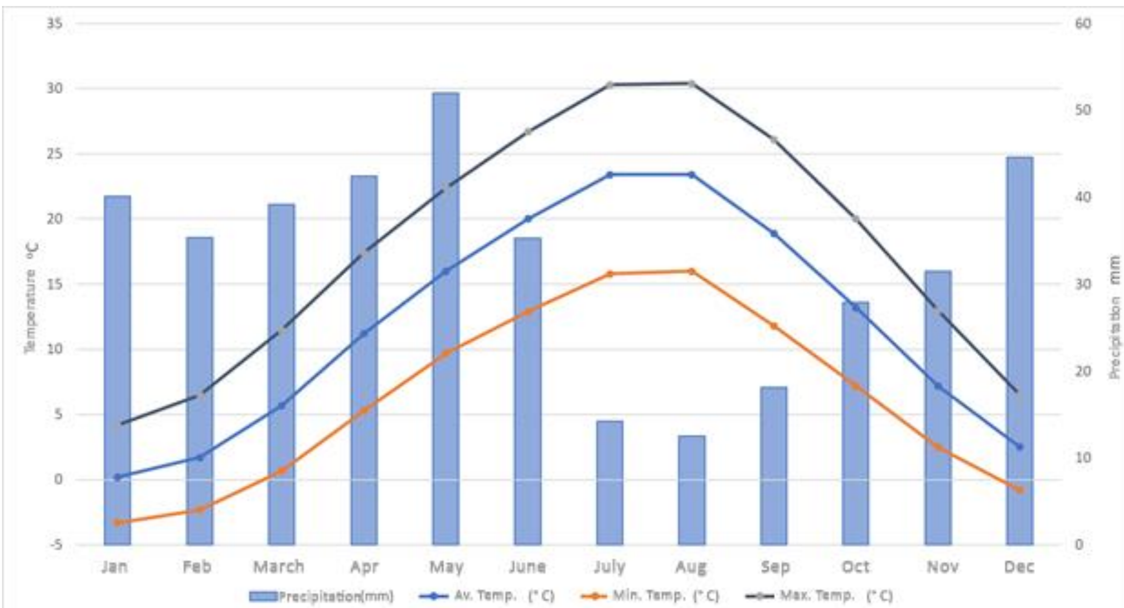


Figure 5.2 Monthly temperature (maximum, minimum and average) and precipitation distribution

5.2.2 Trend Analysis

5.2.2.1 Temperature

Climate parameters vary from year to year and for longer periods (decades) due to natural reasons. In recent years, natural variability of the climate and human-induced change occur together. While the human-induced change manifests itself as an increasing trend especially in the temperature parameter, the natural variability continues to occur above this trend. Era5 Reanalysis product was used for historical temperature values and monthly average temperatures of Ankara Province were evaluated between 1975-2020.

The monthly average temperature values show the warming as of 1995. As of 2000, temperature anomaly values are seen above 2°C. Considering the urbanization effect, an increase in temperature has been observed in recent years.

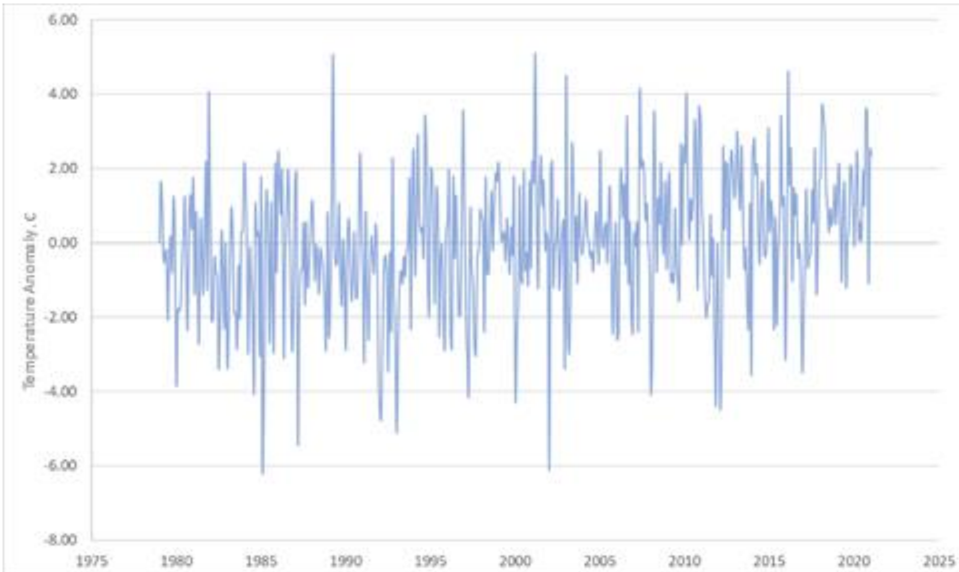


Figure 5.3 Ankara Province temperature anomaly (1975- 2020)

5.2.2.2 Precipitation

It is seen that the variability from year to year in annual precipitation is quite high. The wettest years are 1983, 2001 and 2015. The driest years are 1992, 2001, 2006, 2013 and 2015. No significant trend could be detected for annual total precipitation.

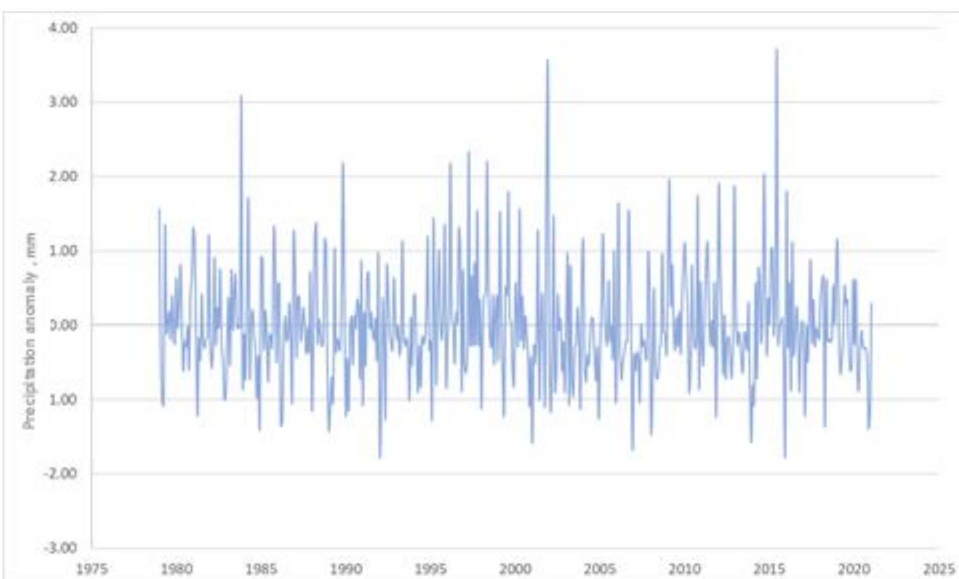


Figure 5.4 Ankara Province precipitation anomaly (1975- 2020)

5.2.2.3 Urban Heat Island

Urban heat island is defined as the situation where urban centers are warmer than suburban, rural and natural areas as a result of urbanization and land change dynamics. The urban heat island arises due to the scarcity of green areas, the increase in the areas covered by heat retaining materials (eg concrete and asphalt), the congested urban fabric and the inability to ventilate the city, the density of waste heat sources (eg industry, vehicle use and air conditioning systems) in the city, the geographical and microclimatic characteristics of the city. It may vary locally within the city.

As the vegetation density increases, the surface temperature decreases, because it will cause more total evaporation, the energy lost on the vegetated surfaces causes cooling. When the impermeability value increases, the surface temperature increases as the ratio and mass of the covering materials that cause heating and heat preservation increase. Accordingly, the highest temperature is observed in dense urban residential areas, and the lowest temperature is observed in green areas.

'Surface Temperature' data is generated by various transformations from the thermal bands of satellite images. In this context, surface temperature (LST) data obtained from MODIS-TERRA satellites were used in the creation of heat maps. MODIS products provide a range of environmental products such as land cover / land use change, wildfire detection, plant indices and vegetation survey, heat island detection, emissivity values and surface temperature. Accordingly, MODIS LST (MOD11A2) has a spatial resolution of 1 km and an average temporal resolution of 8 days under clear sky conditions. Using these data, the monthly average values of the surface temperature for many years were calculated and the surface temperature differences were examined.

Figure 5.5 and Figure 5.6 show the urban heat island observed in June in Ankara for the years 2019 and 2020.

It is seen that Ankara is topographically surrounded by elevations from the north, east and south directions and has a bowl-shaped form. The urban heat island effect occurs due to the fact that it is in a pit due to the mountains around it and the dense construction in the city center. Current trends and scenarios regarding climate change indicate that temperatures in Ankara will increase further in the future.

The fact that Ankara will be a warmer city also shows that heat waves and the urban heat island effect will be an important climatic hazard and risk factor for Ankara. Another danger triggered by heat is undoubtedly the danger of drought. In order to prevent and reduce all these dangers and risks, it is recommended that the Ankara Metropolitan Municipality take the necessary measures and plan the actions in advance.

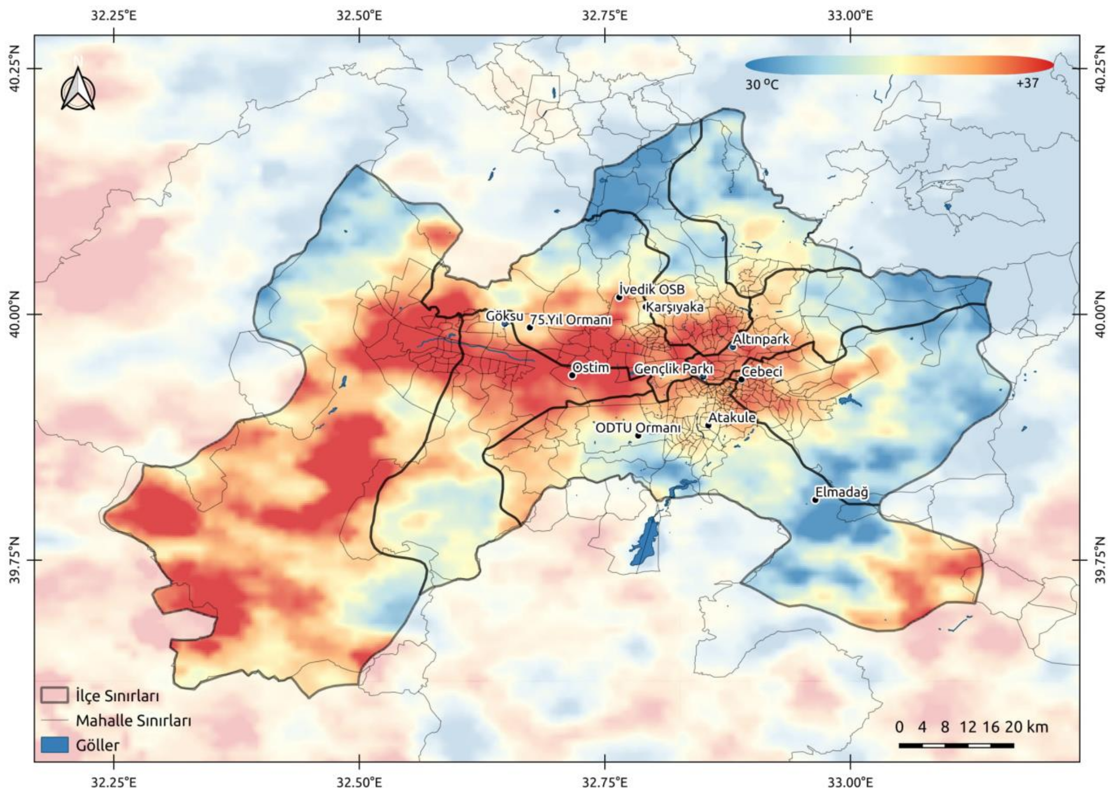


Figure 5.5 Average surface temperatures observed in Ankara Province in June 2019

The surface temperature maps produced based on the data of 2019 and 2020 show the sub-regions of the city that can be considered as risky in terms of heat waves and urban heat island effect. In order to interpret the situation shown by these maps, some additional studies and field studies are needed. It is recommended that Ankara Metropolitan Municipality make more comprehensive results and evaluations through field studies in the regions that are considered risky in terms of heat waves and heat island effect in the future. With the help of the available data and information, it is possible to reach some conclusions and develop solutions based on them.

When the surface temperature maps of the city of Ankara are examined, it is seen that the coolest areas are urban forests and large open-green areas, while the hottest areas are dense urban areas, hard and impermeable floors and large production areas. It is seen on the maps that large areas such as AOÇ, Cebeci State Cemetery, Anıtkabir garden, university campus areas and METU forests are the coolest areas.

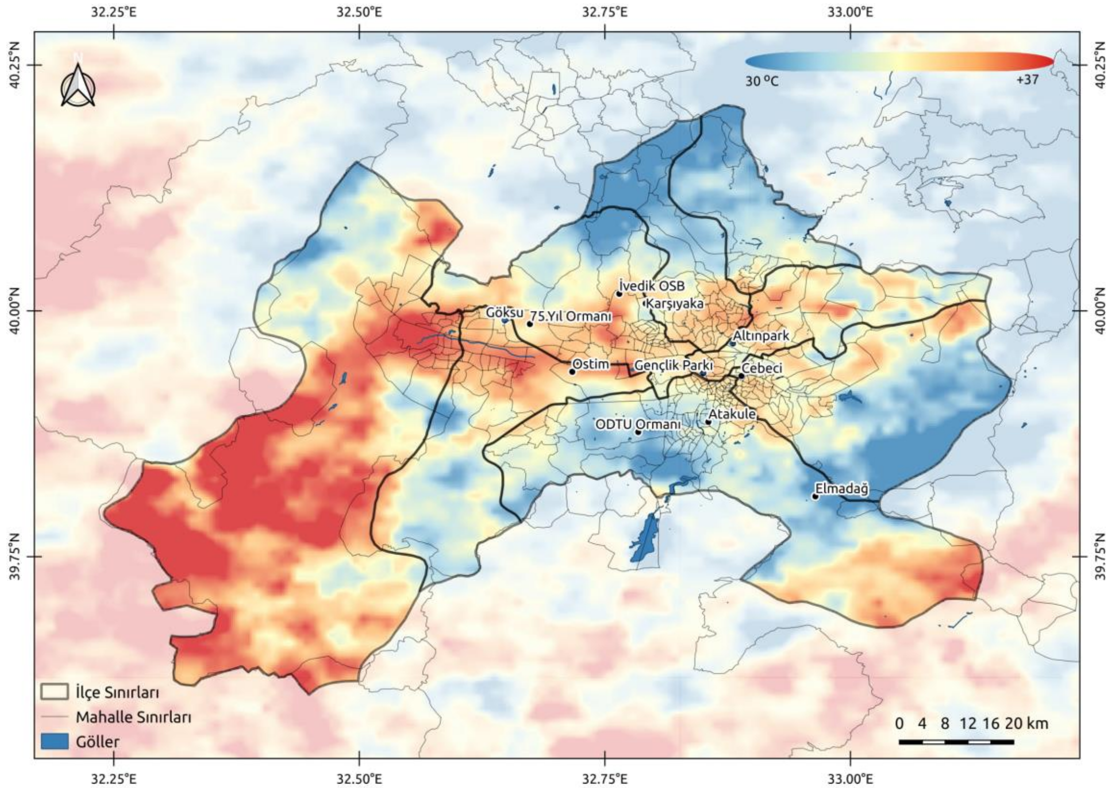


Figure 5.6. **Average surface temperatures observed in Ankara Province in June 2020**

The map of 2019, where surface temperatures are higher, shows regions with a high risk potential in terms of heat island. Accordingly, two main regions in the city draw attention.

The first of these is the region extending in the east-west direction and containing a significant part of the settled area of the city and some production areas. The second risk area in the city is the south-west part of the city, in the direction of Polatlı, away from the existing settled area of the city. It is seen that this region mostly includes the Temelli, Malıköy and Türkobası sections.

The first region starts from Sincan in the west, includes Eryaman, Etimesgut and Ostim, reaches the center of the city like Ulus and Kızılay, and extends eastward, including Cebeci and Altındağ. This first region also continues in the north direction and includes districts such as Etlik and Keçiören. The first region covers a large part of the central districts of the city of Ankara and therefore the settled area. Looking at the existing urban fabric, it is seen that there is a clear north-south separation on the temperature map. While the surface temperatures are found to be higher in the northern parts of Ankara, the temperatures are observed to be lower in the southern part of the city, which includes Gölbaşı and Çankaya. Considering the settled area of the city as a four-part matrix, it can be said that the region with the highest risk potential is the northwest, and the second risk region is the northeast. In the southern part, it can be said that the parts to the east and west of the METU Forest (Çayyolu districts in the west, Çankaya districts and its surroundings in the east) have similar characteristics.

In brief, high surface temperatures, which are continuous in the east-west direction within the existing residential area of Ankara, decrease as one goes south. The main factors causing this situation are evaluated below.

It can be said that one of the factors causing the north-south separation in terms of temperatures is the altitude differences. Since the southern parts of the city, especially Çankaya and its surroundings are located at high altitudes, it can be relatively cooler compared to the northern part at lower elevations.

Another reason why the south of the city has a more positive quality in terms of temperatures compared to the north is the differences observed in the characteristic of the built environment between the two sections. The residential development areas in the north of the city have a high density, and the presence of open green spaces within the built environment is relatively limited. The existence of large institutional green areas within the settlement pattern in these regions is also very limited. However, in the southern part, urban forests, especially the METU Forest, large green areas and partially preserved valleys make a difference due to their cooling effects. In this part of the city; Apart from the METU Forest, there are the green corridor starting from Mogan and Eymir Lakes and continuing with Imrahor Valley in this region, and large green areas such as Dikmen Valley corridor, Botanical Park and Seğmenler Park. It can be said that the METU Forest constitutes an extremely important ecosystem for the southern part of Ankara, and among the ecosystem services it provides to the city are temperature control and heat island effect reduction.

It is thought that the temperature difference between the north and the south is caused by the differences in urban usage and function between the regions as well as the two reasons mentioned. In the southern part of Ankara, there are mainly residential areas and the central regions, which include commercial, cultural and office working areas. In addition, campus universities such as METU, Bilkent and Hacettepe University are located in this region. On the other hand, in the northern part of the city, which is seen to be more risky in terms of temperature, there are large production areas as well as residential and commercial uses. In this region from west to east, Ankara Organized Industrial Zone in Sincan, Şaşmaz Auto-Industry Zone and Ostim Organized Industrial Sites and Siteler Furniture Production Zone are located. It can be thought that these production areas contribute to the increase in temperatures based on the production and therefore the intense energy consumption.

In a similar vein, the high temperatures observed in Temelli and its surrounding south-west region, which is the second risk zone of the city in terms of temperatures, are also thought to be associated with large-scale production facilities. This region is not a dense area in terms of urban uses. In this region, there are partial suburban housing areas belonging to the upper middle income group. However, there are large-scale production facilities and infrastructure facilities in the region. Among the major production regions are Başkent Organized Industrial Zone, Anadolu Organized Industrial Zone, Ankara Dökümcüler Specialized Organized Industrial Zone, Ankara Chamber of Industry 2nd and 3rd Organized Industrial Zone. It is considered that the production facilities concentrated in this region are the source of temperature increases.

5.2.2.4 Meteorological Disasters

Meteorological disasters in Ankara correspond to 1-2% of the annual total disasters in Turkey. However, even if the number of incidents is low compared to other cities, considering the density of the population and assets exposed to these threats in Ankara, it is revealed that the city's vulnerability is high.

Table 5.3 According to the Turkish State Meteorological Service data, disasters with meteorological character in Ankara (2015-2020)

Yıl		2015	2016	2017	2018	2019	2020
Turkey Total		**731**	**654**	**598**	**871**	**936**	**984**
Ankara Total		**13**	**3**	**6**	**14**	**12**	**12**
Disaster	Floods	8	2	4	8	3	5
	Heavy Rain/Storm	3	1	1	1	3	5
	Hail	2	-	-	1	3	2
	Lightning	-	-	1	2	1	-
	Strong Snow	-	-	-	1	1	-
	Frost	-	-	-	1	1	-

As seen in Table 5.3, the most frequent meteorological disasters in Ankara are floods, heavy rains and storms. On the maps related to meteorological disasters, it is seen that districts such as Çankaya, Mamak, Etimesgut, Sincan, Keçiören, which are the most central and dense settlement areas of the settled area of Ankara, are places where events have been observed intensely in the recent period. It is highly probable that all central parts of the city's settled area will be exposed to such disaster events and resulting floods. It is known that as a result of the flood events that have been increasing in recent years, material damage and even loss of life have occurred in many parts of the city.

It is considered that the floods observed in the current settled area of the city in Ankara are sometimes river floods occurring along covered stream beds and sometimes sudden floods due to excessive precipitation and rapid surface fluidity. It is necessary to carry out a comprehensive hazard and risk analysis regarding the causes and possible solutions of these flood events, to determine the risk focus in line with the analysis and to plan the necessary measures and risk reduction actions immediately.

- **Floods:** Between 2018 and 2020, 3,128,000 TL disaster payments were made to 689 houses affected by floods. In the urban flood event in 2019, three lives were lost. The districts most affected by this type of disaster are Mamak and Çankaya (Figure 5.7). This situation points to infrastructural deficiencies and unplanned urbanization problems in these districts.
- **Heavy Rains and Storms:** Between 2018 and 2020, 1,120,500 TL disaster payments were made to 407 houses affected by storms and heavy rains. The districts most affected by this disaster are Bala, Mamak, Sincan and Etimesgut (Figure 5.8). This situation draws attention to the structural fragility in the housing stock as well as the infrastructure inadequacies in these districts.

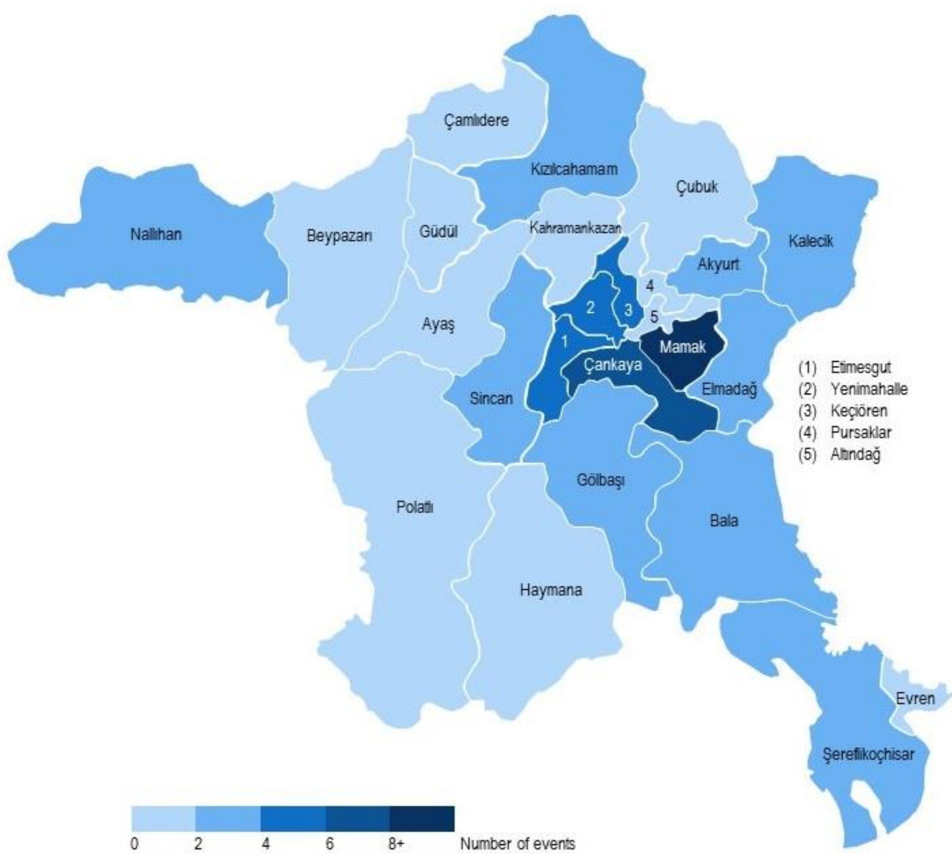


Figure 5.7 Flood events in Ankara districts between 2018-2020

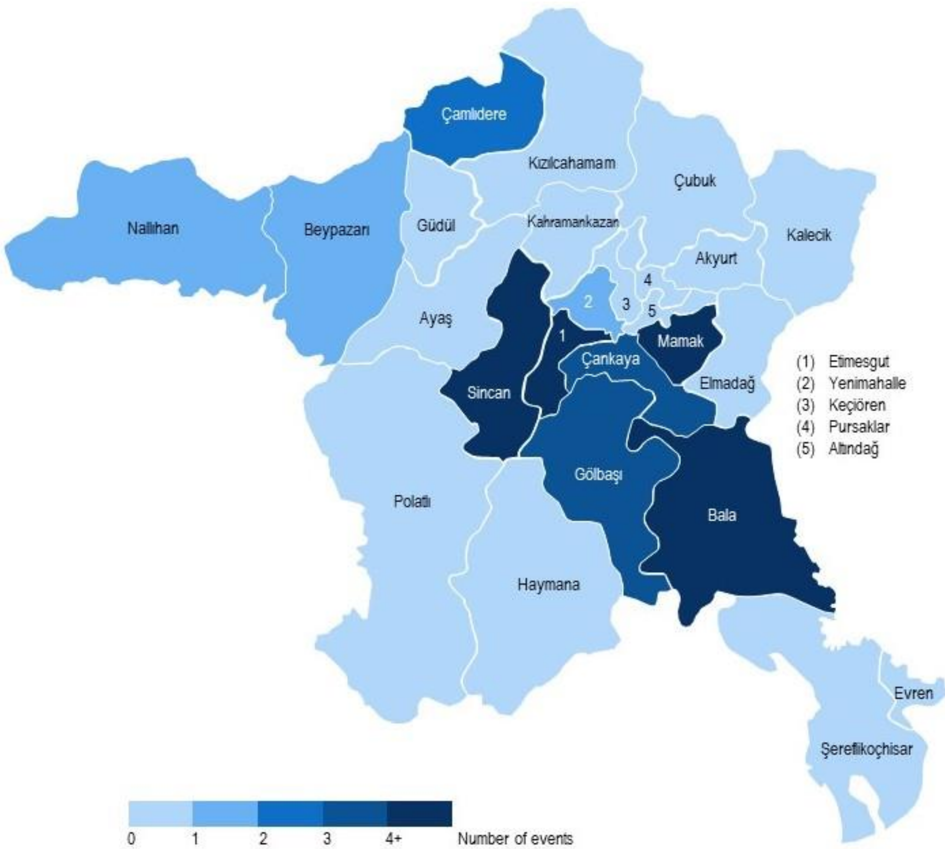


Figure 5.8. Storm and heavy rain events in Ankara districts between 2018-2020

5.3 Future Climate Analysis

5.3.1 Change in Major Climate Parameters

5.3.1.1 Average Temperature

Temperature projections indicate that towards the end of the century, monthly average temperatures in Ankara will increase by 1 to 6°C compared to today (1910-2010 average). The optimistic scenario RCP2.6 indicates a temperature rise of 2°C. The pessimistic scenario, RCP8.5, shows that monthly average temperatures will rise up to 6°C until 2100. All scenarios show a trend towards an increase in temperature.

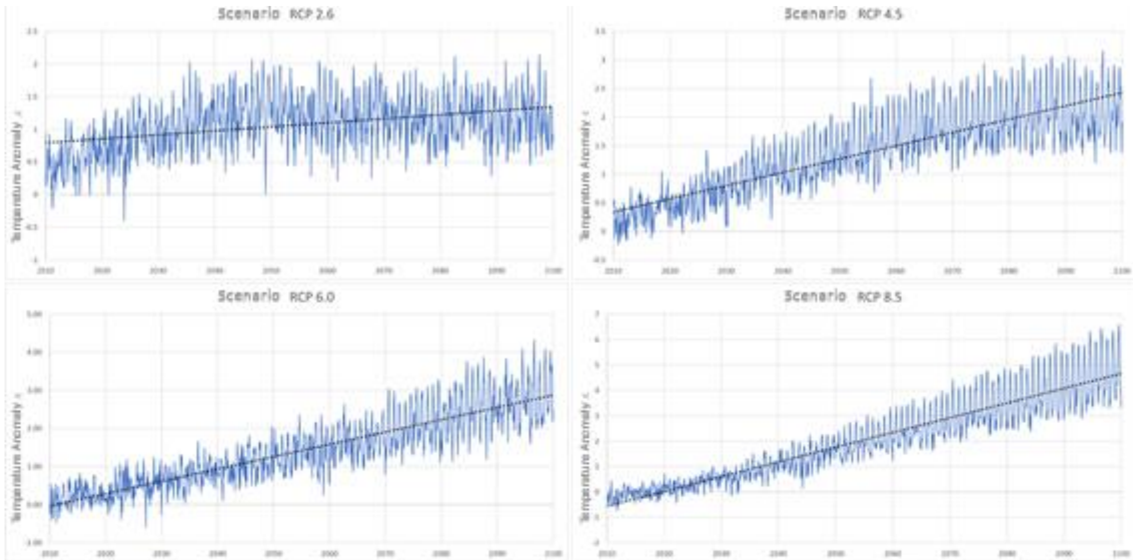


Figure 5.9 Monthly temperature anomaly values according to different climate scenarios

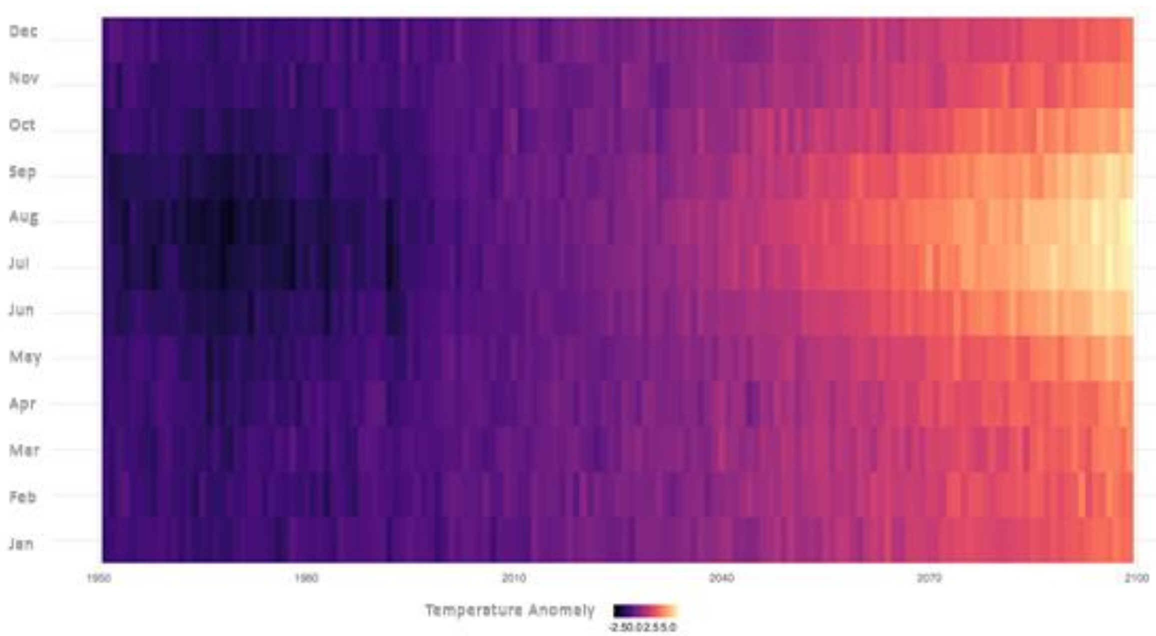


Figure 5.10 Observed and predicted temperature anomaly values

5.3.1.2 Precipitation

In monthly average precipitation values, the optimistic scenario (RCP2.6) shows that there will be no significant change in Ankara until 2100. However, RCP4.5, 6.0 and the pessimistic scenario RCP8.5 indicate the trend of decreasing monthly average precipitation. The RCP4.5 scenario predicts a decrease of 0.2 mm/day, the RCP6.0 0.25 mm/day, and the RCP8.5 scenario 0.3 mm/day.

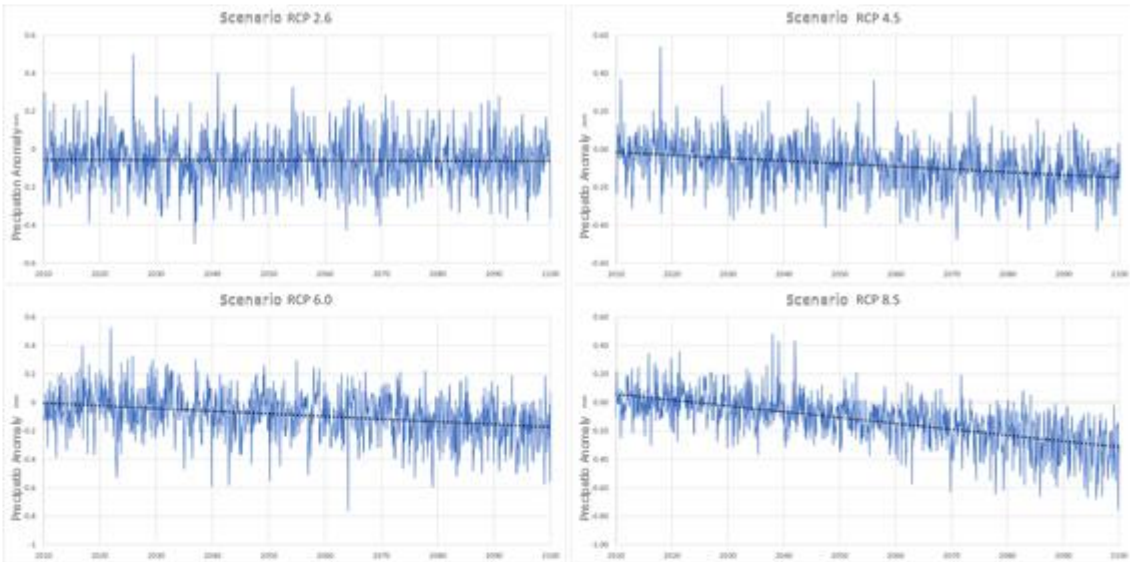


Figure 5.11 Monthly precipitation anomaly values according to different climate scenarios

5.3.2 Change in Extreme Climate Parameters

Extremes in the climate system are defined as rare events with extreme values when long-term averages of climate parameters are taken into account. As an effect of climate change, the severity and frequency of extreme events are changing.

5.3.2.1 Cool days (days with Tmax < 10% of normal)

Maximum temperatures occur usually just after noon during the day. They therefore provide general information on daytime temperatures. It is observed that the percentage of cool days tends to decrease in all scenarios. In 2040, all scenarios show that the rate of days when the temperature is below seasonal normals will decrease to 4%. In 2100, the RCP2.6 scenario gives the result that the percentage of cool days will continue to be around 4%, while the RCP8.5 scenario gives the result that the percentage of cool days will be approximately 1%.

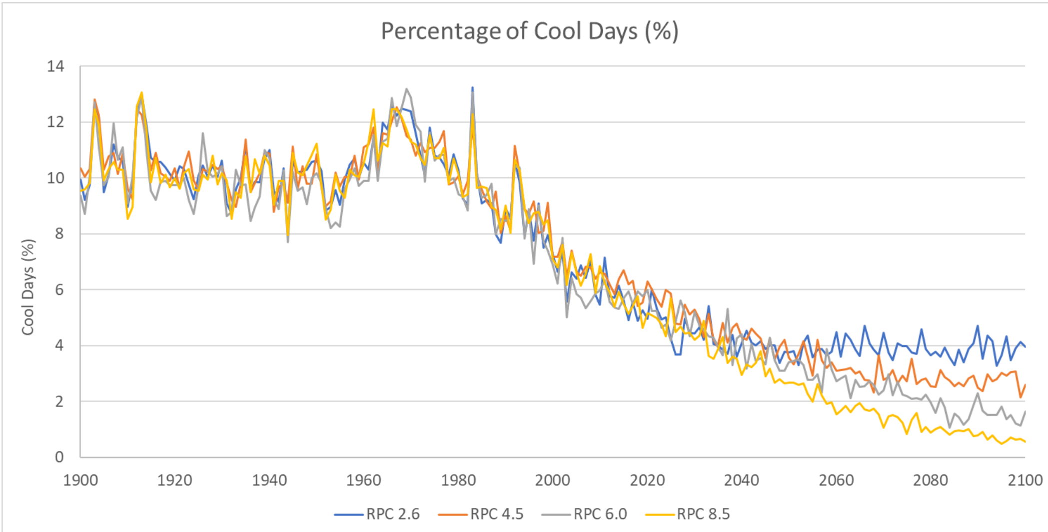


Figure 5.12 Variation of cool days according to different scenarios

5.3.2.2 Warm days (days with Tmax > 90% of normal)

The days when the daily maximum temperature is above the seasonal normals are around 10-20% in the reference period. All scenarios show that the percentage of hot days will increase to 30% in 2040. In 2100, the RCP2.6 scenario gives the result that the percentage of hot days will continue to be around 30%, while the RCP8.5 scenario gives the result that the percentage of hot days will increase to 70%.

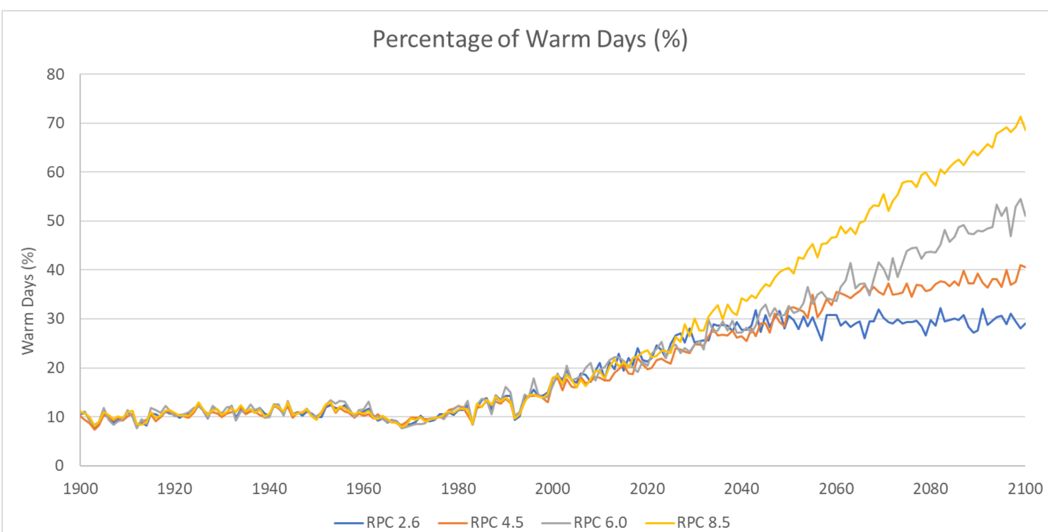


Figure 5.13 Variation of warm days according to different scenarios

5.3.2.3 Annual minimum of daily maximum temperatures

This reference period value, which expresses the smallest maximum temperature, is slightly below -5°C. It is seen that the index entered an increasing trend as of 2020 and exceeded 0°C for the worst scenario until 2100.

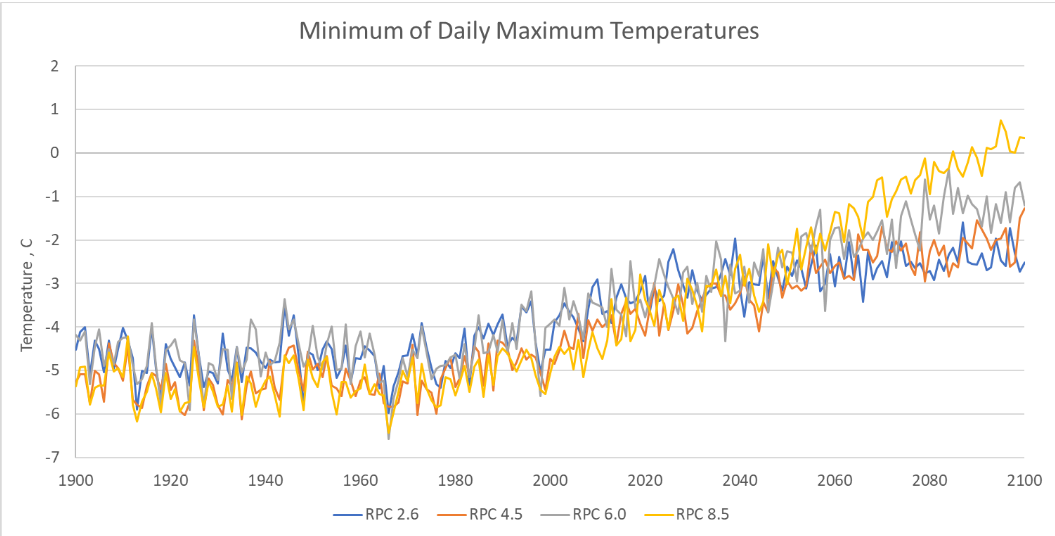


Figure 5.14 Minimum of Daily Maximum Temperatures, variation according to different scenarios

5.3.2.4 Annual maximum of daily maximum temperatures

This index represents the highest maximum temperature. In the reference period, the index value is around 36°C. With the increase in temperatures, an increase in the maximum temperature values is also observed. The trend is upward for all scenarios. In the RCP8.5 scenario, it was observed that the temperatures went up to 44°C.

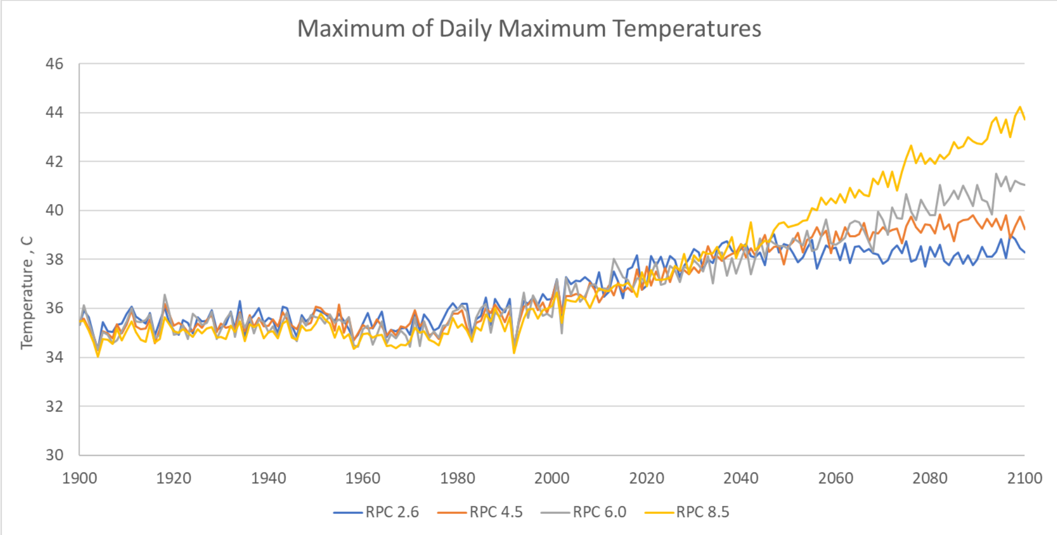


Figure 5.15 Maximum of Daily Maximum Temperatures, variation according to different scenarios

5.3.2.5 Annual minimum of daily minimum temperatures

The reference period value of this index, which is a measure of the annual lowest temperature, has been calculated around -12°C by global models. It is seen that the annual minimum temperatures are in an increasing trend as of the beginning of the century. Projected increases for mid-century are around 2°C for the RCP2.6 scenario and 1°C for the RCP8.5 scenario. By 2100, the increase is likely to rise to 5°C.

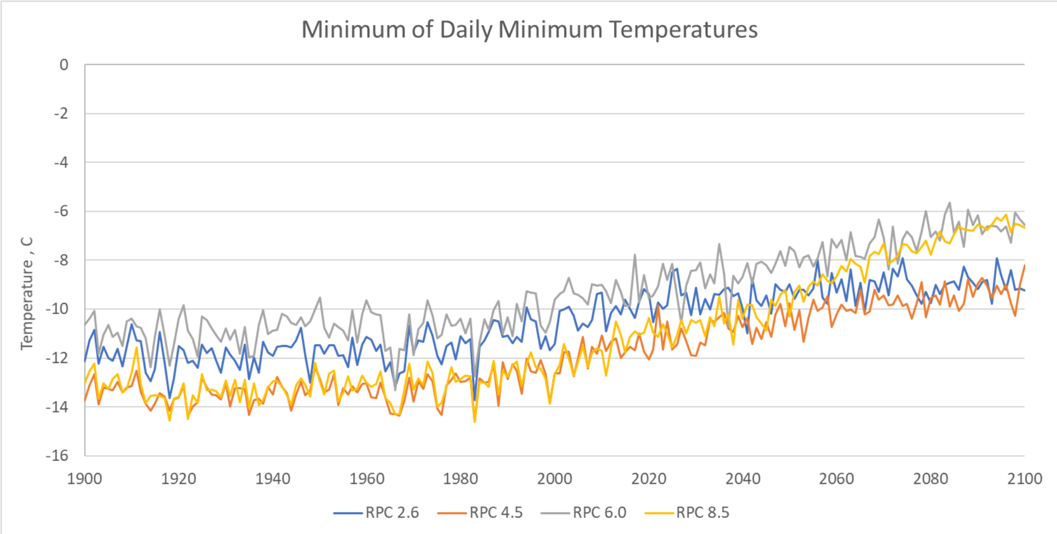


Figure 5.16 Minimum of Daily Minimum Temperatures, variation according to different scenarios

5.3.2.6 Annual maximum of daily minimum temperatures

The reference period value of this index, which is a measure of the hottest night, is around 20°C. It has been observed that this index is in an increasing trend as of 2000. By the middle of the century all scenarios show an increase of 2°C, by the end of the century the temperature increase is 6°C in the worst case scenario.

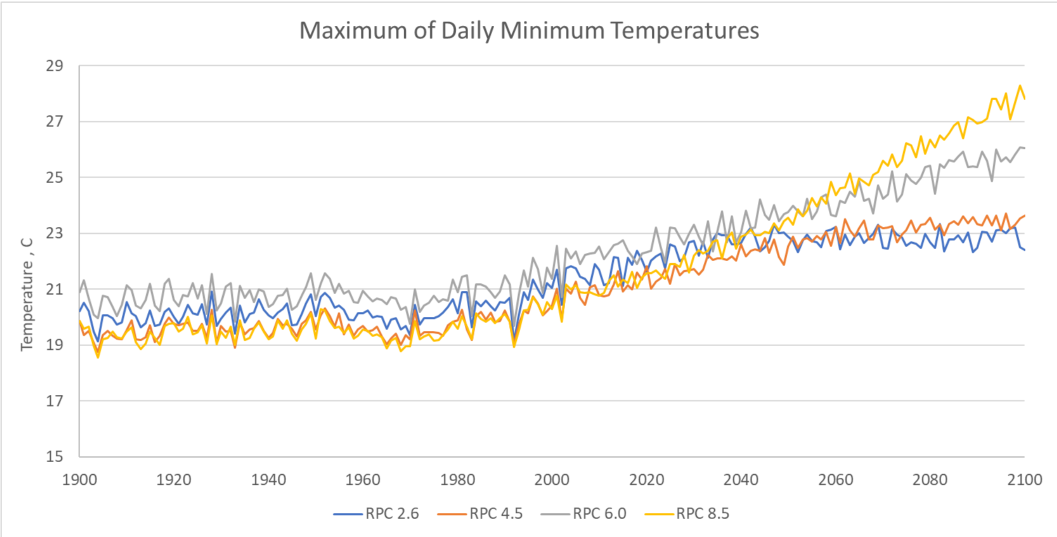


Figure 5.17 Maximum of Daily Minimum Temperatures, variation according to different scenarios

5.3.2.7 Frost Days

The value of this index, which gives the number of days when the daily minimum temperature is below 0°C, is around 90 days, calculated by global models for the reference period. All models for the next period indicate a decrease in the number of days with frost. In the middle of the century, it was seen that days with frost decreased to 60, and in the worst case scenario, it decreased to 40 days in 2100.

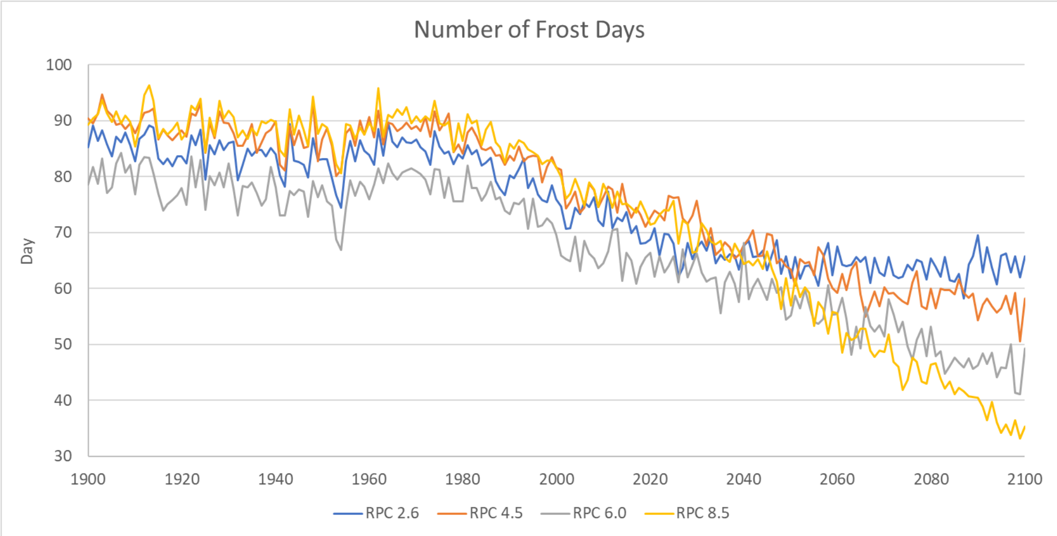


Figure 5.18 Change of frost days according to different scenarios

5.3.2.8 Icing Days

The value of this index, which gives the number of days when the daily maximum temperature is below 0 °C, is around 15 days, calculated by global models for the reference period. All models for the next period indicate a reduction in the number of days with ice. In the middle of the century, it was seen that days with ice decreased to 7, and in 2100, it decreased to 3 days in the worst case scenario.

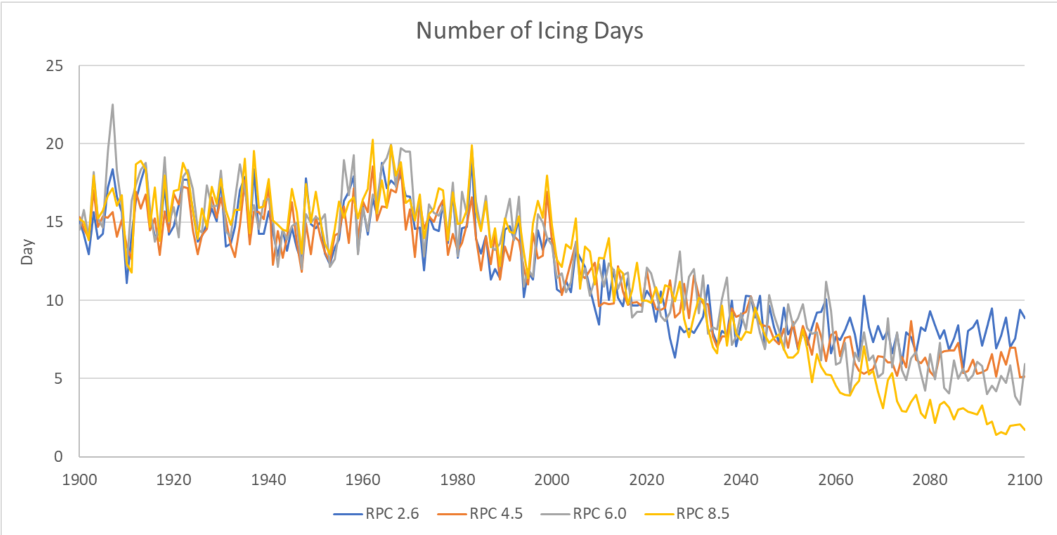


Figure 5.19 Change of icing days according to different scenarios

5.3.2.9 Number of days with precipitation of 1 mm or more

This index gives information about the number of rainy days in the year. The number of rainy days in the reference period is around 120 days in Ankara. With the decreasing effect of climate change on precipitation, there is also a decrease in rainy days. In the optimistic scenario, it is seen that the rainy days decreased to 110 days in 2100 and to 80 days in the pessimistic scenario.

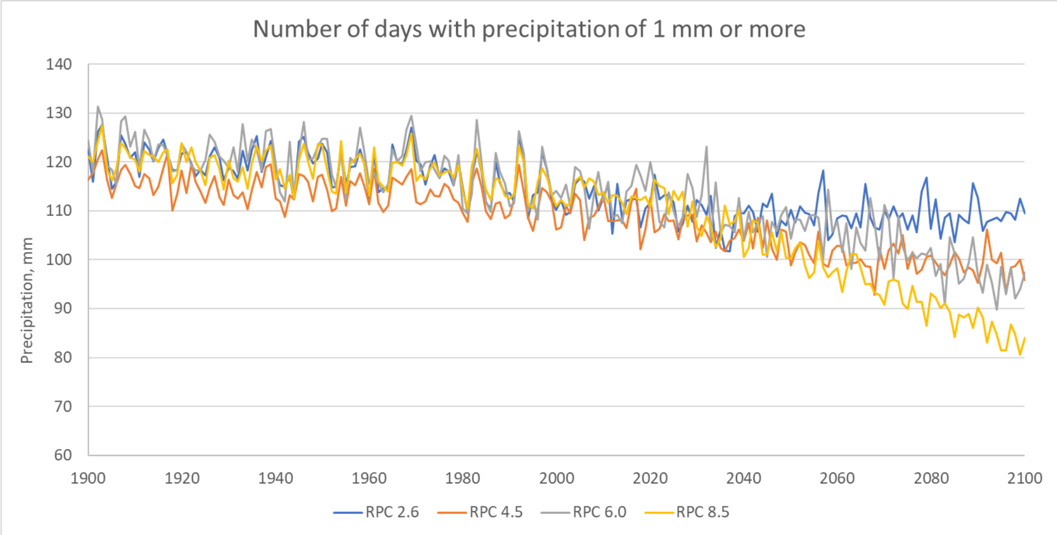


Figure 5.20 Change of rainy days according to different scenarios

5.3.2.10 Number of days with precipitation of 10 mm or more

This index gives information about the number of days in the year when precipitation is above 10 mm. In the reference period, the number of days with precipitation over 10 mm in Ankara is around 14 days. Scenario simulations predict that this index will not change significantly in the future. It is foreseen that there will not be a significant change in this index in the future for Ankara province.

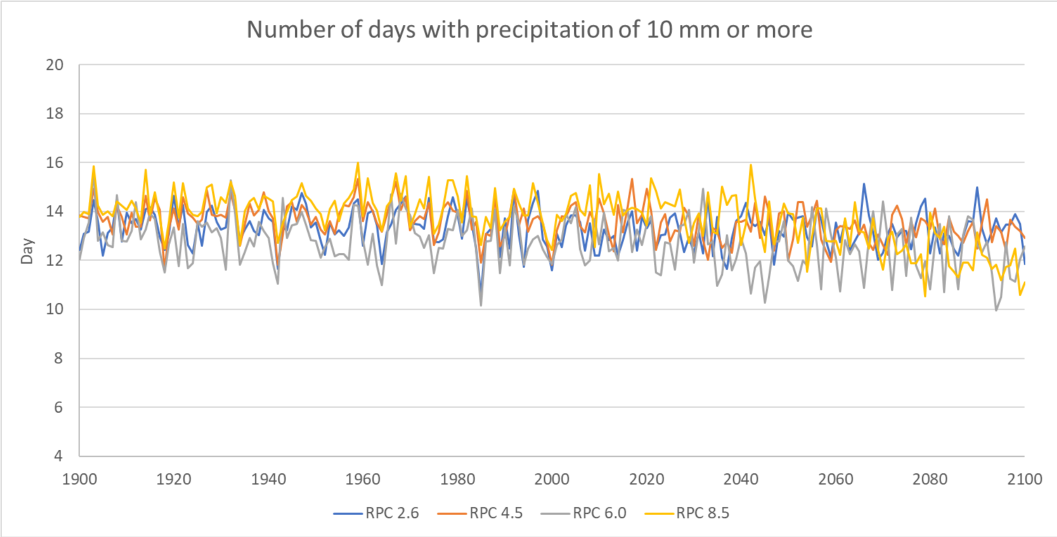


Figure 5.21 Variation of the number of days with 10 mm or more precipitation according to different scenarios

5.3.2.11 Number of days with precipitation 20 mm or more

This index gives information about the number of days in the year when precipitation is above 20 mm. During the reference period, the number of days with precipitation above 20 mm in Ankara is around 2 days. Ankara province is generally in arid climate, so the number of days when precipitation is 20 mm or more is quite low. According to global climate models, it can be said that there will be no significant change in this index.

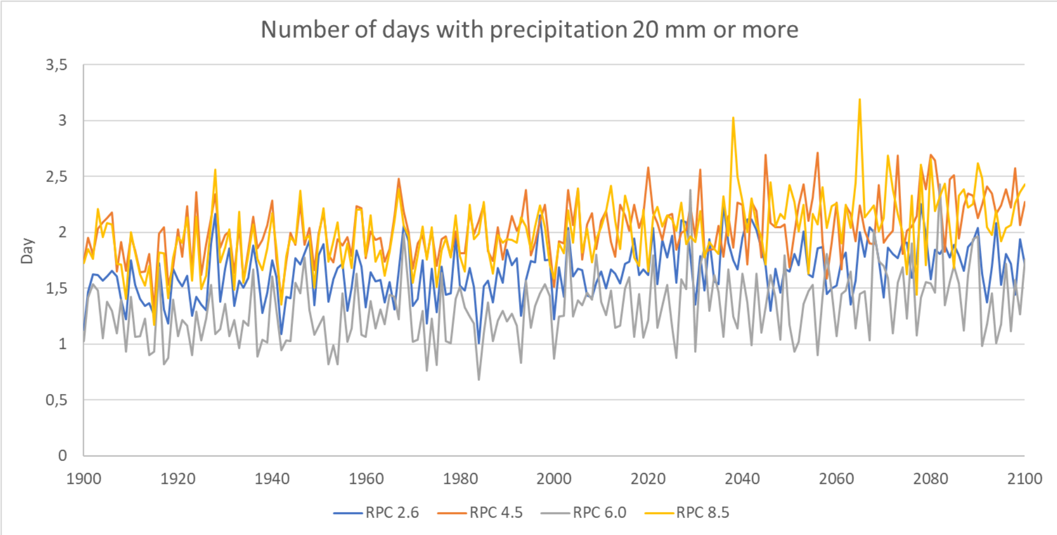


Figure 5.22 Variation of the number of days with 20 mm or more precipitation according to different scenarios

5.3.2.12 Daily temperature range

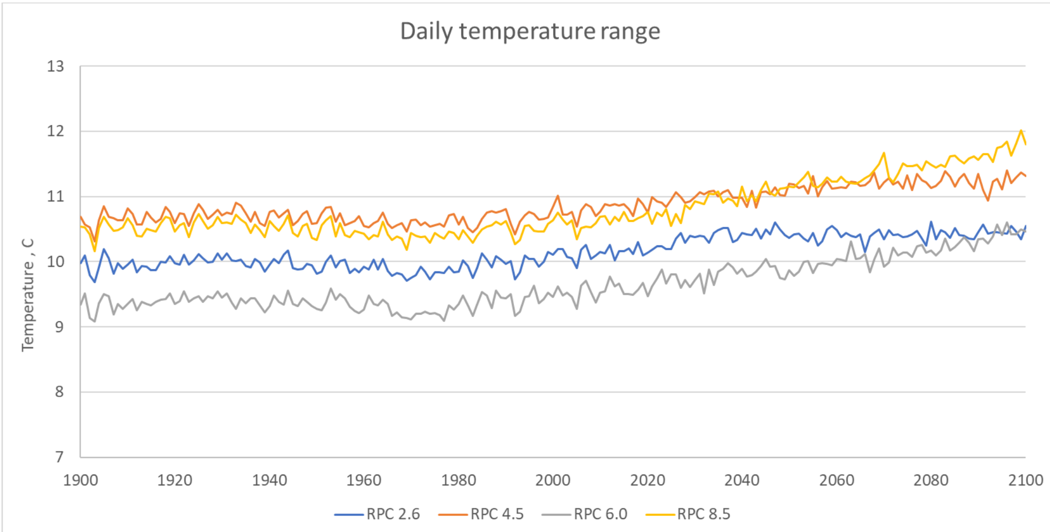


Figure 5.23 Variation of daily temperature range according to different scenarios

5.3.2.13 Growing season length

The growing season length index provides information on the increase or decrease in the arablity of a specific geographical region within the framework of climate projections. The past years' analysis and future projection of this index, which expresses the number of days between the first 6 consecutive days when the mean daily temperature rises above 5 °C and the first 6 consecutive days when it falls below 5 °C in a year, are expressed in Figure 5.24 for Ankara within the framework of the 1900-2100 period. When the aforementioned figure is examined, it provides a prediction that the index of the growing season will increase gradually until 2100 and therefore the convenience of the soil for agricultural activities within the borders of Ankara Province will increase. However, it should be noted that the average temperature values of consecutive days are not the only criteria in terms of agricultural convenience.

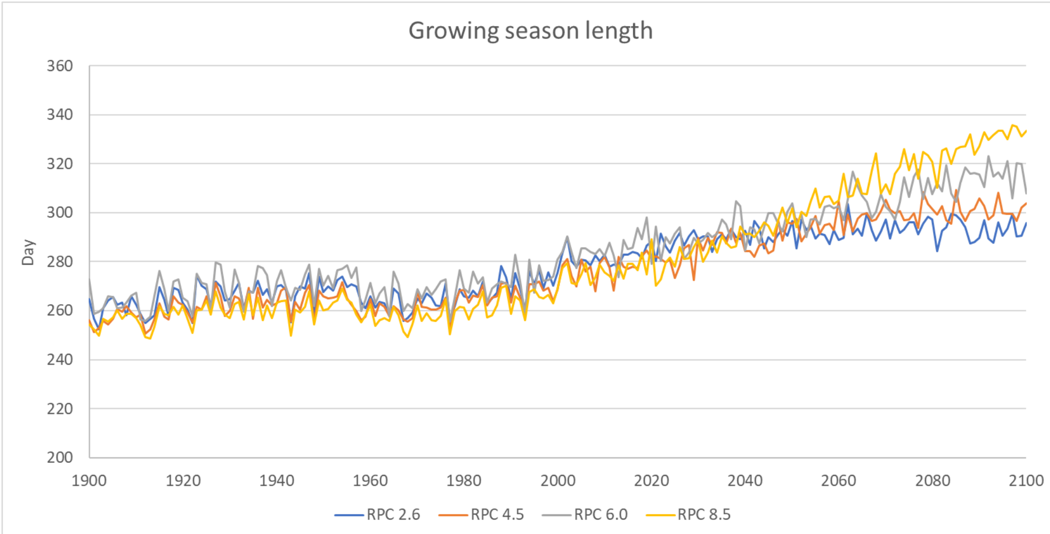


Figure 5.24 Variation of length of growing season according to different scenarios

5.3.2.14 Summer days

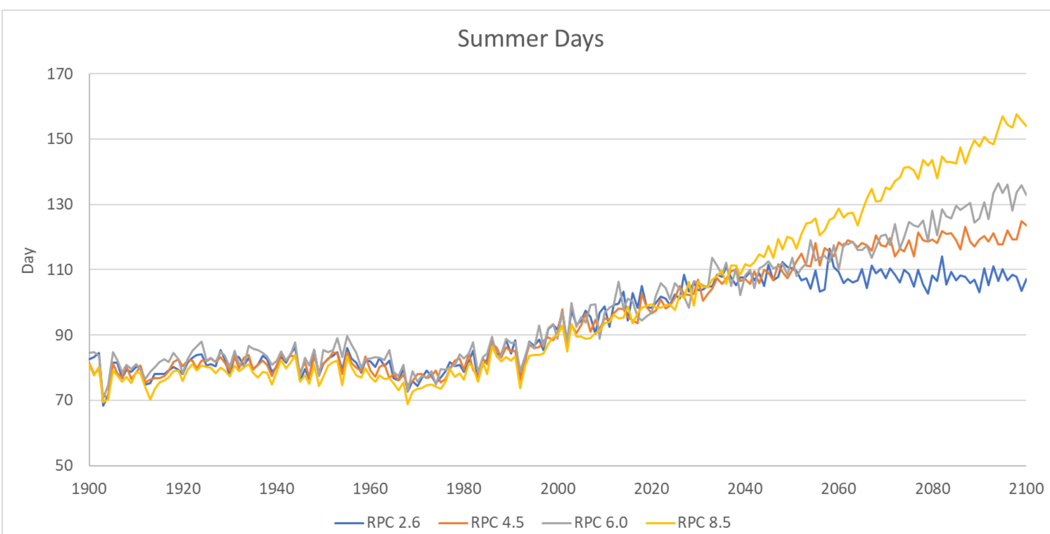


Figure 5.25 Variation of the number of summer days according to different scenarios

5.3.2.15 Extremely dry days

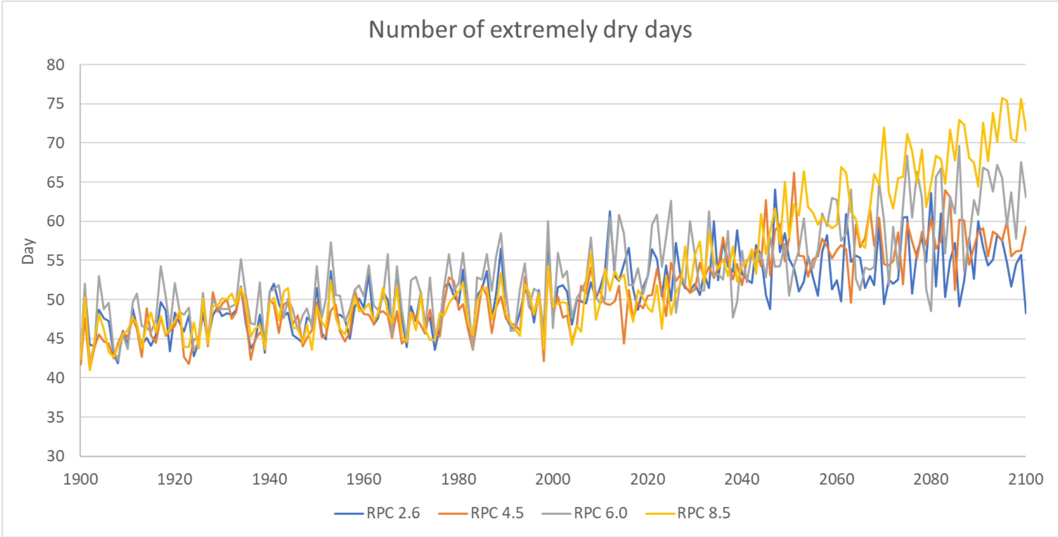


Figure 5.26 Variation of the number of extremely dry days according to different scenarios

5.3.2.16 Heavy rainy days

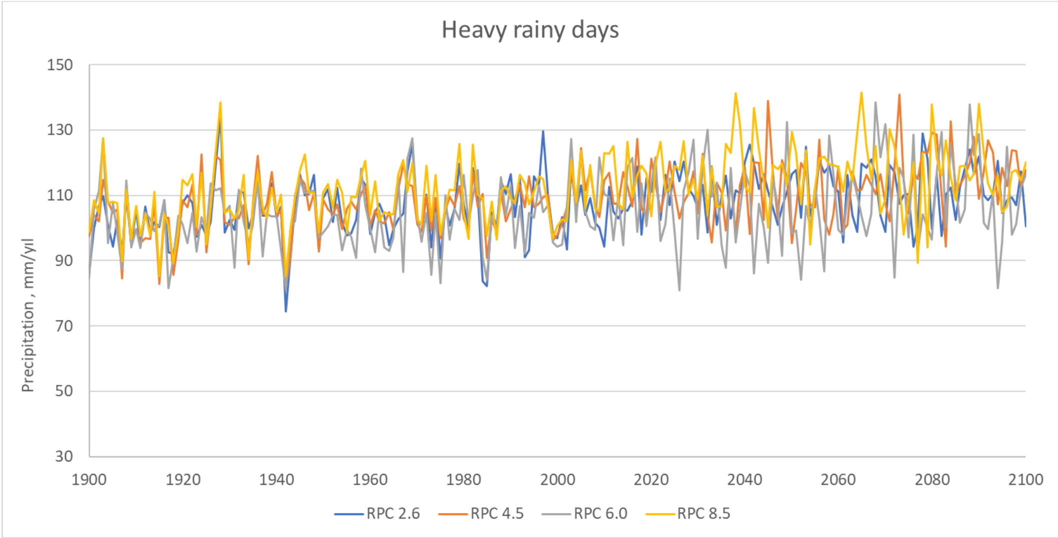


Figure 5.27 Variation of precipitation amount in heavy rainy days according to different scenarios

5.3.2.17 Extremely heavy rain days

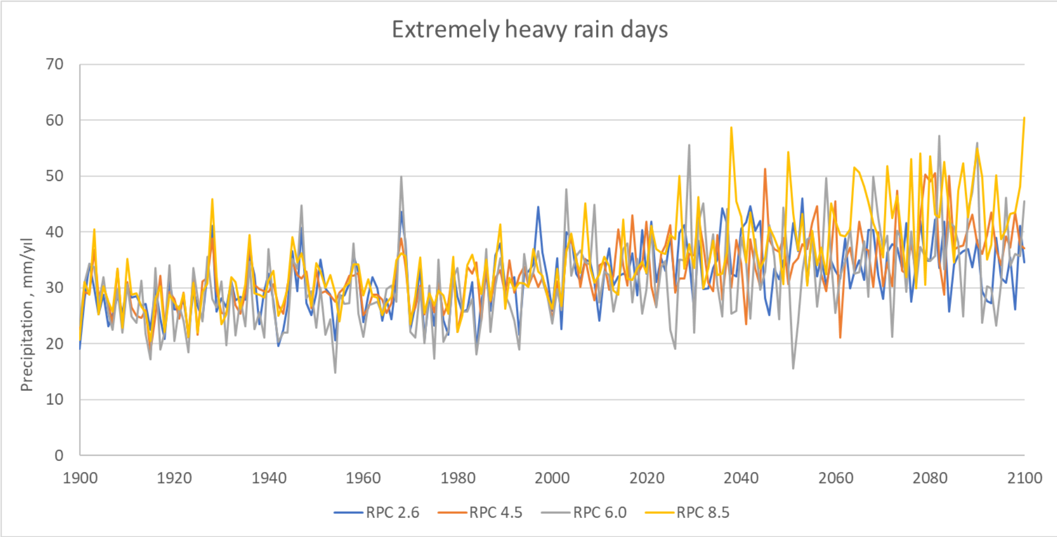


Figure 5.28 Variation of precipitation amount in extremely heavy rain days according to different scenarios

5.3.2.18 Maximum daily precipitation

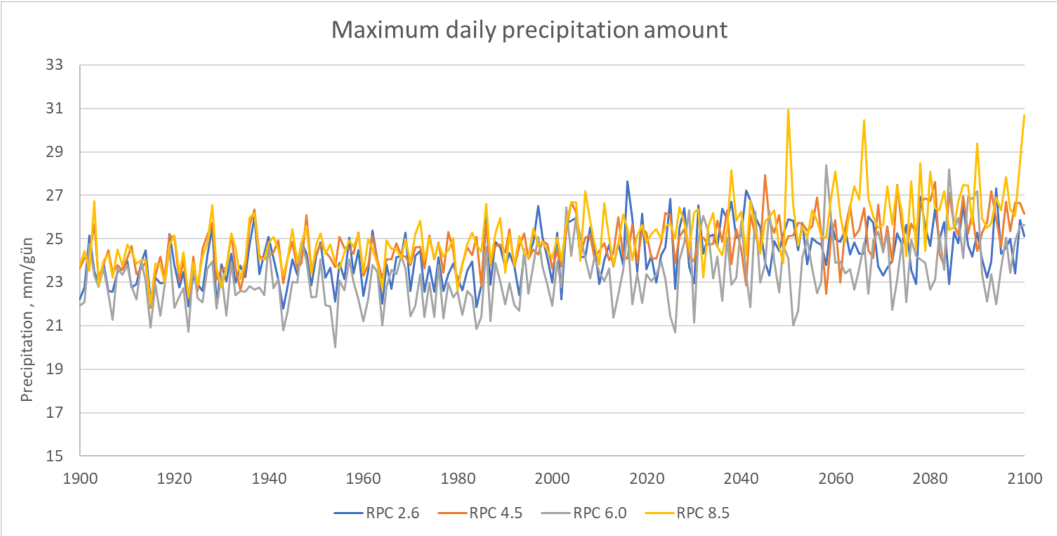


Figure 5.29 Variation of daily maximum precipitation according to different scenarios

5.3.2.19 Maximum consecutive 5-day precipitation

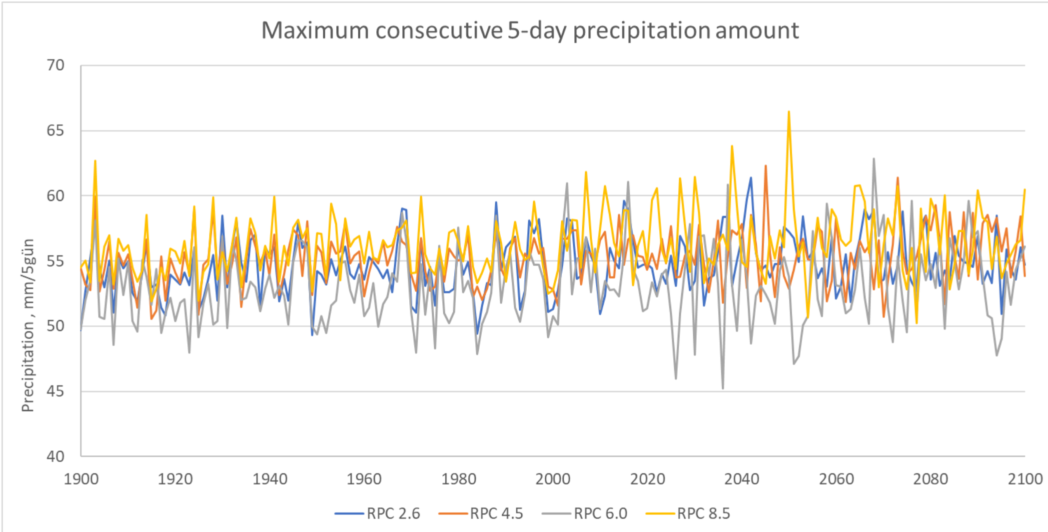


Figure 5.30 Variation of maximum consecutive 5-day precipitation according to different scenarios

5.4. Conclusion: Vulnerability and Risk Assessment

Climate scenario studies reveal that Ankara has evolved into a hotter and drier climate as a result of climate change. In Ankara in 2100 compared to the average of 1910-2010:

- Average temperatures will increase by 1 - 6°C.
- The rate of cool days will decrease by 2-5% to 1-4%.
- The rate of hot days will increase by 10-50% to 30-70%.
- Annual maximum temperatures will rise from an average of 36°C to 38-44°C.
- Annual minimum temperatures will rise from -12°C to -6 - -10°C on average.
- The number of days (days with frost) where the daily minimum temperature is below 0°C will fall between 35-65 days.
- The number of days (days with ice) where the daily maximum temperature is below 0 °C will decrease between 2-10 days.
- The number of days with 1 mm or more precipitation will decrease between 80-100 days.

These results; Trends in average and extreme temperature parameters point to a serious warming towards the end of the century. In case the land use changes in Ankara continue in the direction of dense and unplanned construction and the natural areas shrink, the increasing urban heat island effect will be added to the temperature increases and the average temperatures will increase even more. It can be said that the summer season increases will be higher than the winter season increases, the temperature distribution will shift upwards without changing due to the fact that the daily temperature range does not change significantly, and in this case, the indices on the cool side will decrease and the indices on the hot side will increase.

As a result of the evaluations, the annual precipitation in Ankara shows a general decreasing trend in the coming years, while the absence of a significant change in heavy precipitation signals that the precipitation will be less frequent but more intense and the dry periods will be prolonged. This situation will increase the possibility of floods on the one hand, and the risks of drought and water shortage on the other.

In the light of this information, the main risks regarding the sensitivity of human health, agriculture and food safety, ecosystem services, infrastructure and related sectors to climate parameters in Ankara are summarized below.

- Temperatures that can reach up to 44°C in the worst-case scenario will increase the health risks faced by the elderly, children, low-income groups and those with cardiovascular diseases.
- Increasing temperatures will reduce snow-fighting activities in winter.
- The decrease in days with frost and ice may alleviate the municipality's services such as salting in winter and the problems experienced in urban transportation.
- The increase in average temperatures and the frequency of heat waves will increase the loads on the energy infrastructure for cooling purposes.
- An increase in temperature will increase disaster events such as fire risk.
- The decrease in spring and summer precipitation and increase in evaporation will lead to a decrease in water resources.
- The decrease in water resources will increase the vulnerability of extreme events such as drought.
- Ecosystem services will be adversely affected by temperature increases, drought and water stress.
- The increase in temperature and the prolongation of the dry period will increase the maintenance cost of parks, gardens and green areas.
- With the increase in greenhouse gas emission concentration and temperature, there may be yield losses in wheat farming. There are studies carried out by the Soil Fertilizer and Water Resources Central Research Institute on this subject, and according to the results of the studies, it has been stated that there are risks regarding the possibility of yield loss. It is thought that this risk, expressed through wheat farming, should be taken into account within the framework of preserving product diversity in agriculture in a region like Ankara where grain production is a priority in farming.
- The increase in temperature and the decrease in spring and summer precipitation cause the transitions between seasons to vary. This is a risk that causes imbalances in the synchronization of pollinators and blooming plants, thereby reducing agricultural productivity and diversity.
- With the increase in temperature, diseases caused by invasive species in cultivated plants have started to shift from the southern regions to the northern regions, both nationally and internationally. For instance; It is also stated by the Plant Health Central Research Institute that the common fruit fly species, which is generally seen in the Antalya region, has also started to be seen in the Central Anatolia and Black Sea regions. This is a risk that may have negative consequences for food safety. In the report published by the Switzerland-based Internal Displacement Monitoring Centre (IDCM), it

was stated that 17.2 million people from 144 countries had to migrate due to natural disasters in 2018 alone. According to the "Climate Change, Migration and Displacement" report published by the United Nations Development Program (UNDP) and the Overseas Development Institute in 2017, climate change is the reason for the top 10 migration movements in 2016. According to the aforementioned report, it is predicted that very large population movements will occur in 2050 due to reasons such as sea level rise, drought and floods. Although the aforementioned studies show that the migration rate due to climate and disasters is lower in Turkey compared to countries such as the Philippines, China and India, it is estimated that 275,313 people have come to Turkey as climate migrants in the last 10 years. In a country like Turkey, located on international migration routes, there is a climate migrant risk not only within its own borders but also for transit passes, and it is thought that Ankara and all other provinces should attach importance to this risk.

6. ADAPTATION ASSESSMENTS AND ADAPTATION ACTIONS ON CLIMATE CHANGE

Being an issue beyond an environmental problem at the global level, climate change will continue to affect the world in the long term. Today, it is a scientifically proven fact that the planet will face an increase in temperatures and changes in precipitation patterns in the coming decades.[24]

As a result of increased terrestrial and marine temperatures and changes in precipitation amount and types due to climate change, risks of global average sea level rise and coastal erosion are also increasing and increased intensity in natural disasters linked to weather conditions are being witnessed. Changing water levels, temperatures and fl ows aff ect the integrity of the ecosystem as well as aff ecting food supply, agriculture, health, industry, tourism and transportation sectors. Today communities in certain regions of the world face with the negative impacts of climate change at a greater extent and more frequently.

Extreme climate events cause considerable economic and social impacts. Therefore, adaptation[25] policies come to the fore in planning studies related to land and sea areas, including disaster management, transportation, regional development, industry, tourism and energy sectors.

According to the Draft Climate Change Law; Adaptation policies cover the determination of current or potential risks and damages due to climate change and adaptation capacities; eliminating or minimizing risks and harms and increasing adaptation capacity; the determination, implementation and monitoring of strategies, targets and actions that aim to identify and evaluate the opportunities created or to be created by climate change. Generation and carrying out of climate change scenarios, risk maps and other determination tools; all kinds of practices aiming at minimizing the current or potential risks and damages caused by climate change, especially on society, ecosystems and biological diversity, and healing those who suffer; Increasing access to financial resources, technologies and techniques needed to carry out adaptation activities, and research and development projects regarding adaptation are included in the adaptation policy.[26]

It is aimed within the framework of adaptation ; ensuring the effective risk management, management of natural resources and food security; adapting the health, transportation,

[24] Turkey's Climate Change Adaptation Strategy and Action Plan 2011-2023, Ministry of Environment and Urbanization, Ankara-2012

[25] Adaptation: Adapting to the impacts of climate change. In the narrow sense, harmony with/adjustment to new and changing environments. In the broad sense, reducing the vulnerability level against climate change and variability that are real or envisaged to occur in natural and human systems; or adjustments that aim to benefi t from its opportunities.

[26] Climate Change Law, Ministry of Environment and Urbanization, Ankara-2021

communication, disaster and emergency response infrastructures to climate change; ensuring sustainability in regional and urban development and land use; protecting from the negative effects of climate change at national and local level, especially ecosystems, biodiversity, society, forest resources and soil; carrying out training, awareness and capacity building studies on adaptation.

Risks and threats such as sea level rise, heat waves, extreme weather events, floods, droughts, etc. that arise due to changing climatic conditions directly affect cities, and cities are often the source of climate change problems. Climate-related problems not only affect sectors such as agriculture, industry and economy, but also have a direct negative impact on human life. Accordingly, adverse effects are foreseen on many areas such as agricultural production, food security, living life and ecosystems. In the face of the risks, threats and negative effects of climate change, it is necessary to develop climate scenarios for the future of cities and to determine adaptation policies where necessary interventions are made and precautions are taken.

It is important to transfer the aforementioned policies from the national level to the local/urban level, and in this context to integrate climate change adaptation policies with urban land use policies and plans. Cities will face different risks and threats of climate change in the future, depending on their physical, morphological and socio-economic characteristics. In order to build cities that are resilient to the uncertainties and unexpected developments arising from climate change, it is necessary to both reduce / mitigate the risks, threats and effects of climate change (thus increasing the resilience of the system) and ensuring adaptation (increasing the rate of self-correction of the system). Based on this requirement, within the scope of this report, it is aimed to reveal the climate change adaptation strategy and action plan developed within the framework of the possible risks and vulnerability of the city to climate change scenarios in order to make Ankara adaptable and resilient to climate change on a local scale.

In the Ankara Province Climate Change Adaptation Measures Report, the areas of vulnerability to climate change determined within the scope of climate projections and risk analysis, supported by technical and scientific studies and accepted through participatory processes are as follows:

- Open-Green Space and Corridors
- Urban Heat Island Effects,
- Urban Streams,
- Water Management,
- Waste Management

- Land Use,
- Agriculture/Forestry, Food Security and Biodiversity,
- Transport and Infrastructure.

6.1 Ankara Climate Change Adaptation Strategy and Measures

6.1.1 Open-Green Spaces and Green Corridors

Open and green spaces can be defined as the breathing spaces of cities. Open spaces with soft or hard grounds have an impact on the formation of urban micro-climate and thermal comfort. Determining the urban climate and comfort level has an important place in creating walkable cities. Studies show that urban systems that cannot provide a comfortable walking experience in open spaces push the citizens to use motorized vehicles. For example, open areas covered with radiation-reflecting hard surface materials such as asphalt in hot and arid climates offer the citizens an uncomfortable use of space in terms of climate due to the dust and hot air flow they will create. Therefore, while designing the open spaces system, it is necessary to consider the balance of soft (green) and hard ground and open space, which can meet the needs created by the local climatic conditions.

The pattern of medium and small-scale green areas evenly distributed over the lower parts of the city can function as a breathing space that provides thermal comfort in hot and arid climate zones, or as sinks that absorb water in rainy and temperate zones. An open space system in which wide open spaces are articulated in cold climate zones is one of the preferred strategies to get maximum benefit from solar radiation. The point to be noted here is that the planned open spaces system should be designed with urban landscape elements such as afforestation, canopies and water elements that will facilitate the use of the city in different seasons.

Along with Ankara becoming the capital, it was expected to experience many spatial, social and economic changes. In this direction, the planning studies prepared for the city of Ankara from past to present are 1924 Lörcher Plan, 1932 Jansen Plan, 1957 Yücel-Uybadin Plan, 1990 Metropolitan Area Master Plan. Then, the period of 1990-2007 as the period of local plans where there is no upper scale plan, and after 2007 the 2023 Capital Ankara Master Plan and the 2038 Ankara Environmental Plan can be listed.

The development area of the city has been determined according to the 2023 and 2038 environmental plans, and a balanced distribution of land use has been tried to be achieved. However, there have been some negativities brought by the increasing population over the years. As shown in Table 6.1, the city of Ankara has experienced a rapid population growth over the years. With the increasing population, urban density has also increased. The population density, which was 1.26 ha in 1990, became 1.56 ha in 2000 with a 23.80% change. This rate increased by 70.63% in 2018.

Table 6.1 Distribution of Ankara population by years (TURKSTAT, 2019)[27]

Years	Male	Female	Total	Density (capita/ha)
1990	1.658.276	1.578.350	3.236.626	1.26
2000	2.027.105	1.980.775	4.007.860	1.56
2010	2.379.226	2.392.490	4.771.716	1.86
2015	2.621.235	2.649.340	5.270.575	2.06
2018	2.728.900	2.775.085	5.503.985	2.15

With the increase in the urban population, the inadequacy of the park areas, which are defined as carbon sinks, in terms of quantity and balanced distribution has emerged. With the increase in the urban population over the years, the increase in the amount of urban green space has been insufficient. In the 2038 environmental plan report, it has been determined that the increase in the amount of green areas is not sufficient in line with the current population of the districts and the projected population. The qualification status has determined according to the Building Code of Spatial Plans' green space amount, which should be at least 10 m^2 per person. There are districts that are foreseen cannot to have even the minimum amount of green space in the social and technical infrastructure standards of the regulation, and the insufficient amount of green space in the city is clearly seen. For this reason, the urban heat island effect arises from the occupancy-vacancy ratio, especially in the city center.

In order to determine the current Land Use-Land Cover characteristics, open-green area system and amounts of Ankara province and to develop suggestions, current situation maps have been developed by using the CORINE database system, which makes use of GIS (Geographical Information Systems) and IA (Remote Sensing) techniques (Figure 6.1 and Figure 6.2); also, thanks to the detailed query feature of the CORINE database system, the amount of urban open-green space specific to the central districts of Ankara province was determined (Table 6.3 and Table 6.2) and the amount of green space per capita was calculated. The limitation of this study is that the current data of the CORINE database belongs to 2018 and the information about small-scale (neighborhood) parks and recreation areas within the scope of public (active) open-green areas is not included in the databases. Although an analysis in this detail does not allow the marking of the smallest-scale parks, it can be stated that medium and large-scale open-green areas are included in the land use scheme.

[27] Turkish Statistical Institute (TURKSTAT), 2019. Address Based Population Registration System Results.

Open-Green Spaces (OGS) can be grouped into three groups, according to their use or ownership, as public (active), semi-private and private open-green spaces. These;

1. Public (Active) OGS: These are the green areas that are open to the use of everyone for public purposes and where activities for entertainment and recreation are carried out. City and neighborhood parks, urban forests and woodlands, cemeteries, botanical gardens, fair and exhibition areas, sports fields, zoos, entertainment and recreation areas, national parks, etc. are included in this group.

   Within the scope of the report, public (active) green areas are shown as "Green Urban Areas" in the maps (Figure 6.1 and Figure 6.2) regarding the current land use and open-green areas in Ankara, produced according to the CORINE Land Cover/Use Classification. Table 6.3 shows the distribution of these areas in terms of m^2 and the amount of green space per capita at the level of districts within the borders of Ankara metropolitan area.

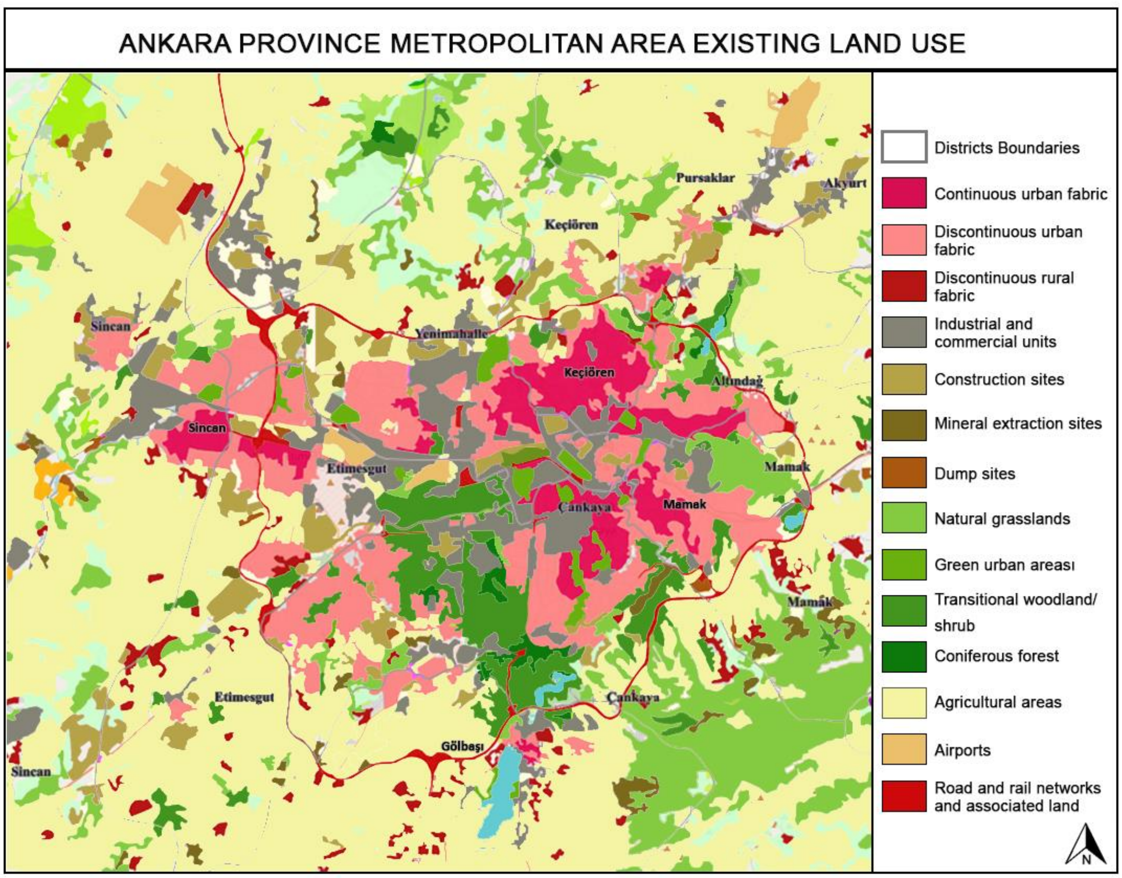


Figure 6.1 Ankara Province Metropolitan Area Existing Land Use

It is seen that the urban green spaces, which constitute the basic elements of the public open-green space system in Ankara, are scattered and disconnected from each other. When Atatürk Boulevard and its continuation Çankırı Avenue and İrfan Baştuğ Avenue are accepted as an axis; It is seen that the part to the west of this axis is much more advantageous in terms of green areas compared to the part to the east. In this part of the city, the parks and gardens of the Faculty of Agriculture and trial areas, Atatürk Cultural Center, Youth Park, AOÇ Park and Gardens and production and afforestation areas, Anıtkabir garden, Güven Park, TBMM Park and Gardens, Sovereignty Park, Military Academy residential area are located in this part of the city. These are the green areas that alleviate the density, provide balance and meet the green space needs of the surrounding people to a certain extent. Another important advantage of the western side of the city is that the large campuses and urban forests belonging to most public institutions (such as MTA, METU, Hacettepe) along the AOÇ and Eskişehir road are located in this section. However, there is no other striking green area to the east of this axis other than Abdi İpekçi Park, Kurtuluş Park, Aktepe Park and Altınpark.

Table 6.3 Amount of Existing Open-Green Areas Per Capita by Districts (2018)

District Name	District Population[28] (person)	Public (Active) Green Area Size (m^2)	Total Green Area Size (m^2)	Public Green Area Per Capita (m^2/capita)	Total Green Area Per Capita (m^2/capita)
Altındağ	370.024	**3.198.300**	9.880.800	**8,64**	26,7
Çankaya	920.890	**4.453.300**	61.016.000	**4,83**	71
Etimesgut	570.727	**1.597.000**	18.712.700	**2,8**	32
Gölbaşı	134.378	**999.200**	9.389.100	**7,4**	69,87
Keçiören	909.787	**781.900**	6.698.500	**0,85**	7,36
Mamak	647.252	**15.200**	17.719.700	**0,02**	27,37
Pursaklar	143.055	**618.400**	1.796.300	**4,32**	12,55
Sincan	518.893	**2.340.300**	25.839.000	**0,65**	49,79
Yenimahalle	663.580	**6.043.900**	8.376.300	**9,1**	12,62

[28] Türkiye İstatistik Kurumu (TÜİK), 2019. Adrese Dayalı Nüfus Kayıt Sistemi Sonuçları.

The quantity of green spaces in cities is as important as their quality. Citizens' access to green areas in a short time or distances is an important factor in increasing the quality of life. In addition to the scarcity of green areas, their accessibility also emerges as an important problem. As can be seen in the maps in Figure 6.1 and Figure 6.2, it can be said that the majority of the population has difficulties in accessing the parks.

2. Semi-private OGS: In general, they are areas which the urban people cannot fully benefit from and open to use only by the employees of institutions and organizations, their families, or a certain segment, under certain conditions or for a certain price. For example; School gardens, military areas, public institutions and organizations, factory areas, campuses, hippodrome, golf-tennis club areas, etc. are included in this group.

   Within the scope of the report, semi-private green areas are shown as “Transitional Woodlands/Shrubs” and “Coniferous Forests” in the maps (Figure 6.1 and Figure 6.2) regarding the current land use and open-green areas in Ankara, produced according to the CORINE Land Cover/Use Classification. Table 6.3 shows the distribution of these areas in terms of m^2 and the total amount of green space per capita at the level of districts within the borders of Ankara metropolitan area.

   Capital city functions and some of the public institution establishment areas, which are very important for the city of Ankara, use a large area and these areas often have a strategic feature in terms of the continuity of the urban open-green area system as important open spaces or landscaped green areas. For example, the Armored Units School Division Command, located near Etimesgut at the western end of the city's settled area, creates a very important buffer and open space at the western end of the city on the Etimesgut-Çayyolu axis. This military area, which is one of the basic elements of an open and green area system that continues with Atatürk Forest Farm and enters into the city, is provided with the land of the Mamak Combat School and Information Systems Command at the east end.

   The military areas, where the Etimesgut and Güvercinlik Airports are located in the western development corridor of the city, have an indisputable value in terms of the urban open space system, as the whole of the Farm land. It is possible to add to these the public institutions on the Istanbul road and the areas belonging to various public institutions located around the Eskişehir and Konya road, and even some of which are afforested. The area that offers the most important open-green area value among these is METU land. This large land, a significant part of which has become a forest and the other part is afforested or preserved as open space, stands out as an open space element that must be absolutely protected in the west and southwest corridor of the city.

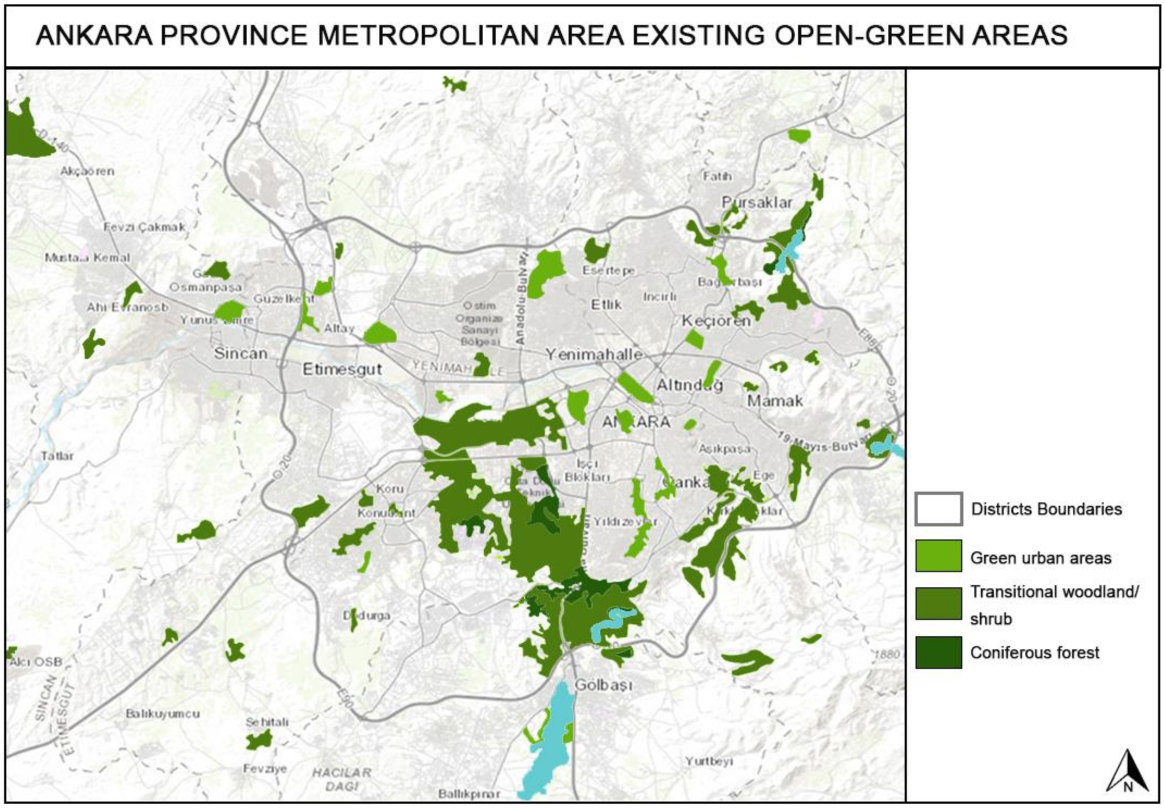


Figure 6.2 Ankara Province Metropolitan Area Existing Open-Green Areas

3. Private OGS: These are areas used only by their owners or residents such as privately owned single and multi-storey residences or mass housing areas, agricultural areas. For example, residential and collective housing gardens, terrace and roof gardens, hobby gardens, facility gardens, hotel and holiday villages gardens, urban agricultural gardens, etc. can be sorted in this category. Private open-green areas were not identified and analyzed within the scope of the study, due to both data constraints and the nature of non-public areas.

In this direction, the adaptation actions regarding Ankara's open-green spaces and green corridors have been determined as follows:

Action 1: Ensure proper identification of existing green spaces, and assess needs

By developing a "Green Area Information System (YABIS)" throughout the city;

- It is recommended that Ankara Metropolitan Municipality collects green area information from 25 district municipalities and obtains park density maps; In this way, to determine the park needs of the districts according to the population and age ratios by making district-based evaluations.
- This study can help to determine which districts need more parks and which districts have priority according to the average age.

Sub-Action 1.1: Ensuring proper identification of existing green spaces and correlate with the population

Sub-Action 1.2: Ensuring revision of applicable regulations with the insertion of new classifications and standards for green spaces to the Building Code of Spatial Plan

Sub-Action 1.3: Determining new requirements by comparing existing green areas with national and international standards on the basis of provinces and districts

Sub-Action 1.4: Preventing existing green areas from being opened to construction

Action 2: Provide accessibility for all citizens by increasing the amount of green space per capita in the city in a well-balanced

Sub-Action 2.1: Ensuring that new green areas through expropriation or new mechanisms to be produced

Sub-Action 2.2: Ensuring a fair and natural design pattern for green spaces

Sub-Action 2.3: The absolute protection and development of existing green areas and urban forests, the planning of measures to minimize the risk of deterioration due to fire and drought in these regions, and in this context, special attention should be paid to the METU Forest and AOÇ area

Sub-Action 2.4: In addition to the existing urban forests, the development of large-scale new urban forests, in this context, absolute protection of the AOÇ area and afforestation with planting works

Sub-Action 2.5: Development of large-scale new urban forests in the Sincan-Eryaman region and the northern and eastern parts of the city

Sub-Action 2.6: Planning of actions to increase the presence of open and green spaces in residential areas where the structural density is high and the amount of open space is limited (especially Mamak, Keçiören, Etimesgut and Sincan)

Sub-Action 2.7: Ensure the enhancement of accessibility by developing green rings in neighborhoods (combination of bicycle paths, pedestrian paths, and passive and active green spaces)

Sub-Action 2.8: Increasing the presence of trees throughout the city

Sub-Action 2.9: Inclusion of school gardens in green space management

Sub-Action 2.10: Increasing the amount of urban green space by including all abandoned public spaces (dolmus/bus stops, industrial sites, etc.) within the scope of green space throughout the city

Sub-Action 2.11: Reviewing the existing strategies and plans for the restoration projects, street rehabilitation projects and landscaping projects related to the cultural areas within the boundaries of the Municipality and the Adjacent Area, considering the climate adaptation and resilience issues, and in this context, preparing new plans that will increase the presence of active open and green spaces

Action 3: Enhancing climate resilience of urban green spaces

Sub-Action 3.1: Research and implementation of energy and water efficient practices in open green areas

Sub-Action 3.2: Providing irrigation of open green areas with treated wastewater and rain water and using smart irrigation methods

Sub-Action 3.3: Giving priority to plant and tree species suitable for Ankara climate and xeriscaping practices in the development of parks and recreation areas

Sub-Action 3.4: Planning of new green corridors in order to reduce the heat island effect and provide thermal comfort

Sub-Action 3.5: Increasing the permeable surfaces in parks and gardens or constructing surfaces according to " Permeable Concrete Technical Specification " to reduce the risk of flash floods

6.1.2 Urban Heat Island Effects

Land cover change, combined with the increase in greenhouse gas emissions, has led to an acceleration of climate change and an increase in change in certain places. Along with this change, cities have become different from their surroundings, have begun to be characterized by different temperature, precipitation, humidity and wind conditions, and urban heat islands have been formed.

Air pollution is increasing due to the dense population living in cities and industrial activity; Pollutants that cause air pollution increase albedo during the day, reduce cooling at night and turn cities into energy storage. Urban heat islands increase this its negative effect due to the expansion of the urban sprawl area, the increase in population and construction, and human-induced activities.

Different meteorological conditions prevail in different land use areas in cities, which creates different environments within the city. Temperatures vary according to the morphological structure and functions in different parts of the city, and do not show a homogeneous distribution within urban areas. Parks, pools, newly built areas, areas with low-rise buildings show low temperature characteristics compared to the city in general. High temperatures are measured in areas of economic activity with heavy traffic in the city center, high-rise building areas, and areas where the ground cover is completely covered with artificial material.

When the climatic and topographic data of Ankara city center are evaluated, it is seen that the city center is gathered in an area remaining in a pit and forms a settlement network towards its surroundings. Ankara's this bowl-shaped model originating from the land structure, has taken the city away from the compact form over the years and transformed it into a form where dense construction is seen together. For all these reasons, a barrier has formed around the city and has revealed the heat island effect that prevents air flow.

When the surface temperature map of the city (Figure 6.3), produced within the scope of Ankara Province Impact, Vulnerability and Risk Analysis, is examined, it is seen that the coolest regions are urban forests and large open green areas, while the hottest regions are dense urban areas, hard and impermeable surfaces and large production areas. On the maps, it is seen that areas such as large public institution areas and universities such as AOÇ, Cebeci State Cemetery, Karşıyaka Cemetery, Anıtkabir garden, university campuses and METU forests are the coolest areas. In addition, it is seen that military zones and large urban parks are open and green areas that contribute to the reduction of heat stress caused by dense construction areas and industrial zones. The change in air temperature up to 5-7^{o}C in areas with intense urbanization compared to rural areas is explained by the urban heat island effect.

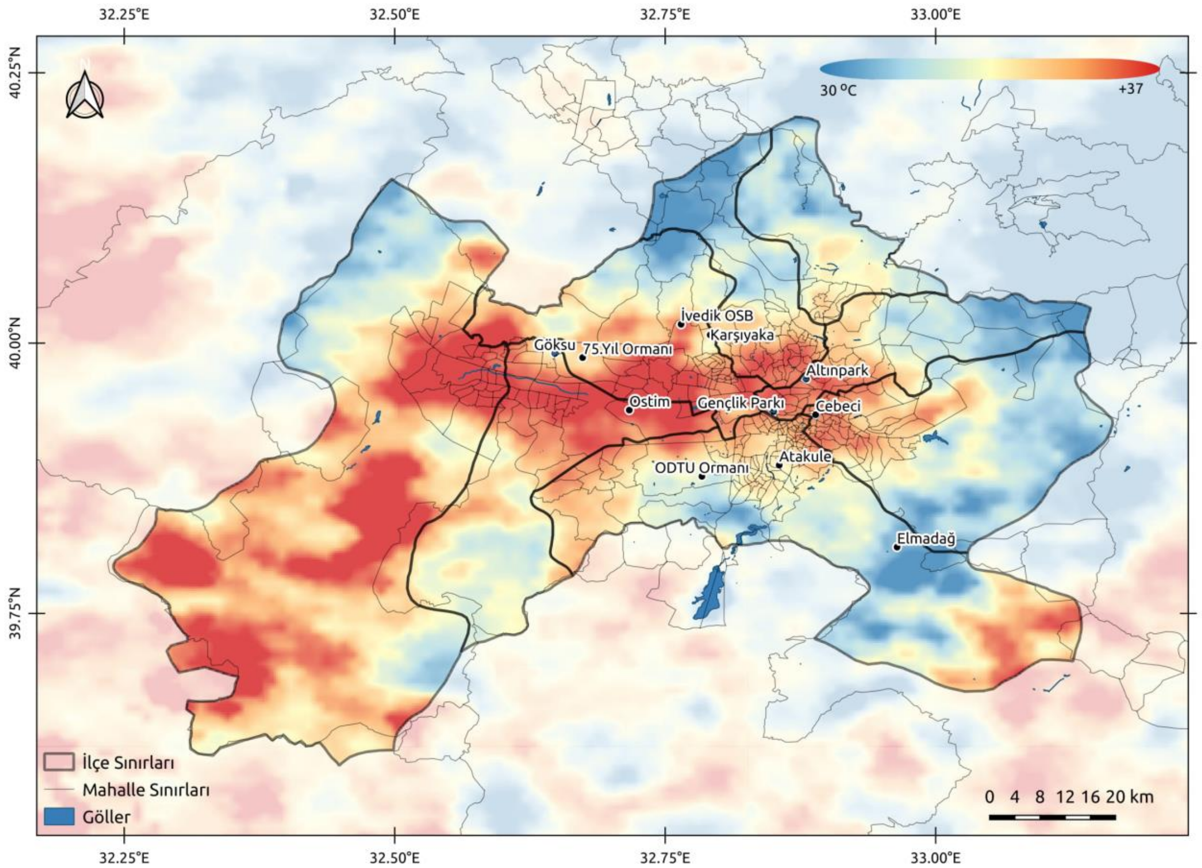


Figure 6.3 Average surface temperatures observed in Ankara Province in June 2019

A significant increase has been observed in the negative effects of heat waves worldwide after 2000. After the death of about 70,000 people on the European continent in 2003 from heat wave events that caused sudden increases in air temperature, The "Urban Heat Island Reduction Strategies" catalogs have been prepared for many cities in Europe and America in order to make cities and governments resistant to these events and to reduce the effects against the urban heat island effect and heat waves.

Current trends and scenarios regarding climate change indicate that temperatures in Ankara will increase further in the future. The fact that Ankara will be a warmer city shows that heat waves and the urban heat island effect will also be an important climatic hazard and risk factor for Ankara. For this purpose, the "Urban Heat Island Adaptation Actions" for Ankara are stated below:

Action 1: Identification of risk zones and determination of public health impacts in these zones

In order to identify the sub-regions of the city that can be considered as risky and to interpret the current situation, some additional surveys and field studies are needed. It is recommended that Ankara Metropolitan Municipality make more comprehensive results and evaluations through field studies in the regions that are considered risky in terms of heat waves and heat island effect in the future.

Sub-Action 1.1: Conducting scientific measurement studies related to the positioning of the heat island effect, revealing the sensitive areas

Sub-Action 1.2: Determination of short to long-term effects of public health with the benefit of national and international scientific findings, to carry out modelling studies

Sub-Action 1.3: Developing a Heat Wave Action Plan to reduce health problems caused by the urban heat island effect

Action 2: Increase the open-green spaces to mitigate the impact of heat island

Another area of focus in producing a climate change adaptation strategy for reducing and preventing the urban heat island effect is green systems and planting studies. The most important tools developed and widely used to reduce the urban heat island effect are planting and green systems. For this reason, while planning a green system on a macro scale, the areas where the urban heat island effect is intensely determined should be taken into account, with the awareness that green areas are natural coolers. On the micro-scale, it should be attempted to reduce the heat island effect by using plan decisions, urban transformation and green roof applications.

Within the scope of increasing the green area to reduce the heat island effect, the following additional actions have been determined in addition to the actions aimed at protecting the existing green areas associated with open-green areas and corridors, increasing the number of green areas and creating green corridors:

Sub-Action 2.1: Attach importance to the preservation of existing old and large trees during forestation carried out across the province (these trees let the ground remain cool since they are broad-leaved and have a large shading area)

Sub-Action 2.2: Building medium and large-scale urban parks in areas with high density in the city (especially Keçiören, Etlik, Yenimahalle, Etimesgut and Sincan) and giving priority to the natural landscape with appropriate plant and tree species in the design of these parks

Sub-Action 2.3: Achieving a reduction in solar power absorption rate and in ground temperature, using light-coloured building materials in hard floor coverings

Sub-Action 2.4: Creating a large and green cool area in the city center with pedestrianization practices in the Kızılay-Ulus-Tandoğan triangle

Sub-Action 2.5: Performing green roof and vertical garden applications in residential areas where there are not many tall buildings and where construction and traffic are intense (especially in Kızılay, Ulus, Cebeci, Aydınlıkevler, Bahçelievler)

Sub-Action 2.6: Implementing the health protection band in OIZs and encouraging green roof applications on OIZ roofs

Sub-Action 2.7: Creating continuous air corridors in the north-south direction of the city and making use of the existing valleys for this purpose

Sub-Action 2.8: Uncovering the suitable ones among the covered streams passing through the city, planning the close surroundings of these streams as open green areas and creating ecological and natural coolness corridors in this way

Action 3: Increase the number of wetlands

Sub-Action 3.1: Preferring building materials with high permeability in order to ensure the absorption of rain water by the soil on the streets

Sub-Action 3.2: Identification and implementation of Blue-Green Infrastructure techniques

Sub-Action 3.3: Development of urban-artificial wetlands

Action 4: Reduction of Heat Island Effect at Planning Level

Urban policies, land-use decisions and activities are intervention areas that are effective in shaping the urban climate. For this reason, it is important to consider and implement the adaptation measures for the urban heat island in the renewal or reproduction of the city's environmental plans and zoning plans.

Sub-Action 4.1: Taking into account the heat island effect, especially in dimensions such as building and population density, blue-green equipment and infrastructures, in upper scale plans along with the Development and Environmental plans

Sub-Action 4.2: Preparation or update of Environmental Plans and Master Plans in a way to include ecological analysis and long term climate change scenarios

Sub-Action 4.3: Adopting an approach that considers the Urban Heat Island Effect, especially in urban transformation projects

6.1.3 Urban Streams

Ankara is an important centre of attraction due to intense urbanization, increasing commercial activities, and various cultural and sports activities. This situation creates various pressures on the infrastructure of the city. The decrease in green areas in the city centre and the increase in concrete have a significant negative effect on the absorption of water in precipitation. The measures taken against increasing run-off are not always adequate. Improper or inadequate practices cannot prevent floods, and precipitation cannot feed groundwater reservoirs. It would not be wrong to predict that a considerable reason for possible droughts in the future may be due to decreases in groundwater levels.

Considering the examples of green cities on a world scale, they are designed as large green areas open to public use, where water areas such as rivers and streams passing through the city are integrated with green areas (e.g. Madrid Rio, Hamburg Elbe River, Vitoria Gasteiz, Heidelberg River). In Ankara, it is observed that the relationship between the rehabilitated and closed streams and greenery is not well established, and residential housing is developed in their immediate surroundings.

In addition, impermeable surfaces used in improvement projects pose a problem. It is considered necessary to make interventions regarding these practices, which both increase the flood and flood risk and are not suitable for climate adaptation strategies. It is necessary to prevent such constructions with the development plans and the strategies to be developed.

Action 1: **Carrying out studies on covered streams of Ankara**

Sub-Action 1.1: Renewal of rehabilitation works, uncovering the streams that are determined to be at high risk and taking risk reduction measures along the stream bed

Sub-Action 1.2: The permeability of the bed material of the rehabilitated streams and the integration of the water channels with the green

Sub-Action 1.3: Uncovering the suitable ones among the covered streams passing through the city and planning the close surroundings of these streams as open green areas

6.1.4 Water Management

Water and wastewater services have been identified as a fragile sector that will be affected by climate change, and current and future impacts are expected to be felt strongly due to population density, intense urbanization (an increase of impermeable surfaces), and water-intensive industrial and agricultural production.

caused by climate change in Ankara; effects such as an increase in summer temperatures, decrease in winter precipitation, loss of surface waters, more frequent droughts, soil degradation, erosion and floods; It threatens the existence of water resources necessary for food production and rural development.

By reason of the adverse effects of climate change, the flash city floods/overflows that occur as a result of excessive precipitation in Ankara province, decrease in snowfall and decrease in water resources due to drought, the amount and quality of underground and surface waters and the impact of ecosystems dependent on them are foreseen as the main danger. In this section, adaptation measures regarding the risks that critical infrastructures in water and wastewater services will encounter are discussed.

Action 1: Recovery and reuse of wastewater

There are currently several projects in Ankara on the use of wastewater in landscaping with a package treatment. In the first of these, the Karaköy Wastewater Treatment Plant, 43,000 m3 of wastewater is treated daily. 5,000 m3/day of this amount will be subjected to advanced treatment processes and will be used for irrigation of Çubuk 1 and Kuzey Ankara Recreation areas. Although the project is currently in the tender process, it is planned to be operational in 2022.

On the other hand, in the Gölbaşı region, there are studies to gain irrigation water for recreation areas as a result of package treatment of sewage water. As a result of treating 200 m3 of sewage water per day, 3 different park/garden areas within the boundaries of Gölbaşı district will be irrigated. The project is currently in the planning phase.

In addition to these projects, the recommendations prepared within the scope of adaptation are presented below:

Sub-Action 1.1: Recovery and use of wastewater in large recreation areas and valleys

- The average daily water requirement for irrigation of Dikmen Valley Recreation Area is 3.000 m3. Irrigation of this recreation area can be carried out with irrigation water to be obtained as a result of package treatment of sewage water, as in the example of Gölbaşı.
- Ankara Metropolitan Municipality is planning to build a large recreation area similar to Dikmen Valley in the Batıkent region. Since the recreation area is not yet available, the daily water requirement is not estimated, but it is thought that there will be a need close to the irrigation water requirement of the Dikmen Valley recreation area. It can be done with irrigation water to be obtained as a result of package treatment of sewage water, as in the example of Gölbaşı.

Sub-Action 1.2: Irrigation of green areas in the central median and roadsides with purified water

Sub-Action 1.3: Irrigation of all recreational areas that do not have a wastewater treatment plant in or near the adjacent areas of Ankara with the water obtained as a result of treatment from sewage water with package treatment

Action 2: Utilization of waste water treatment plant effluents

The recovery and reuse of the water treated in the Wastewater Treatment Plants, especially in the agriculture and industry sectors, makes a significant contribution to the adaptation measures regarding water management. Agricultural lands are irrigated by reusing the used water from Ankara Tatlar Wastewater Treatment Plant and Beypazarı Wastewater Treatment Plant, which is the largest Wastewater Treatment Plant in our country.

Sub-Action 2.1: Utilizing the effluent of wastewater treatment plants in agricultural irrigation and feeding groundwater resources

Action 3: Taking precautions for regions under risk of flood and owerflow

Ankara Metropolitan Municipality currently has rainwater drainage grids, underground storage of rainwater, flood traps, etc. drainage applications and similar projects planned for some problematic areas of Ankara (Çayyolu, İncek etc.) against flood and overflow risks.

Districts such as Çankaya, Mamak, Etimesgut, Sincan and Keçiören, which are the most central and dense settlement areas of the settled area of the city of Ankara, are the places where floods and overflow events have been observed intensely in the recent period. It is highly probable that all central parts of the city's built-up area will be subject to flooding and overflows. For this reason, up-to-date hazard and risk analysis in all these risk areas, determination of risk focals in line with the analyzes and planning of necessary measures and risk mitigation actions should be done urgently.

Sub-Action 3.1: Identification of risky areas

Sub-Action 3.2: Preventing illegal housing in stream/river beds

Sub-Action 3.3: Ensuring the implementation of urban drainage solutions

Sub-Action 3.4: Developing alternative routes for rainwater collection lines to reduce the stormwater load on streams

Sub-Action 3.5: Preferring permeable materials on firm grounds (walkways, highways, etc.)

Sub-Action 3.6: Producing long-term solutions by considering the city's growth projections

Action 4: **Perform an effective rainwater management**

Sub-Action 4.1: Research and development of methods for rainwater harvesting and its use in urban water management

Sub-Action 4.2: Promote rainwater retention through green roof applications

Sub-Action 4.3: Using underground reservoirs (either permeable or impermeable) for effective rainwater management

Sub-Action 4.4: Developing rainwater retention ponds, and use accumulated water for street sweeping and plant irrigation purposes

Sub-Action 4.5: Conducting work on the use of rainwater in the building complexes (eg the requirement of using rainwater for green area irrigation)

Sub-Action 4.6: Instead of raising the sidewalk for the trees and similar greenery on the pavements, to drop the elevation in order to both use area as green area and to ensure that the rainwater flows to the ground

Sub-Action 4.7: Building of rainwater storage systems in connection with green spaces in municipal or municipally operated buildings and infrastructure, at the building level and underground

Action 5: Reuse of greywater

Sub-Action 5.1: To ensure that greywater is reused in municipal buildings, public buildings, commercial offices and residences after physical, chemical or biological treatment processes in order to reach the desired standards depending on its characteristics

6.1.5 Waste Management

According to Law No 5216 Law of Metropolitan Municipalities, it is within the District and first-tier municipalities responsibility to collect solid waste at the origin and transport it to transfer stations and it is within the Ankara Metropolitan Municipality's responsibility to store and dispose of solid waste. Changes made and to be made in the legislation within the context of EU harmonization require separate accumulation and duplication in the source in order to disseminate and streamline the recovery and reduce the entry of organic matter into landfills. In this case, the importance of collecting is increasing evermore.

Measures related to solid waste management are presented below:

Action 1: Adoption of sustainable waste management plans and development of recycling mechanisms

Sub-Action 1.1: Partner and/or cooperate with relevant institutions and organisations that can act jointly in line with Zero Waste Regulation to develop and invest in the necessary recycling infrastructures (bins, trucks, routes etc)

Sub-Action 1.2: Making organic fertilizer from the organic wastes of fruit and vegetable wholesale market hall and neighbourhood markets by composting method

- Investigation of the possibility of providing these organic fresh vegetable and fruit wastes to cattle breeders as feed service/support

Sub-Action 1.3: Developing and disseminating organic fertilizer production techniques in order to support rural development and increase the carbon and water holding capacity of the soil

- Increasing the projects such as transforming the grass collected from parks and green areas into "organic fertilizer" by composting, production of "liquid fertilizer" etc. and developing R&D opportunities in order to ensure sustainability

Sub-Action 1.4: Investigate potential to provide dedicated waste collection for restaurant / food industry traders in-line with management infrastructure and technology

Sub-Action 1.5: Establish a municipality-wide awareness campaign (schools, public education center etc) for waste reduction and separation at household level

Sub-Action 1.6: Make separate collection of key dry recyclable materials mandatory, formulating policy at the district municipality level

Sub-Action 1.7: Municipality to commit to banning the use of single-use plastics within their buildings, encouraging local businesses to do the same

6.1.6 Land Use

As a sector that both drives and is heavily impacted by climate change, it is important to develop and implement strategies and mitigation measures that consider the inter-connected nature of land-use patterns. These incorporate factors such as; inappropriate land use, urbanisation, industrialisation, tourism, agricultural activities, biodiversity, water resources, soil quality and other technical and socio-economic aspects. A balance is required when developing efforts to adapt land-use change noting that what may be beneficial in one aspect, has the ability to be detrimental for another.

The recommendations determined in this context are as follows:

Action 1: Identifying stakeholders and collaborate with them to make the necessary arrangements in the regulations in order to design and development of the risky areas determined within the scope of the Law on Transformation of Areas Under Disaster Risk No. 6306

This would include reducing the vulnerability of those who reside in these areas to climate events, increasing energy efficiency and reducing associated GHG emissions, as well as improving the quality of life and health and wellbeing of the residents.

Action 2: Encourage urban transformation, acting on the Urban Transformation and development areas declared by the Council of Minister's decision for the creation of healthy, liveable urban spaces

By encouraging and facilitating urban transformation, many benefits can be obtained, such as local job creation through development, increasing the living standards and health and wellbeing of the residents within the identified areas, reducing urban pollution and reducing current and preventing future building related emissions.

Action 3: Review and update local-level policies, planning regulations and guidelines for future and new infrastructure development to ensure they consider climate projections and urban resilience in design and construction

Developing resilient infrastructure make it's sustainable, with increased resource use efficiency and greater adoption of clean and environmental sound technologies and industrial processes. It will help support long-term economic development and also human well-being, alongside reducing the long-term impacts, such as disruption and maintenance / repair costs as a result of a climatic event.

Action 4: Further development the green and blue infrastructure strategy

Alongside other environmental benefits, interconnected, green spaces will help mitigate against the urban heat island effect and enhance the stormwater management capacity of the city, providing natural storage and interception for the rainwater, reducing lag time for flooding event and enhance carbon sequestration.

6.1.7 Agriculture/Forestry, Food Security and Biodiversity

Agriculture and livestock activities, which are important livelihoods of the people living in Ankara, are directly dependent on the health of the ecosystems, that is, the maintenance of their functions. Short and long-term adverse effects on ecosystems will not be limited to wetlands or forests, but will affect agricultural products, food and water supply, industrial production, human and environmental health sectors.

It is known that the effects of climate change on agricultural areas and livestock sector especially affect economically vulnerable groups in rural areas. Crops affected by extreme heat, decline in irrigation water quality, expected increase in water prices with drought and excessive dependence on irrigation will be the main challenges. The recommendations developed in this direction are as follows:

Action 1: Enhancing climate resilience of agricultural practices

Sub-Action 1.1: Determining the negative effects of climate change on plant and animal breeding, raising the awareness of the producers about the measures

Sub-Action 1.2: Establishment of an R&D center where agricultural practices resilient to Ankara climate will be developed

Sub-Action 1.3: Mainstreaming water efficiency systems in agricultural areas, making windbreaks, irrigation ponds and canals on the edges of the fields

Sub-Action 1.4: Providing training to municipal teams and agricultural cooperatives on combating invasive species that were not seen before in Ankara and taking necessary precautions

Sub-Action 1.5: Rehabilitation of wholesale market halls and improvement of logistics activities in order to increase food safety

Sub-Action 1.6: Taking necessary precautions for invasive species and other pests like sunn pest with early warning system studies in agriculture and conducting biotechnical-based researches and training seminars on combating these species

Sub-Action 1.7: Conscious use of fertilizers in agriculture

- It is important to apply both the amount of fertilizer applied to the land and the split application in studies to optimize the use of commercial fertilizers and to optimize the use of chemical fertilizers. The Split Fertilizer Application can be expressed as the application of the total amount of fertilizer to be used not at once, but in parts and on different dates. Particularly, with the split application of nitrogen fertilizer, the plant will benefit from the fertilizer at the highest level possible (the fertilizer is not lost due to rapid infiltration with precipitation and irrigation and it does not cause groundwater pollution) and the greenhouse gas emissions from the use of nitrogen fertilizers will be reduced. In addition, the polymer or biochar coating of the chemical fertilizer will contribute to the long-term confinement of the fertilizer in the soil and to obtain positive results in terms of both plant growth and greenhouse gas emissions.

Sub-Action 1.8: With the use of biochar in agriculture, regulation of soil pH value, balancing of salinity and prevention of water pollution due to the filtration feature of biochar

Biochar is a material that can contribute directly to very effective results in terms of stable carbon sequestration in the soil. For example, the application of compost to the soil also contributes to the carbon sequestration in the soil, but since compost degrades quickly in the soil compared to biochar, the carbon sequestration is not stable but short-term. In this respect, the use of biochar stands out as a more advantageous application. Another point that can be expressed about biochar is that it is not a type of fertilizer and therefore it is not a material to be used instead of fertilizer. However, biochar can ensure that the fertilizer applied to the soil is fixed in the soil for a longer time, and therefore the plant can access the materials in the fertilizer content for a longer time. At this point, in order to reduce nitrogen compound emissions caused by the use of nitrogenous fertilizers, both the split application of fertilizer and the use of biochar on the same land are considered as an important application to reduce greenhouse gas emissions originating from agricultural activities.

Sub-Action 1.9: With mulch laying on the land within the framework of agricultural studies based on natural precipitation:

- Increasing the positive contribution to keeping the water close to the roots and stems of the plant for a longer time and thus to the plant growth.
- Long-term retention of soil moisture without water infiltrating and evaporating quickly in the soil

Action 2: Biodiversity inventory studies specific to Ankara, and planning of actions for biodiversity enhancement

Sub-Action 2.1: Ensure development of biodiversity inventory

Sub-Action 2.2: Ensure performance of tree planting and vegetation that requires less water in green spaces as a measure against the risk of reduced precipitation expected in Ankara

Sub-Action 2.3: Enhance biodiversity by building orchards

Sub-Action 2.4: Enhance biodiversity through water gardens (growing aquatic plants in these zones

Sub-Action 2.5: Ensure preparation of a vegetation plan in case of exceptions regarding climate adaptation (e.g. which plants should be grown when the temperature increases by 2 ˚C with the impact of climate change)

Sub-Action 2.6: Dissemination of technical practices and awareness-raising activities that will increase pollination by supporting the bee population (For example, distributing flower seeds in types that attract the attention of bees to the students in schools to grow them in the garden/balcony of their own homes)

6.1.8 Transportation and Infrastructure

The morphological structure consists of many factors such as open and built areas of the city, topography, ground structure, climate and vegetation. It is seen that the city of Ankara is topographically surrounded by elevations from the north, east and south directions and has a bowl-shaped form.

Over the years, the city has spread over agricultural lands and water protection basins and is fringed in terms of macro form. With this spread over the years, accessibility has decreased and the number of private vehicles has increased due to the distances to be travelled and the inadequacy of public transportation systems. Therefore, carbon emissions from transportation and the heat island effect have increased.

In addition to mitigation actions for the transport sector, within the context of adaptation the following additional actions are proposed to increase accessibility, reduce the heat island effect and contribute to public health:

Action 1: Improve transportation operations

Sub-Action 1.1: Ensure development of urban green roads and tour rotes

Sub-Action 1.2: Provide primary integration of green spaces with rail systems for the achievement of accessibility to green spaces

Sub-Action 1.3: Increase the number of bicycle paths and stimulate the public to use bicycle

Sub-Action 1.4: Provide connected access roads between districts to ensure the continuation of existing bicycle paths

Sub-Action 1.5: Put the light rail mass transit system into service, and ensure the installation of this rail system over the natural green system

Sub-Action 1.6: Planting horizontal and vertical transportation axes

Sub-Action 1.7: Narrow the motorways in zones available for encouragement of walk and mass transportation and plant other remaining zones

Action 2: Developing urban and spatial planning and design strategies and policies that contribute to local transportation options and accessibility

Sub-Action 2.1: Revision of themes such as 'climate friendly', 'energy efficient urban design', 'compact city' etc. in the existing environmental layout and zoning plans, and ensuring their integration into new planning and design policies and projects of the municipality

Another significant factor that increases the risk of flooding and overflow in the existing settled areas of the city is the lack of infrastructure. Since many regions of Ankara do not develop in line with the existing Environmental and Development Plans, today, the biggest result of lack of planning appears as infrastructural inadequacies. In many parts of the city, the capacity of infrastructure systems is not adequate for the population they serve. Urban infrastructure, which is likely to cause problems even during normal precipitation periods, should not be expected to handle the extreme precipitation and weather events that climate change will bring. This situation requires infrastructure improvement and development work in the central districts of Ankara.

Another infrastructure element that should be considered within the scope of infrastructure improvement works is underpasses. In the last few decades in Ankara, many underpasses have been built to cope with the traffic problem. These underpasses become a serious risk factor in flood and overflow events. Flood waters that gain fluidity on the surface fill the underpasses and increase the risk of loss of life and property here. Among the existing underpasses in the city, those with high risk should be identified and appropriate solutions should be developed.

Action 3: Conducting improvement and development studies regarding infrastructural inadequacies

Sub-Action 3.1: Separating rainwater drainage system from the sewage network

Sub-Action 3.2: Improvement of system capacities considering the effects of population growth and climate change

Sub-Action 3.3: Planning additional infrastructure investments, such as underground flood discharge channels and retention reservoirs in high-risk areas

Sub-Action 3.4: Reducing the risk of flash flooding by increasing the use of permeable covering materials that will absorb stormwater in large urban areas

Sub-Action 3.5: Identifying high-risk underpasses and developing suitable transportation solutions

Sub-Action 3.6: Conversion of underpasses, which do not contribute significantly to the solution of the traffic problem, to level crossing after providing the right solutions to the traffic problem

Sub-Action 3.7: Where it is not possible or appropriate to conversion the underpasses into level crossings, supporting the underpasses with infrastructure applications that will allow rapid water discharge

6.2 Ankara Climate Change Adaptation Strategy and Action Plan Table

ACTION		SUB-ACTION	
OPEN-GREEN SPACES AND GREEN CORRIDORS			
1	**Ensure proper identification of existing green spaces, and assess needs**	1.1	Ensuring proper identification of existing green spaces and correlate with the population
		1.2	Ensuring revision of applicable regulations with the insertion of new classifications and standards for green spaces to the Building Code of Spatial Plan
		1.3	Determining new requirements by comparing existing green areas with national and international standards on the basis of provinces and districts
		1.4	Preventing existing green areas from being opened to construction
2	**Provide accessibility for all citizens by increasing the amount of green space per capita in the city in a well-balanced**	2.1	Ensuring that new green areas through expropriation or new mechanisms to be produced
		2.2	Ensuring a fair and natural design pattern for green spaces
		2.3	The absolute protection and development of existing green areas and urban forests, the planning of measures to minimize the risk of deterioration due to fire and drought in these regions, and in this context, special attention should be paid to the METU Forest and AOÇ area
		2.4	In addition to the existing urban forests, the development of large-scale new urban forests, in this context, absolute protection of the AOÇ area and afforestation with planting works
		2.5	Development of large-scale new urban forests in the Sincan-Eryaman region and the northern and eastern parts of the city

		2.6	Planning of actions to increase the presence of open and green spaces in residential areas where the structural density is high and the amount of open space is limited (especially Mamak, Keçiören, Etimesgut and Sincan)
		2.7	Ensure the enhancement of accessibility by developing green rings in neighborhoods (combination of bicycle paths, pedestrian paths, and passive and active green spaces)
		2.8	Increasing the presence of trees throughout the city
		2.9	Inclusion of school gardens in green space management
		2.10	Increasing the amount of urban green space by including all abandoned public spaces (dolmus/bus stops, industrial sites, etc.) within the scope of green space throughout the city
		2.11	Reviewing the existing strategies and plans for the restoration projects, Street rehabilitation projects and landscaping projects related to the cultural areas within the boundaries of the Municipality and the Adjacent Area, considering the climate adaptation and resilience issues, and in this context, preparing new plans that will increase the presence of active open and green spaces
3	**Enhancing climate resilience of urban green spaces**	3.1	Research and implementation of energy and water efficient practices in open green areas
		3.2	Providing irrigation of open green areas with treated wastewater and rain water and using smart irrigation methods
		3.3	Giving priority to plant and tree species suitable for Ankara climate and xeriscaping practices in the development of parks and recreation areas
		3.4	Planning of new green corridors in order to reduce the heat island effect and provide thermal comfort

		3.5	Increasing the permeable surfaces in parks and gardens or constructing surfaces according to "Permeable Concrete Technical Specification " to reduce the risk of flash floods
ACTION		**SUB-ACTION**	
URBAN HEAT ISLAND EFFECTS			
1	**Identification of risk zones and determination of public health impacts in these zones**	1.1	Conducting scientific measurement studies related to the positioning of the heat island effect, revealing the sensitive areas
		1.2	Determination of short to long-term effects of public health with the benefit of national and international scientific findings, to carry out modelling studies
		1.3	Developing a Heat Wave Action Plan to reduce health problems caused by the urban heat island effect
2	**Increase the open-green spaces to mitigate the impact of heat island**	2.1	Attach importance to the preservation of existing old and large trees during forestation carried out across the province
		2.2	Building medium and large-scale urban parks in areas with high density in the city (especially Keçiören, Etlik, Yenimahalle, Etimesgut and Sincan) and giving priority to the natural landscape with appropriate plant and tree species in the design of these parks
		2.3	Achieving a reduction in solar power absorption rate and in ground temperature, using light-coloured building materials in hard floor coverings
		2.4	Creating a large and green cool area in the city center with pedestrianization practices in the Kızılay-Ulus-Tandoğan triangle
		2.5	Performing green roof and vertical garden applications in residential areas where there are not many tall buildings and where construction and

			traffic are intense (especially in Kızılay, Ulus, Cebeci, Aydınlıkevler, Bahçelievler)
		2.6	Implementing the health protection band in OIZs and encouraging green roof applications on OIZ roofs
		2.7	Creating continuous air corridors in the north-south direction of the city and making use of the existing valleys for this purpose
		2.8	Uncovering the suitable ones among the covered streams passing through the city, planning the close surroundings of these streams as open green areas and creating ecological and natural coolness corridors in this way
3	**Increase the number of wetlands**	3.1	Preferring building materials with high permeability in order to ensure the absorption of rain water by the soil on the streets
		3.2	Identification and implementation of Blue-Green Infrastructure techniques
		3.3	Development of urban-artificial wetlands
4	**Reduction of Heat Island Effect at Planning Level**	4.1	Taking into account the heat island effect, especially in dimensions such as building and population density, blue-green equipment and infrastructures, in upper scale plans along with the Development and Environmental plans
		4.2	Preparation or update of Environmental Plans and Master Plans in a way to include ecological analysis and long term climate change scenarios
		4.3	Adopting an approach that considers the Urban Heat Island Effect, especially in urban transformation projects

	ACTION		SUB-ACTION
URBAN STREAMS			
1	**Carrying out studies on covered streams of Ankara**	1.1	Renewal of rehabilitation works, uncovering the streams that are determined to be at high risk and taking risk reduction measures along the stream bed
		1.2	The permeability of the bed material of the rehabilitated streams and the integration of the water channels with the green
		1.3	Uncovering the suitable ones among the covered streams passing through the city and planning the close surroundings of these streams as open green areas

	ACTION		SUB-ACTION
WATER MANAGEMENT			
1	**Recovery and reuse of wastewater**	1.1	Recovery and use of wastewater in large recreation areas and valleys
		1.2	Irrigation of green areas in the central median and roadsides with purified water
		1.3	Irrigation of all recreational areas that do not have a wastewater treatment plant in or near the adjacent areas of Ankara with the water obtained as a result of treatment from sewage water with package treatment
2	**Utilization of waste water treatment plant effluents**	2.1	Utilizing the effluent of wastewater treatment plants in agricultural irrigation and feeding groundwater resources

3	**Taking precautions for regions under risk of flood and owerflow**	3.1	Identification of risky areas
		3.2	Preventing illegal housing in stream/river beds
		3.3	Ensuring the implementation of urban drainage solutions
		3.4	Developing alternative routes for rainwater collection lines to reduce the stormwater load on streams
		3.5	Preferring permeable materials on firm grounds (walkways, highways, etc.)
		3.6	Producing long-term solutions by considering the city's growth projections
4	**Perform an effective rainwater management**	4.1	Research and development of methods for rainwater harvesting and its use in urban water management
		4.2	Promote rainwater retention through green roof applications
		4.3	Using underground reservoirs (either permeable or impermeable) for effective rainwater management
		4.4	Developing rainwater retention ponds, and use accumulated water for Street sweeping and plant irrigation purposes
		4.5	Conducting work on the use of rainwater in the building complexes (eg the requirement of using rainwater for green area irrigation)
		4.6	Instead of raising the sidewalk for the trees and similar greenery on the pavements, to drop the elevation in order to both use area as green area and to ensure that the rainwater flows to the ground
		4.7	Building of rainwater storage systems in connection

			with green spaces in municipal or municipally operated buildings and infrastructure, at the building level and underground
5	**Reuse of greywater**	5.1	To ensure that greywater is reused in municipal buildings, public buildings, commercial offices and residences after physical, chemical or biological treatment processes in order to reach the desired standards depending on its characteristics
ACTION		**SUB-ACTION**	
WASTE MANAGEMENT			
1	**Adoption of sustainable waste management plans and development of recycling mechanisms**	1.1	Partner and/or cooperate with relevant institutions and organisations that can act jointly in line with Zero Waste Regulation to develop and invest in the necessary recycling infrastructures (bins, trucks, routes etc)
		1.2	Making organic fertilizer from the organic wastes of fruit and vegetable wholesale market hall and neighbourhood markets by composting method
		1.3	Developing and disseminating organic fertilizer production techniques in order to support rural development and increase the carbon and water holding capacity of the soil
		1.4	Investigate potential to provide dedicated waste collection for restaurant / food industry traders in-line with management infrastructure and technology
		1.5	Establish a municipality-wide awareness campaign (schools, public education center etc) for waste reduction and separation at household level
		1.6	Make separate collection of key dry recyclable materials mandatory, formulating policy at the district municipality level

		1.7	Municipality to commit to banning the use of single-use plastics within their buildings, encouraging local businesses to do the same
	ACTION		**SUB-ACTION**
	LAND USE		
1	**Identifying stakeholders and collaborate with them to make the necessary arrangements in the regulations in order to design and development of the risky areas determined within the scope of the Law on Transformation of Areas Under Disaster Risk No. 6306**	1.1	This would include reducing the vulnerability of those who reside in these areas to climate events, increasing energy efficiency and reducing associated GHG emissions, as well as improving the quality of life and health and wellbeing of the residents
2	**Encourage urban transformation, acting on the Urban Transformation and development areas declared by the Council of Minister's decision for the creation of healthy, liveable urban spaces**	2.1	By encouraging and facilitating urban transformation, many benefits can be obtained, such as local job creation through development, increasing the living standards and health and wellbeing of the residents within the identified areas, reducing urban pollution and reducing current and preventing future building related emissions
3	**Review and update local-level policies, planning regulations and guidelines for future and new infrastructure development to ensure they consider climate projections and urban resilience in design and construction**	3.1	Developing resilient infrastructure make it's sustainable, with increased resource use efficiency and greater adoption of clean and environmental sound technologies and industrial processes. It will help support long-term economic development and also human well-being, alongside reducing the long-term impacts, such as disruption and maintenance / repair costs as a result of a climatic event
4	**Further development the green and blue infrastructure strategy**	4.1	Alongside other environmental benefits,

			interconnected, green spaces will help mitigate against the urban heat island effect and enhance the stormwater management capacity of the city, providing natural storage and interception for the rainwater, reducing lag time for flooding event and enhance carbon sequestration
ACTION		**SUB-ACTION**	
AGRICULTURE/FORESTRY, FOOD SECURITY AND BIODIVERSITY			
1	**Enhancing climate resilience of agricultural practices**	1.1	Determining the negative effects of climate change on plant and animal breeding, raising the awareness of the producers about the measures
		1.2	Establishment of an R&D center where agricultural practices resilient to Ankara climate will be developed
		1.3	Mainstreaming water efficiency systems in agricultural areas, making windbreaks, irrigation ponds and canals on the edges of the fields
		1.4	Providing training to municipal teams and agricultural cooperatives on combating invasive species that were not seen before in Ankara and taking necessary precautions
		1.5	Rehabilitation of wholesale market halls and improvement of logistics activities in order to increase food safety
		1.6	Taking necessary precautions for invasive species and other pests like sunn pest with early warning system studies in agriculture and conducting biotechnical-based researches and training seminars on combating these species
		1.7	Conscious use of fertilizers in agriculture
		1.8	With the use of biochar in agriculture, regulation of soil pH value, balancing of salinity and prevention

			of water pollution due to the filtration feature of biochar
		1.9	Efficient use of water by laying mulch on the land within the framework of agricultural activities based on natural precipitation
2	**Biodiversity inventory studies specific to Ankara, and planning of actions for biodiversity enhancement**	2.1	Ensure development of biodiversity inventory
		2.2	Ensure performance of tree planting and vegetation that requires less water in green spaces as a measure against the risk of reduced precipitation expected in Ankara
		2.3	Enhance biodiversity by building orchards
		2.4	Enhance biodiversity through water gardens (growing aquatic plants in these zones)
		2.5	Ensure preparation of a vegetation plan in case of exceptions regarding climate adaptation (e.g. which plants should be grown when the temperature increases by 2 ˚C with the impact of climate change)
		2.6	Dissemination of technical practices and awareness-raising activities that will increase pollination by supporting the bee population (For example, distributing flower seeds in types that attract the attention of bees to the students in schools to grow them in the garden/balcony of their own homes)
ACTION		**SUB-ACTION**	
TRANSPORTATION AND INFRASTRUCTURE			
1	**Improve transportation operations**	1.1	Ensure development of urban green roads and tour rotes
		1.2	Provide primary integration of green spaces with rail systems for the achievement of accessibility to

			green spaces
		1.3	Increase the number of bicycle paths and stimulate the public to use bicycle
		1.4	Provide connected access roads between districts to ensure the continuation of existing bicycle paths
		1.5	Put the light rail mass transit system into service, and ensure the installation of this rail system over the natural green system
		1.6	Planting horizontal and vertical transportation axes
		1.7	Narrow the motorways in zones available for encouragement of walk and mass transportation and plant other remaining zones
2	**Developing urban and spatial planning and design strategies and policies that contribute to local transportation options and accessibility**	2.1	Revision of themes such as 'climate friendly', 'energy efficient urban design', 'compact city' etc. in the existing environmental layout and zoning plans, and ensuring their integration into new planning and design policies and projects of the municipality
3	**Conducting improvement and development studies regarding infrastructural inadequacies**	3.1	Separating rainwater drainage system from the sewage network
		3.2	Improvement of system capacities considering the effects of population growth and climate change
		3.3	Planning additional infrastructure investments, such as underground flood discharge channels and retention reservoirs in high-risk areas
		3.4	Reducing the risk of flash flooding by increasing the use of permeable covering materials that will absorb stormwater in large urban areas
		3.5	Identifying high-risk underpasses and developing suitable transportation solutions
		3.6	Conversion of underpasses, which do not contribute significantly to the solution of the traffic

			problem, to level crossing after providing the right solutions to the traffic problem
		3.7	Where it is not possible or appropriate to conversion the underpasses into level crossings, supporting the underpasses with infrastructure applications that will allow rapid water discharge

7. CIRCLE CITY SCAN TOOL – ANKARA CASE STUDY

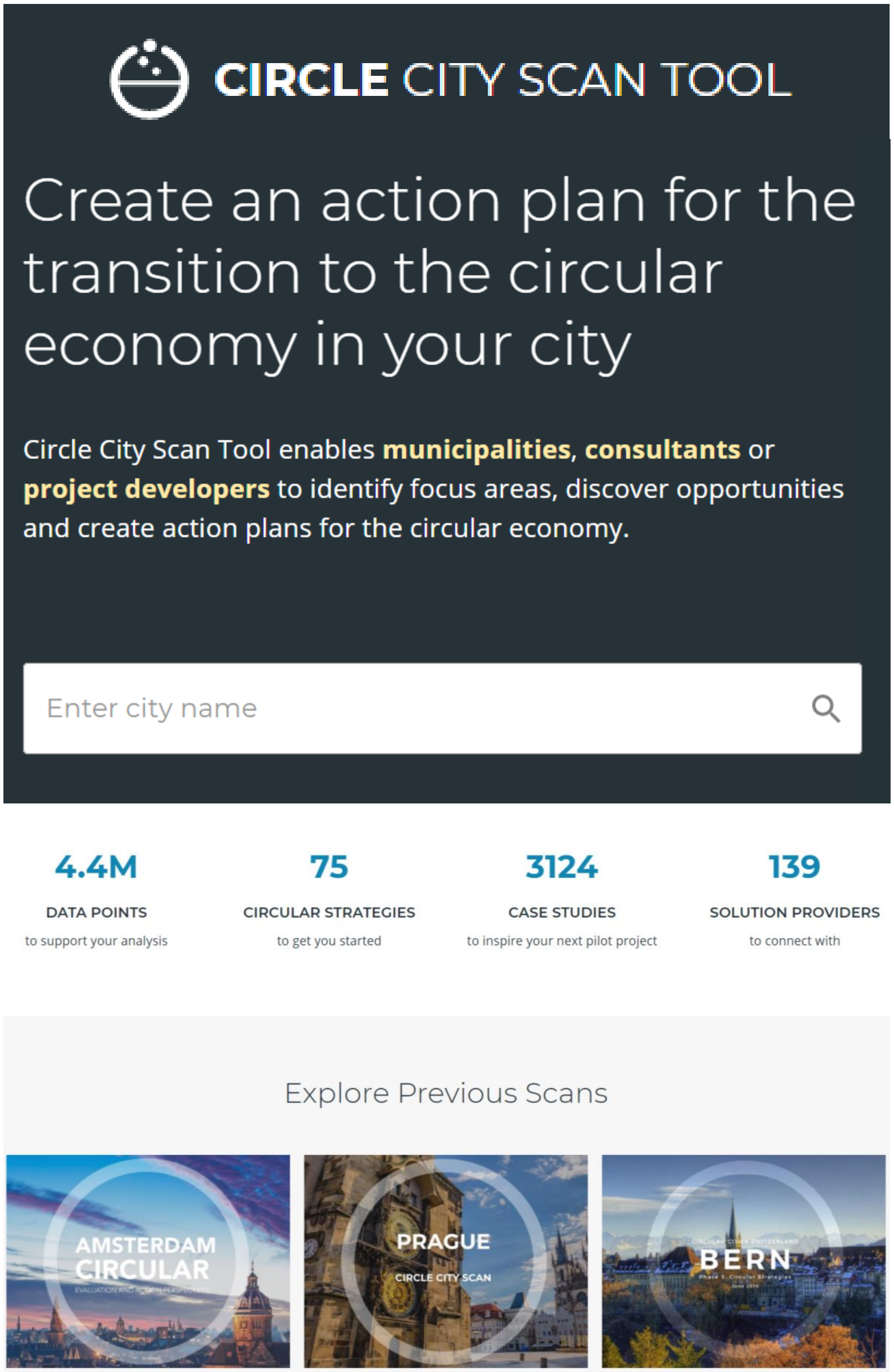


Figure 7.1 Circle City Scan Tool

7.1. Method

7.1.1. Emission Data Input (by NACE codes)

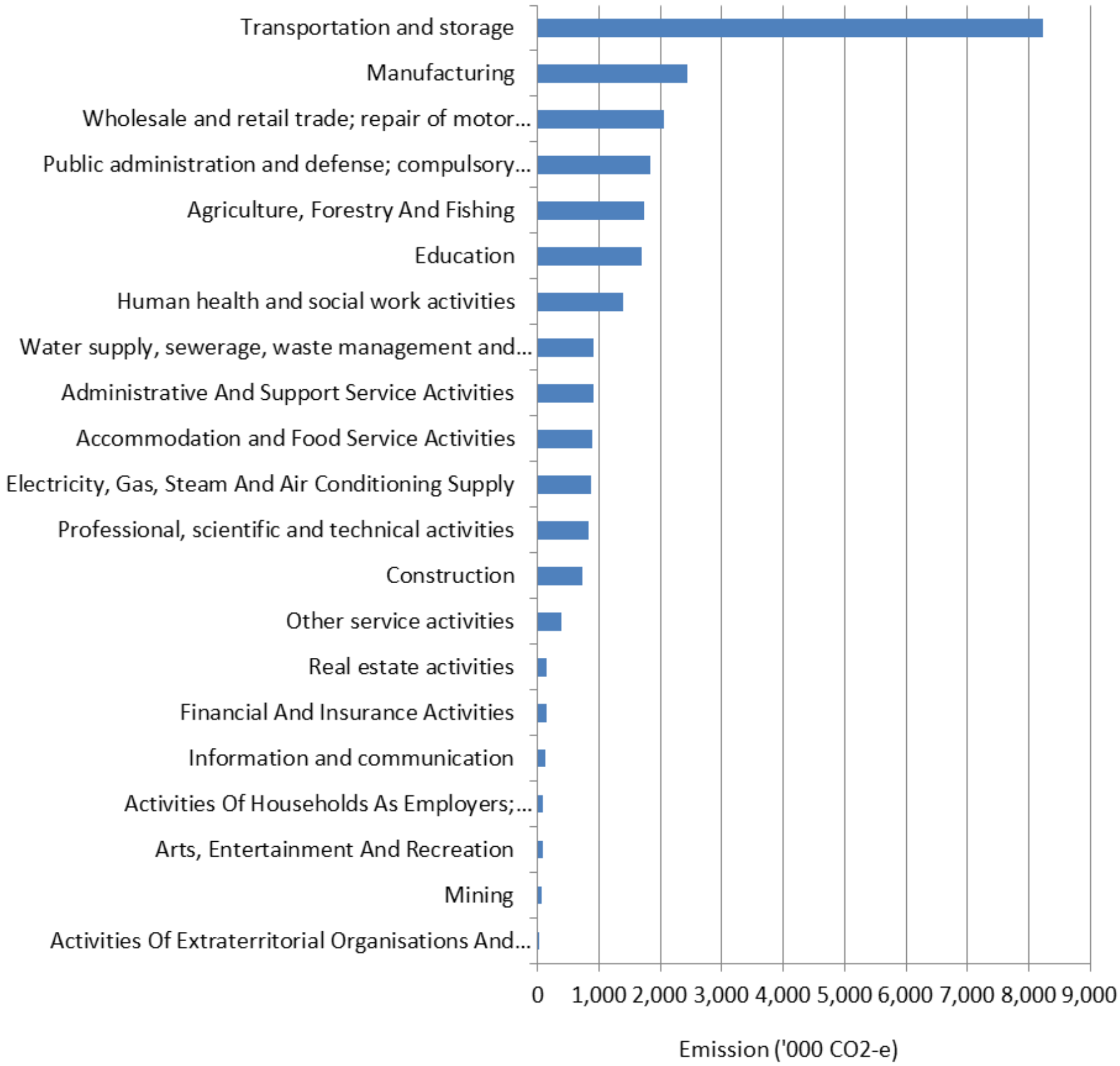


Figure 7.2 Emission data for Ankara province based on NACE codes

7.1.2. Gross Domestic Product - GDP Data Input (by NACE codes)

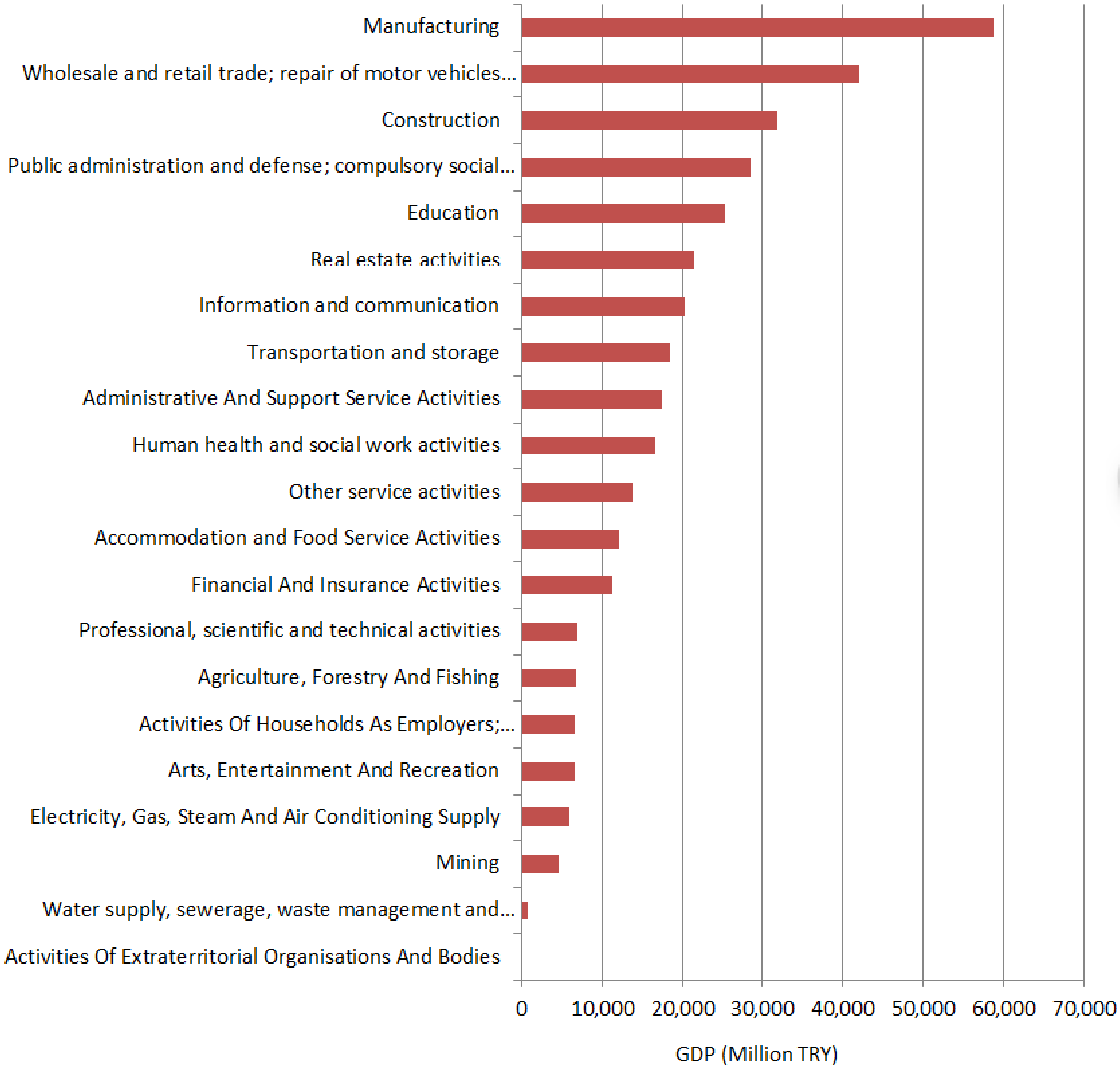


Figure 7.3 GDP data for Ankara province based on NACE codes

7.1.3. Jobs Data Input (by NACE codes)

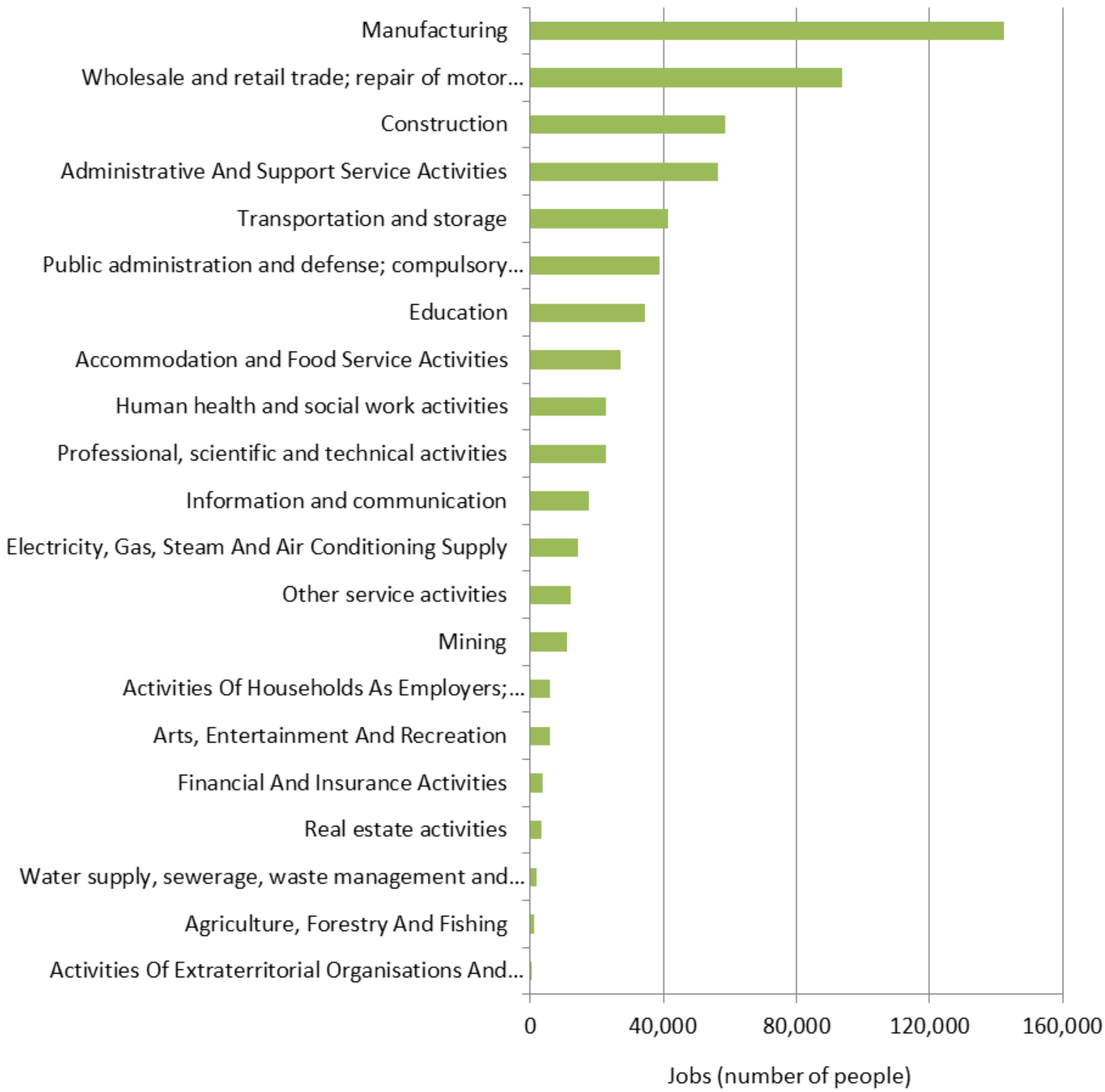


Figure 7.4 Employment data based on NACE codes for Ankara province

7.2. Conclusion and Evaluations

7.2.1. Sectoral Prioritization Study

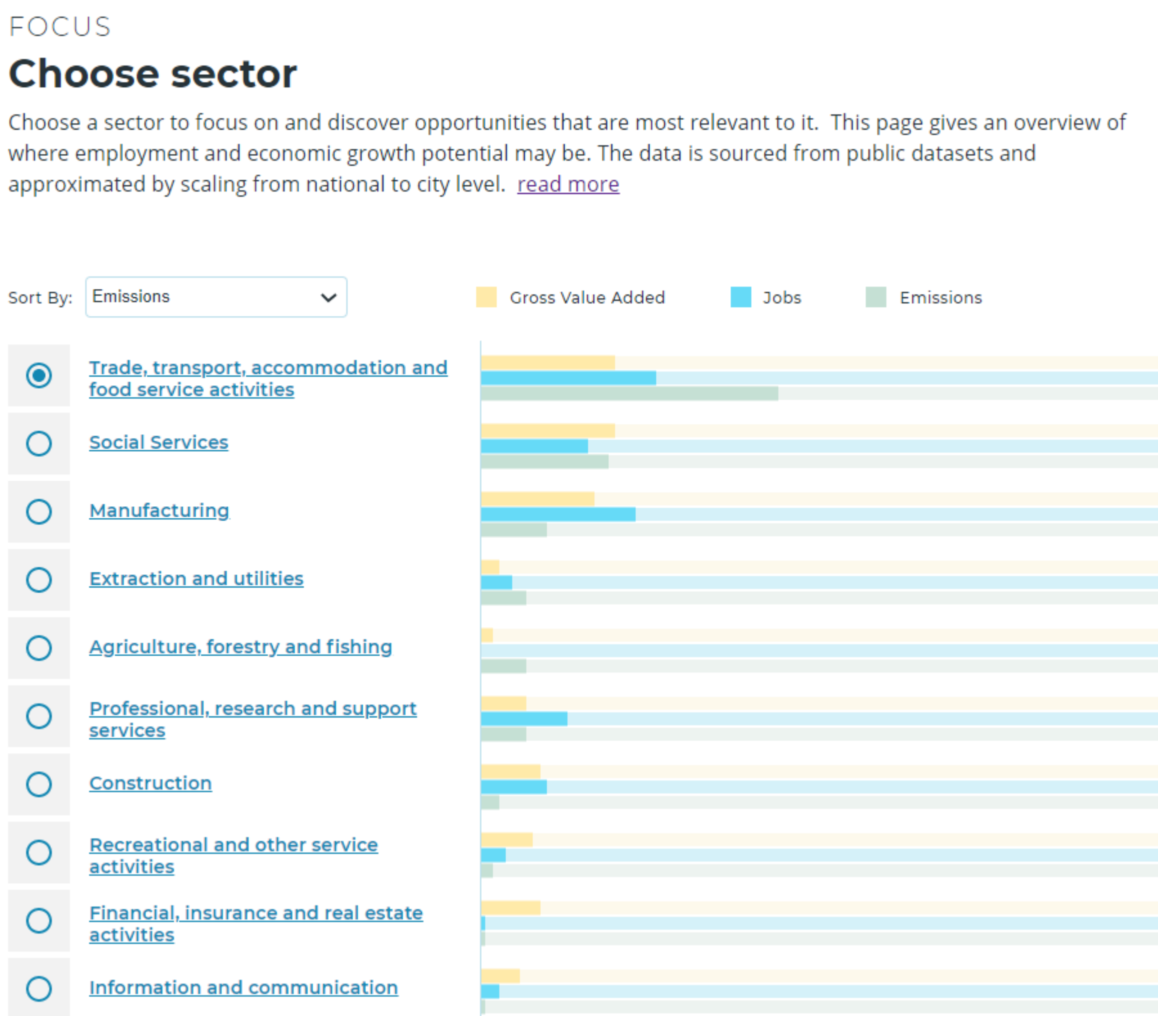


Figure 7.5 Priority sectors for the circular economy assessment of Ankara province

7.2.2. Trade, Transport, Accommodation and Food Service Activities

The trade, transport, accommodation and food service activities sector comprises of 3 sub-sectors;

1) Wholesale and retail trade, 2) Transportation and storage and, 3) Accomodation and food service activities.

1) The wholesale and retail sub-sector includes sale without transformation of any type of goods, and rendering services incidental to the sale of merchandise.

2) Wholesaling and retailing are the final steps in the distribution of merchandise. The transportation and storage sub-sector includes the provision of passenger or freight transport, whether scheduled or not, by rail, pipeline, road, water or air and associated activities such as terminal and parking facilities, cargo handling and storage.

3) The accommodation and food services sector includes the provision of short-stay accommodation for visitors and other travellers and the provision of complete meals and drinks fit for immediate consumption.

Common circular strategies within this sector are:

Regeneration: increase circular procurement, mobility as a service, designing products to enable multiple uses and lifecycles of a product and its materials, more efficiently using energy that is ideally renewable and electric, reduce water loss and misuse,

Preservation: maintenance of important public transportation infrastructure

Waste as a resource: use waste as a resource, food waste avoidance, reverse logistics and re-commerce.

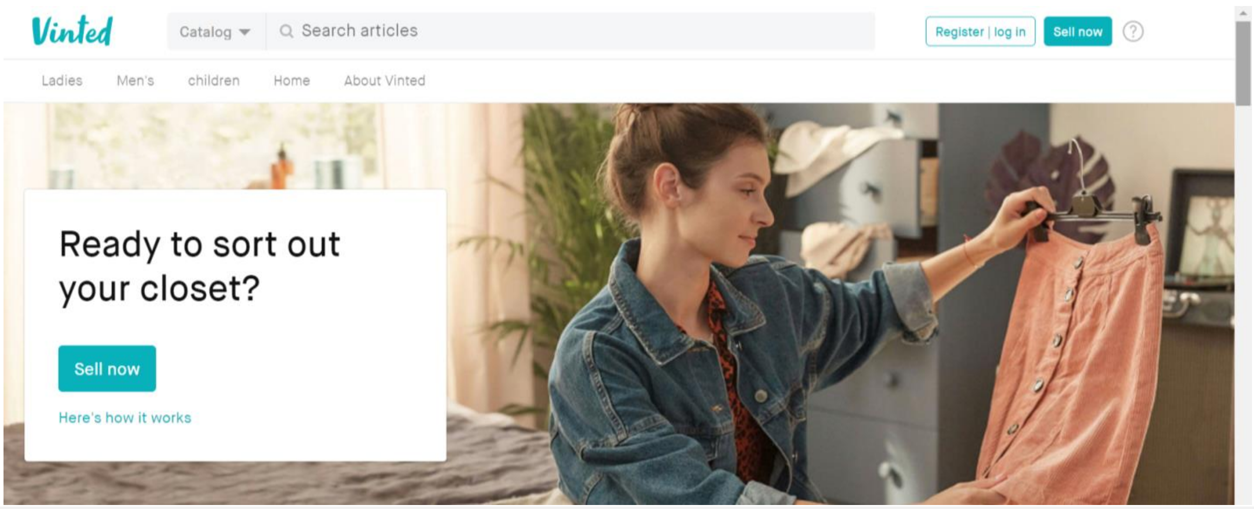
Enabling strategies: rethink business platforms for example to deal with food waste or more efficient use of transportation infrastructure, technical tools for efficiency in freight and software to produce more on demand delivery.

Select all	Inputs (ktons)
Biomass	4,505.3
Crop Residues	2,812.1
Crops	1,429.6
Wood	251.6
Animal Products	12.0
Fossil carriers	3,599.5
Liquids and gases	3,032.8
Coal and solids	566.7
Minerals & chemicals	2,720.1
Construction Dominant	2,626.3
Industrial / Agricultural Dominant	93.8
Metal & ores	111.3
Ferrous metals	64.3
Non ferrous metals	46.9

Figure 7.6 Circularity assessment of Trade, Transport, Accommodation and Food Service Activities

CASE STUDY

Online service for a second fashion life



LOCATION

Germany

Key Takeaway

Vinted is one of the largest platforms for the trade of second-hand fashion in Germany. The online platform initiates the direct trade of second-hand clothing between private individuals. Revenue is generated through service fees, advertising and PR.

Sector:

Fashion and Textiles

Impact area:

Minimise waste (SDG12)

Sources:

https://www.vinted.de/

7.2.3. Social Services

This composite sector comprises of 3 sub-sectors: Public administration and defence, Education and Human health and social work activities.

1) The public administration and defence sub-sector includes activities of a governmental nature, normally carried out by the public administration. This includes the enactment and judicial interpretation of laws and their pursuant regulation, as well as the administration of programmes based on them, legislative activities, taxation, national defence, public order and safety, immigration services, foreign affairs and the administration of government programmes.

2) The Education sub-sector includes education at any level or for any profession. The instructions may be oral or written and may be provided by radio, television, internet or via correspondence.

3) The human health sub-sector and social work activities comprises of the provision of health and social work activities. Activities include a wide range of activities, starting from health care provided by trained medical professionals in hospitals and other facilities, over residential care activities that still involve a degree of health care activities to social work activities without any involvement of health care professionals.

Social services have a powerful role to play in enabling a circular economy. Legislative activities can keep governmental organisations accountable of their environmental plans, education sector plays a big role in providing knowledge about the jobs and skills required for a career in the circular economy. Within human health reduce-reuse-recycle measures are also relevant to decrease the impact and amount of single use materials used and discarded.

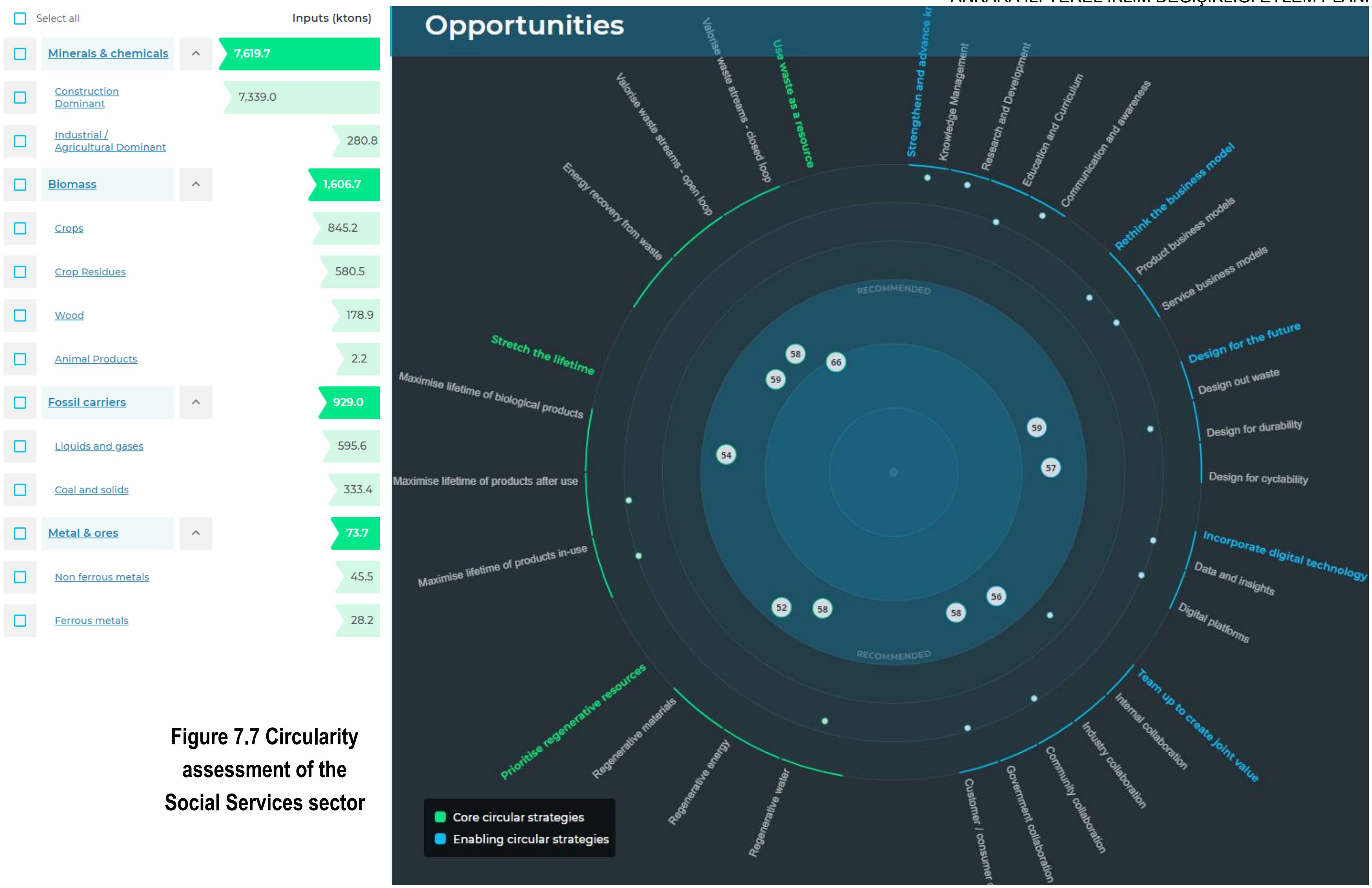


Figure 7.7 Circularity assessment of the Social Services sector

CASE STUDY

Socially-inclusive eco-district

Key Takeaway

The City of Hannover addressed its metropolitan challenges, including a lack of affordable housing and social inclusion through the creation of the ecological district, Kronsberg. A key factor underlying the District's success, was the City's integration of institutions, services, facilities and social behaviors throughout the entirety of the planning, construction and completion of the neighborhood. This was undertaken by founding the Kronsberg Environmental Liaison Agency, KUKA (Kronsberg-Umwelt-Kommunikations-Agentur GmbH). Today, the District of Kronsberg provides a unique example of how scaling up technologies and behavioral changes through consequent integrated planning practices for capacitating communications ensured a highly ecological, economical and socially inclusive community for Hannover's residents.

Policy Type:

Living labs

Sector:

Materials and Fuels, Transportation and Logistics, Construction and Infrastructure

Sources:

http://old.iclei.org/fileadmin/PUBLICATIONS/Case_Studies/Urban_NEXUS_cs04_Hannover_ICLEI-GIZ_2014.pdf

7.2.4. Manufacturing

The manufacturing sector comprises of the physical or chemical transformation of materials, substances, or components into new products. The materials, substances, or components transformed are raw materials that are products of agriculture, forestry, fishing, mining or quarrying, as well as products of other manufacturing activities.

Common circular strategies within this sector are:

Regeneration: Sourcing of lowest impact materials, either secondary or regenerative materials as appropriate, for both raw materials and energy supply, reduce water loss and misuse.

Preservation: maintenance and repair of equipment and machinery, reverse logistics and extended producer responsibility.

Waste as a resource: maximize lifetime of products after use, use waste as a resource either in the same or other industry, design for cyclability; zero out waste during manufacture phase; design out waste during use phase and close water cycles.

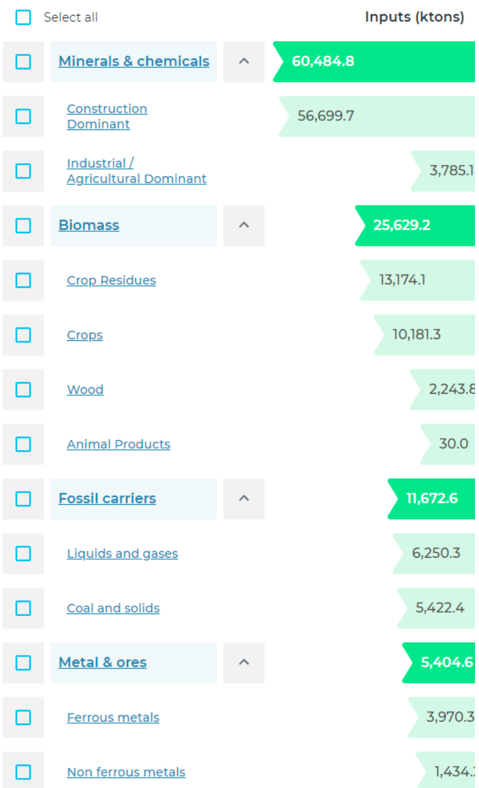
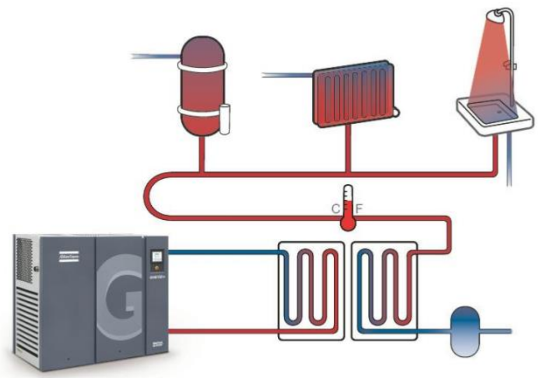


Figure 7.8 Circularity assessment of the manufacturing sector

CASE STUDY

Recovering energy from heat throughout manufacturing



Key Takeaway

Autofil is one of Europe's leading manufacturers and suppliers of polyester yarns for the automotive sector. Throughout their UK based manufacturing plant, heat is produced and recovered by an air compressor. As a result the company is able to reduce the overall energy consumption used for the manufacturing of polyester yarns. They also offer products based on post-consumer recycled polymer.

Sources:

https://www.atlascopco.com/en-uk/compressors/News-and-stories/autofil-energy-recovery

7.2.5. Extraction and Utilities

The Industry & utilities sector comprises 3 sub-sectors; 1) Mining and Quarrying, 2) Electricity, Gas, Steam and Air Conditioning Supply and 3) Water Supply; Sewerage, Waste Management and Remediation Activities.

1) Mining and quarrying include the extraction of minerals occurring naturally as solids (coal and ores), liquids (petroleum) or gases (natural gas). Extraction can be achieved by different methods such as underground or surface mining, well operation and seabed mining.

2) Electricity, Gas, steam and Air conditioning supply includes the activities of providing electric power, natural gas, steam, hot water and the like through a permanent infrastructure (network) of lines, mains and pipes.

3) Water supply includes activities related to the management including collection, treatment and disposal of various forms of waste, such as solid or non-solid industrial or household waste, as well as contaminated sites. The output of the waste or sewage treatment process can either be disposed of or become an input into other production process.

Common circular strategies within this sector are:

Regeneration: improved processing of mining using conventional and new technologies, zero-out waste, increasing energy efficiency, and electrifying sectors, reduce water loss and misuse, develop pricing systems that encourage the wise use of water, minimise non-renewable material use and smart energy networks.

Preservation: reusing treated wastewater for beneficial purposes, use of secondary materials, heating networks for industrial symbiosis, reusing waste to its highest value, maintenance and repair of equipment and machinery.

Waste as a resource: increased recycling rates, close water cycles, better sorting facilities, better collection and infrastructure, nutrient recycling and industrial symbiosis.

Select all	Inputs (ktons)
Fossil carriers	16,907.8
Coal and solids	14,541.1
Liquids and gases	2,366.8
Minerals & chemicals	2,417.7
Construction Dominant	2,346.7
Industrial / Agricultural Dominant	71.0
Biomass	177.4
Wood	77.5
Crops	61.2
Crop Residues	38.5
Animal Products	0.2
Metal & ores	31.5
Ferrous metals	17.9
Non ferrous metals	13.6

Figure 7.9 Circularity assessment of Industry and Utilities Services sectors

CASE STUDY

Nexus solutions for the development of the North-West Sahara aquifer system

LOCATION

Tunisia

Key Takeaway

Algeria, Tunisia and Libya are water-scarce regions where the groundwater represents over 30% in Algeria, about 50% in Tunisia and more than 80% in Libya of renewable water resources. The current water extraction from the aquifer greatly exceeds the recharge capacity and puts sustainable development at high risk. To decrease the extraction the Nexus solution for the development of the North-West Sahara aquifer system was developed.

Problem

Agriculture is the largest water consumer in Tunisia, Algeria and Libya: water consumption on average is around 11,000 m3/ha but could reach in the future about 16,800 m3 / ha. This inefficient irrigation leads to salinization and further loss of soil fertility. Circular economy solutions through non-conventional water resources and renewable energy including strategies of financing brackish and wastewater recovery as well as transboundary sharing of information and experience about renewable energy could help the sustainable transformation of this region.

Solutions

To work against the challenges which the countries are facing the NWSAS Nexus Assessment was developed and is an outcome of a participatory process that included national consultations and two transboundary workshops. The nexus assessment has helped identify key linkages among energy, water, land, and ecosystem resources, together with potential solutions for making resource management sustainable and efficient.

Outcomes

The nexus package includes 15 high-priority, implementable solutions ranging from governance and international cooperation, to economic and policy instruments, infrastructure and innovation. The solutions are broken down into 65 actions in the water, energy, food, and environment sectors.

Policy Type:

Infrastructure, Develop regenerative infrastructure, Visions and Ambitions, Roadmaps and strategies and targets, Govern the Transition, Institutional design to enable circularity, Regulate, Regulation, Monitoring & enforcement

Sector:

Societal Services, Water and Sewage

Impact area:

Ecological Impact, Social Impact, Economic Impact, Increase Awareness, Well-being, Innovation, Save water (SDG6)

Sources:

https://unece.org/DAM/env/water/publications/WAT_NONE_15_NWSAS_Nexus/Policy-Brief-Sahara-Aquifer-FINAL_rev__1_.pdf

7.2.6. Agriculture, Forestry and Fishing

The agriculture sector comprises of all activities related to the growing of perennial and non-perennial crops, plant propagation, animal production, mixed farming, support activities to agriculture and post-harvest crop activities, hunting, trapping and related service activities.

Common circular strategies within this industry are:

Regeneration: optimise land use, achieve greater resource efficiency and reduce waste, mitigate the amount of greenhouse gasses.

Preservation: healthy soil and surrounds, achieved via management, enrichment, conservation & preservation of landscapes, storage and supply chains designed to minimise or zero food waste.

Waste as a resource: close nutrient, water, carbon and waste cycles.

Select all	Inputs (ktons)
Biomass	283.8
Crops	240.8
Crop Residues	40.1
Wood	3.0
Animal Products	0
Minerals & chemicals	92.1
Construction Dominant	81.3
Industrial / Agricultural Dominant	10.8
Fossil carriers	24.6
Liquids and gases	16.1
Coal and solids	8.5
Metal & ores	0.6
Ferrous metals	0.4
Non ferrous metals	0.2

Figure 7.10 Circularity assessment of the Agriculture, Forestry and Fisheries sectors

CASE STUDY

From coal to wood pellets


LOCATION

Norway

Key Takeaway

Arbacore pellets have been specially developed to replace or mix with fossil fuel in coal-fired power plants. Arbacore is produced using a steam explosion process in which the wood fibers are broken down and lignin, the binding agent in wood, is released. A similar solution is torrefaction, making torrefied pellets. These process creates pellets that are brown, almost black, with a higher energy content and a film that makes them water-resistant. During pulverization, the particles become so fine that they are more similar to coal than the regular white pellets.

Problem

The world rapidly needs to reduce CO2 emissions and to phase out coal power generation, while still maintaining reliable base load to the electricity grid. The transition needs to happen quickly, at low cost and at a minimum CO2 footprint.

Solutions

Arbaflame neutralize coal plants used for balancing power by replacing coal with pellets from residual waste (sawdust) from sawmills practicing sustainable forestry. In the process they also make chemicals used in bio-plastics, food flavouring, polymers, solvents and fish feed.

Outcomes

The steam treated wood pellets have similar characteristics as coal; being utilized, transported and stored in the same way. The patented technology has been proven for +10 years at full-scale demo plant, and tested & verified at 14 power plants in Europe & North America.

Sector:

Wood and Paper

Impact area:

Ecological Impact, Economic Impact

Sources:

https://www.arbaflame.no/about-arbaflame

7.2.7. Professional, Research and Support Services

This composite sector comprises of 2 sub-sectors 1) Professional, scientific and technical activities and 2) Administrative and support service activities.

1) Professional, scientific and technical activities comprise of specialised professional, scientific and technical activities. These activities require a high degree of training, and make specialised knowledge and skills available to users.

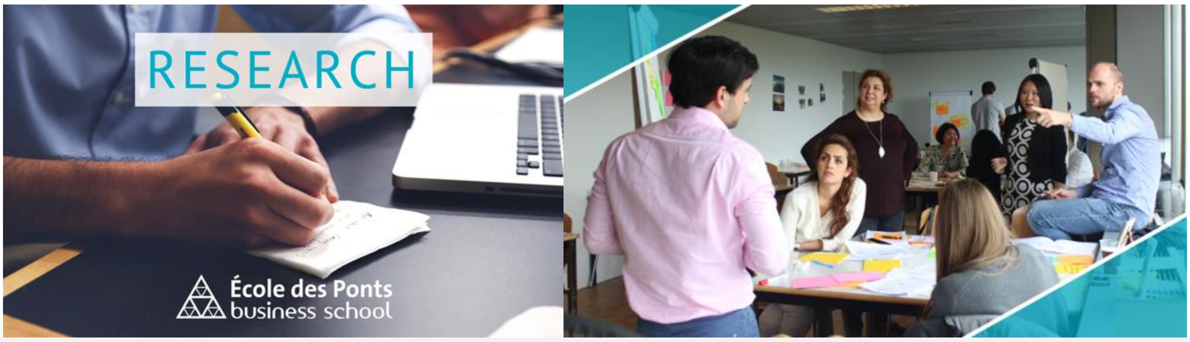
2) Administrative and support service facilities includes a variety of activities that support general business operations. Includes the rental and leasing of tangible and non-financial intangible assets, such as automobiles, computers, consumer goods, and industrial machinery and equipment, to customers in return for a periodic rental or lease payment. Also includes activities of employment placement and travel agencies.

Professional, research and support services have a powerful role to play in enabling a circular economy by channeling their efforts to the benefit of other core sectors with circular design strategies, development of new renting and leasing models, research and advertising.

Figure 7.11 Circularity assessment of the Professional, Research and Support Services sectors

CASE STUDY

Ecole des Ponts Circular Economy Research Centre



LOCATION

France

Key Takeaway

As the concept of circular economy increasingly attracts attention, more resources are being poured into research and development; to that end, the Ecole des Ponts business school launched a Circular Economy Research Centre in 2017. Students and alumni alike now have the opportunity to learn about the changes and challenges the circular economy presents, as well as how principles of circularity fit into each student's professional sector. The sharing economy, sustainability, energy efficiency and waste management are all included in the centre's curriculum. Training and research activities are also carried out as part of the initiative. Research topics have included innovation, business models, big data, IoT, smart and circular cities, artificial intelligence and data economy, among others.

Policy Type:

Educate, Circular Economy in school programmes, Conduct research

Sector:

Materials and Fuels, Goods and Services, Societal Services, Energy Utilities and Independent Power Producers, Waste Management

Impact area:

Increase Awareness

Sources:

https://circulareconomy.europa.eu/platform/en/good-practices/circular-economy-research-center-cerc

https://pontsbschool.com/faculty-research/circular-economy-research-center-cerc/

ANNEX A

ACCOUNTING AND REPORTING PRINCIPLES

The GPC defines five accounting and reporting principles:

- Relevance,
- Completeness,
- Consistency,
- Transparency,
- Measurability.

These principles are summarized in ***Table 2-1*** and were applied to all data collected for this study.

Table 7-1 Summary of accounting and reporting principles

Principle	***GPC description***
Relevance	The reported GHG emissions shall appropriately reflect emissions occurring as a result of activities and consumption from within the city's geopolitical boundary.
Completeness	All emission sources within the inventory boundary shall be accounted for. Any exclusion of emission sources shall be justified and clearly explained. Notation keys should be used when an emission source is excluded, considered not relevant, and/or not occurring.
Consistency	Emissions calculations shall be consistent in approach, boundary, and methodology. Accounting of emissions should follow the standardized, preferred methodologies provided by the GPC. Any deviation from the preferred methodologies should be justified and disclosed.
Transparency	Activity data, emission sources, emission factors, and accounting methodologies should be adequately documented and disclosed to enable verification. The information should be sufficient to enable individuals outside of the inventory process to use the same source data and derive the same results. All exclusions need to be clearly identified and justified.

Principle	***GPC description***
Measurability	The data required to support completion of an inventory should be readily available or made available with reasonable time and/or cost. Any exclusions of emission sources shall be justified and disclosed. The use of proxy data and estimated figures should be justified and clearly disclosed.

Source: Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories

ANNEX B

NOTATION KEYS

Notation keys are used for each data point, which align with common practices used by national governments in the IPCC and United Nations Framework Convention on Climate Change (UNFCCC) processes. The notation options are noted below.

- **IE – Included Elsewhere:** Emissions for this activity are estimated and presented in another category of the inventory. The category where these emissions are included should be noted in explanation.
- **NE – Not Estimated:** Emissions occur but have not been estimated or reported; justification for exclusion should be noted.
- **NO – Not Occurring:** An activity or process does not occur or exist within the community.
- **C - Confidentional:** The activities take place within the boundaries, but it is protected with the principle of confidentiality since it is based on private sector data. Therefore, it could not be used in inventory studies.

ANNEX C

EMISSION FACTORS

Table A. 1 Emission Factors and Related Sources (tCO2eq)

Activity/Fuel Type	Value	Unit	Sources	Quality
Domestic Coal (consumption in residences and public buildings for heating)	0.397	kg CO_2e/kWh	UNFCC Turkey 2019 National Inventory (Table 1A(b)) Unit conversions were done using calorific values in Table A.3, below.	Medium
Imported Coal (consumption in residences for heating)	0.385	kg CO_2e/kWh	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 2). Unit conversions were done using calorific values in Table A.3, below.	Medium
Domestic Coal (consumption in industrial facilities)	0.397	kg CO_2e/kWh	UNFCC Turkey 2019 National Inventory (Table 1A(b)) Unit conversions were done using calorific values in Table A.3, below.	Medium

Activity/Fuel Type	Value	Unit	Sources	Quality
Imported Coal (consumption in industrial facilities)	0.398	kg CO_2e/kWh	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 2). Unit conversons were done using calorific values in Table A.3, below.	Medium
Coke Coal (consumption in industrial facilities)	0.350	kg CO2e/kWh	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 2). Unit conversons were done using calorific values in Table A.3, below.	Medium
Natural Gas (for heating purposes in residences and public buildings)	0.194	kg CO_2e/ kWh	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 4). Unit conversons were done using calorific values in Table A.3, below.	Medium
Natural Gas (for heating purposes in commercial buildings)	0.194	kg CO_2e/kWh	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 4). Unit conversons were done using calorific values in Table A.3, below.	Medium

Activity/Fuel Type	Value	Unit	Sources	Quality
Natural Gas (in industrial facilities)	0.193	kg CO_2e/ kWh	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 4). Unit conversions were done using calorific values in Table A.3, below.	Medium
Electricity Consumption	0.457	kg CO_2e/kWh	UNFCC Turkey 2019 National Inventory (Table 1, page 1). TEİAŞ 2020 electricity Statistics " Change of Electric Energy Production, Consumption and Loss Data in Turkey by Years"	Medium
Diesel (on-road transportation)	2.602	kgCO2e/liter	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 2). Unit conversions were done using calorific values in Table A.3, below.	Medium
Gasoline (gasoline for on-road transportation)	2.307	kg CO2e/liter	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 2). Unit conversions were done using calorific values in Table A.3, below.	Medium

Activity/Fuel Type	**Value**	**Unit**	**Sources**	**Quality**
LPG (consumption as fuel in vehicles)	7.331	kg CO_2e/liter	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 2). Unit conversons were done using calorific values in Table A.3, below.	Medium
LPG (industrial use)	10.637	kg CO2e/liter	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 2). Unit conversons were done using calorific values in Table A.3, below.	Medium
LPG (for heating purposes in residences)	7.193	kg CO2e/liter	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 2). Unit conversons were done using calorific values in Table A.3, below.	Medium
CNG	0.205	kg CO2e/kWh	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 2). Unit conversons were done using calorific values in Table A.3, below.	Medium

Activity/Fuel Type	Value	Unit	Sources	Quality
Fuel oil 3-5-6 (industrial use)	0.339	kg CO2e/kWh	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 2). Unit converisons were done using calorific values in Table A.3, below.	Medium
				Medium
Gas Oil (industrial use)	2.547	kg CO_2e/lt	UNFCC Turkey 2019 National Inventory (Table 1A(a), page 2). Unit converisons were done using calorific values in Table A.3, below.	Medium
CO_2 from wastewater treatment activities	2.128	kg CO2e/m^3	2006 IPCC Guidelines, Vol 5 - Waste, Chapter 6" was used in calculations	High
Landfill	0.8735	kg CO2e/kg	2006 IPCC Guidelines, Vol 5 - Waste, Chapter 6" was used in calculations	High
Unmanaged Solid Waste Sites	1.1647	kg CO2e/kg	2006 IPCC Guidelines, Vol 5 - Waste, Chapter 6" was used in calculations.	High

Activity/Fuel Type	Value	Unit	Sources	Quality
Clinker/Cement Production	0.526	kg CO2e/kg	UNFCC Turkey 2019 National Inventory (Table A2(1).A-H).	Medium
Enteric Fermentation – Cattle (CH$_4$ source)	2,332.518	kg CO$_2$e/capita/year	UNFCC Turkey 2019 National Inventory (Table 3A (page 1-2). UNFCC Turkey 2019 National Inventory (Table 3A (page 1-2).	Medium
Enteric Fermentation – Native Sheep (CH$_4$ source)	140.0	kg CO$_2$e/capita/year	UNFCC Turkey 2019 National Inventory (Table 3A (page 1-2).	Medium
				Medium
Enteric Fermentation Merino Sheep (CH$_4$ source)	182.0	kg CO$_2$e/capita/year	UNFCC Turkey 2019 National Inventory (Table 3A (page 1-2).	
Enteric Fermentation Goat (CH$_4$ source)	140.0	kg CO$_2$e/capita/year	UNFCC Turkey 2019 National Inventory (Table 3A (page 1-2).	Medium
Animal Manure Management –Cattle (CH$_4$ source)	549.715	kg CO$_2$e/capita/year	UNFCC Turkey 2019 National Inventory (Table 3B (a) (page 1-2).	Medium
Animal Manure Management –Native Sheep (CH$_4$ source)	3.401	kg CO$_2$e/capita/year	UNFCC Turkey 2019 National Inventory (Table 3B (a) (page 1-2).	Medium

Activity/Fuel Type	Value	Unit	Sources	Quality
Animal Manure Management – Merino Sheep (CH_4 source)	4.664	kg CO_2e/capita/year	UNFCC Turkey 2019 National Inventory (Table 3B (a) (page 1-2).	Medium
Animal Manure Management – Goat (CH_4 source)	4.169	kg CO_2e/capita/year	UNFCC Turkey 2019 National Inventory (Table 3B (a) (page 1-2).	Medium
Hayvan Dışkısı Yönetimi Animal Manure Management –Cattle (N_2O source)	144.065	kg CO_2e/capita/year	UNFCC UNFCC Turkey 2019 National Inventory (Table 3B (b), page 1-1).	Medium
Animal Manure Management –Native Sheep(N_2O source)	17.784	kg CO_2e/capita/year	UNFCC Turkey 2019 National Inventory (Table 3B (b), page 1-1).	Medium
Animal Manure Management –Merino Sheep(N_2O source)	18.422	kg CO_2e/capita/year	UNFCC Turkey 2019 National Inventory (Table 3B (b), page 1-1).	Medium
Animal Manure Management –Goat (N_2O source)	23.426	kg CO_2e/capita/year	UNFCC Turkey 2019 National Inventory (Table 3B (b), page 1-1).	Medium
Commercial fertilizer (urea)	0.733	tCO_2e/ton	UNFCC Turkey 2019 National Inventory (Table 3D, page 1-1).	Medium

Activity/Fuel Type	**Value**	**Unit**	**Sources**	**Quality**
Change in land use (conversion of cultivated areas to other areas)	-1.40	tCO_2e/ha	UNFCC Turkey 2019 National Inventory (Table 4F, page 1-1).	Medium
Change in land use (conversion of other areas to forested areas)	0.70	tCO_2e/ha	Turkey 2019 National Inventory (Table 4A, page 1-1).	Medium
Change in land use (conversion of cultivated areas to meadow and pasture areas)	-0.67	tCO_2e/ha	Turkey 2019 National Inventory (Table 4C, page 1-1).	Medium

ANNEX D

GLOBAL WARMING POTENTIAL OF GHGS

Global Warming Potentials of Greenhouse Gases

Greenhouse Gas	Value	Unit	Source
Carbondioxide (CO_2)	1	kg CO_2e/kg	IPCC 2014
Methane (CH_4)	28	kg CO_2e/kg	IPCC 2014
Nitrous Oxide(N2O)	265	kg CO_2e/kg	IPCC 2014

Source: IPCC. 2014, IPCC Fifth Assessment Report: Climate Change 2014

ANNEX E

UNIT CONVERSION FACTORS

Fuel Type	**Density (liter / ton)**	**Net Calorifc Value (kWh / kg) or (kWh / m^3 – for natural gas)**	
Diesel	1,183	11.86	Regulation on Increasing Efficiency in the Use of Energy Resources and Energy Annex_2 (27.10.2011, Resmi Gazete: 28097)
Fuel oil[a]	1,075	11.56	Regulation on Increasing Efficiency in the Use of Energy Resources and Energy Annex_2 (27.10.2011, Resmi Gazete: 28097)
Gas Oil	1,282	9.64	Regulation on Increasing Efficiency in the Use of Energy Resources and Energy Annex_2 (27.10.2011, Resmi Gazete: 28097)
LPG	403,71	12.68	DG Renewable Energy
Natural Gas	1,492,537	9.59	DG Renewable Energy for NCV and density: www.eie.gov.tr/verimlilik/document/GA_izleme_form.xls
Gasoline	1,361	12.0871	DG Renewable Energy for NCV and density: www.eie.gov.tr/verimlilik/document/GA_izleme_form.xls

a: Average density value of fuel oil 5 and 6. Since there is no density value for Fuel oil 3 and 4 in Annex-2, the average density of Fuel-oil 5 and 6 has been used for these fuel oil types.