2025

ÇANKAYA MUNICIPALITY SUSTAINABLE ENERGY AND CLIMATE ACTION PLAN

(SECAP)

Çankaya
BELEDİYESİ

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FOREWORD

The global climate crisis, whose profound impacts are increasingly felt in our country as well, has emerged as one of the most significant threats facing our planet today. This crisis not only impacts nature, biodiversity, and meteorological patterns, but also affects the economy, public health, quality of life, and socially vulnerable groups. As such, the role of local governments has become increasingly critical, especially in terms of taking preventive measures.

Cities, which cover only 3% of the Earth's surface, accommodate 55% of the global population. Moreover, they are responsible for approximately two-thirds of global energy consumption and 75% of total CO_2 emissions. With 123 neighbourhoods, an area of 455 km^2, and a population density of 2,023 people per km^2, Çankaya stands as the second most developed district of Türkiye according to the Ministry of Industry and Technology’s Socio-Economic Development Index (SEGE). As a developed urban centre, Çankaya has taken responsibility in the face of this global transformation and has mobilized to shape policies accordingly.

The "Sustainable Energy and Climate Action Plan" (SECAP), which commenced in September 2024 and was completed in April 2025, has been meticulously prepared with this awareness in mind. The Action Plan is based on rational data and developed through scientific methodologies. It provides an effective, sustainable, and actionable roadmap to enhance our district’s resilience against the climate crisis.

In accordance with international methodologies, the year 2023 was determined as the base year for the preparation process of the Action Plan. Using data from the period 2018–2023, Çankaya’s first greenhouse gas emission inventory was established. Based on this analysis, mitigation and adaptation actions for the 2025–2030 period were planned. The Action Plan clearly outlines the proportion of emissions arising from residential, commercial, and transportation sectors in the total emissions profile. Additionally, physical climate risks such as flooding, drought, and extreme heat events were assessed through spatial analyses, and vulnerable population groups along with critical risk zones were identified.

This document is not only an action plan; it is also a strategic expression of Çankaya’s vision to become a city that is prepared for the climate crisis, utilizes its resources efficiently, and is resilient against environmental and social risks. At the same time, it fulfils our international commitment under the Covenant of Mayors and reaffirms our determination to act as a local stakeholder in this global struggle.

In the face of the global climate crisis, we must act with collective wisdom and strong cooperation for the sake of our shared future. This is not merely an environmental issue; it is also a matter of intergenerational justice, human rights, and the moral conscience of the public.

I extend my sincere thanks to all my colleagues, institutions, organizations, academics, and experts who contributed to the preparation of this plan, and I hope that this roadmap will be of great benefit to our beloved Çankaya.

Respectfully,

Hüseyin Can GÜNER

Mayor of Çankaya Municipality

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Abbreviations

EPDK	Energy Market Regulatory Authority
EU	European Union
GCoM	Global Covenant of Mayors for Climate & Energy
GDP	Gross Domestic Product
GIS	Geographic Information System
GPC	Global Protocol for Community-Scale Greenhouse Gas Emission Inventories
GWP	Global Warming Potential
IPPC	Intergovernmental Panel on Climate Change
KI	Kaya Identity
NID	National Inventory Document
PPP	Purchasing Power Parity
SECAP	Sustainable Energy and Climate Action Plan
TEIAS	Turkish Electricity Transmission Corporation
TEP	Ton of Equivalent Petroleum
TURKSTAT	Turkish Statistical Institute
UNDP	United Nations Development Programme
UNFCC	United Nations Framework Convention on Climate Change

Introduction/Project Information

Çankaya Municipality began its efforts to combat climate change and enhance energy efficiency at the local level in 2015 by preparing a Sustainable Energy Action Plan (SEAP). This initiative included key goals such as reducing greenhouse gas emissions, promoting renewable energy sources, and implementing energy-saving measures. Expanding institutional-level activities to a district-wide scale naturally brought certain challenges. Furthermore, due to the municipality's limited jurisdiction, it was emphasized that informing and mobilizing all stakeholders was crucial to achieving the stated goals. However, over the nine years that have passed, changes in environmental and socio-economic conditions have highlighted the need for a more comprehensive and integrated action plan.

Accordingly, Çankaya Municipality initiated the preparation process for the Sustainable Energy and Climate Action Plan (SECAP) in 2024. In addition to energy efficiency and renewable energy efforts, SECAP includes actions aimed at enhancing communities' resilience to the impacts of climate change. The main goal of this initiative is to contribute to a carbon-neutral future and support the development of an environmentally friendly urban structure. The project process consists of the following steps:

- **Current Situation Analysis:** The first stage within the scope of SECAP involves a detailed analysis of Çankaya's current energy consumption, greenhouse gas emissions and climate risks. Key areas such as municipal services, industrial and commercial activities, residential sectors, waste management, and transportation are prioritized in this analysis.
- **Carbon Reduction Targets:** SECAP establishes carbon reduction targets to help Çankaya Municipality progress toward carbon neutrality, in alignment with international agreements such as the European Green Deal and the Paris Agreement.
- **Adaptation Actions:** SECAP also includes adaptation strategies to address the environmental, social, and economic impacts of climate change. These strategies involve actions such as managing water resources, implementing measures to enhance resilience to extreme weather events, and conserving biodiversity and ecosystems.
- **Stakeholder Engagement:** SECAP adopts a transparent and inclusive approach. Internal stakeholders (municipal units) and external stakeholders (public institutions, NGOs, the private sector, and citizens) were actively engaged in the process. Stakeholder meetings held in 2024 contributed to the preparation of a comprehensive and effective action plan.
- **Implementation and Monitoring of the Action Plan:** SECAP provides a roadmap that includes both short-term and long-term strategies. Regular monitoring and evaluation mechanisms will be established to increase the feasibility of achieving the defined targets.

As a result of the study, outputs will be obtained in the following areas:

- Greenhouse gas emissions inventory results for the 2023 calendar year
- Potential for greenhouse gas emissions reduction
- Potential to enhance the city's resilience to climate change

1. Introduction

1.1. About SECAP

The Sustainable Energy and Climate Action Plan (SECAP) is a strategic roadmap prepared by local governments to turn their commitments on energy and climate change mitigation into concrete actions. SECAP is a key commitment under the Global Covenant of Mayors for Climate and Energy (GCoM), which supports a future for cities by 2050 that is more resilient, sustainable, and provides fair access to energy.

SECAP includes actions that optimize energy consumption, promote renewable energy sources, and enhance the resilience of communities to the impacts of climate change, helping municipalities achieve their sustainability goals. During the preparation process, a current situation analysis, assessment of local conditions, and a participatory approach involving stakeholders are adopted.

1.2. Participation in the Mayors' Covenant and Commitments

GCoM is an important initiative that enables cities to join an international cooperation network in line with their climate change mitigation and sustainable energy goals. Cities that are signatories to GCoM have the advantage of promoting their local governments' climate and energy actions on a global scale, benefiting from national and international financing opportunities, and contributing to shaping the European Union (EU) climate policies.

The process of joining GCoM takes place in three main steps:

- Presenting the initiative to the City Council,
- The City Council making the decision to join the initiative and the Mayor signing the GCoM Participation Letter,
- Declaring city information online and uploading the signed GCoM commitment document to the system.

Cities that are signatories to GCoM commit to reducing greenhouse gas emissions by 55% by 2030, increasing resilience to climate change, and improving access to safe, sustainable energy[1].

Within the scope of these commitments, cities:

- Prepare a Greenhouse Gas Emission Inventory in accordance with the SECAP guidelines,
- Assess climate risks and vulnerabilities,
- Set time-bound and measurable emission reduction targets,
- Define climate adaptation goals supported by scientific data.

[1] https://eu-mayors.ec.europa.eu/en/about/objectives-and-key-pillars

- They are responsible for developing official plans that include sustainable energy access and low-emission development goals.

GCoM provides various methodologies and tools that align with the existing plans and policies of local governments. This flexibility offers an easy start for new municipalities and an opportunity for experienced municipalities to improve their current approaches.

1.3. Çankaya Municipality's Emission Reduction Goal and Vision

Located in the Central Anatolia Region, which is an important hub of Ankara, the Çankaya district faces climate change-related risks such as rising temperatures, water scarcity, drought, and floods caused by sudden rainfall. Çankaya Municipality supports its determination to mitigate these risks and adapt to climate change through sustainability policies and international commitments.

Çankaya Municipality aims to reduce its emissions by 55% by 2030, based on the year 2023, within the scope of SECAP to achieve its climate crisis mitigation goals. In line with this target, strategic steps such as energy efficiency, the use of renewable energy sources, and the expansion of carbon sink areas have been prioritized.

The Risk and Vulnerability Analysis prepared specifically for the Çankaya district has detailed the climate hazards observed in the area and guided the development of adaptation strategies. According to the analysis results, sudden temperature increases, floods caused by heavy rainfall, drought, and the reduction of green spaces have emerged as priority issues. Additionally, topics such as rainwater harvesting, wastewater recycling, the development of sustainable transportation systems, and energy transition projects are of critical importance.

Çankaya Municipality aims to realize a low-carbon, resilient, and green city vision by promoting the use of innovative technologies, participatory planning approaches, and public-private sector collaborations. By integrating the district's existing plans with SECAP actions to enhance resilience against climate change and reduce its carbon footprint, Çankaya is making steady progress toward creating a sustainable, accessible, and environmentally friendly living space.

1.4. Purpose of the Report

SECAP developed for the Çankaya district is designed as a strategic policy and action plan to combat the effects of climate change and reduce these impacts. This plan defines concrete steps to be taken in both mitigation and adaptation to address climate change and minimize its effects. Key focal points include increasing energy efficiency, promoting the use of renewable energy sources, and reducing the district's carbon footprint. In addition, SECAP aims to translate actions into implementation by setting concrete targets, timelines, and defining relevant responsibilities.

The plan, developed in accordance with the European Commission's guide on "How to Develop a Sustainable Energy and Climate Action Plan," offers recommendations to enhance Çankaya's existing planning processes and governance structure, taking these frameworks into consideration.

SECAP adopts a flexible and dynamic approach to combating climate change, rather than being a static document. Regularly reviewing the plan will be useful and/or necessary to respond to changing local and global conditions, assess the effectiveness of actions, and ensure continuous improvement.

1.5. Türkiye's Climate Change Strategies and Local Climate Planning

Türkiye has made significant strides in recent years in combating climate change and adapting to its effects, demonstrating its determination through long-term strategies and comprehensive action plans. "The Climate Change Adaptation Strategy and Action Plan (2024-2030)", prepared in line with the 2053 net-zero emissions target, was published in 2024 as an important indicator of these efforts.

Under the leadership of the Ministry of Environment, Urbanization, and Climate Change, efforts are being made to develop a "Climate Change Strategy" at the national level and "Climate Action Plans" at the local level. Local planning is designed to encompass various sectors such as water management, energy, agriculture, biodiversity, transportation, public health, and urbanization. In this regard, both national and local levels are working to increase resilience to climate change and achieve adaptation.

The "EU Partnership for Local Climate Action in Türkiye" project, implemented with the technical support of the United Nations Development Programme (UNDP) Türkiye and co-financed by the European Union and the Republic of Türkiye, is among the local-level projects. This project focuses on strengthening local climate actions by supporting initiatives aligned with Türkiye's 2024-2030 climate targets. Additionally, efforts have been initiated to prepare local climate action plans in the earthquake-affected regions, aiming to enhance communities' resilience to climate change-induced disasters.

In addition to all these developments, the opening of Türkiye's first Climate Portal in 2024 has been an important step in strengthening information sharing and collaboration in this field. The portal facilitates communication among stakeholders, allowing for the sharing of best practices and the adoption of innovative approaches in the fight against climate change. Furthermore, the "EU-Türkiye Climate Change Grant Program," launched in 2024, aims to directly support local climate projects and enhance the country's climate resilience.

2. Current Situation

2.1. In Today's Çankaya

Çankaya, as the central district of Türkiye's capital Ankara, is at the heart of the country's political, economic, cultural, and administrative structure. In addition to critical institutions such as the Grand National Assembly of Türkiye, ministries, military commands, public agencies, and embassies, Çankaya also houses commercial, social, and cultural centers. It is also an important representative of the Republic's history and Türkiye's modernization process.

As of 2024, the population of the district is 937,546, and its daily population exceeds 2 million. Çankaya is also a hub for education and research, hosting 7 state and 7 private universities, with over 100,000 university students.

Çankaya was selected as the second most developed district in Türkiye in a study conducted by the Ministry of Industry and Trade of the Republic of Türkiye. In addition, Ankara's status as the cultural capital further elevates the significance of Çankaya, which is home to numerous art and cultural centers.

Youth and Social Services

Çankaya Municipality has developed strategies for youth by adopting priorities such as reducing youth unemployment, EU citizenship, and active civic participation, in line with the European Commission's objectives. It supports young people through services such as free meals for university students, the Employment and Job Office, and exam preparation courses for disadvantaged students.

In addition, it offers services to a wide audience through facilities such as Çankaya Houses, Bahar Houses, the Korkmaz Tedik Youth Workshop, the Aşık Veysel Accessible Living

Center, and daycare centers. The Audio Library established for visually impaired individuals, music and youth workshops for children, youth, and people with disabilities, are part of the municipality's mission to provide equal opportunities to citizens.

2.2. Existing Plan and Strategies

Çankaya Municipality continues to develop projects within the framework of local and international collaborations, adopting an integrated approach to environmental sustainability and social development. In this context, projects implemented across a broad spectrum, ranging from European Union initiatives to local social enterprises, provide tangible contributions in various areas, such as sustainable urban planning, energy efficiency, raising public awareness, and promoting green infrastructure. The completed and ongoing projects by Çankaya Municipality in this focus area are presented below.

Environmental and Social Projects

- **N4C (Nature for Cities) Project:** This project, which aims to integrate nature-based solutions into urban planning, design, implementation, and management processes, is part of the Horizon 2020 initiative, where Çankaya Municipality is one of the pilot municipalities. The project provides a database and decision support platform to guide decision-makers in supporting the sustainable development of cities.
- **Empowering Women and Climate-Friendly Cities:** In collaboration with Frankfurt Municipality, this project focuses on raising awareness among women regarding energy efficiency and climate adaptation, and it has increased awareness across all segments of society through the "Climate-Friendly Women" group.
- **Nature and Cities Project:** This project promotes information sharing and collaboration between civil society organizations in Türkiye and the Netherlands, facilitating knowledge and experience exchange on nature-based solutions and green infrastructure.
- **Improving Street Quality and Accessibility in Çankaya Neighborhoods:** This project, with Bahçelievler Neighborhood selected as a pilot area, aims to create inclusive, safe, and healthy public spaces and to establish healthy living environments under sustainable development principles. The project outcomes offer a framework that can be adapted to other neighborhoods.

3. Method

The method followed in the Çankaya SECAP process and the greenhouse gas reporting framework is based on the "Emission Inventory Guide" created by the Covenant of Mayors for Climate and Energy (CoM).

The methodology used for calculating and evaluating city-scale greenhouse gas emissions within the scope of the study is shared in the subsequent sections of the report.

3.1. SECAP Planning Approach and Principles

Under the SECAP framework, greenhouse gas emissions are addressed under four main sectors: stationary energy, transport, waste, and others. Each of these sectors allows for the categorization and detailed analysis of emissions stemming from activities within the city.

- The **Stationary Energy** category covers emissions resulting from energy consumption in stationary sources within the city boundaries. In this category:
    - Emissions from residential buildings, commercial buildings, public buildings, industry, and agricultural activities are calculated based on the fuel used and grid energy.
    - Emissions from electricity consumption-related losses or theft within the city are also included in the inventory. These emissions are allocated according to the energy consumption of stationary sources by category.
- The **Transportation** sector includes emissions from fuel consumption during transportation and individual mobility. In this category:
    - Emissions resulting from all transportation activities across the city are thoroughly addressed based on fuel types and transportation categories.
    - Specifically, the vehicle fleets used by local governments within transportation activities are reported as a separate category within the scope of municipal operations.
- **Waste management** covers emissions from the disposal of municipal solid waste and domestic wastewater treatment processes in the city. In this category
    - Greenhouse gas emissions from the processes of waste storage, sorting, recycling, and disposal of municipal solid waste are detailed.
    - Emissions arising from the treatment and management of domestic wastewater are included in both the base year inventory and future projections.
- **Others** cover the emissions outside the fixed energy, transportation, and waste management categories in the city. Due to the absence of an organized industrial zone within the boundaries of Çankaya Municipality, industrial activities are observed to be

limited. Similarly, since there are no livestock activities in the area, there are no emissions originating from such activities. In this category, only the emissions from chemical fertilizers used in parks and gardens located within the boundaries of Çankaya District have been taken into account.

3.2. Selection of Baseline Year and Emission Inventory Approach

The first greenhouse gas inventory prepared in accordance with SECAP standards for Çankaya District is for the year 2023. Therefore, the year 2023 is referred to as the baseline year.

The boundaries of the inventory cover emissions within the jurisdiction and responsibility of Çankaya Municipality, which are within the administrative boundaries of Çankaya District. The definitions related to emissions within the district boundaries are as follows:

• Greenhouse gas emissions from sources within the district boundaries

• Greenhouse gas emissions resulting from electricity, heat, steam, and/or cooling purchased from the grid within the district boundaries

• All other greenhouse gas emissions occurring both within and outside the district boundaries as a result of activities taking place within the district

These emissions have been calculated using the calculation principles described below, based on the compilation of relevant activity data and the calculation of emission factors.

Activity Data (MWh) x Emission Factor (tCO2e/ MWh) = Greenhouse gas Emission (tCO2e)

The greenhouse gases considered within the inventory include carbon dioxide (CO_2), methane (CH_4), and nitrous oxides (N_2O). These gases are the major greenhouse gases in terms of emissions from energy use within the city boundaries and emissions from activities other than energy use. In other words, emissions are predominantly from CO_2, CH_4, and N_2O sources. Emissions from CH_4 and N_2O sources are included in the inventory using the global warming potentials published in April 2022 by the team of the IPCC Working Group II, which prepared the 6th Assessment Report (AR6), in terms of carbon dioxide equivalent (tCO2e).

The emission categories considered within the inventory for the Çankaya District and Çankaya Municipality are summarized below.

3.2.1. Emission Inventory Approach within the Boundaries of Çankaya District

This section of the report addresses emissions from fixed sources such as energy use in residential areas, commercial buildings, and industry, as well as emissions related to transportation and waste management within the boundaries of Çankaya District.

3.2.1.1. Fixed Energy Sources within the Boundaries of Çankaya District

To specify the amount of emissions from fixed units, the method outlined in Section 2.1 of the IPCC Good Practice Guidance and Uncertainty Management, Chapter 2, has been utilized. The emission quantities were obtained by multiplying activity data by the emission factor corresponding to the fuel type.

3.2.1.1.1. Residential Buildings

The quantities of direct emissions related to the combustion of fossil fuels for heating and cooking purposes in residential buildings are presented in the inventory as Scope 1 emissions. Scope 2 emissions related to electricity consumption have also been determined. The quantities of fuel and electricity consumed in residential buildings are provided in Table 3.1. Data on natural gas and LPG consumption have been obtained from the annual sector reports prepared by the Energy Market Regulatory Authority (EPDK) for 2023. The relevant sector reports include consumption values specific to the city of Ankara for the 2023 calendar year. For natural gas activity data:

- The ratio of the number of active subscribers in Çankaya District to the number of active subscribers in Ankara Province,
- Data from gas distribution companies in Ankara Province and those distributing gas in Çankaya District,
- The ratio of natural gas consumption in residential, industrial, and commercial buildings to electricity consumption values obtained from the electricity distribution company for the same categories,

are the parameters considered in calculations for residential, commercial, and non-municipal public buildings categories.

LPG data has been adapted to Çankaya District based on the ratio of its population to the total population of Ankara Province. Electricity data has been provided by Başkent Electricity Distribution Inc.

Natural gas and electricity consumption for public institutions' buildings are not separately mentioned in the referenced documents.

Table 3.1 Fuel and Electricity Consumption in Residential Buildings

Fuel	Consumption Area	Quantity	Unit
Electricity	Total Residental Buildings	1,014,306,405	kWh
Natural Gas	Total Residental	193,984,816	m^3
LPG	Total Residental	3,227	tons

Assumptions and Exclusions

- As there is no data covering leakage in natural gas distribution lines for the entire district, it has been assumed that 100% of natural gas consumption is burned at this stage.

- Losses and theft have been included in the calculations, considering the transmission loss rate (2.01%) shared by Başkent Electricity Distribution Inc. for Türkiye in 2023, and the distribution loss rate (5.60%) shared for Ankara.
- According to the 2023 LPG Market Sector Development Report by EPDK, the amount of bottled LPG sold within the boundaries of Ankara Province is 19,976 tons. The same report also addresses two different LPG usage categories, bulk and autogas, on a provincial basis. Since the data for bulk and autogas usage is separated, it has been assumed that the entire amount of bottled LPG is used in residential buildings. The total consumption for Ankara Province has been calculated based on the ratio of the population of Çankaya District to the population of Ankara Province.

3.2.1.1.2. Commercial Buildings and Non-Municipal Public Buildings

Direct emissions from fossil fuel consumption in commercial buildings have been included in the inventory. Emissions resulting from the use of grid electricity are addressed under Scope 2. The quantities of fuel and electricity consumed in commercial and public buildings are provided in Table 3.2.

Natural gas data has been obtained from the annual sector reports prepared by the Energy Market Regulatory Authority (EPDK) for 2023. The relevant sector reports include consumption values specific to Ankara Province for the 2023 calendar year. For natural gas activity data:

- The ratio of the number of active subscribers in Çankaya District to the number of active subscribers in Ankara Province,
- Data from gas distribution companies in Ankara Province and those distributing gas in Çankaya District,
- The ratio of natural gas consumption in residential, industrial, and commercial buildings to electricity consumption values obtained from the electricity distribution company for the same categories,

are the parameters considered in calculations for residential, commercial, and non-municipal public buildings categories.

It is assumed that the natural gas and electricity consumption values for public institution buildings are included within the consumption data for commercial buildings.

Table 3.2 Fuel and electricity consumption in commercial buildings and non-municipal public buildings

Fuel	Consumption Area	Quantity	Unit
Electricity	Total electricity consumption in commercial buildings and non-municipal public building	2,173,619,029	kWh
	Public Lighting	54,536,417	kWh
Natural Gas	Total natural gas consumption in commercial buildings and non-municipal public buildings	377,912,893	m^3

Assumptions and Exceptions

- Since there is no data covering gas leaks in the entire district, it is assumed that 100% of natural gas consumption is burned at this stage.
- The loss rates for transmission (2.01%) provided by Başkent Elektrik Dağıtım A.Ş. for Türkiye in 2023, and the distribution loss rate (5.60%) shared specifically for Ankara, have been taken into account, and losses have been included in the calculations.

3.2.1.1.3. Industry

Emissions resulting from the use of grid electricity in industry are considered. The amount of electricity consumed in the industry is presented in Table 3.3.

Electricity data is provided by Başkent Elektrik Dağıtım A.Ş.

Table 3.3 Fuel and electricity consumption in industry

Fuel	Consumption Area	Quantity	Unit
Electricity	Electricity consumption in industry	315,391,729	kWh

Assumptions and Exceptions

The transmission loss rate (2.01%) shared by Başkent Elektrik Dağıtım A.Ş. for Türkiye in 2023 and the distribution loss rate (5.60%) shared for Ankara have been taken into account in the calculation of losses.

3.2.1.1.4. Agricultural Activities

Emissions resulting from the use of network electricity in agricultural activities have been considered. The amount of fuel and electricity consumed in agricultural activities is presented in Table 3.4.

The electricity data is provided by Başkent Elektrik Dağıtım A.Ş.

Table 3.4 Fuel and electricity consumption in agricultural activities

Fuel	Consumption Area	Quantity	Unit
Electricity	Electricity consumption in agriculture	1,208,868	kWh

Assumptions and Exceptions

- The transmission loss rate (%2.01) shared by Başkent Electricity Distribution Inc. for Türkiye as a whole and the distribution loss rate (%5.60) specific to Ankara have been taken into account and included in the calculation of losses.

3.2.1.2. Transportation within the Borders of Çankaya District

When it comes to transportation in Çankaya District, road transport and rail systems are prominent. The electricity consumed by rail systems is embedded within the electricity consumption values under the category of commercial buildings and public buildings outside the municipality. Therefore, in this study, only data related to road transportation in Çankaya District have been considered.

For the quantification of direct emissions from road vehicles, the methodology described in the IPCC Good Practice Guidance and Uncertainty Management, Section 2.3, Mobile Combustion: Road Transport, in the National Greenhouse Gas Inventories was used. In line with the chosen method, CO2 emissions were calculated based on the amount, type, and carbon content of the fuel burned. Since the emission factors for CH4 and N2O depend on vehicle technology, fuel, and operational characteristics, they were not included in the inventory scope.

Fuel data are based on the sales statistics presented in the 2023 Annual Petroleum Market Report by the Energy Market Regulatory Authority (EPDK). In the calculations, it was assumed that all fuel sold within the borders of Ankara Province was used within Ankara. Based on this assumption, the consumption in Çankaya District was calculated considering its share of the population in the total population of Ankara. The numerical data for the fuel presumed to have been sold in Çankaya District are presented in Table 3.5 below. The emissions from road transport were derived by multiplying the presumed amount of fuel sold in Çankaya in 2023 by the fuel-type-specific emission factor. These emission factors were calculated using the data from the 2022 National Inventory Document (published in November 2024) and applying the Tier 2 approach.

Table 3.5 Fuel Amounts Sold in Çankaya in 2023 by Type

Fuel	Consumption Area	Quantity	Unit
Diesel	Energy/Fuel Usage in Private Public Transport Vehicles	29,856.45	liters
	Energy/Fuel Usage in Private Commercial and Passenger Vehicles*	367,633,259	liters
Gasoline	Energy/Fuel Usage in Private Commercial and Passenger Vehicles**	78,133,454	liters
LPG	Energy/Fuel Usage in Private Commercial and Passenger Vehicles	62,726	tons

*According to the 2023 Petroleum Market Report of EPDK, the amount of diesel sold within the borders of Ankara is 1,937,063 tons. The total diesel consumption calculated for Çankaya District using the defined methodology is 305,346 tons. In these calculations, the diesel consumption used for road transportation was adjusted by excluding the consumption data from Çankaya Municipality Buildings and Affiliates, as well as the data shared by EGO General Directorate, to avoid double-counting in relation to the EPDK data.

**According to the 2023 Petroleum Market Report of EPDK, the amount of gasoline sold within the borders of Ankara is 361,229 tons. The total gasoline consumption calculated for Çankaya District using the defined methodology is 58,305 tons. In these calculations, the gasoline consumption used for road transportation was adjusted by excluding the consumption data from Çankaya Municipality Buildings and Affiliates, as well as the data shared by EGO General Directorate, to avoid double-counting in relation to the EPDK data.

Assumptions and Exceptions

- It has been assumed that the consumption of electric vehicles in Çankaya is included in the emissions arising from "Commercial/Corporate" activities in the inventory.

3.2.2. Emission Inventory Approach within the Borders of Çankaya Municipality

This section of the report addresses emissions from fixed sources such as energy use in buildings and affiliates (İmar A.Ş., BEL-PET A.Ş., Belde A.Ş., and ÇANPAŞ), transportation, and waste management within the boundaries of Çankaya Municipality.

3.2.2.1. Fixed Energy Sources within the Borders of Çankaya Municipality

To determine the amount of emissions from fixed units, the method described in the IPCC Good Practice Guidance and Uncertainty Management, Section 2, Part 2.1 has been used. Emission quantities are obtained by multiplying activity data by the emission factor based on the type of fuel.

Emissions from fossil fuel combustion for heating and cooking purposes and electricity consumption in municipal buildings and affiliates are included in this category. The fuel and electricity consumption values for the municipality's buildings and affiliates are presented in Table 3.6.

The calculations are based on the total consumption for billing purposes for natural gas and electricity.

Table 3.6 Fuel and Electricity Consumption in Municipal Buildings and Affiliates

Fuel	Consumption Area	Quantity	Unit
Electricity	Directorate of Municipal Police	451,316	kWh
	Directorate of Veterinary Services	5,640.398	kWh
	Directorate of Social Assistance Affairs	172,556.884	kWh
	Directorate of Support Services	2,410,202.656	kWh
	Directorate of Culture and Social Affairs	1,271,332.43	kWh
	Nursery (or Daycare Center)	333,076.96	kWh
	Directorate of Public Works	982,770	kWh
	Directorate of Women and Family Services	272,627.004	kWh
	Directorate of Parks and Gardens	3,127,664.780	kWh
	Directorate of Cleaning Services	89,261.09	kWh
	İmar lnc.	27,756.71	kWh
	BEL-PET lnc.	181,110.191	kWh
Natural Gas	Directorate of Municipal Police	23,343	m^3
	Directorate of Veterinary Services	47,585	m^3
	Directorate of Social Assistance Affairs	27,042.98	m^3
	Directorate of Support Services	210,420.20	m^3
	Directorate of Culture and Social Affairs	377,094.23	m^3
	Nursery (or Daycare Center)	127,476.00	m^3
	Directorate of Public Works	138,750	m^3
	Directorate of Women and Family Services	80,481.163	m^3
	Directorate of Parks and Gardens Services	4,279.00	m^3
	Directorate of Cleaning Services	423,812.93	m^3
	İmar lnc.	9,964.84	m^3
	BEL-PET lnc.	3,192	m^3
	ÇANPAŞ	7,074.41	m^3
	Belde lnc.	8,089.72	m^3

Assumptions and Exceptions

Since there is no data covering the entire district regarding leaks in natural gas distribution lines, it has been assumed that 100% of the natural gas consumption is burned at this stage.

The loss rates shared by Başkent Elektrik Dağıtım A.Ş. for the year 2023, including the transmission loss rate for Türkiye as a whole (2.01%) and the distribution loss rate for Ankara (5.60%), have been considered and included in the calculation of losses and theft.

3.2.2.2. Transportation Within the Borders of Çankaya Municipality

The quantification of direct emissions from road vehicles was carried out using the methodology described in the IPCC Good Practice Guidance and Uncertainty Management, Chapter 2.3, Mobile Combustion: Road Vehicles, as applied in National Greenhouse Gas Inventories. In line with the chosen method, CO2 emissions were calculated based on the quantity, type, and carbon content of the fuel burned. Since CH4 and N2O emission factors depend on vehicle technology, fuel type, and operating characteristics, they were not included in the inventory.

The numerical data for fuels assumed to have been sold within the Çankaya District are presented in Table 3.7 below. Road transportation emissions for 2023 in Çankaya were determined by multiplying the quantity of fuel assumed to have been sold by the emission factor associated with the fuel type. The emission factors for different fuel types were calculated using data from the 2022 National Inventory Document (publication date: November 2024) and the Tier 2 approach.

CNG consumption data for 2023 were calculated based on the number of vehicles provided by EGO, their average fuel consumption, and the distances traveled.

Table 3.7 Fuel Consumption in Çankaya Municipality Buildings and Affiliates

Fuel	Consumption Area	Quantity	Unit
Diesel	Fuel/Energy Use in Municipality-Owned Public Transport Vehicles	15,552	liters
	Fuel/Energy Use in Municipal Heavy Equipment	4,059,232	liters
	Fuel/Energy Use in Municipality-Owned Light and Heavy Commercial Vehicles	128,786	liters
	Fuel/Energy Use in Municipality-Owned or Rented Passenger Vehicles	280,827	liters
Gasoline	Fuel/Energy Use in Municipal Heavy Equipment	17,129	liters

Fuel	Consumption Area	Quantity	Unit
	Fuel/Energy Use in Municipality-Owned Light and Heavy Commercial Vehicles	6,677	liters
	Fuel/Energy Use in Municipality-Owned or Rented Passenger Vehicles	43,997	liters
CNG	Fuel/Energy Use in Municipality-Owned Public Transport Vehicles	12,719,022	Sm^3

3.2.3. Waste Management

3.2.3.1. Solid Waste Disposal

Solid waste data is based on the waste quantity figures presented in the 2023 Ankara Provincial Environmental Status Report. Using these figures, the amount of solid waste in Çankaya District was calculated by considering the proportion of Çankaya's population within the total population of Ankara Province. Accordingly, the total amount of solid waste generated within the boundaries of Çankaya District in 2023 is 284,800 tons. There are no solid waste landfill sites or any waste disposal facilities within the district boundaries.

3.2.3.2. Wastewater Treatment and Discharge

Data on wastewater treatment for the 2023 calendar year was obtained from the Ankara Water and Sewerage Administration (ASKİ). The total amount of domestic wastewater generated and sent for treatment in Çankaya in 2023 was 70,208,885 m^3. The average per capita consumption and annual consumption in Çankaya are presented in Table 3.8.

Table 3.8 Annual Wastewater Generation in Çankaya District

Year	Consumption (m^3)	Average Per Capita Consumption (m^3/person)
2023	70,208,885.23	15.19

3.2.4. Others

3.2.4.1. Use of Chemical Fertilizers in Parks and Gardens

The data on the types and quantities of fertilizers used in 489 parks and gardens within the boundaries of Çankaya Municipality were obtained from the Parks and Gardens Directorate of Çankaya Municipality. In 2023, the amount of chemical fertilizers used within the boundaries of Çankaya District was 165 tons.

3.3. Emission Factors

The emission factors used to calculate in this study are provided in Table 3.9. These factors are based on the United Nations Framework Convention on Climate Change (UNFCCC) Türkiye 2022 National Inventory Report. For the calculation of emission factors for natural gas, liquid fuels, LPG, and grid electricity, the national data for natural gas, LPG, and liquid fuels presented in the most accessible year, 2022 National Inventory Report (EPDK 2023 Annual Sector Reports), and the Türkiye Electricity Transmission Corporation (TEİAS) electricity statistics database were used.

Table 3.9 Emission Factors

Activity/Fuel Type	Value	Unit	Source
Electricity consumption	0.433	tCO2e/MWh	UNFCCC Türkiye 2022 National Inventory Report (publication date: 2024) (Table 1s1). TEİAS 2022 Electricity Statistics “Changes in Electricity Energy Production, Consumption, and Loss Data in Türkiye by Years”
Natural gas consumption (residential heating)	0.201	tCO2e/MWh	UNFCCC Türkiye 2022 National Inventory Report (publication date: 2024) (Table 1A(4) Page Name: Table 1.A(4)b). Units converted using the net calorific values provided below in Table 5.
Diesel (road transport and freight)	0.262	tCO2e/MWh	UNFCCC Türkiye 2022 National Inventory Report (publication date: 2024) (Table 1A(a), Page Name: Table 1.A(a)s3). Units converted using the net calorific values provided below in Table 5.
Diesel (non-road vehicle activities)	0.286	tCO2e/MWh	UNFCCC Türkiye 2022 National Inventory Report (publication date: 2024) (Table 1A(a), Page Name: Table 1.A(a)s3). Units converted using the net calorific values provided below in Table 5.

Gasoline (road transport and freight)	0.250	tCO2e/MWh	UNFCCC Türkiye 2022 National Inventory Report (publication date: 2024) (Table 1A(a), Page Name: Table 1.A(a)s3). Units converted using the net calorific values provided below in Table 5.
Gasoline (non-road vehicle activities)	0.250	tCO2e/MWh	UNFCCC Türkiye 2022 National Inventory Report (publication date: 2024) (Table 1A(a), Page Name: Table 1.A(a)s3). Units converted using the net calorific values provided below in Table 5.
LPG (road transport and freight)	0.230	tCO2e/MWh	UNFCCC Türkiye 2022 National Inventory Report (Table 1A(a)) Sheet 3 of 4
LPG (non-road vehicle activities)	0.230	tCO2e/MWh	UNFCCC Türkiye 2022 National Inventory Report (Table 1A(a)) Sheet 3 of 4
Chemical Fertilizer (NPK)	0.86	tCO2e/ton	2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Table 11.3)

The global warming potentials (GWPs) of the gases assessed in this study, based on carbon dioxide equivalence, are provided in Table 3.10.

Table 3.10 GWPs of Gases Assessed in the Inventory Based on Carbon Dioxide Equivalence

Greenhouse Gas	**Value**	**Unit**	**Source**
Carbondioxide (CO_2)	1	kg CO_2e/kg	IPCC 2023 AR6
Methane (CH_4)	27.9	kg CO_2e/kg	IPCC 2023 AR6
Nitric oxide (N_2O)	273	kg CO_2e/kg	IPCC 2023 AR6

Source: IPCC, 2023. Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report: Climate Change 2023

Details of Wastewater Emission Factor Calculations

The calculation of CH_4 and N_2O emissions resulting from wastewater treatment was based on the methods presented in the *2006 IPCC Good Practice Guidelines: Volume 6 – Wastewater Treatment and Discharge* and the data from Türkiye 's 2022 National Inventory Document.

According to the referenced method, indirect N_2O emissions occur due to the discharge of effluent into aquatic environments, while direct N_2O emissions originate from centralized wastewater treatment systems involving nitrification and denitrification processes. In the province where the facility is located, the majority (almost all) of the wastewater is treated using biological treatment systems. Therefore, as a precautionary approach, N_2O emissions are calculated for the entirety of the wastewater.

Constant Values, Assumptions, and Exclusions Used in Calculations

Protein: The annual per capita protein consumption is 42.26 kg/person/year (Türkiye National Inventory Document 2022, (Published in 2023), Table 5.D)

F_{NPR}: The nitrogen fraction in protein is 0.16 kgN/kg protein (constant).

Fnon-con=	1,4	
F ind-com=	1,25	
Protein	42,26 (kg/person/year) (Türkiye 2022 National Inventory Document, Table 5D)	
BOD=	53 g/person/day (Türkiye 2022 National Inventory Document page 424)	
S =	54,664,263kg	Calculated value
Ui, rural =	0.00	2006 IPCC Section 6, Table 6.5
Ui, urban, high =	0.75	2006 IPCC Section 6, Table 6.5
Ui, urban, low =	0.25	2006 IPCC Section 6, Table 6.5
Tij, urban, high, central aerobic treatment plant =	1,0	2006 IPCC Section 6, Table 6.5
Tij, urban, high, sewage =	0,00	2006 IPCC Section 6, Table 6.5
Tij, urban, low, central aerobic treatment plant =	1,0	2006 IPCC Section 6, Table 6.5

Tij, urban, low, sewage =	0,00	2006 IPCC Section 6, Table 6.5	
EFj, central erobic treatment plant =	0,15	Türkiye 2022 National Inventory Document page 424, Table 7.34	
EFj, sewage =	0,00	Türkiye 2022 National Inventory Document page 424, Table 7.34	
R =	0,00	Assumed as “0”	
Bo =	0,60	kg CH_4/kg BOD	2006 IPCC Section 6, Table 6.2

In the calculation of emissions resulting from wastewater treatment activities, the "S" value (the organic matter fraction of the sludge removed from the wastewater as a result of the treatment activity, kg BOD/year) and "TOW" (total organics in wastewater) values have been calculated using the values shared for Türkiye as a whole in the Türkiye National Inventory Document 2022. The national inventory provides the "TOW" value for Türkiye as a whole. Using the relevant national inventory coefficients, a city-specific "TOW" value for the location of the facility has also been calculated. At this point, the ratio between the population of the city where the facility is located and the population of Türkiye in 2021 has been used to divide the "TOW" value shared in the national inventory for Türkiye by the ratio between the national "TOW" value and the value calculated specifically for the facility's location, resulting in a correction factor (1.200- correction factor). This correction factor has been used in the calculations of the "S" value specific to the city where the facility is located in the subsequent steps.

Household Solid Waste Emission Factor Calculations

The solid waste characterization shared by the Çankaya Municipality and the default data for West Asia and the Middle East in Table 2.4 of IPCC’s Volume 5: Waste, Section 2 have been used as references. The emission factor calculations have been carried out in accordance with the “2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 5 Waste, Chapter 3[2] ”.

3.4. Greenhouse Gas Emission Projection Model

The Kaya Identity (KI) model has been used in calculating greenhouse gas emission projections. As a result of using the Kaya Identity, greenhouse gas emissions for the Çankaya District have been projected for the years 2023-2030. In these calculations, the greenhouse gas emissions for 2023 have been taken as the base year values.

[2] https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol5.html

The Kaya Identity provides an important foundation for estimating greenhouse gas emissions, identifying emission-intensive areas, and developing policies accordingly. The most commonly used method for predicting greenhouse gas emissions is the equation known as the Kaya Identity, developed by Japanese energy economist Yoichi Kaya (Kaya, 1990). The KI model, used for greenhouse gas emission projections by the IPCC and the C40 Cities Climate Leadership Group, assumes that greenhouse gas emissions change in direct proportion to four main factors. These factors are as follows:

1. Population,
2. Gross Domestic Product
3. Energy intensity of the economy and
4. Carbon intensity of the economy

Definitions and related projection explanations for the four main factors listed above are provided below.

3.4.1. Population

The population projections for Ankara Province and Çankaya District for the period of 2023-2030 are used in the Kaya Identity Model. The reference sources for these projections are provided by the Turkish Statistical Institute (TUIK), including:

- Provincial population projections by year, 2023-2030
- Address-Based Population Registration System (ADNKS), 2023
- Türkiye 's population projection for 2023-2100.

Based on the data provided by these reference sources, the population projection data for Türkiye and Ankara Province are calculated as shown in Table 3.11.

Table 3.11 Türkiye Total and Ankara Province Population Projections (2023-2030)

Population	**2023**	**2026**	**2030**
Türkiye	85,372,377	86,654,276	88,188,221
Ankara	5,803,482	5,923,283	6,062,005

Population projections for Ankara Province from 2023 to 2030 are also presented in Figure 3.1. The provincial population projection values calculated by TUIK until 2030 are directly used in the calculations.

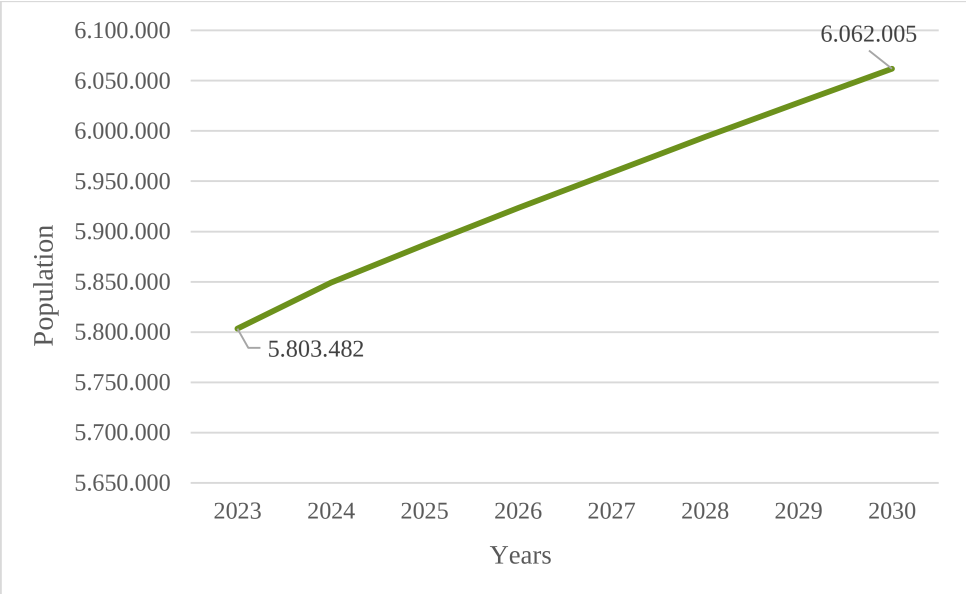

Figure 3.1 Ankara Province Population Projection

3.4.2. Gross Domestic Product (GDP)

Another factor used in per capita GDP greenhouse gas emission projections is the per capita GDP itself. For the per capita GDP projections, the statistics titled "Gross Domestic Product per Capita by Province, 2004–2022," published by TÜİK (Turkish Statistical Institute), have been used.

Between 2004 and 2022, the average annual increase in per capita GDP in Ankara, calculated in USD, was approximately 1.032%. Accordingly, in the emission projections, it has been assumed that the annual increase in per capita GDP between 2024 and 2030 will be 1.0062%.

3.4.3. Carbon Intensity of the Economy

The carbon intensity of the economy is defined as the amount of carbon emissions per unit of economic activity. It indicates the ratio of carbon emissions to GDP based on Purchasing Power Parity (PPP) values (CO_2/GDP). The carbon intensity of the economy is the product of the energy intensity of the economy and the carbon intensity of energy supply. This factor is also one of the parameters used in greenhouse gas emission projection calculations in Turkey's 8th National Communication. Accordingly, this factor has also been used in this study to calculate the greenhouse gas emission projections for the Çankaya District.

Table 3.12 Carbon Intensity of the Economy in Türkiye (tons CO2-eq / 1000 USD) (Constant 2015 USD)

Carbon Intensity of the Economy	2015	2016	2017	2018	2019	2020	2021	2022
Türkiye	0.55	0.58	0.62	0.66	0.68	0.74	0.71	0.62

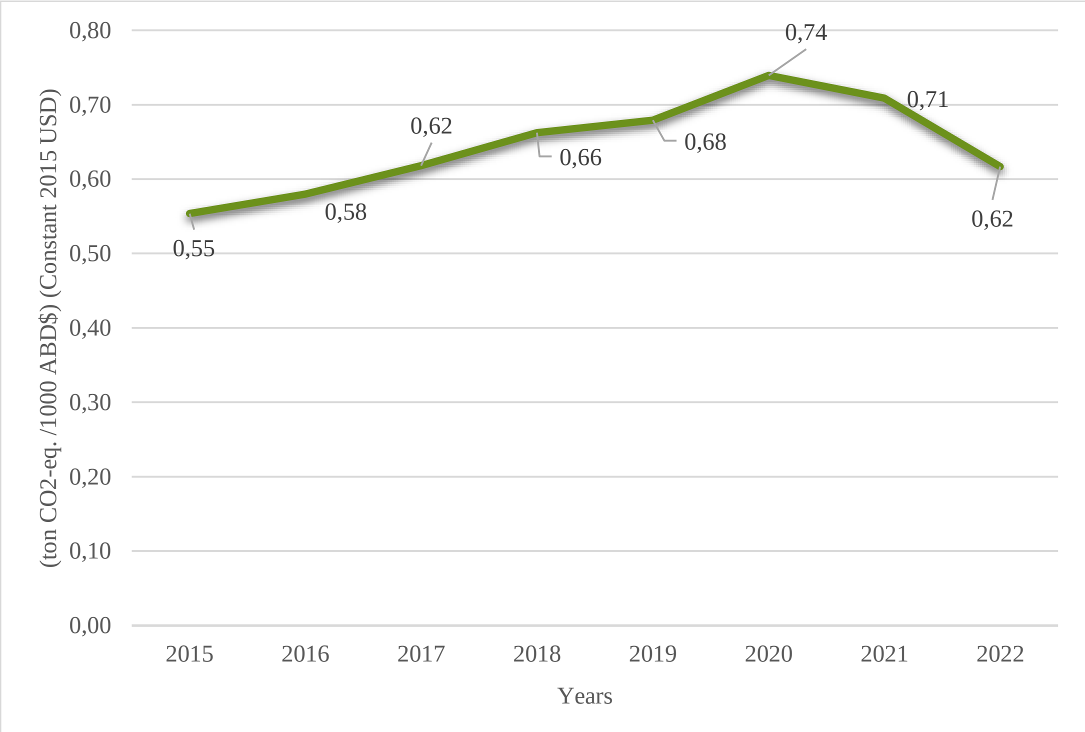

Figure 3.2 Carbon Intensity of the Economy in Türkiye (1990-2016) (Source: Ministry of Environment, Urbanization and Climate Change, Türkiye 's 8th National Communication, 2023)

In terms of the carbon intensity of the economy across Türkiye, the annual reduction in carbon intensity between 2015 and 2022 has been calculated as 1.014%. Based on this trend, it has been assumed that the carbon intensity will continue to decrease annually by 1.014% from 2016 to 2030. The annual carbon intensity values derived from this assumption have been used in the calculation of greenhouse gas emission projections for Ankara Province.

3.4.4. Energy Intensity of the Economy

The energy intensity of the economy is the ratio of primary energy consumption to Gross Domestic Product (GDP) based on Purchasing Power Parity (PPP) values (TOE/GDP(PPP)). Energy intensity reflects both the efficiency of energy use and the efficiency of the economic structure. It indicates the economic structure, energy consumption pattern, climatic conditions, and technical energy efficiency of countries or regions. The trend in energy intensity is influenced by structural changes in the economy and industry, changes in energy consumption patterns, and efficiency improvements in the equipment used by end-users and the building sector. Energy intensity of the economy has been used as another factor in calculating the greenhouse gas emission projections for Ankara Province.

Table3.13 Energy Intensity of the Economy in Türkiye (TEP/1000 USD) (Constant 2015 USD)

Energy Intensity of the Economy	2015	2016	2017	2018	2019	2020	2021	2022
Türkiye	0.0640	0.0650	0.0650	0.0620	0.0630	0.0620	0.0600	0.0560

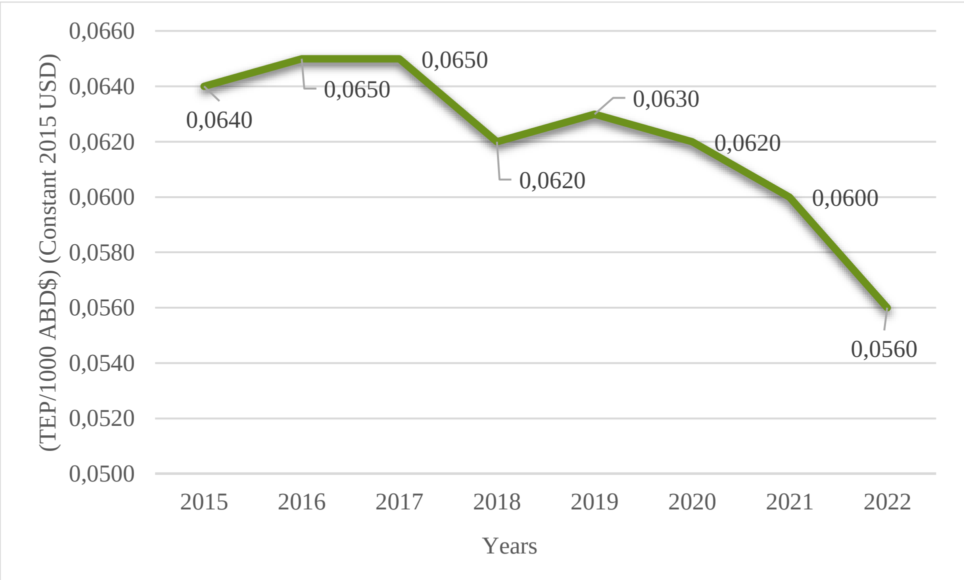

Figure3.3 Energy Intensity of the Economy in Türkiye (2015-2022) (Source: Ministry of Environment, Urbanization and Climate Change, Türkiye 's 8th National Communication, 2018)

The data on the Energy Intensity of the Economy in Türkiye shows a decrease in carbon intensity of 1.04% per year between 2015 and 2022. Based on this, it is assumed that energy intensity will continue to decrease by 1.04% annually from 2016 to 2030. The values obtained with this assumption Greenhouse Gas Emission Projection Calculations for Çankaya were used in the calculation of greenhouse gas emission projections for Ankara Province.

3.4.5. Greenhouse Gas Emission Projection Calculations for Çankaya Distict

The previous sections of the report have defined the factors used in the projection calculations and provided explanations for their values. This section presents detailed calculation formulas and the resulting outcomes.

To calculate the projected greenhouse gas emissions for a specific region in a given activity year, the following formula is used within the Kaya Identity framework:

CO_2 equivalent (greenhouse gas) emissions = Population × (Gross Domestic Product/Population) × (Energy/Gross Domestic Product) × (CO_2/Energy)

The "CO_2/Energy" factor in the formula can be calculated as follows:

CO_2/Energy = (Carbon Intensity of the Economy/Energy Intensity of the Economy)

Based on the values for the economy's energy intensity and carbon intensity as outlined in the previous sections, the "CO2/Energy" factor is calculated as **1.0139**.

The base year for Çankaya District's Greenhouse Gas Emission Inventory is 2023. The greenhouse gas emissions for this year have already been calculated. For the projections from 2023 onward, the Kaya Identity formula is used, considering factors such as population, energy intensity of the economy, carbon intensity of the economy, and the annual percentage increase/decrease in per capita GDP. The mathematical formula for this calculation is provided below.

*The **2024 CO2 equivalent (greenhouse gas) emissions** = [2023 CO2 equivalent (greenhouse gas) emissions × (2024 Çankaya District Population / 2023 Çankaya District Population) × (2024 Per Capita GDP / 2023 Per Capita GDP)] × (CO2/Energy)*

The emission projections by sector and fuel/electricity for 2023-2030 are provided in Table 3.14. As of 2023, the total emissions of Çankaya District amount to 4,726,503 tCO_2e. It is projected that by 2030, the emissions will reach 6,782,499 tCO_2e. In accordance with the SECAP, it is planned to reduce these emissions by 55% by 2030, aiming for a target level of 2,126,926 tCO_2e.

Table 3.14 Emission Projections

SECTOR	Greenhouse Gas Emission (tCO2e)							
BUILDINGS, FACILITIES AND INDUSTRY	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Municipal Buildings	8,335	8,776	9,241	9,730	10,246	10,788	11,359	11,961
Municipal Affiliates	159	167	176	185	195	205	216	228
Public Lighting	27,008	28,438	29,944	31,529	33,198	34,956	36,807	38,756
Commercial Buildings and Public Buildings other than Municipal Buildings	1,828,317	1,925,124	2,027,056	2,134,386	2,247,398	2,366,394	2,491,691	2,623,622
Residential Buildings	934,492	983,972	1,036,071	1,090,930	1,148,693	1,209,514	1,273,556	1,340,989
Industry	156,190	164,460	173,168	182,337	191,991	202,157	212,861	224,132
Subtotal	2,954,500	3,110,937	3,275,656	3,449,097	3,631,721	3,824,015	4,026,491	4,239,687
TRANSPORTATION		0	0	0	0	0	0	0
Public Transport	34,279	36,094	38,005	40,017	42,136	44,367	46,716	49,190

Public Construction Machinery/Equipment	6,046	6,366	6,703	7,058	7,432	7,825	8,240	8,676
Public Light and Heavy Commercial Vehicles	351	369	389	409	431	454	478	503
Public Rental and Passenger Vehicles	10,204	10,744	11,313	11,912	12,543	13,207	13,906	14,642
Private Public Transport	7,830	8,245	8,681	9,141	9,625	10,135	10,671	11,236
Private Rental and Passenger Vehicles	1,322,000	1,391,998	1,465,702	1,543,308	1,625,024	1,711,066	1,801,665	1,897,060
Subtotal	1,380,709	1,453,816	1,530,793	1,611,846	1,697,191	1,787,054	1,881,676	1,981,308
OTHERS		0	0	0	0	0	0	0
Agricultural Irrigation	57,911	60,978	64,206	67,606	71,186	74,955	78,924	83,103
Solid Waste Management	265,886	279,964	294,788	310,396	326,831	344,136	362,358	381,544
Waste Water Management	67,497	71,070	74,833	78,796	82,968	87,361	91,987	96,857
Fertilizer Use (Parks and Gardens)	147	150	153	155	158	161	164	167
Subtotal	391,441	398,718	406,130	413,681	421,371	429,205	437,184	445,311
TOTAL	**4,726,650**	**4,814,522**	**4,904,027**	**4,995,196**	**5,088,060**	**5,182,650**	**5,278,999**	**5,377,139**

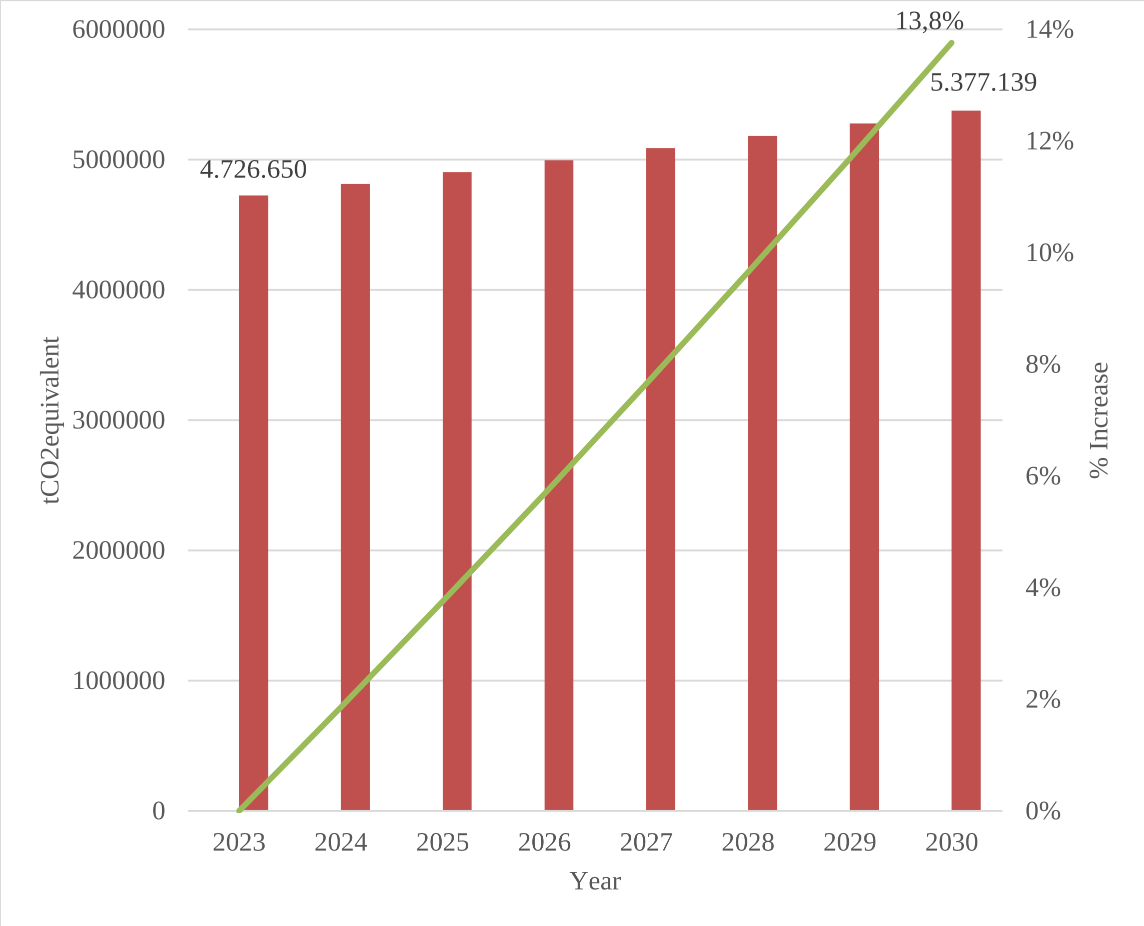

Figure 3.4Greenhouse Gas Emission Projection for Çankaya District between 2023 and 2030

Table 3.15 The projection of greenhouse gas emissions from Çankaya Municipality's operational activities for the period between 2023 and 2030

GREENHOUSE GAS EMISSIONS FROM ÇANKAYA MUNICIPALITY OPERATIONS (2023–2030) – BASELINE SCENARIO (TCO_2e/YEAR)								
MUNICIPAL BUILDINGS	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Electricity Consumption in Çankaya Municipality Buildings (excluding lighting, cooling, irrigation—includes electric motors, etc.)	4,564	4,649	4,735	4,823	4,913	5,004	5,097	5,192
Electricity Consumption in Çankaya Municipality Subsidiaries (excluding lighting,	98	100	102	104	105	107	109	111

cooling, irrigation—includes electric motors, etc.)								
Electricity Consumption for Park and Garden Irrigation (consumed by electric motors)	113	115	117	119	121	123	126	128
Natural Gas Consumption in Çankaya Municipality Buildings	3,771	3,841	3,913	3,986	4,060	4,135	4,212	4,290
Natural Gas Consumption in Çankaya Municipality Subsidiaries	61	62	63	64	65	66	68	69
TRANSPORTATION	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
BELPET Fuel Sales (Excluding Municipal Vehicles)	8,200	8,352	8,507	8,666	8,827	8,991	9,158	9,328
Diesel Consumption by Municipal Construction Equipment	6,315	6,432	6,552	6,674	6,798	6,924	7,053	7,184
Diesel Consumption by Municipal Waste Collection Vehicles	5,264	5,362	5,462	5,563	5,667	5,772	5,879	5,989
Diesel and Gasoline Consumption by Municipal Light Commercial Vehicles	351	357	364	371	378	385	392	399
Diesel and Gasoline Consumption by Municipality-Owned or Leased Passenger Cars	833	848	864	880	896	913	930	947
OTHERS								
Use of Chemical Fertilizers in Parks and Gardens	143	146	148	151	154	157	160	163
GRAND TOTAL	29,711	30,264	30,826	31,399	31,983	32,578	33,183	33,800

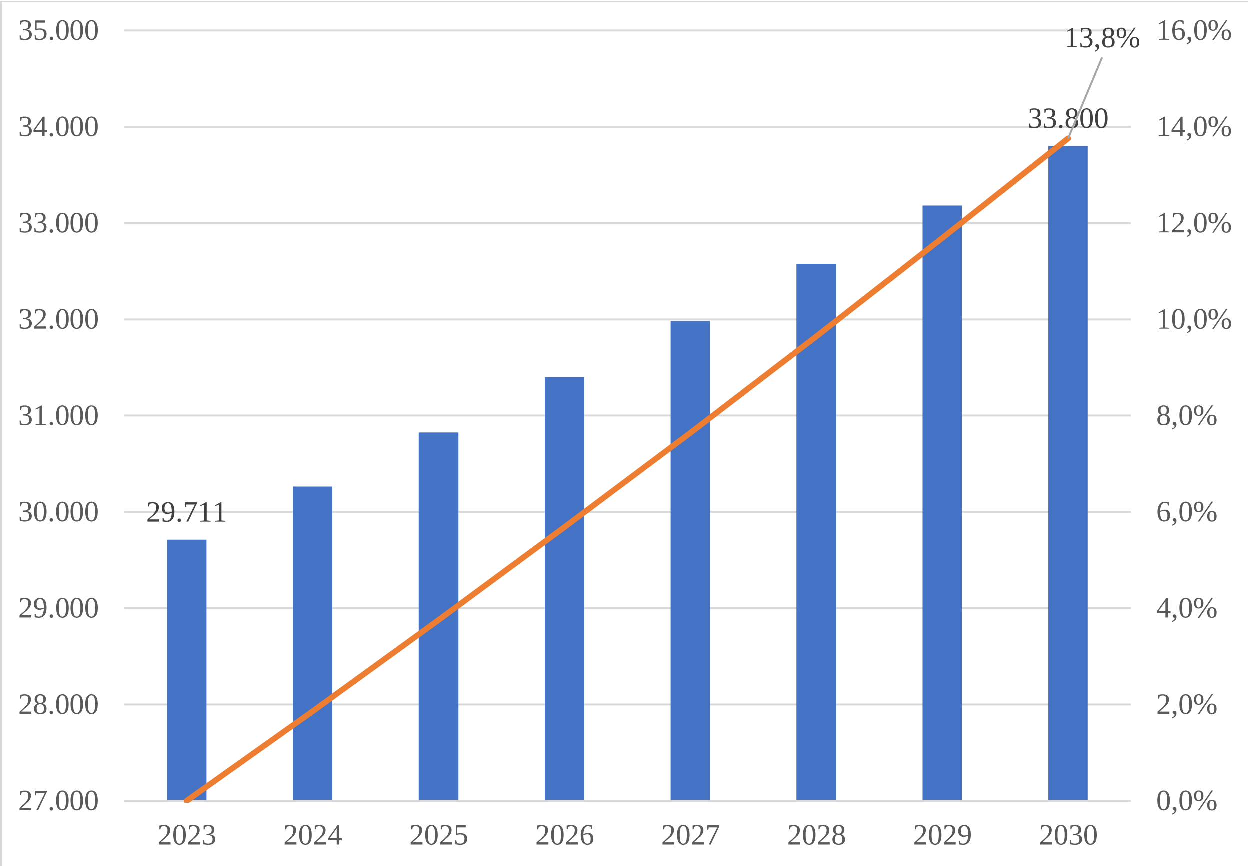

Figure 3.5 Emissions from Çankaya Municipality Operations Between 2023 and 2030 – Baseline Scenario (tCO₂e/year)

3.5. Method and Process in Determining Adaptation Actions

To determine adaptation actions for climate change-related events that have occurred from the past to the present and are likely to occur shortly as well as mitigation actions, the process has been managed with the following operational management (Figure 3.6). In the following sections, the findings of the stages in this process will be explained. First of all, the spatial distribution of hazards and the areas exposed to high risk that may arise due to the distribution of vulnerabilities are some of the stages using indices in temperature and precipitation data that may arise due to climate change and predictions for the future. Thus, in determining risk reduction and adaptation actions, the prominence of site-specific priority actions as well as general policies for the whole district would guide local governments in making proper decisions while maintaining resource management.

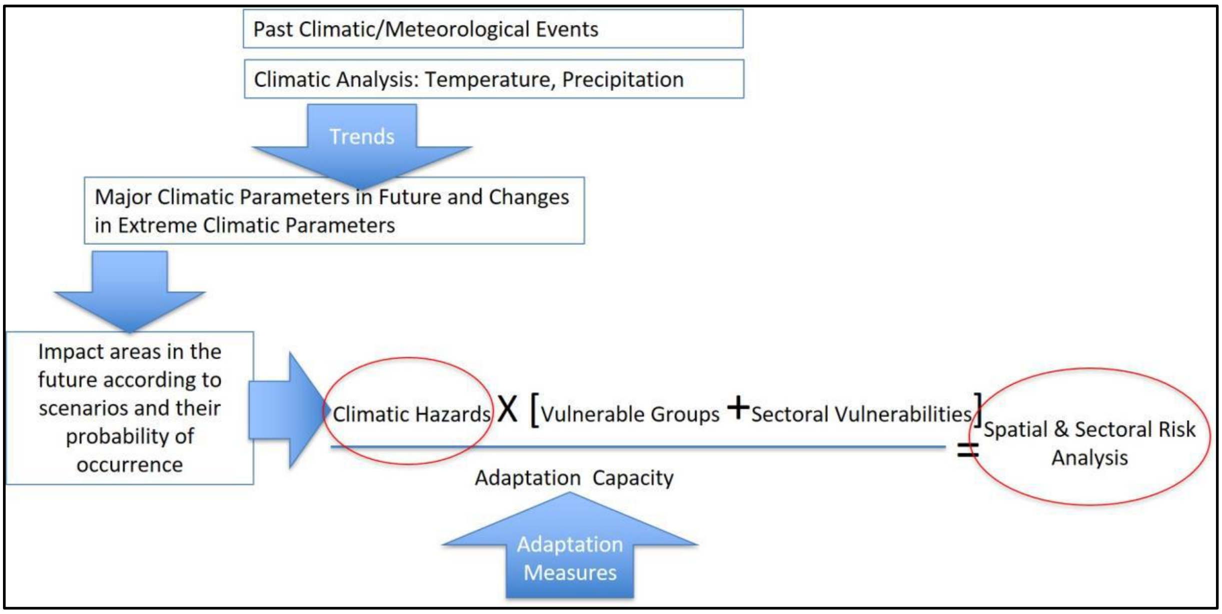

Figure 3.6 Flowchart for Determination of Adaptation Actions

As we can follow in the next section (climate risks, vulnerabilities, and adaptation strategies); in the light of the data obtained, it is one of the first stages to statistically provide past climatic and meteorological events both in Ankara and in Çankaya district. In addition, there is a stage of explaining the climate parameters of the past and present as well as the extreme climate parameters of the future according to various scenarios. Thus, some spatial analyses would be made on the extent to which vulnerable communities and sectors are affected in the face of situations. The increase or decrease in the frequency and the impact area of climate hazards in the future could be estimated and to what extent the adaptation capacity should be increased in the face of this situation.

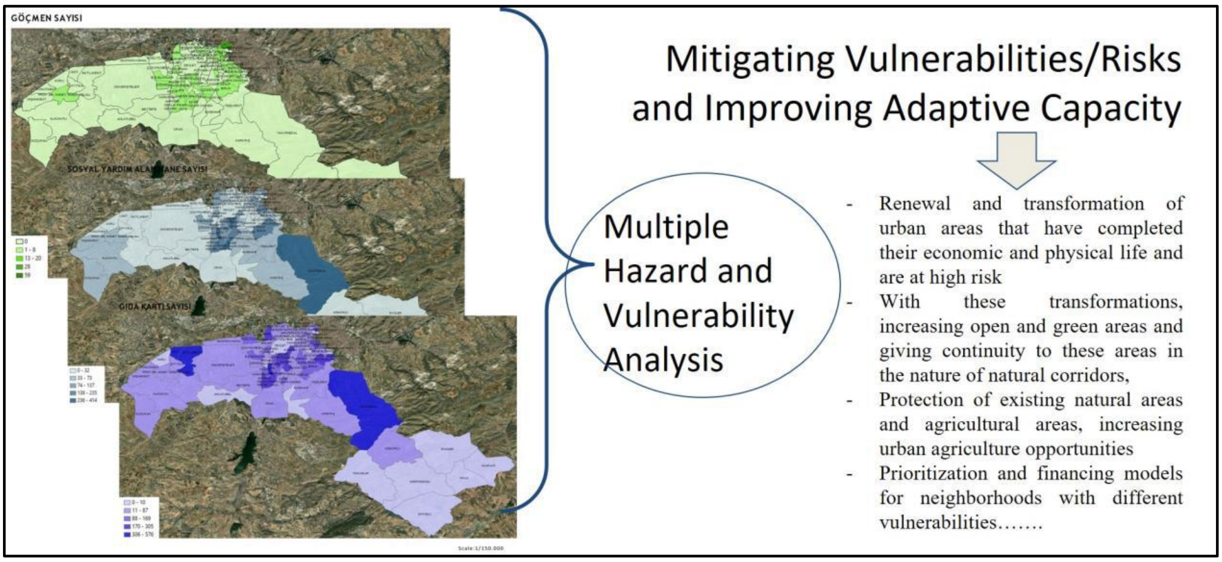

Figure 3.7 Risk Mitigation and Adaptation Capacity Building on the Identification of Multiple Hazards and Vulnerabilities

4. Climate Risks, Vulnerabilities, and Adaptation Strategies

This section would like first to determine the areas where climate-related hazards and the vulnerable population exposed to these hazards coexist, then to find the risks based on some predictions over the impact areas and frequencies of the events that are likely to increase in the future; and finally to put forward strategies to reduce these risks, as well as actions to increase the adaptation capacity against irreversible situations in the future.

In the beginning, it is necessary to identify the relationships between basic concepts such as hazard, vulnerability, exposure, risk, and adaptive capacity. As can be seen in the figure below, it is necessary to find the risk situations spatially through the relationships of concepts such as exposure to climatic hazards, the vulnerability of these values, and the capacity to cope with the consequences of hazards and to adapt to them. By using the current hazard maps, the hazards and vulnerabilities were identified by obtaining them from various institution reports, the most up-to-date data provided by the municipality, and the predictions produced within the scope of the SECAP project. However, the limited or insufficient spatial data of sectors such as buildings, land uses, critical infrastructures, transportation, etc., which are in use about the vulnerability of the values of the district exposed to hazards, has led to more general expressions in determining the risk levels. In the whole district, high degree hazard areas have been pointed out roughly. In this context, it is considered necessary and beneficial to renew the SECAP study and rate the risks by updating the data or completing the missing data in the upcoming period to calculate the vulnerable values and prioritize them more clearly through the method revealed by the SECAP study carried out for the first time in Çankaya district.

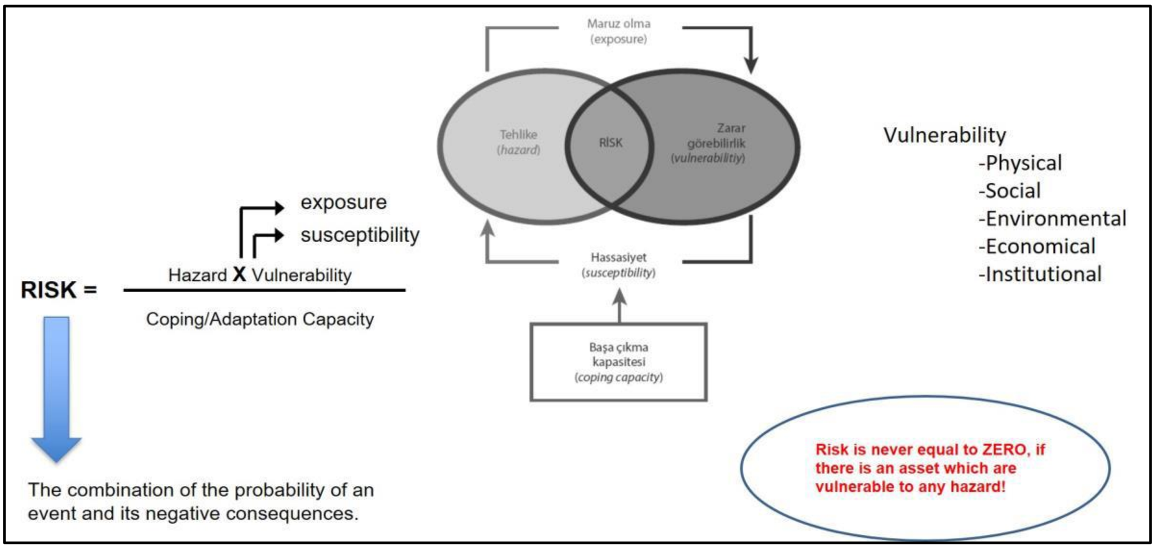

Figure 4.1 Conceptual Scheme for Hazard-Exposure-Vulnerability-Risk Relationship

Before conducting detailed spatial, social and climatic studies carried out for Çankaya district, basic information about Ankara in general will be given. In the subsections, climatic hazards and social vulnerabilities would be generated at the neighborhood scale. In this way, it is aimed to highlight the more vulnerable neighborhoods that are exposed to many hazards and to prioritize them accordingly within the scope of adaptation measures.

4.1. General Climatic Characteristics and Spatial Changes Specific to Ankara Province and Districts

Ankara and its surroundings are diverse in terms of geographical conditions and climatic characteristics. In this area, which spreads over a wide area, the typical steppe climate of the Central Anatolia Region is effective in the south, while the temperate and rainy characteristics of the Black Sea climate can be observed in the north. A continental climate prevails throughout the region; Temperatures are quite low in winter and quite high in summer. The hottest months were recorded as July and August, and the coldest month was January.

Rainfall amounts in the region vary significantly between the north and the south. In the north, Kızılcahamam and Çubuk attract attention with their precipitation regime typical of the Black Sea climate, while in the south, the characteristic features of Central Anatolia are dominant. Fog, which is frequently seen especially in winter, negatively affects life in the region from time to time.

While the average annual temperature in Ankara varies between 10-13°C, the average monthly rainfall is recorded between 11-55 mm. The highest temperature was measured in Sarıyar with 41.4°C, while the lowest temperature value was recorded in Esenboğa with -32.2°C. The number of days with annual frost events in the region varies between 60-117, while the number of snow-covered days is between 10-70 days. The highest snow thickness was measured in Kızılcahamam with 82 cm.

Wind analysis varies depending on the topographic structure. The prevailing wind direction in Ankara center, Esenboğa, Çubuk, Ayaş and Yenimahalle is northeast; west in Haymana, Sincan, Dikmen and Nallıhan; north in Polatlı and Şereflikoçhisar; southwest in Etimesgut and Elmadağ; Southeast in Kızılcahamam; in Beypazarı, it is north-northeast. The strongest winds are seen in March and April. The highest wind speed detected in Ankara was recorded as 32.1 m/s blowing from the southeast.

Pressure variations are usually limited on a daily basis; however, differences can be observed depending on the air masses that affect our country. According to the data of many years, the average pressure value of Ankara was recorded as 912.7 mb, the highest pressure was 936.5 mb, and the lowest pressure was 882.6 mb. In Ankara, which is surrounded by mountains, winters are cold and summers are dry, while the rainiest period is spring.

These climatic and topographic conditions allowed the development of two different vegetation in the region, steppe and forest. Steppe vegetation is common in hollow areas and plateaus with low rainfall. Trees are very few in this plant community; thorny shrubs and grasses of small stature predominate. Tree species such as spindle, willow and poplar are found on the banks of the stream. This diversity constitutes the basic elements of Ankara's natural texture.[3]

Çankaya district has continental climate characteristics. The winter months are cold and snowy, and the summer months are hot and dry. While dry frost is generally effective in the winter season, elevation precipitation (Kırkikindi precipitation) is observed in the spring months. Since the Central Anatolia Region is the region with the least rainfall in Turkey, one-third of the year in Çankaya consists of sunny days.

Çankaya is a district where industry, trade, and service sectors are concentrated rather than agricultural activities. However, agricultural production continues on a limited scale in Beytepe, Dodurga, Alacaatlı, Karataş, Çavuşlu, Akarlar, Evciler, Kömürcü, Karahasanlı, Yayla and Tohum neighborhoods. Wheat, barley, chickpeas, safflower, sunflower, and melon are produced in these regions. Although Çankaya is a district mainly focused on the service and trade sector, agricultural activities in rural neighborhoods meet local needs and offer economic diversification.[4]

To better analyze the cause and spatial equivalents of climate risks, changes in spatial land use were examined through Corine data between 1990 and 2018. As a result, it has been observed that the most change is the transformation from agricultural to urban areas.

[3] https://www.ktb.gov.tr/yazdir?67927A2F4D87EE98FC9D090954FDF53F

[4] https://www.ktb.gov.tr/yazdir?67927A2F4D87EE98FC9D090954FDF53F

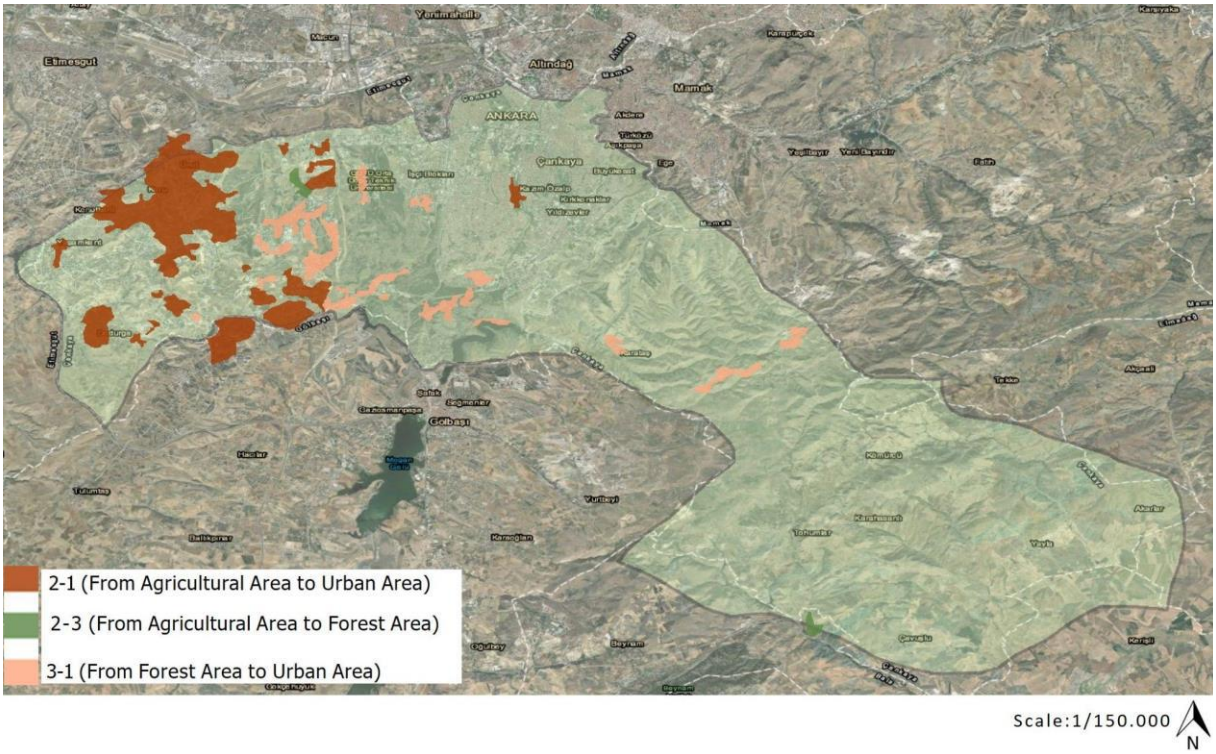

Figure 4.2 Land Use Change in Çankaya District Between 1990-2000 (Thematic maps were prepared in GIS from Corine, 2024 data)

Between 1990 and 2000, it was observed that the most change was from agricultural land to urban area. Particularly in the western part of Çankaya district, agricultural lands have been opened for development in quite large areas. In addition, there are areas that have transformed from forest to urban areas. These are spread as building plots throughout the district.

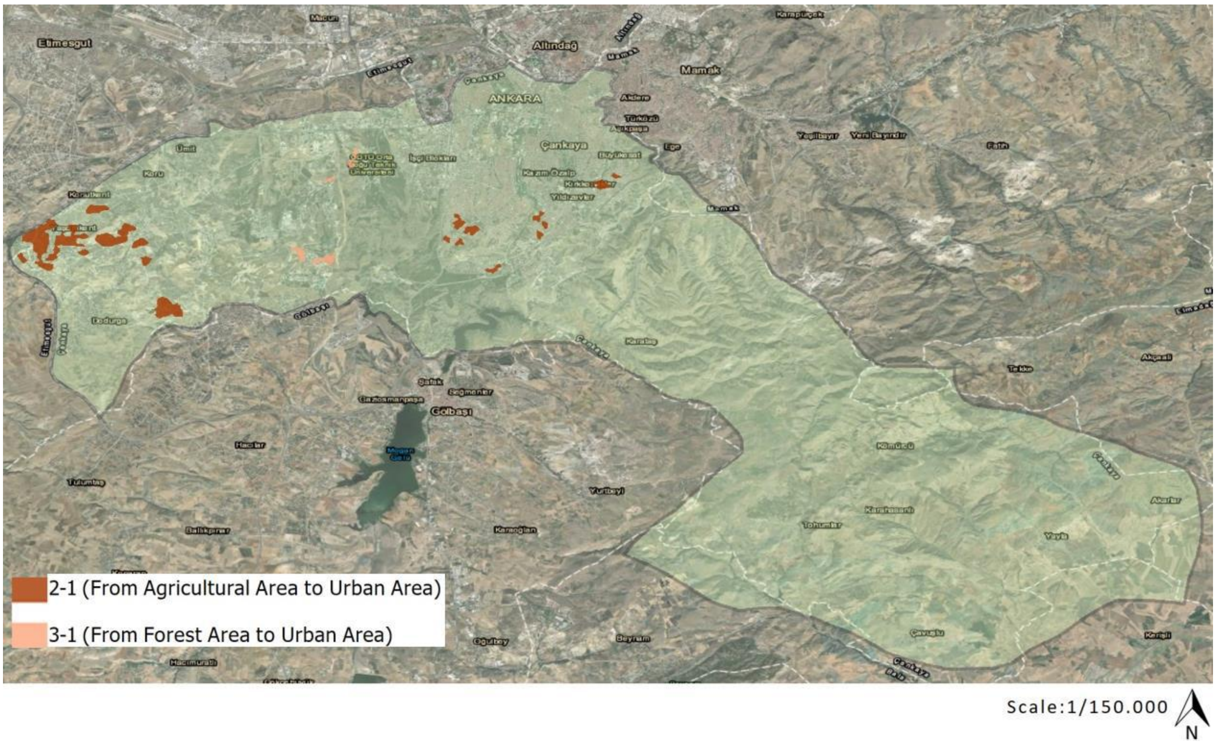

Figure 4.3 Land Use Change in Çankaya District Between 2000-2006 (Thematic maps were prepared in GIS from Corine, 2024 data)

Although there were no major changes in the district between 2000 and 2006, agricultural lands that were transferred into urban uses were identified, especially in the central neighborhoods and in the west of the district.

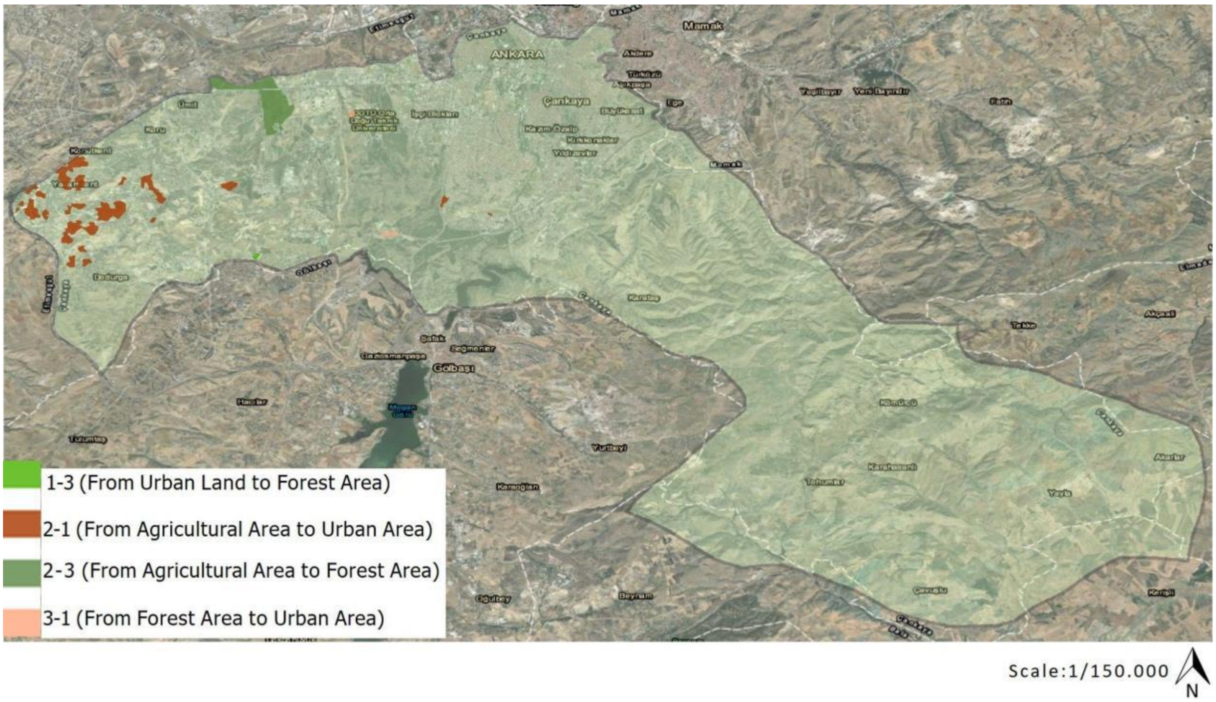

Figure 4.4 Land Use Change in Çankaya District Between 2006-2012 (Thematic Maps were prepared in GIS from Corine, 2024 Data)

Between 2006 and 2012, various agricultural lands in the west of the district were changed into urban areas and agricultural land in the northwest was turned into a forest area.

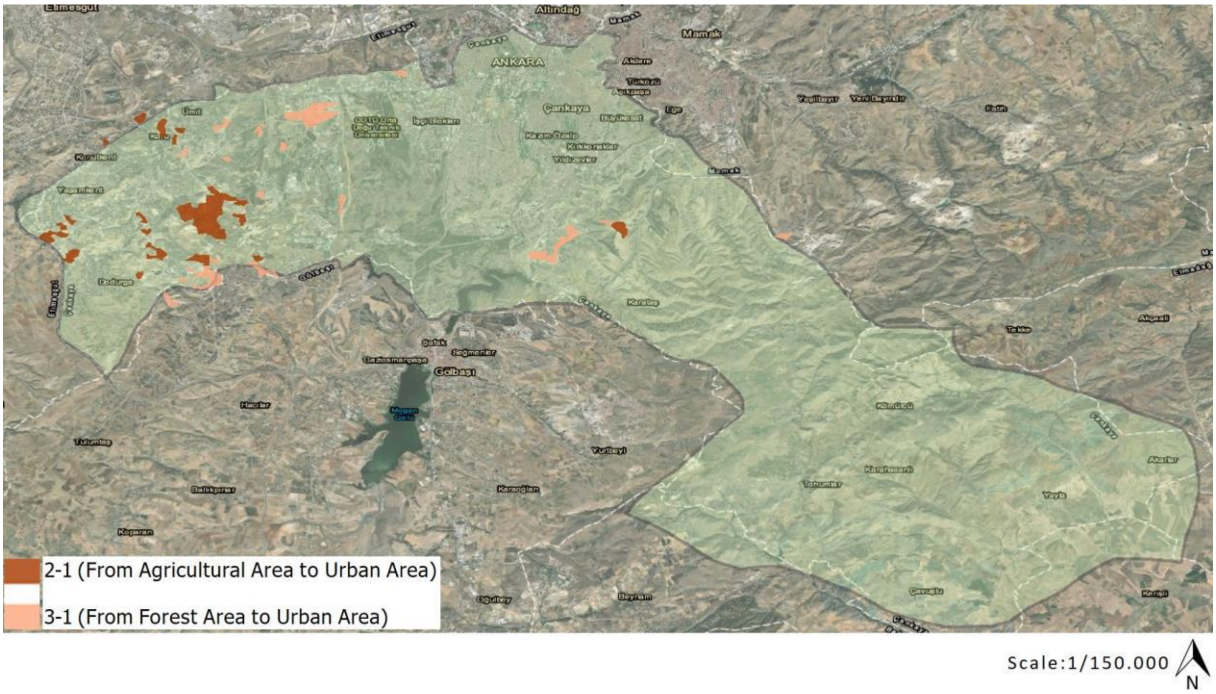

Figure 4.5 Land Use Change in Çankaya District Between 2012-2018 (Thematic Maps were prepared in GIS from Corine, 2024 Data)

Between 2012 and 2018, with the transformation of agricultural lands into urban areas, the opening of forest areas to land use zoning and their transformation into urban areas came to the fore. It has been analyzed that there are more areas that have turned into urban areas in the west of the district.

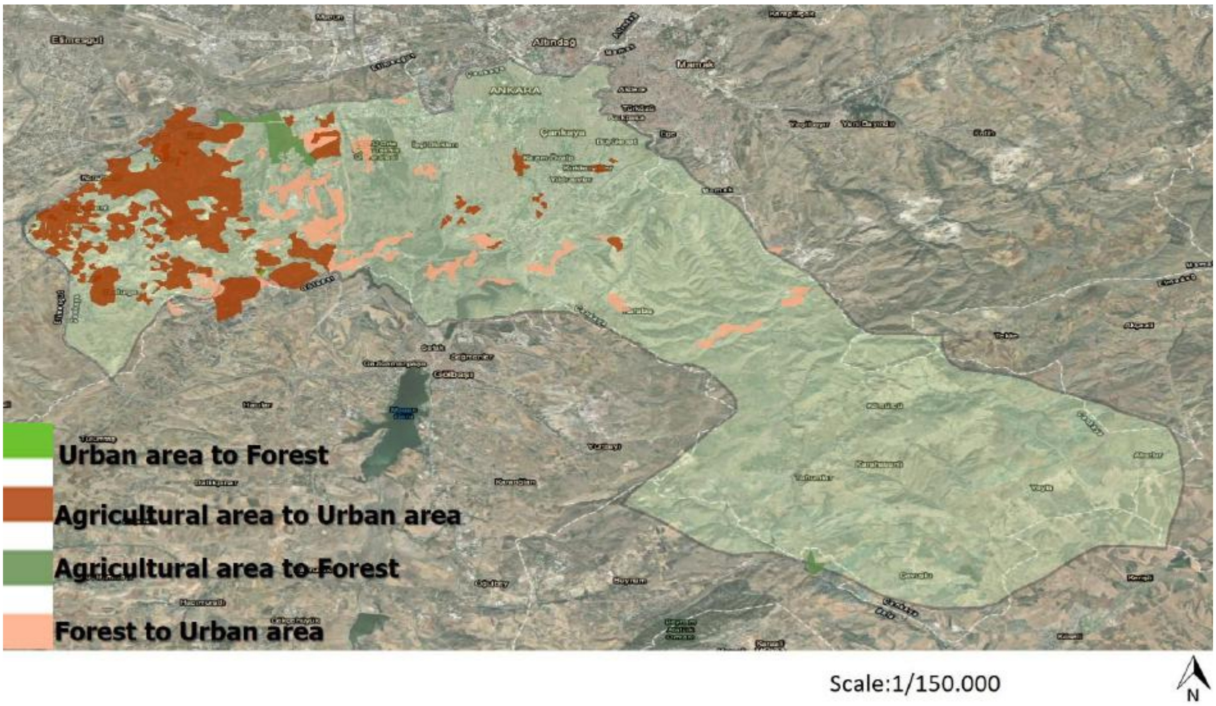

Figure 4.6 Land Use Change in Çankaya District Between 1990-2018 (Thematic Maps were prepared in GIS from Corine, 2024 Data)

In summary, based on the change between 1990 and 2018 examined, it is observed that agricultural lands were opened for development and quite a large area in the west of the district turned into an urban area and served the settlement. In addition, it stands out that the forest lands spread throughout the district are open to development and added to the urban fabric. However, it is rarely seen throughout the district that urban areas turn into forest areas or agricultural land. This raises questions in terms of climatic hazards and vulnerability.

Based on analyses using other data sources, such as the Urban Atlas 2018 dataset, it is evident that the older neighborhoods in the central parts of the district are heavily occupied by dense urban uses (indicated in dark red tones), and consequently, the amount of public open green space at the neighborhood level has decreased (Figure 4.7). In contrast, the peripheral neighborhoods of Çankaya District appear to have relatively more open space uses.

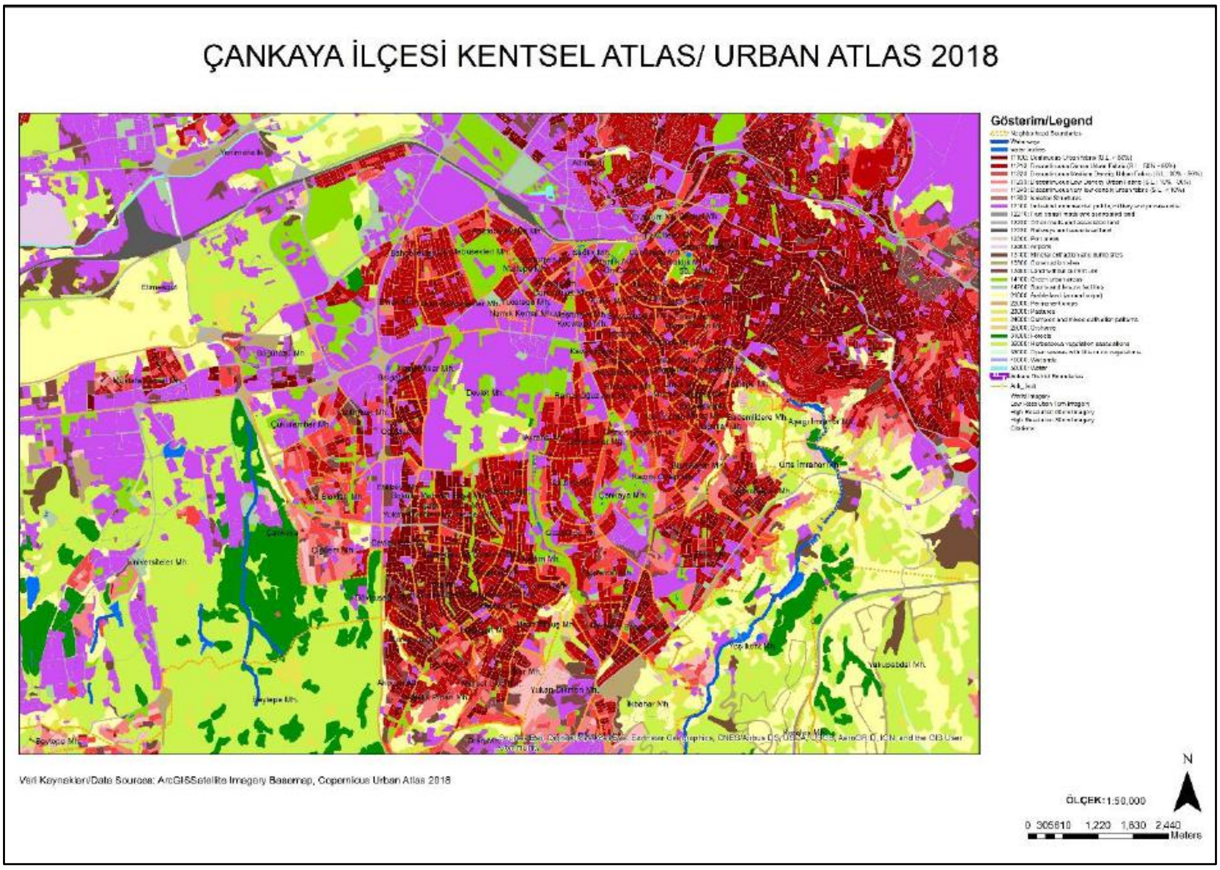

Figure 4.7 Urban Land Use Map of Çankaya District – 2018 (Based on Copernicus Urban Atlas 2018 Data)

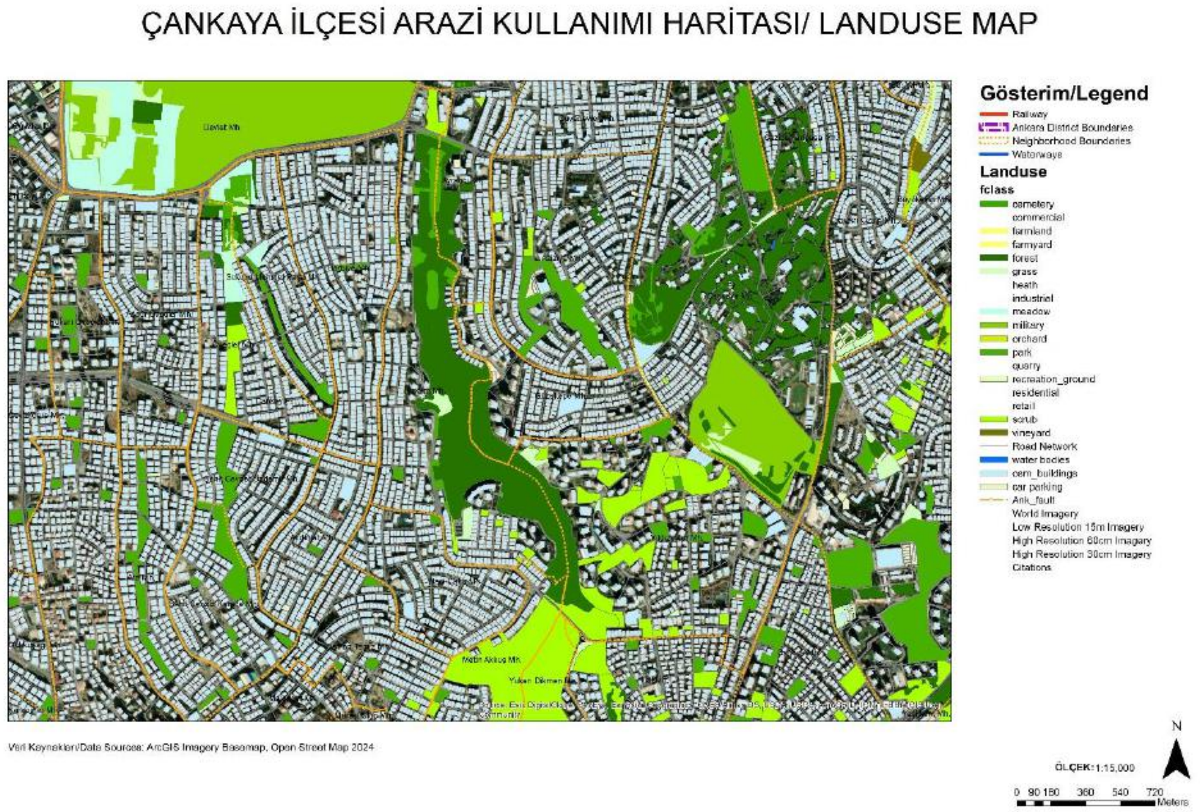

Figure 4.8 Distribution of Open Spaces and Buildings in Çankaya District (Based on Copernicus Urban Atlas 2018 Data)

4.1.1. Past Disaster

Between 1960 and 2021, a total of 925 disaster events occurred in Ankara as a result of earthquakes, landslides, rockfalls, floods and other types of disasters, and 7,679 housing units and workplaces were transferred due to these events. 60 of these disasters, i.e. approximately 6.5%, took place in Çankaya district, and 448 housing units and workplaces (5.8%) were moved to another area within the boundaries of the district. An area of approximately 250 hectares throughout the province has been declared as a disaster-prone area.

Table 4.1Distribution of Disasters in Ankara Between 1960-2021 by Districts (Source: IRAP (Provincial Local Disaster Risk Reduction Plan) Ankara, 2021)

Name of Districts	Earthquake	Landslide	Flood	Rockfall	Others	Total
Akyurt	2	15	23	0	0	40

Altındağ	0	8	2	29	7	46
Ayaş	0	14	0	1	0	15
Bala	2	10	19	3	3	37
Beypazarı	0	19	5	15	21	60
Çamlıdere	0	8	2	1	11	22
ÇANKAYA	**0**	**42**	**12**	**2**	**4**	**60**
Çubuk	2	34	16	2	8	62
Elmadağ	1	11	8	0	0	20
Etimesgut	0	14	4	0	0	18
Evren	0	0	0	0	0	0
Gölbaşı	1	5	4	0	6	16
Güdül	0	3	3	2	6	14
Haymana	0	5	6	3	4	18
Kalecik	4	49	21	5	6	85
K.Kazan	0	8	0	3	1	12
Keçiören	0	8	3	6	5	22
Kızılcahamam	1	20	22	2	12	57
Mamak	0	100	13	4	3	120
Nallıhan	0	45	5	17	21	88

Polatlı	0	2	16	2	1	21
Pursaklar	0	8	1	0	1	10
Sincan	1	8	7	1	3	20
Ş.Koçhisar	1	18	7	0	4	30
Yenimahalle	1	18	9	1	3	32
TOTAL	16	472	208	99	130	925

Table 4.2 Distribution of the Number of Transfers of developments realized as a result of the disaster in Ankara between 1960-2021 by districts (Source: IRAP Ankara, 2021)

Name of Districts	**Earthquake**	**Landslide**	**Flood**	**Rockfall**	**Others**	**Total**
Akyurt	7	144	10	0	15	176
Altındağ	0	54	17	339	19	429
Ayaş	0	148	7	7	0	162
Bala	1138	26	140	0	2	1306
Beypazarı	0	128	5	164	97	394
Çamlıdere	0	11	0	0	94	105
ÇANKAYA	**0**	**374**	**25**	**49**	**0**	**448**
Çubuk	68	107	55	1	66	297
Elmadağ	33	237	195	0	0	465

Etimesgut	0	30	0	0	0	30
Evren	0	0	0	0	0	0
Gölbaşı	20	0	1	0	0	21
Güdül	0	4	28	14	0	1446
Haymana	0	28	4	4	5	41
Kalecik	78	382	98	15	1	574
K.Kazan	0	3	6	3	0	12
Keçiören	0	65	43	43	0	151
Kızılcahamam	19	71	134	13	71	308
Mamak	0	1296	12	28	0	1336
Nallıhan	0	201	0	63	441	705
Polatlı	0	0	193	0	0	193
Pursaklar	0	84	0	0	0	84
Sincan	0	57	11	0	0	68
Ş.Koçhisar	2	165	115	0	2	284
Yenimahalle	0	24	13	0	7	44
TOTAL	1365	3639	1112	743	820	7679

4.1.1.1. Earthquake

Although Ankara has not been the center of destructive earthquakes to date, the earthquakes around it have been effective. The 2000 Çankırı (Moderate) earthquake (M 5.9) and the 2007 Bala earthquake (M 5.7-5.5) caused damage in some areas, especially in the Bala earthquake, 1,150 houses were severely and moderately damaged.

As a result of the earthquakes that occurred in Akyurt Ahmetadil (M 4.5) in 2020 and Kalecik Eskiköy (M 4.5) in 2021, heavy damage was recorded in a total of 17 houses and 258,000 TL cash aid was provided for 28 houses.

When the houses in Ankara were examined within the scope of compulsory earthquake insurance, it was determined that 931,310 of the existing 1,525,130 houses had earthquake insurance, which shows that there is 61.10% insurance in the houses. In Çankaya district, between 2017 and 2021, the number of houses insured against earthquakes increased from 168,774 to 198,913, an increase of 17%.

Table 4.3 Change in the Number of Earthquake Insured Houses in Çankaya District by Years (Source: IRAP Ankara, 2021)

	2017 Number of Insurance Certificate	2018 Number of Insurance Certificate	2019 Number of Insurance Certificate	2020 Number of Insurance Certificate	2021 Number of Insurance Certificate
ÇANKAYA	168.774	176.480	180.732	190.042	198.913

4.1.1.2. Landslides and Rockfalls

The largest economic losses after the earthquake in Ankara are due to landslides and rockfall events. Various measures have been taken against rockfall in Keçiören, Bala and Nallıhan districts in the past years. In addition, between 2018 and 2021, 73,000 TL cash aid was provided for 8 houses affected by landslides and rockfalls. It has been reported that 5% of the landslide disaster and 2% of the rockfalls in Ankara are in Çankaya district.

There were landslide incidents in different regions throughout Ankara, in the central districts and in the surrounding districts. In the areas where the construction is intense in the central districts, it has been determined that the geological-geotechnical surveys based on the zoning plan are either not carried out or are carried out to increase the number of floors to a large extent. In these areas, it has been observed that the ground surveys made before the construction decisions were generally used. In addition, the failure to comply with the geological survey reports based on the zoning plan made by Iller Bank in the past years was revealed by the landslide incidents that occurred in the Cevizlidere and Alacaatlı Districts of Çankaya district.

On the boundary of Çankaya and Mamak districts, a major landslide occurred in a slum area with insufficient infrastructure, which required the evacuation of 367 houses. As a result of the landslide that occurred in the Cevizlidere District of Çankaya district, 8 buildings (69 housing units) were evacuated and this area was declared a "Disaster Exposed Area". In Alacaatlı District, necessary precautions were taken by construction of retaining structures in the landslide area affecting the site.

Table 4.4 Disaster-Affected Region Decisions Taken as a Result of Landslides in Çankaya District (Source: IRAP Ankara, 2021)

	Name of Neighborhood	**Disaster Type**	**Report Date**
Çankaya	Akpınar	Landslide	25.03.2014
Çankaya	İlkbahar	Landslide	24.01.2019
Çankaya/Mamak	50. Yıl/Cengiz Topel	Landslide	10.02.2012
Çankaya/Mamak	50. Yıl/Cengiz Topel	Landslide	25.03.2012

Rockfall incidents in Ankara usually occur in Altındağ and Kızılcahamam districts. In Altındağ, overturning and rolling of blocks along the cooling cracks of andesite rocks were observed, while in Beypazarı and Nallıhan, it was observed that the blocks rolled downhill with the degradation of the claystones under the limestones. According to archival records, the most frequent place of rockfall events is the Altındağ district. In Çankaya district, 1 disaster-prone area has been reported.

Table 4.5 Disaster-Affected Area Decisions Taken as a Result of Rockfall in Çankaya District (Source: IRAP Ankara, 2021)

	Name of Neighborhood	**Disaster Type**	**Report Date**
Çankaya	50. Yıl	Rockfall	06.11.1984

4.1.1.3. Floodings

There have been many flooding incidents in Ankara so far, and significant loss of life and property has occurred as a result of these events. In order to determine the floods that have occurred and to determine the necessary measures against the flood risks that may occur in the future, "Ankara Province Flood Hazard Areas Planning Report" has been prepared by the Regional Directorate 5th of State Hydraulic Works. In addition, in 2018, the "Sakarya Basin Flood Management Plan" was published by the General Directorate of Water Management, which also covers the city center of Ankara. In these plans, the river beds passing through the residential areas and the floods that may occur as a result of the overflow of these beds are discussed; the risk reduction measures to be taken against these risks have been examined in detail.

However, it has been observed that most of the floods experienced in the center of Ankara in recent years are caused by reasons such as improper infrastructure practices and surface flooding due to dense artificial surfaces due to settlement developments. In particular, factors such as backlash problems in sewage systems, the inability of rainwater to be absorbed/ infiltrated by the soil during torrential rains and therefore the transition to surface runoff have been effective in the formation of flash floods in the city.

Between 2018 and 2020, when urban floods were intense, a total of 1096 households damaged by floods were provided with cash aid in the amount of 4,363,500 TL within the scope of Emergency Aid Allowance. (IRAP, 2021)

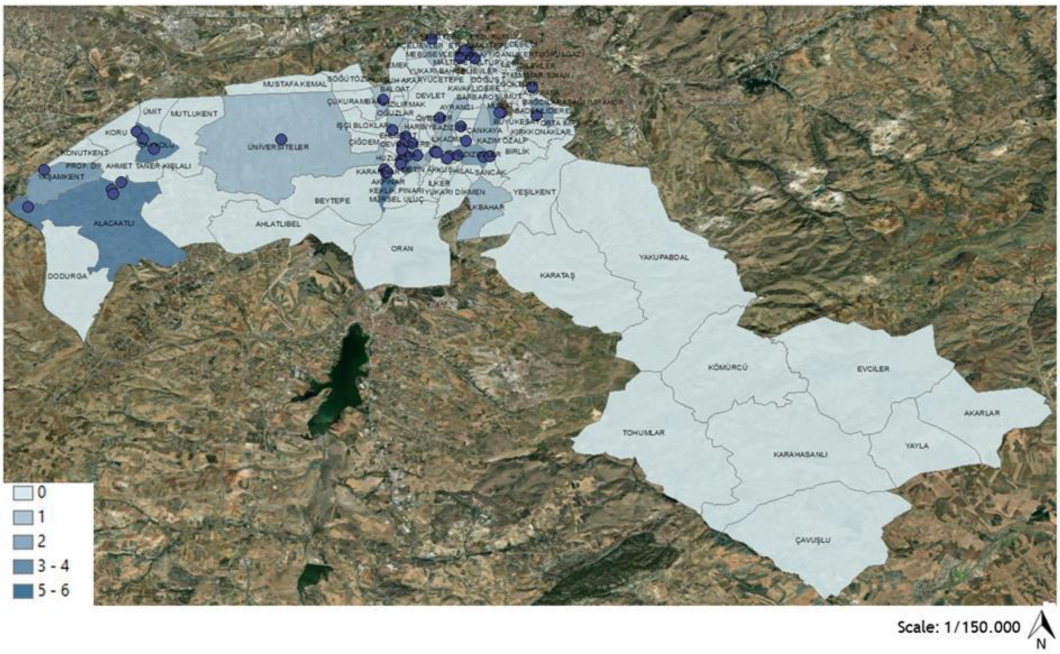

Figure 4.9 Çankaya District 2022 Flood Points (Source data taken from ULUSAV and colored thematically on GIS)

When the flood events that occurred in Çankaya district in 2022 were examined, it was determined that Alacaatlı and Akpınar neighborhoods were most exposed to disasters. In addition, it was analyzed that flooding events were clustered in the central neighborhoods and in the west of the district. Thus, it is possible to understand where the infrastructure problems are concentrated.

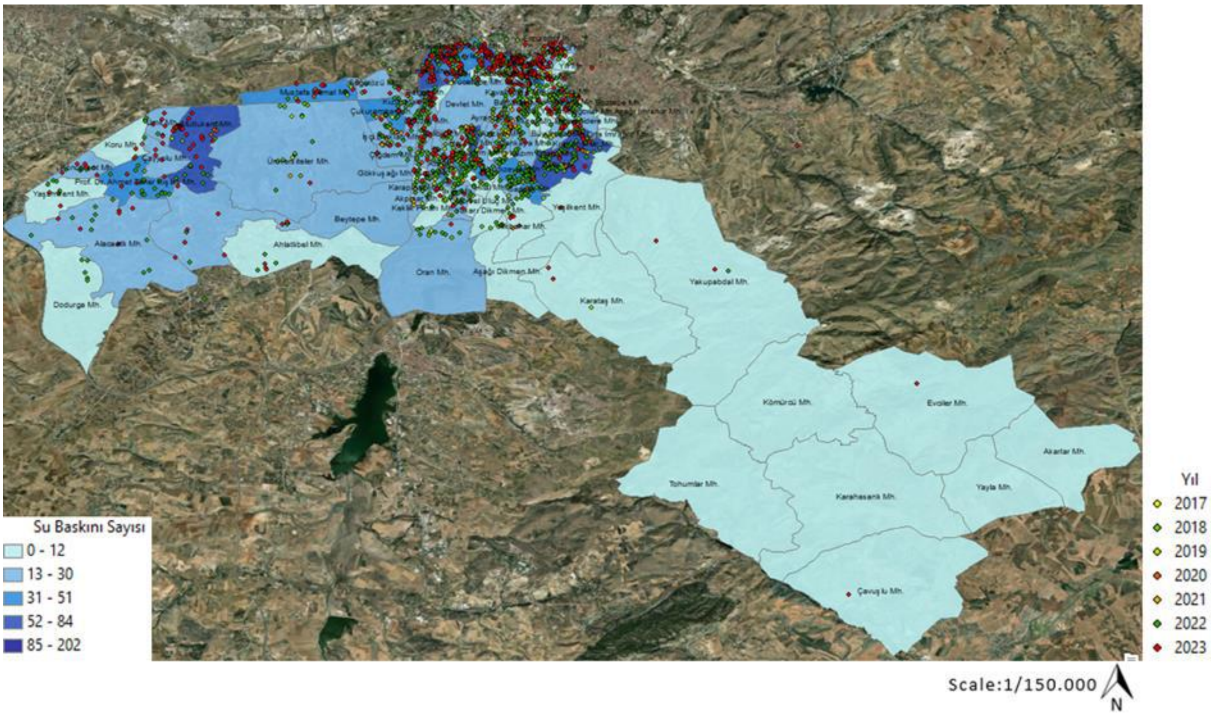

Figure 4.10 Distribution of Flood Locations by Neighborhoods in Çankaya District Between 2017-2023 (Thematic maps were prepared in GIS from Ankara Metropolitan Municipality (AMM) ASKI, 2024 data)

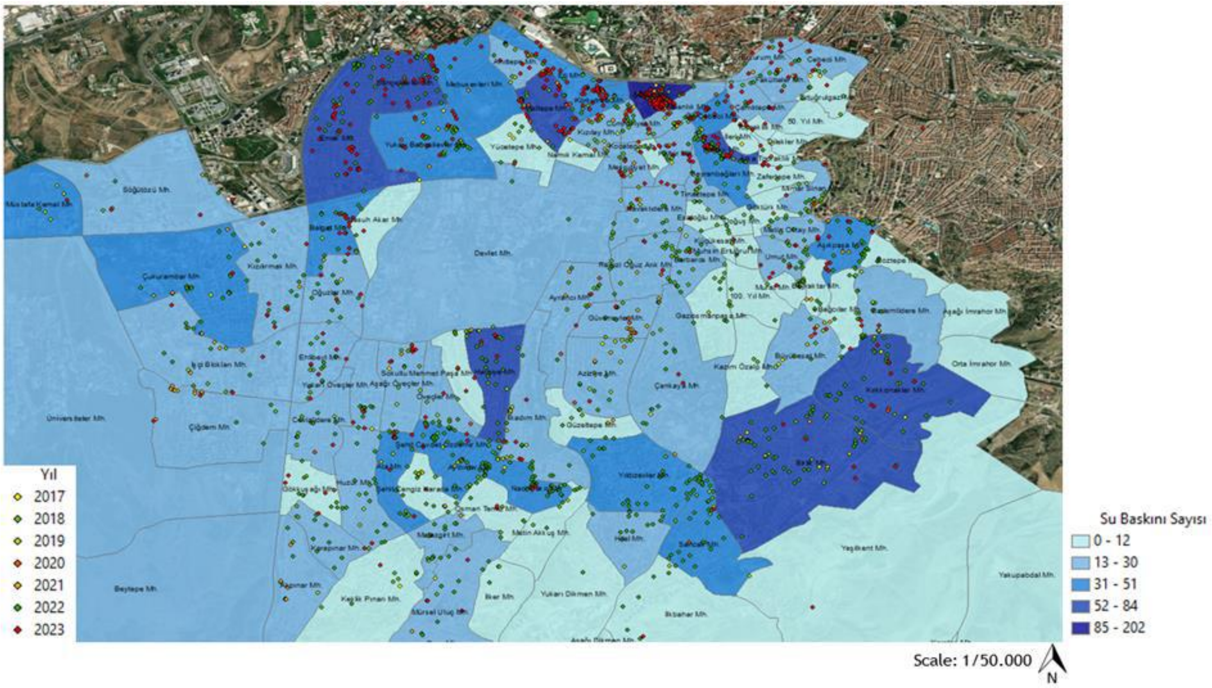

Figure 4.11 Distribution of Flood Locations by Neighborhoods Between 2017-2023 in Çankaya District Central Neighborhoods (Thematic maps were prepared in GIS from AMM ASKI, 2024 data)

When we examined the 7-year period between 2017-2023 in Çankaya district in terms of flood events, it was found that the most affected neighborhood was the Sağlık neighborhood with 202 flood events. According to the 2023 population data, 589 people reside in the Sağlık neighborhood. This is followed by the Emek and Birlik neighborhoods with 84 and 78 flood incidents, respectively. The 2023 population of these neighborhoods is 22458 and 30238, respectively. In general, when we evaluate Çankaya district, we observed that flooding events are concentrated in the central districts. Various flooding events are also seen in the west of the district, but it has been determined that the eastern side is not susceptible in terms of flooding.

According to Table 4.6 and Figure 4.12, between 2017 and 2023, the year with the highest number of flooding events in Çankaya district was 2022 with 1185 floods, followed by 2023 with 670. The increase in the number of flood events, especially in recent years, points to a critical problem and shows the urgency of the situation.

Table 4.6 Distribution of Flood Events by Years in Çankaya District (Source: AMM ASKI, 2024)

Years	Number of Events in Çankaya
2017	44
2018	496
2019	134
2020	62
2021	119
2022	1185
2023	670

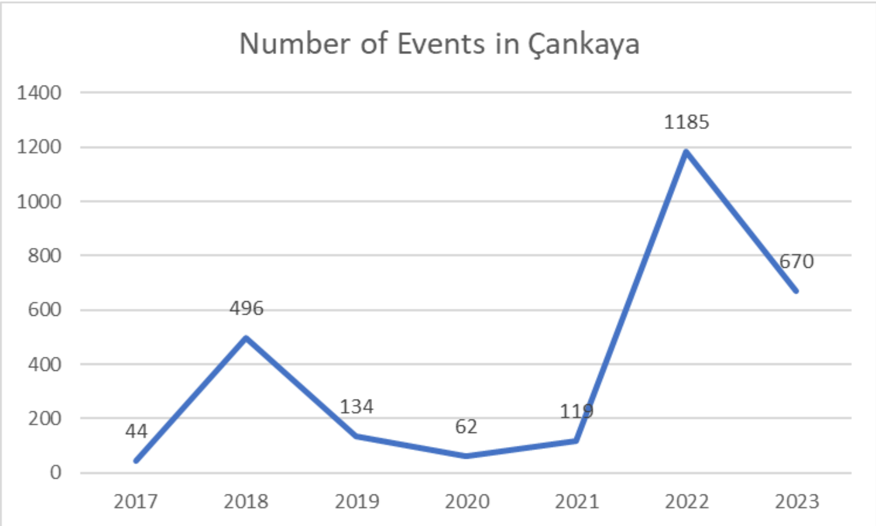

Figure 4.12 Distribution of Flood Events by Years in Çankaya District (Source: AMM ASKI, 2024)

Provincial Disaster Risk Reduction Plans (IRAP) prepared at the provincial level are monitored and evaluated at regular intervals based on the rate of implementation of actions. When we look at the actions based on the types of disasters observed in different districts at the Ankara province level, there are 4 actions observed in Çankaya district.

Table 4.7 Plan of Actions in Çankaya District (Source: IRAP Ankara, 2021)

Action No	Action Explanation	Disaster Type	Geographical Scope	Responsible Institution	Supporting Institution(s)
1	Procurement was made by the Regional Company for the floods in Çankaya District Taner Kışlalı neighborhood, Siyasal Villas, Next to MineSera Hospital. Preparation of a project for laying a rainwater line.	Flood	Çankaya	ASKİ	Ankara Metropolitan Municipality
2	Installation of a rainwater line in the investment program by the Canal Investment Department for floods in Çankaya District Yaşamkent neighborhood, 3222 Street Muhtarlık Altı and 3281 Street Megaron Sitesi front areas.	Flood	Çankaya	ASKİ	Ankara Metropolitan Municipality
	Taking the necessary precautions for floods in Çankaya District, Koru Neighborhood Metro Storage Area area.	Flood	Çankaya	ASKİ	Ankara Metropolitan Municipality
3	Implementation of the projects prepared for problematic and possible floods in Çankaya District, Eti District, Strasbourg Street, Toros Street, Cihan Street, Lale Street, İlkiz Street and Ayrancı District Street and Kuveyt Street as soon as possible.	Flood	Çankaya	ASKİ	Ankara Metropolitan Municipality

5. Current Climate Risk and Vulnerability Analysis

Before addressing the current climate hazards, vulnerabilities, and risk analysis, the international agenda on climate change will be discussed. The general climate conditions and parameters of the study area, Çankaya district, will be highlighted, and the methodology of the study for future projections will be explained.

5.1. International Agenda

The Intergovernmental Panel on Climate Change (IPCC) has released six assessment reports on climate change since 1990, with each report increasingly emphasizing the role of human activities in climate change. For instance, in the Sixth Assessment Report (Masson-Delmotte et al., 2021), human responsibility for rising temperatures was described as "unequivocal." Human activities—primarily the use of fossil fuels, deforestation, and agricultural practices—are elevating the levels of greenhouse gases such as carbon dioxide and methane in the atmosphere. This intensifies the greenhouse effect, leading to a rise in temperatures. The increase in temperature is causing the melting of land and sea ice, the reduction of snow cover, the rise in sea levels, changes in precipitation characteristics (such as amount, intensity, duration, and frequency), and the decrease of water resources in some regions, increasingly threatening life on Earth.

Climate Change Adaptation Strategy and Action Plan (2024-2030) by Directorate of Climate Change outlines various climate risks relevant to Ankara and other urban areas in Türkiye such as;

- Flood Risks: Increasing intensity of heavy rainfall and inadequate drainage systems exacerbate urban flood risks. This risk is amplified by rapid urbanization and the construction on flood-prone areas
- Heatwaves and Urban Heat Island Effect: Higher temperatures in urban areas, including Ankara, lead to heatwaves intensified by urban heat islands. Limited green spaces and extensive use of dark materials in urban construction contribute to this risk
- Water Scarcity and Drought: Prolonged droughts threaten water supply security, exacerbated by climate change and population growth. Historical instances, such as the 2007-2008 drought, highlight the vulnerability of urban water systems
- Infrastructure Vulnerability: Urban infrastructure in Ankara is susceptible to damage from extreme weather events like storms and floods. Measures to ensure resilience are critical
- Health Impacts: Increased frequency of heatwaves and air pollution can adversely affect public health, particularly among vulnerable populations like the elderly, children, and those with pre-existing conditions

- Biodiversity Loss: Urbanization and climate change impact local ecosystems and biodiversity. Loss of natural areas in and around Ankara due to urban sprawl further intensifies this challenge

The report emphasizes the need for robust adaptation measures to mitigate these effects, including improvements in water management, disaster risk reduction, and sustainable agricultural practices.

5.2. General Climatic Characteristics of Ankara Province and Çankaya District

Ankara, situated at an altitude of 874 meters above sea level, experiences a predominantly continental climate. While the Central Anatolian steppe climate is dominant, the northern regions exhibit influences of a temperate and rainy climate characteristic of the Black Sea region.

The city's annual average temperature is 11.9°C, with an annual average rainfall of 393 mm. August is the driest month, receiving only 12 mm of precipitation, whereas May sees the highest average rainfall at 58 mm. August is also the warmest month, with an average temperature of 23.4°C, while January is the coldest, averaging 0.2°C. The variation in precipitation between the driest and wettest months is 49 mm, and the average annual temperature fluctuation is approximately 11°C.

Ankara experiences 60 to 117 frost days annually and an average of 30.5 snowy days per year, with a maximum recorded snow thickness of 30 cm. Strong winds are most common in March and April, with the highest recorded wind speed reaching 29.2 m/s. Based on long-term measurements, the city's average atmospheric pressure is 913.1 mb, with the highest recorded at 935.0 mb and the lowest at 891.0 mb.

The study area is selected Çankaya district in Ankara. Çankaya is located in the southern part of Ankara, the capital city of Türkiye. It is one of the central districts of the city, encompassing a mix of urban and semi-urban landscapes. The district spans an altitude range between 850 and 1,200 meters above sea level, contributing to its diverse topography. It is surrounded by other prominent districts of Ankara and serves as a vital hub within the city's geography. The terrain of Çankaya features a blend of flat areas and rolling hills, which shape its urban planning and green spaces.

The map showing the administrative boundaries throughout the region is given in Figure 5.1.

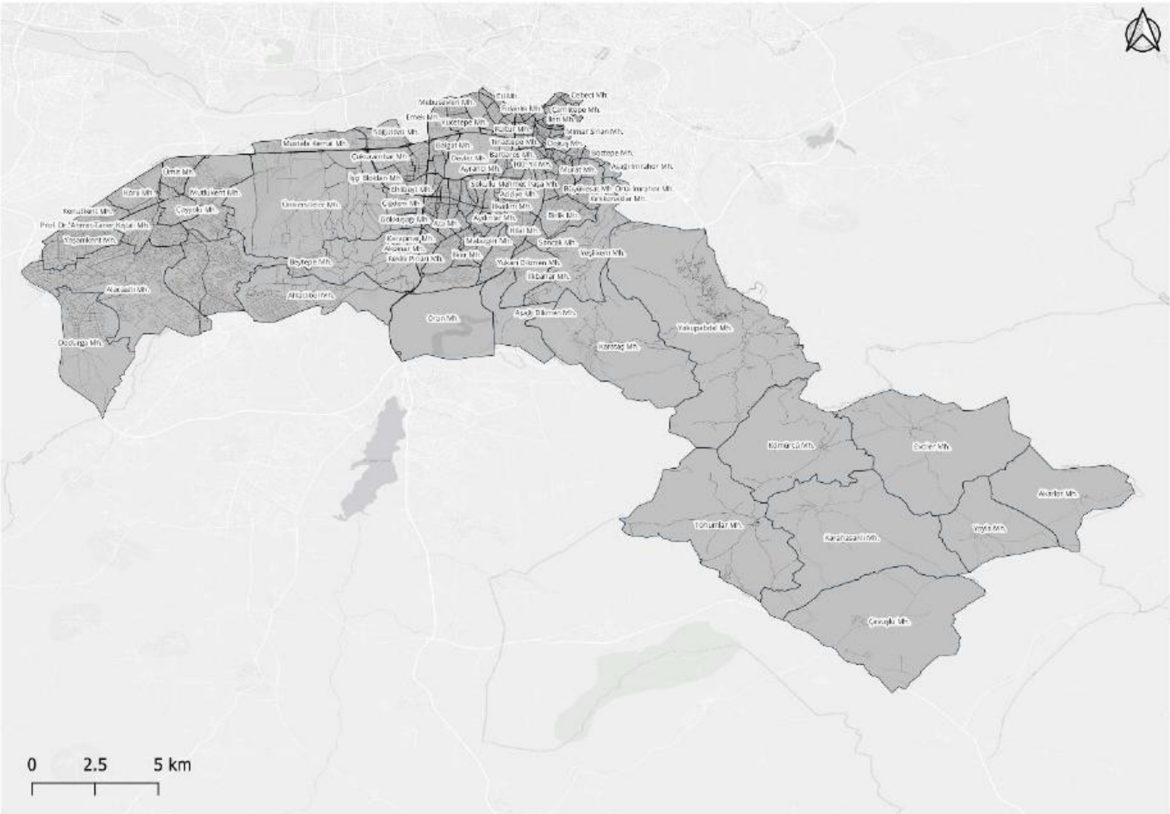

Figure 5.1 General overview of the Çankaya region

Summers in the Çankaya region are generally hot and dry, and winters are quite cold, snowy and partly cloudy. Throughout the year, temperatures usually range from -5°C to 30°C, rarely dropping below -13°C or rising above 35°C. The warm season lasts from June 9 to September 17, during which the average daily high temperature is above 25°C. July is the hottest month of the year, with an average high of 29°C and a low of 15°C. The cold season, on the other hand, lasts from November 27 to March 6. During this period, the average daily high temperature is below 9°C. January is the coldest month of the year, with an average low of -5°C and a high of 4°C. Rainy days in the region are usually measured with at least 1 millimeter of liquid or equivalent rainfall and vary throughout the year. The rainy season lasts for 8.3 months, from October 10 to June 21. There is a 14% chance that any day will be rainy during this period. The wettest month is April, with an average of 6.3 rainy days. The dry season, on the other hand, lasts 3.7 months, from June 21 to October 10, with an average of only 1.8 rainy days in August, the least rainy month. Rain is the most common type of precipitation in Çankaya. The peak rain-only days peaks at 22% on April 28. Changes in annual rainfall are assessed by 31-day moving averages. The rainy season lasts from September 16 to July 14, and the wettest month during this period is April, with an average rainfall of 33 millimeters. The rainless season, on the other hand, runs from July 14 to September 16; August is the driest month of the year, with an average rainfall of 9 millimeters. Wind speed varies seasonally. The windiest period lasts from January 27 to April 15, during which the average hourly wind speed is over 11.5 km/h.

5.3. Methodology for Selecting Climate Models

In this study, NASA Earth Exchange (NEX) Global Daily Downscaled Projections (GDDP) were used for both historical and future periods (Thrasher et al., 2022). Historical records of meteorological variables could not be obtained from the relevant institutes, therefore, NEX-GDDP-CMIP6 dataset were used for analysis.

The NEX-GDDP-CMIP6 dataset consists of globally downscaled climate scenarios originating from the General Circulation Model (GCM) simulations conducted as part of the Coupled Model Intercomparison Project Phase 6 (CMIP6) (Eyring et al., 2016). It includes data across the four "Tier 1" greenhouse gas emissions scenarios, known as Shared Socioeconomic Pathways (SSPs) (Meinshausen et al., 2020; O'Neill et al., 2016)

The dataset consists downscaled, bias corrected historical (1950- 2014) and future (2015 - 2100) climate projections, including variables such as humidity, precipitation, near-surface air temperature and wind speed, derived from the outputs of the Sixth Phase of the Climate Model Intercomparison Project (CMIP6). These downscaled products are available at a 0.25-degree horizontal resolution. Additionally, the data encompass four distinct future climate scenarios from CMIP6, which consider various levels of future radiative forcing, from low to high, and incorporate "Shared Socioeconomic Pathways" (SSPs)—narratives outlining potential societal responses to climate change. In this study, we used SP245 and SSP585 for consideration of optimistic and pessimistic scenarios respectively.

Uncertainty in climate models arises from data limitations, incomplete understanding of complex climate processes, and the inherent variability of the climate system. However, this uncertainty can be minimized by employing multiple models that incorporate diverse approaches and assumptions, thereby providing a broader range of projections. Consequently, daily downscaled projections from NASA's NEX-GDDP-CMIP6 for 35 global climate models obtained from the CMIP6 phase were used for SSP4.5 and SSP8.5 scenarios. The details for each model are presented in Table 5.1.

Table 5.1 The Details of Climate Models

Climate Model	Institution	Country	Variant
ACCESS-CM2	Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bureau of Meteorology (BOM)	Australia	r1i1p1f1

ACCESS-ESM1-5	Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bureau of Meteorology (BOM)	Australia	r1i1p1f1
BCC-CSM2-MR	Beijing Climate Center, China Meteorological Administration	China	r1i1p1f1
CanESM5	Canadian Centre for Climate Modelling and Analysis	Canada	r1i1p1f1
CESM2	National Center for Atmospheric Research	USA	r4i1p1f1
CESM2-WACCM	National Center for Atmospheric Research	USA	r3i1p1f1
CMCC-CM2-SR5	Centro Euro-Mediterraneo sui Cambiamenti Climatici	Italy	r1i1p1f1
CMCC-ESM2	Centro Euro-Mediterraneo sui Cambiamenti Climatici	Italy	r1i1p1f1
CNRM-CM6-1	National Centre for Meteorological Research	France	r1i1p1f2
CNRM-ESM2-1	National Centre for Meteorological Research	France	r1i1p1f2
EC-Earth3	EC-Earth Consortium	International	r1i1p1f1
EC-Earth3-Veg-LR	EC-Earth Consortium	International	r1i1p1f1
FGOALS-g3	LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences	China	r3i1p1f1
GFDL-CM4	Geophysical Fluid Dynamics Laboratory	USA	r1i1p1f1
GFDL-ESM4	Geophysical Fluid Dynamics Laboratory	USA	r1i1p1f1
GISS-E2-1-G	NASA Goddard Institute for Space Studies	USA	r1i1p1f2
HadGEM3-GC31-LL	Met Office Hadley Centre	UK	r1i1p1f3
HadGEM3-GC31-MM	Met Office Hadley Centre	UK	r1i1p1f3

IITM-ESM	Indian Institute of Tropical Meteorology	India	r1i1p1f1
INM-CM4-8	Institute for Numerical Mathematics	Russia	r1i1p1f1
INM-CM5-0	Institute for Numerical Mathematics	Russia	r1i1p1f1
IPSL-CM6A-LR	Institute Pierre-Simon Laplace	France	r1i1p1f1
KACE-1-0-G	Korea Institute of Atmospheric Prediction Systems	South Korea	r1i1p1f1
KIOST-ESM	Korea Institute of Ocean Science and Technology	South Korea	r1i1p1f1
MIROC-ES2L	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo) and National Institute for Environmental Studies	Japan	r1i1p1f2
MIROC6	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo) and National Institute for Environmental Studies	Japan	r1i1p1f1
MPI-ESM1-2-HR	Max Planck Institute for Meteorology	Germany	r1i1p1f1
MPI-ESM1-2-LR	Max Planck Institute for Meteorology	Germany	r1i1p1f1
MRI-ESM2-0	Meteorological Research Institute	Japan	r1i1p1f1
NESM3	NUIST Earth System Model	China	r1i1p1f1
NorESM2-LM	Norwegian Climate Centre	Norway	r1i1p1f1
NorESM2-MM	Norwegian Climate Centre	Norway	r1i1p1f1

TaiESM1	Taiwan Earth System Model Group	Taiwan	r1i1p1f1
UKESM1-0-LL	Met Office Hadley Centre and UK Earth System Modelling Consortium	UK	r1i1p1f2

Ensemble approaches are crucial in climate modeling. This approach helps reduce uncertainty by representing the natural variability and differences in model structures, providing a broader and more reliable picture of future climates. Additionally, ensembles facilitate better model evaluation and improvement by benchmarking multiple models, allowing for the identification of strengths and weaknesses. Therefore, an ensemble of 34 climate model outputs was considered for analyzing the future climate in the Çankaya Region.

5.4. Climate Trends in Çankaya

Climate parameters such as temperature, precipitation, humidity, and wind speed exhibit variability from year to year and over longer periods due to the nonlinear nature of the climate, numerous feedback mechanisms, and natural causes such as volcanic eruptions. For example, a precipitation series includes dry years with below-average rainfall and wet years with above-average rainfall. Similarly, temperature data show relatively warm and cold years compared to the average. However, in recent years, these time series have begun to show clear unidirectional changes. These changes, especially in temperatures, are manifesting as increases. The year-to-year (or longer-term) variability mentioned earlier still exists, but it occurs on top of these trends. Statistical analyses have now shown that these trends have shown significant changes compared to natural variability. Numerous research studies and scientific works conducted with the help of observations and models in recent years have demonstrated that these trends, which cannot be explained by natural variability, are manifestations of human-induced climate change.

5.4.1. Climate Baseline and Future Trends

The reference period used to compare current and future climate conditions were selected between 1981-2010 periods. The 30-year average was considered as a baseline scenario and anomalies of climate variables such as precipitation, humidity, wind speed, average, minimum and maximum temperature values were calculated. Additionally, trend analysis was performed to check the data shows a negative, positive, or neutral trend over the historical period and future periods. The Mann-Kendall statistical test was applied to the data to detect trends in time series data. It is widely used in environmental and climate studies to identify significant trends in temperature, precipitation, and other meteorological variables over time. The trend analysis was conducted with climate variables being averaged spatially and anomalies calculated accordingly.

5.4.1.1. Daily Near-Surface Air Temperature

Figure 5.2 presents the average temperature anomaly relative to the 1981-2010 period, showing the yearly mean temperature anomalies derived from daily observations on two different scenarios: SSP245 and SSP585.

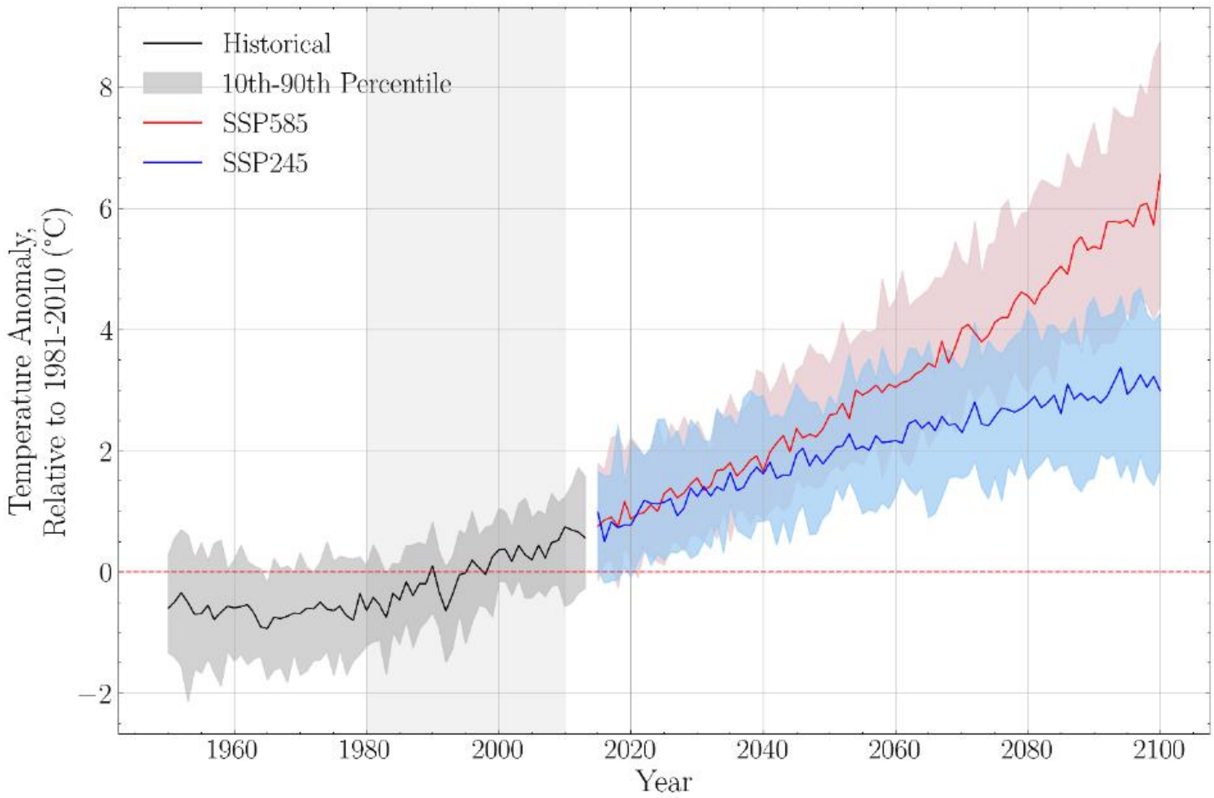

Figure 5.2 Average Temperature Anomaly Relative To The 1981-2010 Period

This graph includes projections from 34 climate models, with the black line representing the median of these models. The shaded area indicates the 10th to 90th percentile range, highlighting the spread of the model projections. The median temperature anomaly shows a noticeable upward trend starting around the mid-1970s, indicating a consistent increase in temperature relative to the 1981-2010 baseline. From the 1980s onwards, there is a clearer upward trend in temperature anomalies, with the median line showing a more pronounced rise. The average annual temperatures were 1°C warmer during the period 2000–2015 than during the baseline period of 1981–2010. Both scenarios in future period shows significant increase in temperature anomalies compared to the historical period, with SSP585 showing a more rise. SSP245 (blue line) and SSP585 (red line) medians diverge significantly, especially towards the latter half of the 21st century, with SSP585 showing a much higher increase in temperature anomalies. The shaded areas indicate the range of predictions (10th-90th percentiles) for each scenario, highlighting the uncertainty and variability among the models. By the end of the century, the SSP245 scenario predicts a temperature increase of 2-3°C, while the SSP585 scenario projects a rise of 5-6°C.

Figure 5.3 also shows the mean daily temperature anomalies for the period 2080-2100 compared to the baseline of 1981-2010 under two climate scenarios, SSP245 and SSP585.

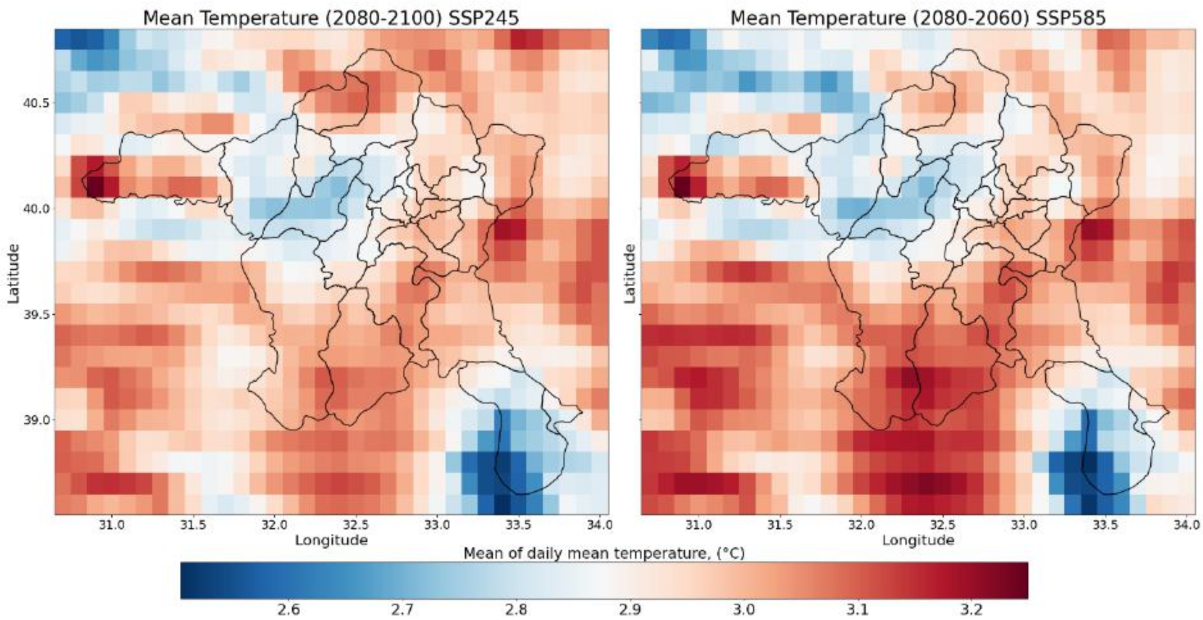

Figure 5.3 The Mean Daily Temperature Anomalies For The Period 2080-2100 Compared To The Baseline Of 1981-2010

The maps also reveal spatial heterogeneity in the warming patterns within Ankara. Some regions exhibit stronger anomalies than others, which may be influenced by local factors such as elevation, land cover, or proximity to urban areas. However, the change is within 2.5 to 3.3 °C.

5.4.1.2. Daily Maximum Air Temperature

Figure 5.4 presents the maximum temperature anomaly relative to the 1981-2010 period.

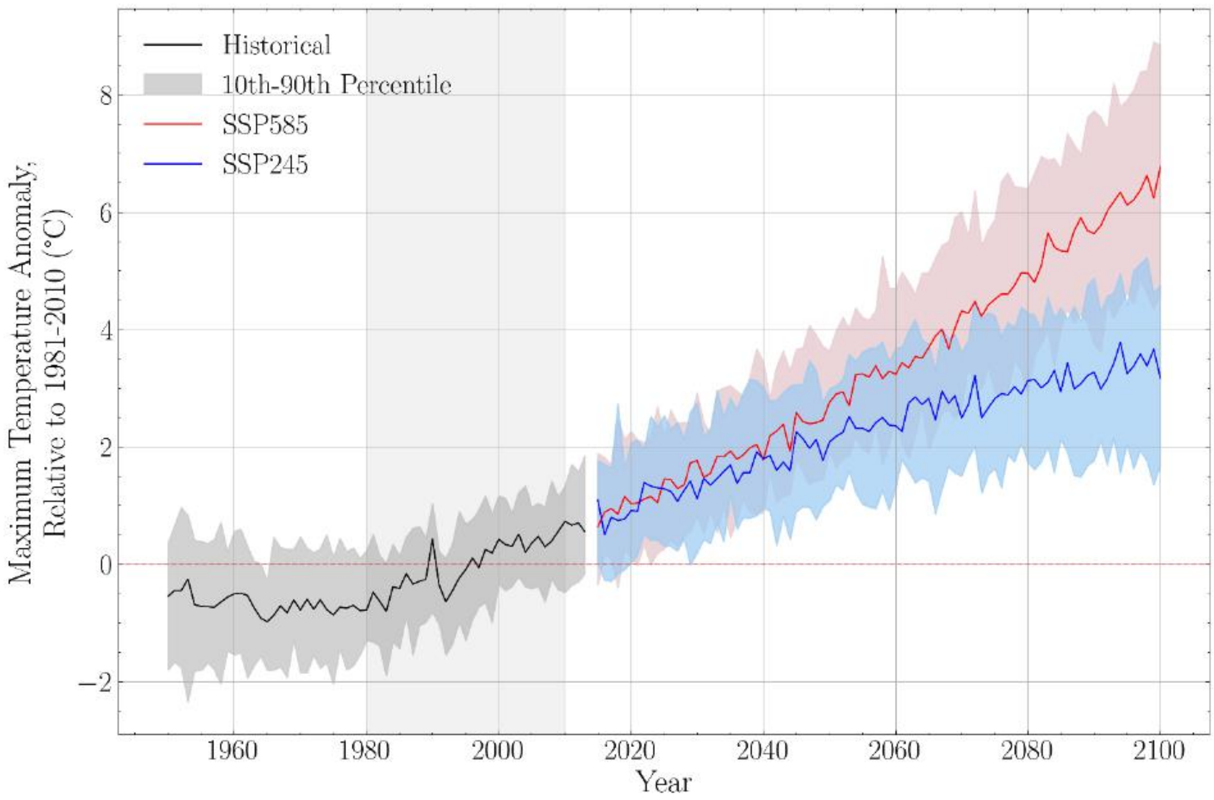

Figure 5.4 Maximum Temperature Anomaly Relative To The 1981-2010 Period

Both scenarios show a significant increase in maximum temperature anomalies compared to the historical period, with SSP585 showing a more pronounced rise. SSP245, a moderate mitigation scenario, projects a gradual rise to about 3°C by 2100, with less uncertainty. SSP585, a high-emission scenario, shows a steep increase, exceeding 6°C by 2100, with broader uncertainty. The stark contrast highlights the importance of emission reductions to limit warming and manage risks effectively.

Figure 5.5 also shows the maximum daily temperature anomalies for the period 2080-2100 compared to the baseline of 1981-2010 under two climate scenarios, SSP245 and SSP585.

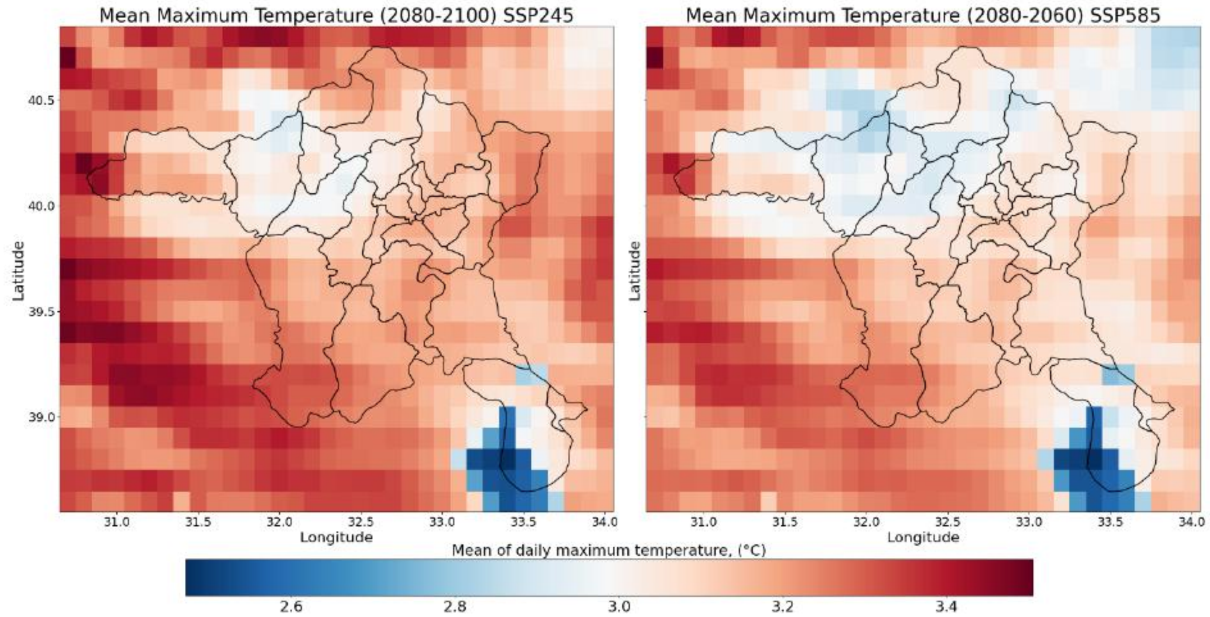

Figure 5.5 The Maximum Daily Temperature Anomalies For The Period 2080-2100 Compared To The Baseline Of 1981-2010

In the SSP245 scenario, the spatial patterns indicate a consistent increase in maximum temperatures across the region, with higher anomalies visible in the southwestern and southern parts. The SSP585 scenario shows significantly higher maximum temperature anomalies, especially in the central and northern parts of the region. The spatial variation is notable, with some areas experiencing anomalies well above the average, emphasizing the severity of a high-emission pathway.

5.4.1.3. Daily Minimum Near-Surface Air Temperature

Figure 5.6 presents the minimum temperature anomaly relative to the 1981-2010 period.

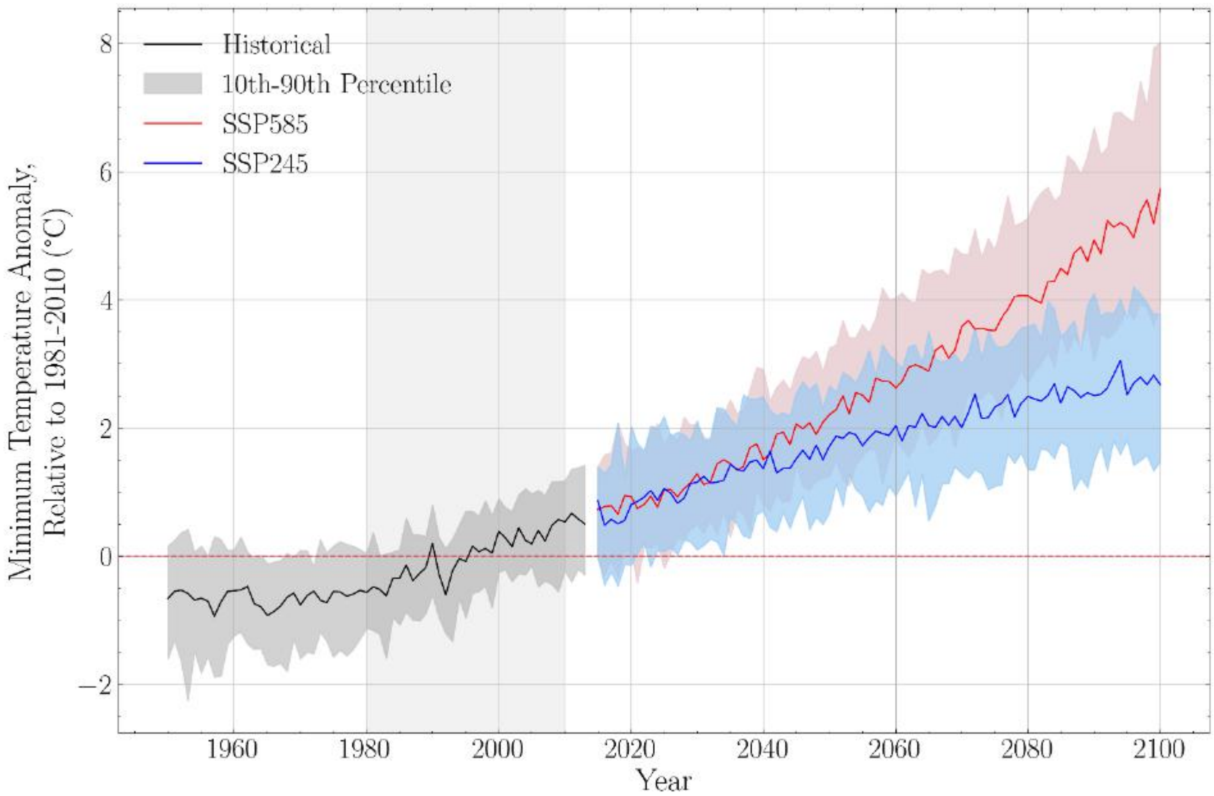

Figure 5.6 Maximum Temperature Anomaly Relative To The 1981-2010 Period

The graph shows minimum temperature anomalies relative to the 1981–2010 baseline, with historical data and projections for SSP245 and SSP585. Historical data remain stable until the late 20th century, followed by a steady increase. SSP245, representing a moderate mitigation scenario, projects a gradual rise in minimum temperatures, reaching about 3°C above the baseline by 2100, with relatively narrow uncertainty.

In contrast, SSP585, a high-emission scenario, predicts a sharper increase in minimum temperatures, exceeding 6°C by 2100, with broader uncertainty. The trends in minimum temperatures are critical as they influence nighttime cooling, heat stress, and ecological processes.

Figure 5.7 also shows the minimum daily temperature anomalies for the period 2080-2100 compared to the baseline of 1981-2010 under two climate scenarios, SSP245 and SSP585.

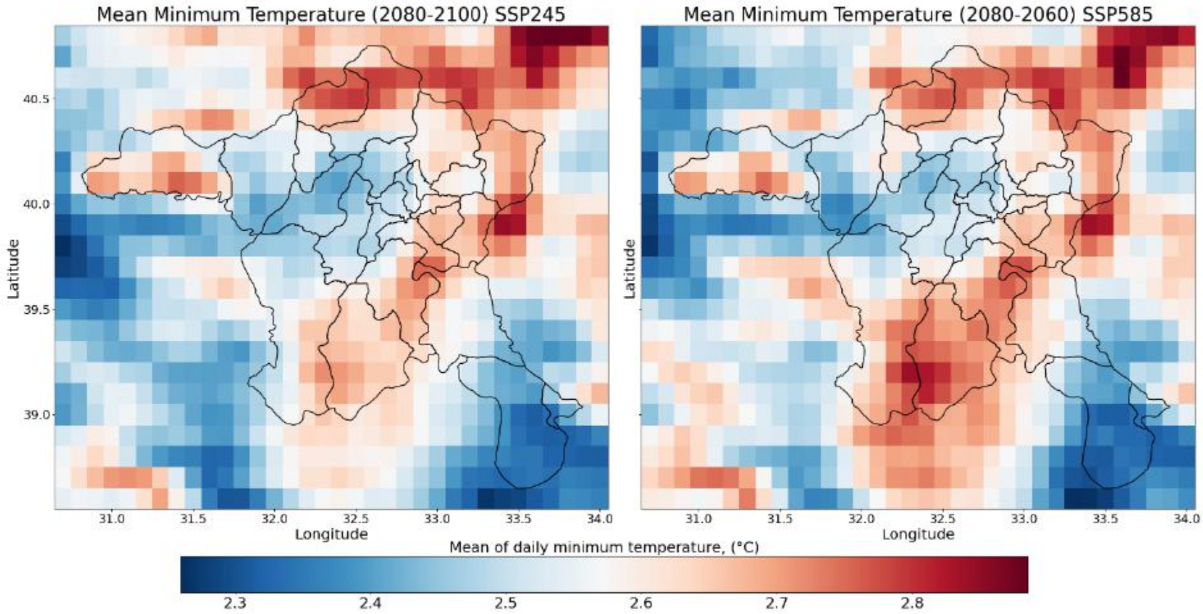

Figure 5.7 The minimum daily temperature anomalies for the period 2080-2100 compared to the baseline of 1981-2010

Under SSP245, the anomalies are more moderate, with increases in minimum temperatures across much of the region. Cooler zones in the southern and western areas reflect a spatial gradient in the temperature changes, suggesting that the impacts of warming may be unevenly distributed. The SSP585 scenario, representing a high-emission future, shows stronger and more widespread warming in minimum temperatures. Notably, there are hot spots in the northern and southeastern parts of the region where the anomalies are more pronounced.

5.4.1.4. Precipitation (Mean Of The Daily Precipitation Rate)

Figure 5.8 presents the daily precipitation anomaly relative to the 1981-2010 period.

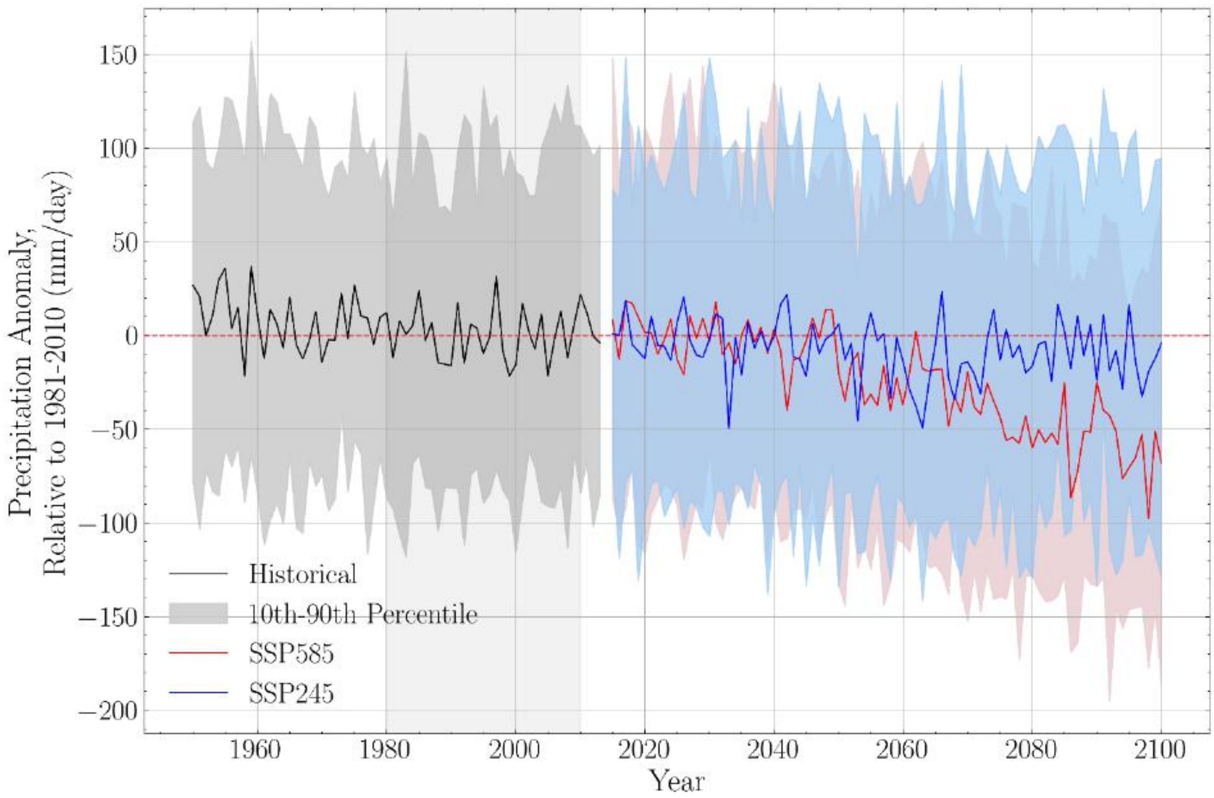

Figure 5.8 Daily Precipitation Anomaly Relative To The 1981-2010 Period

Historically, precipitation anomalies show variability around the baseline, with no significant trend through the 20th century. In the future projections, both SSP245 and SSP585 show continued variability, but the anomalies diverge in magnitude and uncertainty. Under SSP245, the anomalies remain relatively close to the baseline, with smaller fluctuations and less pronounced changes. This suggests that moderate mitigation efforts help stabilize precipitation patterns.

In contrast, SSP585 exhibits greater variability and larger negative anomalies over time. This scenario indicates a higher likelihood of extreme dry periods and disrupted precipitation cycles. The broader uncertainty range under SSP585 reflects the increased unpredictability of precipitation patterns under high emissions.

Figure 5.9 also shows the precipitation anomalies for the period 2080-2100 compared to the baseline of 1981-2010 under two climate scenarios, SSP245 and SSP585.

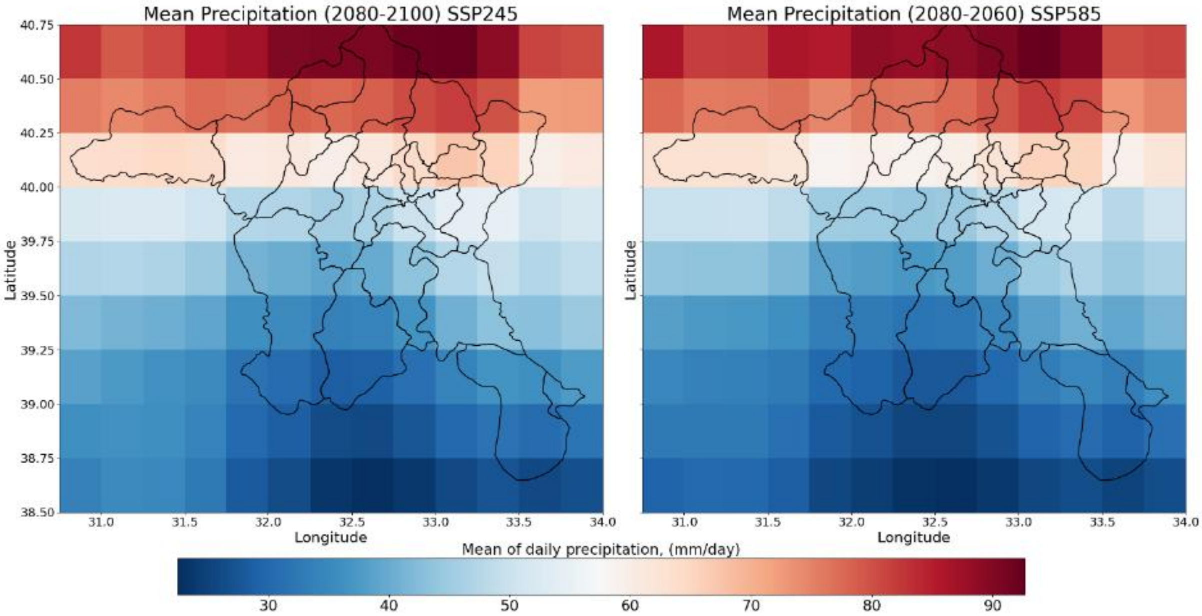

Figure 5.9 The Daily Precipitation Anomalies For The Period 2080-2100 Compared To The Baseline Of 1981-2010

In the SSP245 scenario (2080–2100), the spatial patterns of precipitation anomalies suggest relatively moderate changes compared to the baseline. The northern parts of the region show increases in precipitation, whereas the southern parts experience slight decreases or remain closer to the baseline values. In contrast, the SSP585 scenario (2080–2060) reveals more pronounced and uneven precipitation anomalies. The northern regions exhibit significant positive changes in precipitation, reflecting a wetter future, while the southern areas are projected to experience decreases, signaling a potential increase in aridity.

5.5. Climate Indices

Climate indices are essential tools in understanding and quantifying the impact of climate variability and change on various environmental and socio-economic systems. Climate indices are typically derived from measured variables such as temperature, precipitation, or sunshine duration. The exact definition of an index varies depending on its specific application. However, numerous climate indices have gained global recognition, having been selected by an international team of experts to monitor climate change through standardized indices.

Climate indices defined by The European Climate Assessment & Dataset project (ECAD) have been calculated using the multi-model ensemble for temperature, precipitation and wind speed extremes. These indices were derived following the guidelines of the Expert Team on Climate Change Detection and Indices (ETCCDI) (Klein Tank & Zwiers, 2009).

The extreme indices were also determined as anomalies, using the 1981-2010 period as the reference baseline.

Table 5.2 Climate Indices and Their Descriptions

Indicator Name	Indicator Code	Description	Unit
Consecutive Dry Days	CDD	Maximum number of consecutive dry days	days
Consecutive Wet Days	CWD	Maximum number of consecutive wet days	days
Total Precipitation Amount	PRCPTOT	Total precipitation amount	mm
Heavy Precipitation Days	R10mm	Number of days with precipitation > 10mm	days
Very Heavy Precipitation	R20mm	Number of days with precipitation > 20mm	days
Annual Wet Day Precipitation	RR	Annual total precipitation on wet days (RR > 1mm)	mm
Wet Day Precipitation	RR1	Annual total precipitation when RR > 1mm	mm
Maximum 1-day Precipitation	RX1day	Maximum 1-day precipitation	mm
Maximum 5-day Precipitation	RX5day	Maximum 5-day precipitation	mm
Simple Daily Intensity Index	SDII	Annual total precipitation divided by the number of wet days (RR > 1mm)	mm/day
Moderate Wet Day Precipitation	R75p	Fraction of total precipitation from days with RR > 75th percentile of wet-day precipitation	%

Moderate Wet Day Precipitation Total	R75pTOT	Total precipitation on days with RR > 75th percentile	mm
Very Wet Day Precipitation	R95p	Fraction of total precipitation from days with RR > 95th percentile of wet-day precipitation	%
Very Wet Day Precipitation Total	R95pTOT	Total precipitation on days with RR > 95th percentile	mm
Extremely Wet Day Precipitation	R99p	Fraction of total precipitation from days with RR > 99th percentile of wet-day precipitation	%
Extremely Wet Day Precipitation Total	R99pTOT	Total precipitation on days with RR > 99th percentile	mm
Cool Days	TG10p	Percentage of days when daily mean temperature is below the 10th percentile	%
Warm Days	TG90p	Percentage of days when daily mean temperature is above the 90th percentile	%
Growing Degree Days	GD4	Growing degree days above 4°C	degree-days
Growing Season Length	GSL	Growing season length	days
Heating Degree Days	HD17	Heating degree days below 17°C	degree-days
Mean Minimum Temperature	TGn	Mean minimum temperature	°C
Mean Maximum Temperature	TGx	Mean maximum temperature	°C
Mean Temperature	TG	Mean temperature	°C

Consecutive Summer Days	CSU	Maximum number of consecutive summer days (TX > 25°C)	days
Icing Days	ID	Number of icing days (TX < 0°C)	days
Summer Days	SU	Number of summer days (TX > 25°C)	days
Minimum Daily Max Temperature	TXn	Minimum value of daily maximum temperature	°C
Maximum Daily Max Temperature	TXx	Maximum value of daily maximum temperature	°C
Mean of Daily Max Temperature	TX	Mean of daily maximum temperature	°C
Cool Max Temperature Days	TX10p	Percentage of days when daily maximum temperature is below the 10th percentile	%
Warm Max Temperature Days	TX90p	Percentage of days when daily maximum temperature is above the 90th percentile	%
Warm Spell Duration Index	WSDI	Warm spell duration index (days with at least 6 consecutive days when TX > 90th percentile)	days
Frost Days	CFD/FD	Number of frost days (TN < 0°C)	days
Mean of Daily Min Temperature	TN	Mean of daily minimum temperature	°C
Minimum Daily Min Temperature	TNn	Minimum value of daily minimum temperature	°C
Maximum Daily Min Temperature	TNx	Maximum value of daily minimum temperature	°C

Tropical Nights	TR	Number of tropical nights (TN > 20°C)	days
Cold Spell Duration Index	CSDI	Cold spell duration index (days with at least 6 consecutive days when TN < 10th percentile)	days
Maximum Surface Wind Speed	sfcWind_max	Maximum surface wind speed	m/s
Mean Surface Wind Speed	sfcWind_mean	Mean surface wind speed	m/s
Minimum Surface Wind Speed	sfcWind_min	Minimum surface wind speed	m/s
Windy Days	windy_days	Number of windy days	days
Fog Days	fg	Number of fog days	days
Diurnal Temperature Range	DTR	Mean diurnal temperature range (TX - TN)	°C
Extreme Temperature Range	ETR	Extreme temperature range (TXx - TNn)	°C
Intra-annual Temperature Range	vDTR	Intra-annual extreme temperature range	°C
Warm Winter Days	WW	Number of warm winter days (TX > 20°C)	days

Table 5.1 presents climate indices for historical and future periods in Çankaya, divided into mean values for 2021-2040, 2041-2060, and 2081-2100, under the SSP245 and SSP585 scenarios. The green shading indicates a decrease, while red indicates an increase relative to historical means.

Table 5.3 Climate Indices For Historical And Future Periods İn Çankaya, Ankara

Historical	SSP245			SSP585			Index
1981-2010	2021-2040	2041-2060	2060-2080	2021-2040	2041-2060	2060-2080	
42.00	4.09	7.93	14.63	3.97	11.72	22.68	CDD
33.97	-7.65	-8.89	-13.60	-7.09	-10.08	-18.94	CFD
12.25	-12.15	-12.25	-12.25	-11.40	-12.25	-12.25	CSDI
37.42	17.55	27.23	42.77	19.67	36.16	71.94	CSU
7.63	0.03	-0.02	0.07	-0.02	-0.14	-0.84	CWD
111.85	-12.90	-16.86	-26.72	-12.18	-22.59	-46.72	FD
3.01	-0.05	-0.03	0.01	-0.06	-0.05	-0.04	fg
2900.02	437.14	625.68	949.29	466.53	834.57	1760.79	GD4
246.69	16.96	25.29	35.99	18.55	30.35	69.15	GSL
2778.84	-297.91	-404.13	-591.26	-296.96	-515.18	-1011.95	HD17
14.76	-2.97	-4.12	-7.83	-3.19	-6.15	-11.88	ID
352.43	-0.12	3.01	-0.08	5.25	-9.31	-43.80	PRCPTOT
3.33	0.59	1.06	1.22	0.77	1.00	1.39	R10mm
0.00	0.00	0.02	0.03	0.01	0.05	0.13	R20mm
75.53	72.99	72.15	69.42	73.95	68.73	59.03	R75p
0.92	0.00	0.00	0.00	0.01	0.01	0.01	R75pTOT
17.82	17.33	17.73	17.36	17.92	16.72	15.60	R95p
0.38	0.01	0.03	0.04	0.03	0.04	0.07	R95pTOT
3.12	3.03	3.29	3.48	3.30	3.43	3.37	R99p
0.10	0.01	0.02	0.03	0.01	0.03	0.05	R99pTOT
379.90	-0.38	0.40	-3.91	2.07	-11.96	-50.71	RR
95.23	-3.61	-5.16	-7.79	-3.76	-10.10	-21.39	RR1
15.59	0.77	1.00	1.88	1.01	1.90	2.47	RX1day
32.08	2.22	3.57	3.13	2.29	2.72	2.99	RX5day
3.76	0.16	0.21	0.29	0.14	0.20	0.41	SDII
7.91	-0.09	0.03	0.02	-0.06	-0.12	-0.30	sfcWind_max
3.03	-0.04	-0.03	0.01	-0.06	-0.05	-0.04	sfcWind_mean
0.98	-0.01	-0.02	0.01	-0.01	0.00	0.03	sfcWind_min
89.85	22.27	28.68	39.90	22.32	36.55	67.26	SU
283.85	1.41	2.04	3.09	1.54	2.70	5.58	TG
208.17	163.08	140.62	107.05	165.27	124.48	47.29	TG10p
0.61	1.69	2.52	5.25	0.83	1.79	12.34	TG90p
263.12	0.56	1.54	2.52	0.39	2.05	5.26	TGn
300.86	2.69	3.47	4.96	3.04	4.56	8.72	TGx
278.20	1.29	1.82	2.81	1.39	2.43	5.05	TN
257.80	0.66	1.44	2.80	0.58	2.03	5.95	TNn
292.82	2.89	3.69	5.11	3.23	4.76	8.53	TNx
0.63	7.48	12.67	26.77	8.81	22.03	66.97	TR
289.45	1.54	2.18	3.34	1.66	2.87	5.98	TX
51.85	26.44	20.17	12.09	28.34	17.50	3.66	TX10p
15.68	32.64	44.49	71.29	17.33	34.56	115.48	TX90p
267.24	-0.09	0.41	1.16	-0.56	0.78	3.86	TXn
308.28	3.03	4.10	5.53	3.38	5.12	9.17	TXx
0.00	0.00	0.00	0.00	0.00	0.00	0.00	windy_days
0.45	3.24	7.74	21.56	-0.12	3.84	49.31	WSDI
12.04	4.97	8.69	15.37	2.20	8.69	25.14	WW

5.5.1. Temperature Based Indices

The Warm Spell Duration Index (WSDI) is particularly useful for identifying prolonged periods of excessively high temperatures, which are characteristic of heatwaves. The graph showing the WSDI is presented in Figure 5.10.

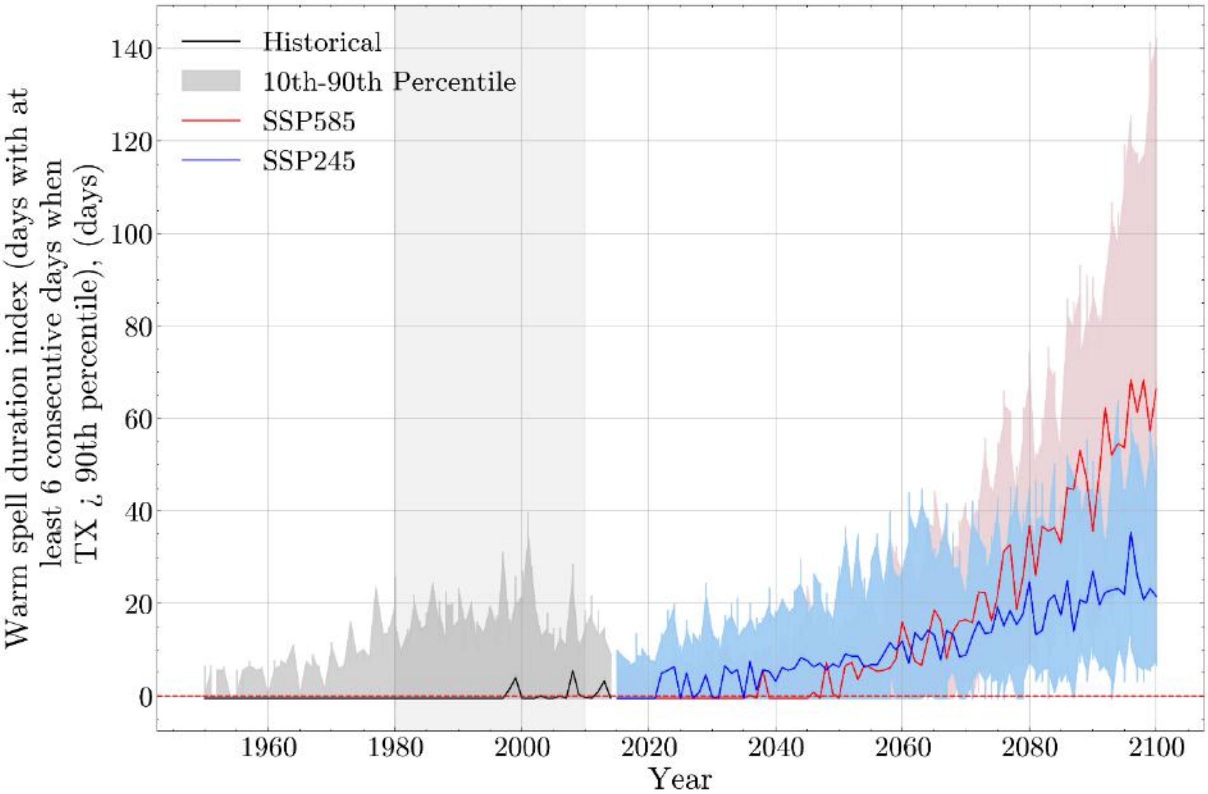

Figure 5.10 The Warm Spell Duration Index İn Historical And Future Periods for SSP245 And SSP585 Scenarios

The graph indicates that both scenarios predict a significant increase in the duration and frequency of warm spells in Çankaya, with a much more severe impact under SSP585. By the end of the century, the region could experience prolonged periods of extreme heat, particularly under SSP585.

The graph showing the Cold Spell Duration Index (CSDI) is presented in Figure 5.11.

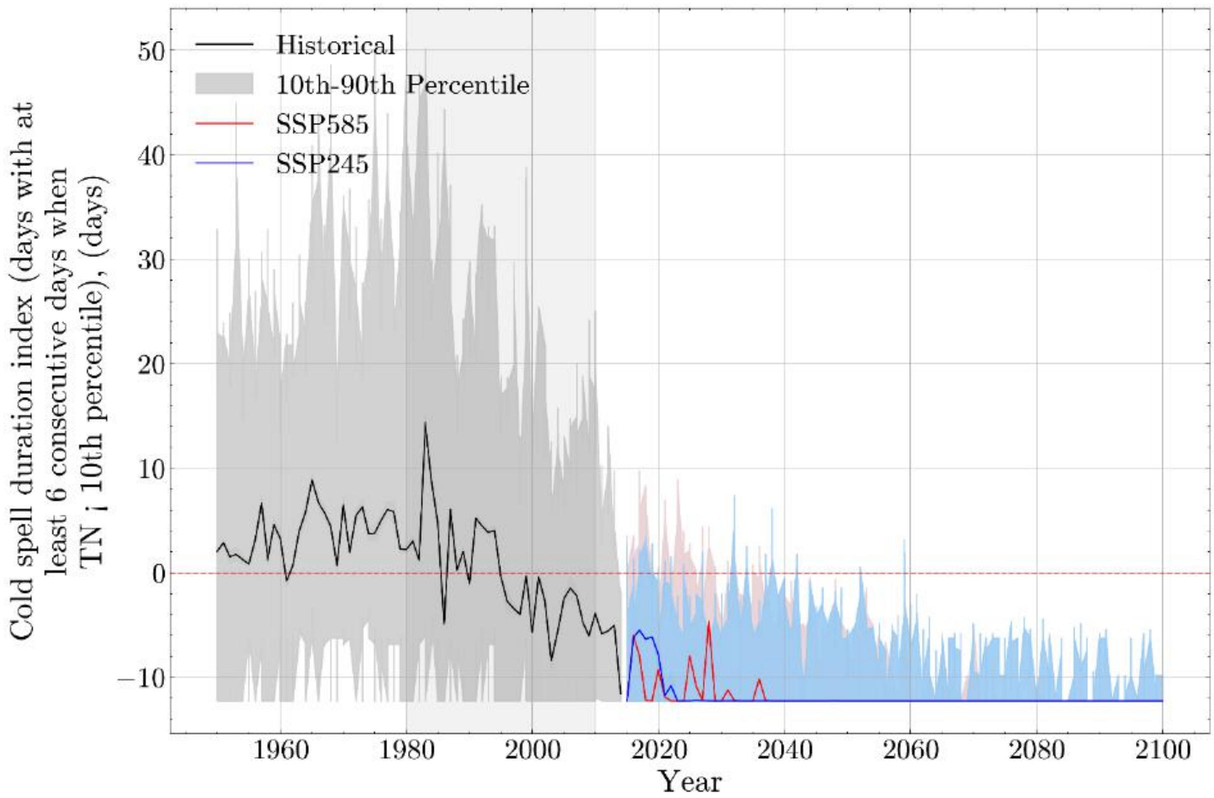

Figure 5.11 The Cold Spell Duration Index İn Historical and Future Periods For SSP245 and SSP585 Scenarios

The results indicate that the "Cold Spell Duration Index," a measure of the length of cold spells, has decreased during the historical period in line with observations and is expected to continue decreasing in the future under both scenarios. This decrease suggests that the length of cold spells will eventually reach zero. On the other hand, the "Warm Spell Duration Index," an indicator of the length of heatwaves, has increased during the historical period in line with observations and is projected to continue increasing in the future, with a more pronounced trend in the pessimistic scenario.

The graph showing the Heating Degree Days (HD17) is presented in Figure 5.12.

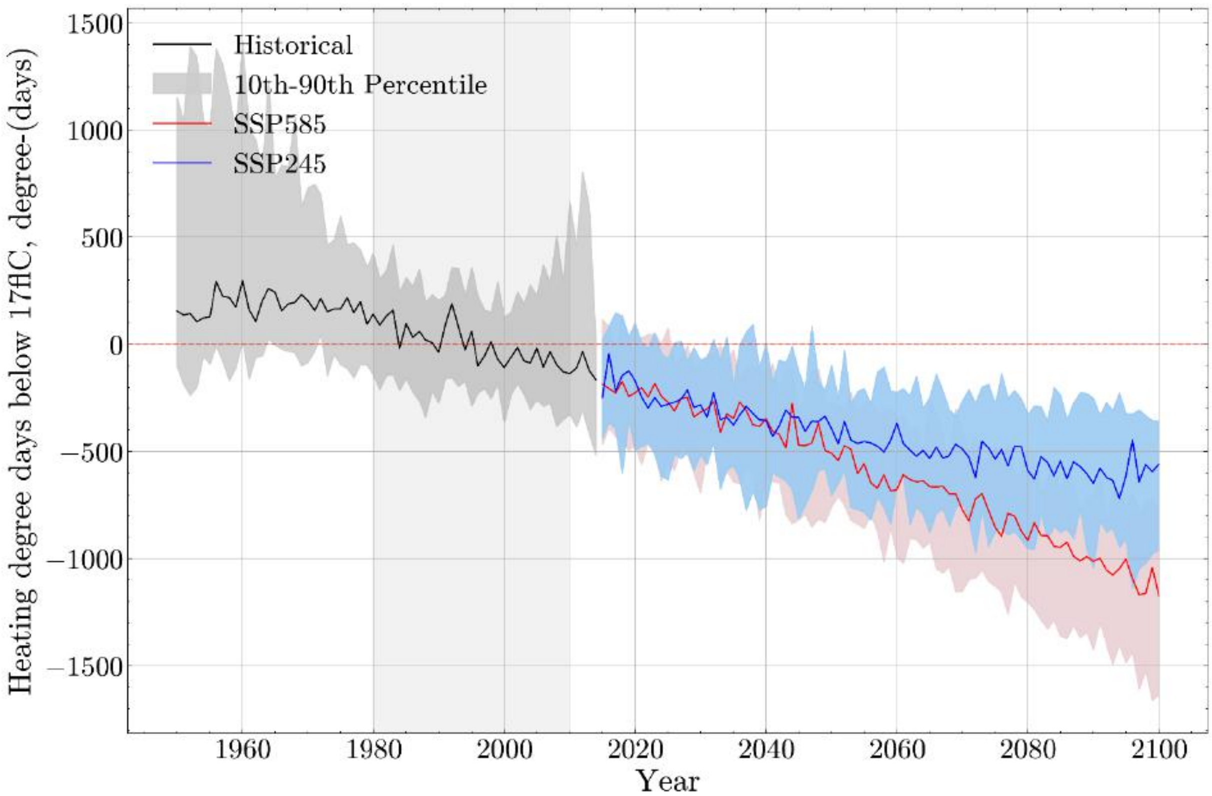

Figure 5.12 The Heating Degree Days in Historical And Future Periods for SSP245 and SSP585 Scenarios

"Heating Degree Days," a measure of the energy required to heat buildings, have decreased during the historical period and are projected to continue decreasing in the future. This graph shows the projected decrease in Heating Degree Days (HDD) for Çankaya, Ankara, under historical data and two future climate scenarios (SSP245 and SSP585). Historical trends are stable, while future projections show significant declines, with a steeper drop under the high-emissions scenario (SSP585). This indicates reduced heating needs due to warming, highlighting the importance of energy planning and climate adaptation strategies.

Figure 5.13 also shows the number of consecutive dry days, frost days, icing days and summer days.

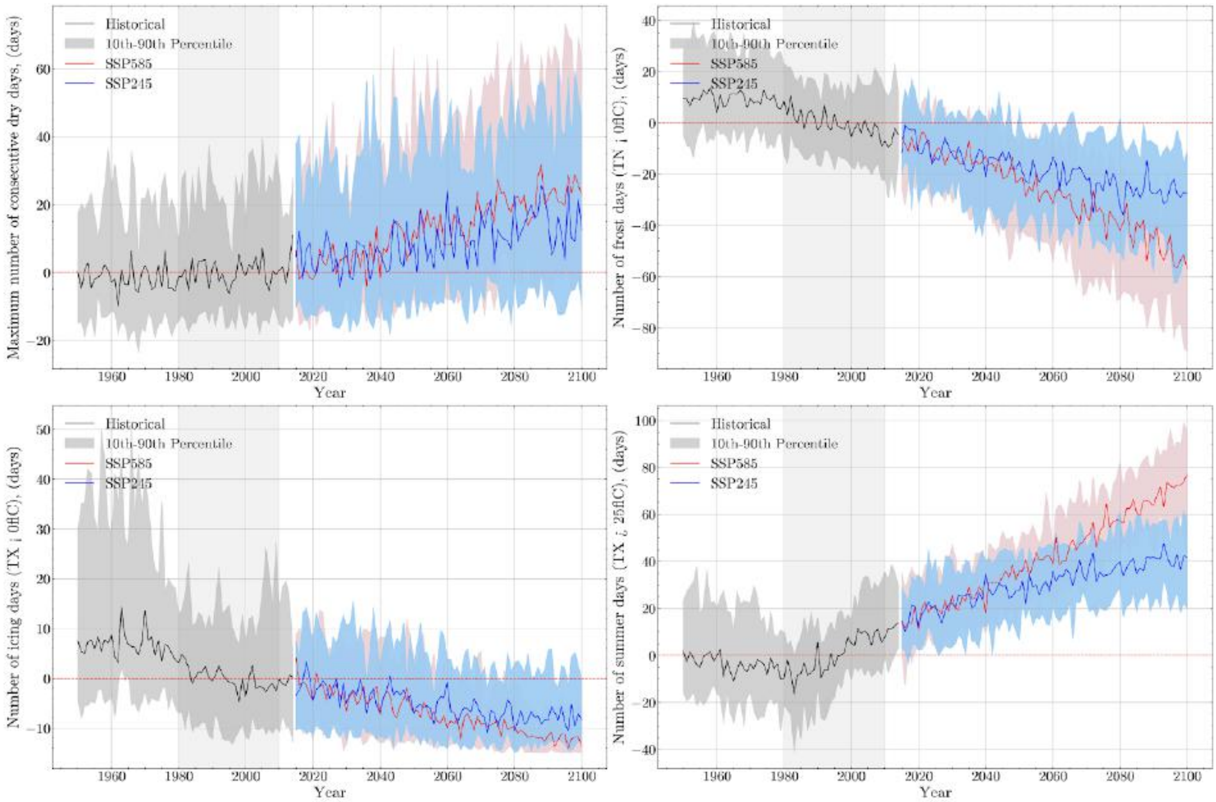

Figure 5.13 Number of Cold Days (A), Frost Days (B), Summer Days (C) and Consecutive Summer Days (D) in Historical and Future Periods For SSP245 and SSP585 Scenarios

Temperature based indices show a future with fewer cold and frost days, and more frequent and prolonged hot days, particularly under the SSP585 scenario. SP585 consistently shows more extreme changes, with sharper declines in cold/frost days and more pronounced increases in summer days and heat waves.

5.5.2. Precipitation Based Indices

Total precipitation amount is presented in Figure 5.14.

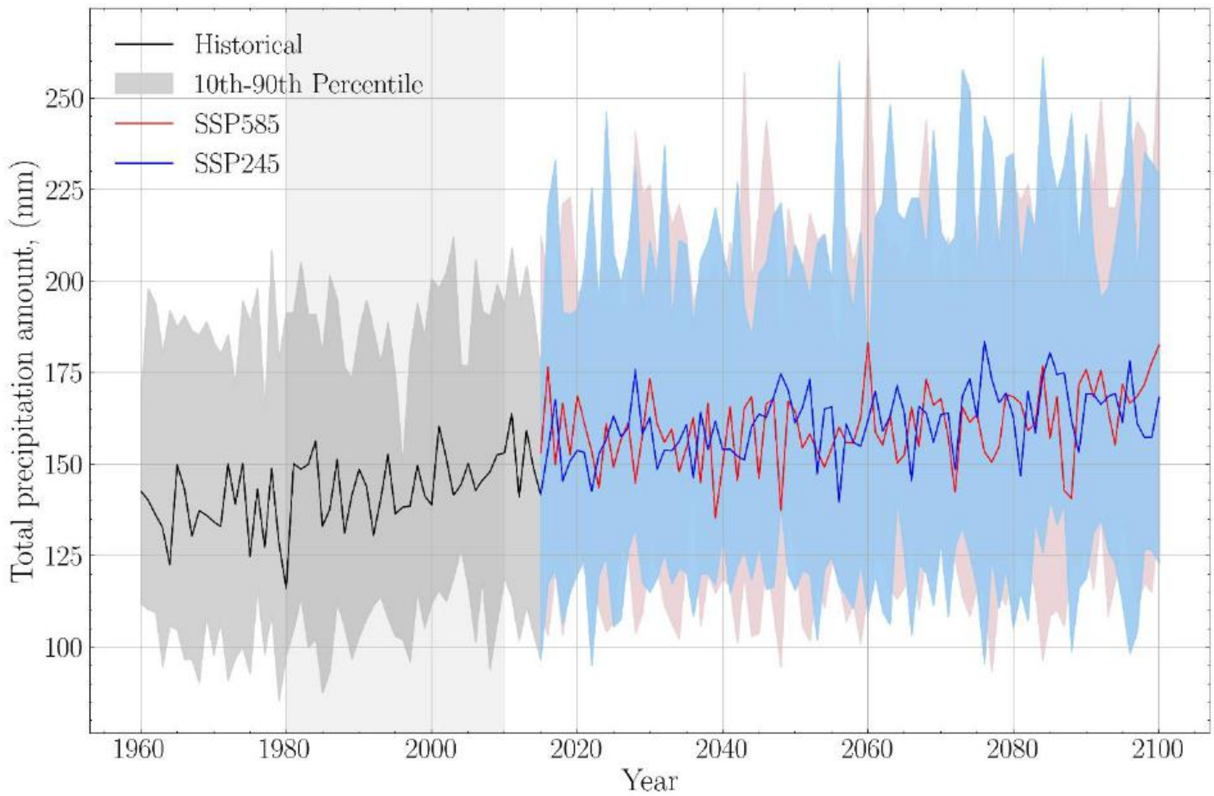

Figure 5.14 Total Precipitation in Historical and Future Periods for SSP245 and SSP585 Scenarios

Future projections under SSP245 and SSP585 do not show significant changes in overall precipitation trends compared to historical data, although variability increases over time, as indicated by the wider shaded areas. This suggests that while annual precipitation totals may remain relatively stable, fluctuations and uncertainties are expected to increase.

The graph showing Maximum 1-day precipitation is presented in Figure 5.15

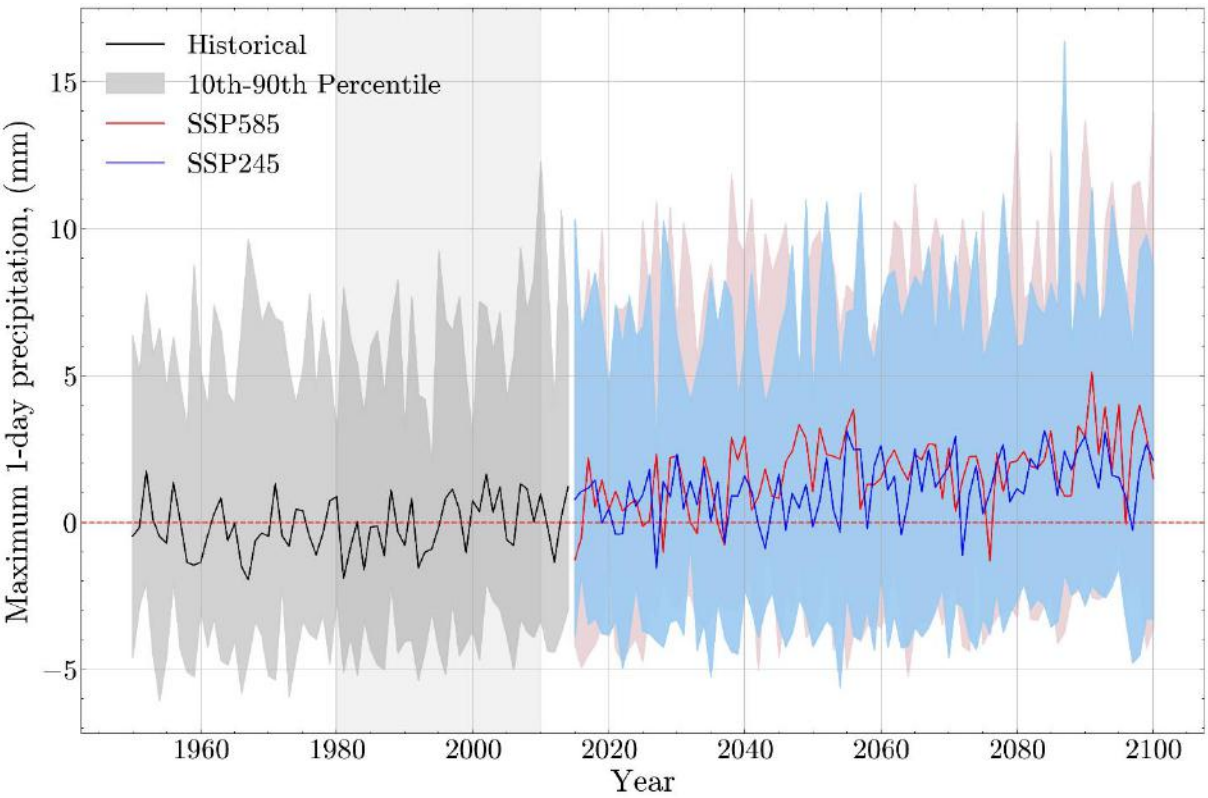

Figure 5.15 Total Precipitation İn Historical and Future Periods for SSP245 and SSP585 Scenarios

RX1day (Max 1-Day Precipitation) represents the highest precipitation amount recorded in a single day, which is crucial for assessing flood risks. In the scenarios, there is an observable increase in variability compared to historical trends, as evidenced by the broader shading. Both scenarios show a slight upward trend in maximum 1-day precipitation events, especially under SSP585, suggesting a potential increase in extreme precipitation events. An increase in RX1day, can have widespread impacts. Higher precipitation extremes intensify the risk of urban flash floods, potentially overwhelming drainage systems and damaging infrastructure. This can disrupt transportation, public services, and daily life. In rural areas, intense rainfall may lead to severe soil erosion, degrading agricultural lands and increasing sedimentation in water bodies. Such events also threaten agricultural productivity by damaging crops and altering planting or harvesting schedules.

5.6. Hazard Projections Based on Climate Scenarios

Evaluations conducted specifically for Ankara—and particularly for the Çankaya district—highlight potential future climate-related hazards in terms of frequency, severity, projected timeframes, and types of data used. Analyses indicate that extreme heat events are expected to increase in both frequency and severity in the short and medium term. Conversely, a decrease in the frequency of extreme cold events is anticipated, although no significant change is expected in their intensity. While extreme precipitation events are projected to occur less frequently, their intensity is likely to increase; flood and flash flood events are expected to rise in both frequency and severity.

The risk of drought and water scarcity is anticipated to increase in the long term. For storms, a decline in frequency is expected, though no significant change is projected in intensity. Landslide events are likely to become more frequent, while forest fire occurrences are also expected to rise—though there remains uncertainty regarding the severity of such events. These projections are based on historical event records, meteorological indicators, disaster management plans, and climate index studies. In conclusion, the Çankaya district faces increasing climate-related risks, particularly in the short term (up to 2025) and medium term (2026–2050).

Table 5.4 Current (Last 5–10 Years) and Future (Mid-Century) Climate Hazards and Impacts

FUTURE CLIMATE HAZARDS FOR ÇANKAYA/ANKARA*	**FREQUENCY**	**SEVERITY**	**PRJECTED TIMEFRAME**	**DATA SOURCED USED**
Extreme Heat	Increase	Increase	Short–Medium Term	Percentage of Hot Days, Warm Spell Duration Index, Annual Max of Daily Max Temp
Extreme Cold	Decrease	No Change	Long Term	Percentage of Cold Days, Cold Spell Duration Index
Extreme Precipitation	Decrease	Increase	Medium Term	Days with ≥10mm Precipitation, Heavy Precipitation Days
Floods / Flash Floods	Increase	Increase	Short Term	Historical Events, AFAD IRAP, Flood Management Plans
Drought and Water Scarcity	Increase	Increase	Long Term	Consecutive Dry Days, Turkish State Meteorological Service 12-Month Drought Index (2024–2025)
Storms	Decrease	Decrease	Medium Term	Historical Events, AFAD IRAP, Flood Management Plans
Landslides	Increase	Increase	Short Term	Historical Events, AFAD IRAP, Flood Management Plans
Forest Fires	Increase	Unknown	Short Term	Historical Events, AFAD IRAP
	FREQUENCY: Increase, Decrease, No Change, Unknown	**SEVERITY:** Increase, Decrease, No Change, Unknown	**PROJECTED TIMEFRAME:** • *Short–Medium Term = by 2030*	

			• *Long Term = post-2030* • *Unknown = No available information on timing of the hazard*	

** Current (last 5–10 years) and Future (mid-century) Potential Climate Hazards and Impacts*

Table 5.5 Climate Hazard Risk Matrix for Çankaya District

Climate Hazards	**Probability (1: Unknown – 4: High)**	**Impact (1: Unknown – 4: High)**	**Risk Score (Probability × Impact)**	**Risk Level**
Extreme Heat	4	4	16	▨ High
Extreme Cold	1	3	3	() Low
Heavy Rainfall	3	4	12	▨ High
Flood / Flash Flood	4	3	12	▨ High
Drought and Water Scarcity	4	4	16	▨ High
Storms	2	3	6	[] Medium
Landslides	4	3	12	▨ High
Forest Fires	2	3	6	[] Medium

**High risk ▨: <=10; Medium risk []: <=9 & >=5; Low risk (): <=4; (Range: 1-16)*

The climate hazard risk matrix developed for Çankaya District is based on risk scores calculated using the probability and impact levels of various climate-related events. Both probability and impact were rated on a scale from 1 (unknown) to 4 (high), and the risk score was determined by multiplying these two values. According to the scoring system, values of 10 and above are classified as high risk, scores between 5 and 9 as medium risk, and scores of 4 or below as low risk.

According to this assessment, extreme heat, floods/flash floods, drought and water scarcity, and landslides pose the highest risk (score of 16) and represent serious threats to the region. Extreme precipitation and storms are also categorized as high risk, each with a score of 12. Forest fires fall into the medium risk category (score of 6) and are identified as another significant hazard that requires monitoring. In contrast, extreme cold events are evaluated as low risk (score of 3).

These findings clearly indicate that the Çankaya District is particularly vulnerable to climate change impacts such as rising temperatures, flooding, water shortages, and landslides.

Table 5.6 Table of Climate Hazards and Sectoral Impacts for Çankaya District (The full list can be found in Section 7 of the report.)

Sectors	**Main Hazard**	**Impact**	**Implementation Period**	**Probability**	**Impact Score**	**Risk Score**	**Risk Level**	**Relevant Indicators to Monitor**
Buildings	Extreme Heat	Extreme heat causes overheating in buildings, increasing cooling demand and leading to higher maintenance costs.	Short term	4	2	8	Medium	
Buildings	Flooding	Surface and river flooding damaging or submerging buildings within municipal borders.	Short term	4	4	16	High	
Buildings	Landslides	Landslides causing damage or collapse of buildings within municipal borders.	Short term	4	3	12	High	
Transport	Extreme Weather Events (heatwaves, heavy rainfall, river floods)	Extreme events damaging transport infrastructure and causing mobility disruptions, leading to high maintenance costs.	Short term	4	3	12	High	Urban flash floods and drainage failures
Energy	Extreme Heat	Increased energy demand and pressure on generation/distribution infrastructure may cause long-term outages.	Short term	3	2	6	Medium	

Energy	Storms and Floods	Damage to generation and transmission infrastructure from extreme weather events causing supply disruptions.	Short term	3	2	6	Medium	Regular monitoring of freshwater and groundwater resources of the province and district
Water	Extreme Heat and Drought	Periods of high heat and drought reduce water quality, deplete underground reserves, and increase scarcity.	Medium term	4	3	12	High	

The climate hazard table assessed by sector for the Çankaya District outlines potential hazards in key sectors (buildings, transportation, energy, and water), their impacts, projected occurrence periods, risk levels based on probability and impact scores, and necessary mitigation measures. All hazards are expected to occur in the short term, while the effects of extreme heat and drought are projected to become more prominent in the medium term.

In the **buildings sector**, extreme heat is expected to increase cooling demand and raise maintenance and repair costs, while floods may cause structural damage due to rising surface water. Landslides are also anticipated to lead to severe structural damage or collapse. Among these threats, floods (risk score: 16) and landslides (risk score: 12) are classified as high risk.

In the **transportation sector**, extreme weather events, including extreme heat, heavy precipitation, and flooding, pose a threat to infrastructure systems and may disrupt mobility. These impacts are categorized as high risk (risk score: 12).

In the **energy sector**, extreme heat events may indirectly pressure energy generation and transmission infrastructure, potentially causing service disruptions. Storms and floods may also damage transmission infrastructure, leading to interruptions. Both are evaluated as medium-risk threats (risk scores: 6).

From the perspective of the **water sector**, the combined effects of extreme heat and drought may severely impact water quality and accelerate the depletion of water resources. This situation is assessed as high risk (risk score: 12), highlighting the need for regular monitoring of water resource capacity.

This analysis reveals how different sectors are affected by climate change at varying degrees and identifies priorities for action. It emphasizes the urgent need to develop sector-specific adaptation measures, particularly in response to threats such as flooding, landslides, and water scarcity.

5.6.1. Hazard Analysis of Buildings

Climate change and other disaster risks directly affect the resilience of building stock, particularly in urban areas. The analysis of building demolition data by year in the Çankaya district is of critical importance in understanding both the current vulnerability of the building stock and where future risks may become concentrated. Within this context, demolition data from 2012 to 2025 have been examined to assess structural changes in the district and to identify neighborhoods where the risk is more pronounced.

The maps presented below illustrate the neighborhood-level distribution of buildings demolished during specific periods in Çankaya and provide insights into both the current state of the building stock and potential future threats

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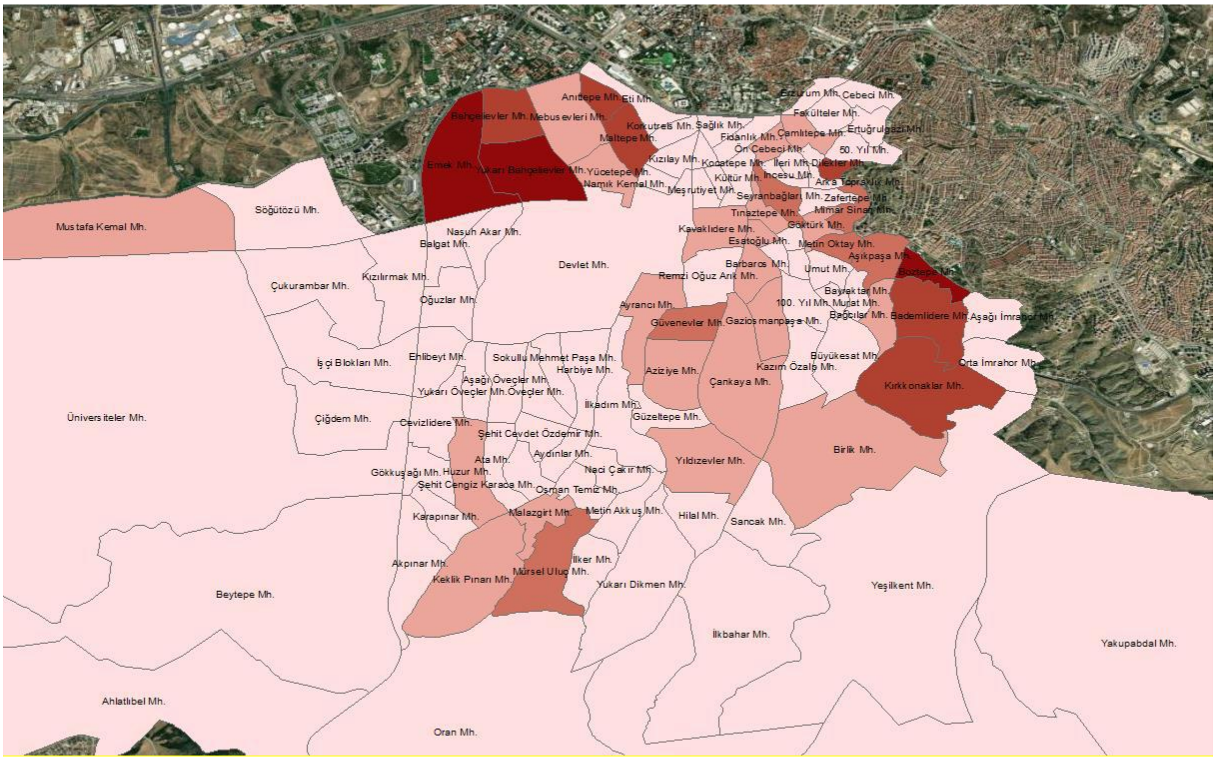

Figure 5.16 Neighborhood-Level Demolished Building Data in Çankaya District (2012–2025)
(Thematic maps were created in GIS using 2025 data provided by the Çankaya Municipality Building Inspection Department.)

Table 5.7 Data on Risky and/or Demolished Buildings in Çankaya Between 2012 and 2025 (Source: Çankaya Municipality Building Inspection Directorate, 2025)

NAME	Building Officially Confirmed as Risky	Building Demolished	Building Excluded from the Scope of Law No. 6306	Confirmed as Not Risky	Building Identified as Risky	Notice Issued to Owners for Evacuation and Demolition	Notification Sent to Municipality to Issue Demolition Notice to Owners
100.YIL	0	12	0	0	0	2	0
50.YIL	0	37	0	0	1	0	1
AHLATLIBEL	0	1	0	0	0	0	0
AKPINAR	0	1	0	1	0	0	0
ALACAATLI	0	5	0	0	0	1	0
ANITTEPE	0	65	1	0	0	2	0
ARKA TOPRAKLIK	0	4	0	0	0	1	0
AŞAĞI ÖVEÇLER	0	9	0	0	0	0	0
AŞIKPAŞA	0	38	0	1	0	0	0
AYDINLAR	0	1	0	0	0	0	0
AYRANCI	0	26	1	0	1	2	1
AZİZİYE	0	23	1	1	0	2	0
BADEMLİDERE	1	55	0	1	0	0	0
BAĞCILAR	0	17	0	1	0	0	0
BAHÇELİEVLER	4	85	0	0	1	8	1
BALGAT	0	8	0	0	0	0	0
BARBAROS	2	14	0	0	0	5	0
BAYRAKTAR	0	2	0	0	0	0	0
BEYTEPE	0	3	0	0	0	1	0
BİRLİK	0	18	0	1	0	0	0
BOZTEPE	3	117	1	0	1	20	0
BÜYÜKESAT	1	6	0	0	0	0	0
CEBECİ	0	4	0	0	0	0	0
CEVİZLİDERE	0	1	0	0	0	0	0
CUMHURİYET	0	3	0	0	0	1	0
ÇAMLITEPE	0	21	1	0	0	0	0
ÇANKAYA	1	13	0	0	1	0	0
ÇAYYOLU	0	2	0	0	0	1	0

ÇİĞDEM	0	9	0	0	0	0	1
ÇUKURAMBAR	0	9	0	0	0	0	0
DEVLET	0	2	0	0	0	0	0
DİLEKLER	0	81	1	0	0	0	1
DODURGA	0	1	0	0	0	0	0
DOĞUŞ	0	7	0	0	0	1	0
EHLİBEYT	0	1	0	0	0	0	0
EMEK	2	196	3	1	0	10	0
ERTUĞRULGAZİ	1	4	0	0	0	2	0
ERZURUM	0	2	0	0	0	0	0
ESATOĞLU	0	18	0	0	0	1	0
ETİ	0	5	1	0	0	1	0
FAKÜLTELER	0	8	0	0	1	1	0
FİDANLIK	0	3	0	0	0	0	0
GAZİOSMANPAŞA	0	17	0	0	1	4	0
GÖKKUŞAĞI	0	2	0	0	0	0	0
GÖKTÜRK	1	15	0	0	0	0	0
GÜVENEVLER	0	45	0	1	0	1	0
GÜZELTEPE	0	7	0	0	0	0	0
HARBİYE	0	4	1	0	0	0	0
HİLAL	0	3	0	0	0	0	0
HUZUR	0	15	0	0	0	0	0
İLERİ	1	8	0	0	0	3	0
İLKADIM	0	4	1	0	0	0	0
İLKBAHAR	0	2	0	0	0	1	0
İLKER	0	1	0	0	0	0	0
İNCESU	0	7	0	0	0	1	0
İŞÇİ BLOKLARI	0	3	0	0	0	0	0
KAVAKLIDERE	1	20	0	0	0	3	0
KAZIM ÖZALP	1	10	0	0	0	1	0
KEKLİK PINARI	0	12	0	0	0	0	0
KIRKKONAKLAR	1	57	1	3	0	1	0
KIZILAY	1	4	0	0	0	1	0
KIZILIRMAK	0	3	0	0	0	0	0
KOCATEPE	0	2	1	0	0	0	0
KORKUTREİS	0	8	0	0	1	1	0

KÜÇÜKESAT	0	8	0	0	0	2	0
KÜLTÜR	0	6	0	0	0	3	0
MALAZGİRT	0	21	0	0	0	1	0
MALTEPE	3	61	1	0	4	7	0
MEBUSEVLERİ	1	24	0	0	0	3	0
MEŞRUTİYET	0	6	1	0	0	1	0
METİN AKKUŞ	0	1	0	0	0	0	0
METİN OKTAY	1	43	1	0	0	0	0
MİMAR SİNAN	0	35	2	0	0	2	0
MUHSİN ERTUĞRUL	0	4	0	0	0	0	0
MURAT	0	1	0	0	0	0	0
MUSTAFA KEMAL	0	11	0	0	1	1	0
MUTLUKENT	0	5	2	0	0	0	0
MÜRSEL ULUÇ	0	35	0	0	0	0	0
NACİ ÇAKIR	0	3	0	0	0	0	0
NASUH AKAR	0	2	0	0	0	1	0
OĞUZLAR	1	1	0	0	0	0	0
ORAN	0	1	1	0	0	0	0
ÖN CEBECİ	2	19	0	0	1	1	0
ÖVEÇLER	0	6	0	0	0	0	0
PROF. DR. AHMET TANER KIŞLALI	0	3	0	0	0	0	0
REMZİ OĞUZ ARIK	0	7	0	0	0	1	0
SAĞLIK	0	3	1	0	0	0	0
SEYRANBAĞLARI	0	33	0	0	0	0	0
SOKULLU MEHMET PAŞA	0	2	0	0	0	0	0
ŞEHİT CENGİZ KARACA	0	1	0	0	0	0	0
ŞEHİT CEVDET ÖZDEMİR	0	2	0	0	0	0	0
TINAZTEPE	2	12	0	0	1	2	0
TOPRAKLIK	0	0	1	0	0	1	0
UMUT	0	2	0	0	0	0	0
ÜNİVERSİTELER	0	1	0	0	0	0	0
YAKUPABDAL	0	1	0	0	0	0	0

YEŞİLKENT	0	1	0	0	0	0	0
YILDIZEVLER	1	11	0	0	0	0	0
YUKARI BAHÇELİEVLER	3	121	5	0	2	7	0
YUKARI DİKMEN	0	9	0	0	0	0	0
YUKARI ÖVEÇLER	0	1	0	0	0	0	0
YÜCETEPE	0	25	1	1	0	5	0
ZAFERTEPE	1	73	0	1	0	0	0

Figure 5.16 and Table 5.7 present the neighborhood-level distribution of demolished buildings in Çankaya District between 2012 and 2025. The analyses reveal that demolition rates have increased particularly in neighborhoods where the building stock has aged or is structurally vulnerable to disaster impacts. Notably, the neighborhoods of **Emek (196 buildings), Yukarı Bahçelievler (121), Boztepe (117),** and **Bahçelievler (85)** have experienced a significant number of demolitions. The concentration of demolitions in certain neighborhoods can be attributed both to the aging of buildings and to ongoing urban transformation processes. Furthermore, the demolitions that occurred during this period provide critical insights into the existing vulnerability of the area to disaster risks and serve as an important data source for future mitigation planning. Therefore, in designing reconstruction processes as part of urban transformation efforts, it is essential to consider the integration of green and open spaces as well as evacuation routes.

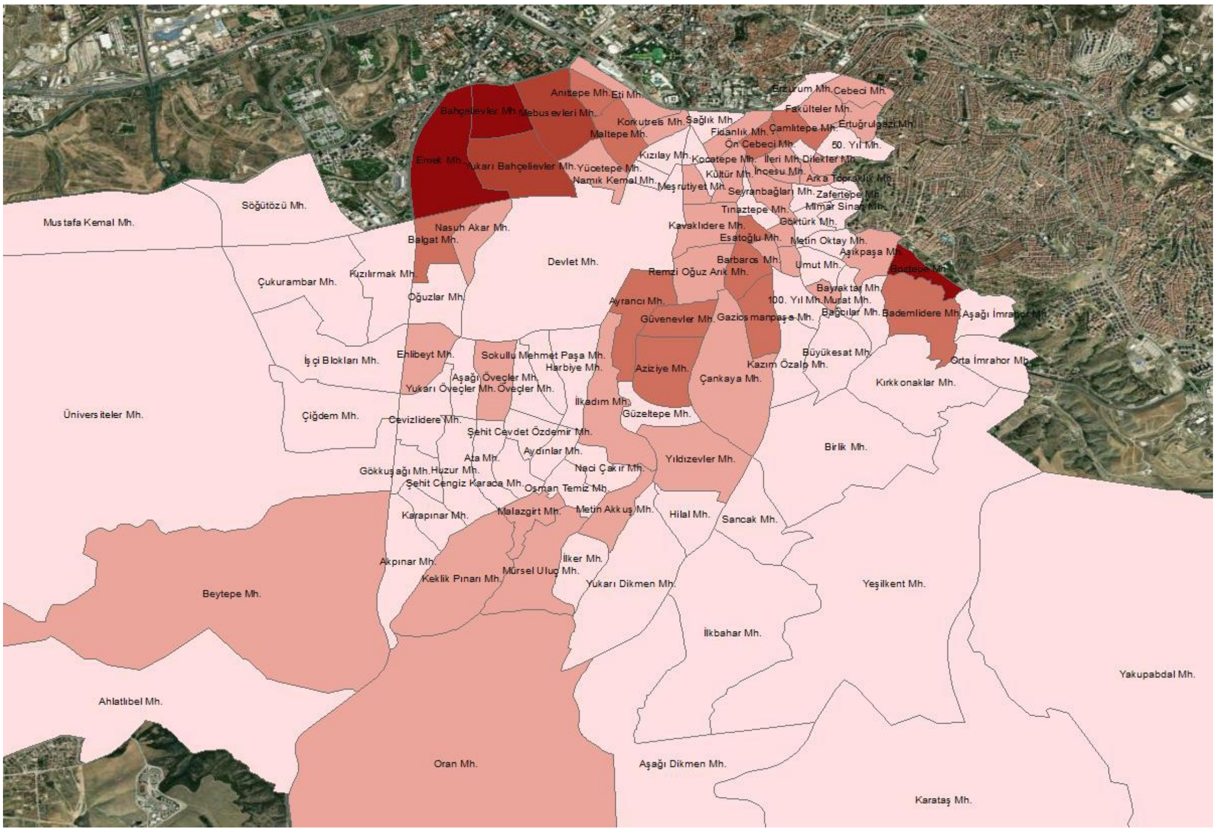

Figure 5.17 Neighborhood-Level Zoomed-In Data on Buildings Demolished After 2023 in Çankaya District (Thematic maps were created in GIS using 2025 data from the Çankaya Municipality Building Inspection Directorate.)

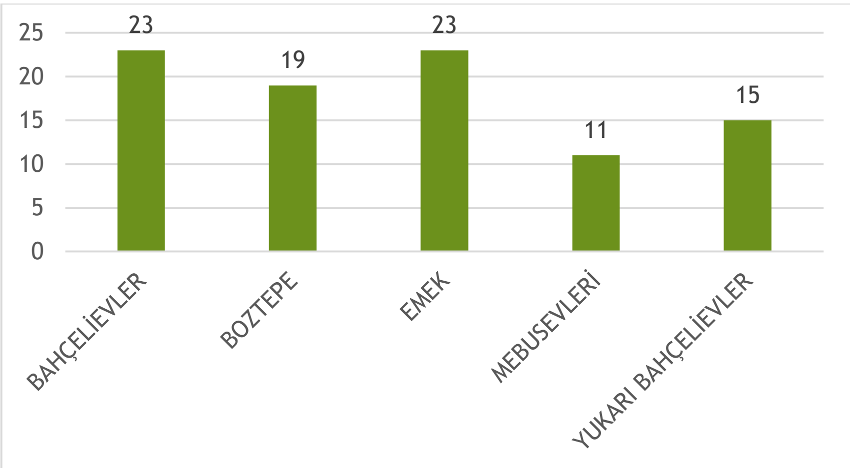

Figure 5.18 Neighborhood-Level Data on Buildings Demolished After 2023 in Çankaya District (Source: Çankaya Municipality Building Inspection Directorate, 2025)

A comparative analysis of demolition data across different time periods reveals that the pattern of building demolitions after 2023 largely mirrors that of the 2012–2025 period. It has been observed that demolition rates have remained consistently high in certain neighborhoods.

Emek, Bahçelievler, Yukarı Bahçelievler, and Boztepe continue to be among the areas with the highest number of demolitions and sustained structural vulnerability.

This indicates that the building stock in these neighborhoods remains at risk and that urban transformation or structural reinforcement efforts have not yet been sufficiently effective. The continuation of demolitions in the same areas highlights the ongoing vulnerability of these neighborhoods to future disaster risks and underscores the need to prioritize them for intervention and resilience planning.

5.7. Analyses for Vulnerable Groups

In risk and vulnerability analyses, assessments based not only on natural and built environment hazards but also on socio-economic and demographic data play a significant role. These analyses are critical in determining climate change adaptation actions. Within this context, the data collected have been evaluated specifically for Ankara—particularly the Çankaya district and its central neighborhoods.

The analysis utilized the ArcGIS Basemap Satellite Imagery, 2023 data from the Turkish Statistical Institute (TÜİK), and data provided by Çankaya Municipality. Based on these analyses, critical areas have been identified, leading to the development of a social vulnerability analysis. This analysis serves as a guide for determining priority intervention areas in light of the identified vulnerabilities.

As a result of these analyses, multi-hazard and social vulnerability assessments will be combined to identify priority urban fabric areas. Additionally, a morphology analysis will be conducted to evaluate the location and strategic significance of these urban areas within the city.

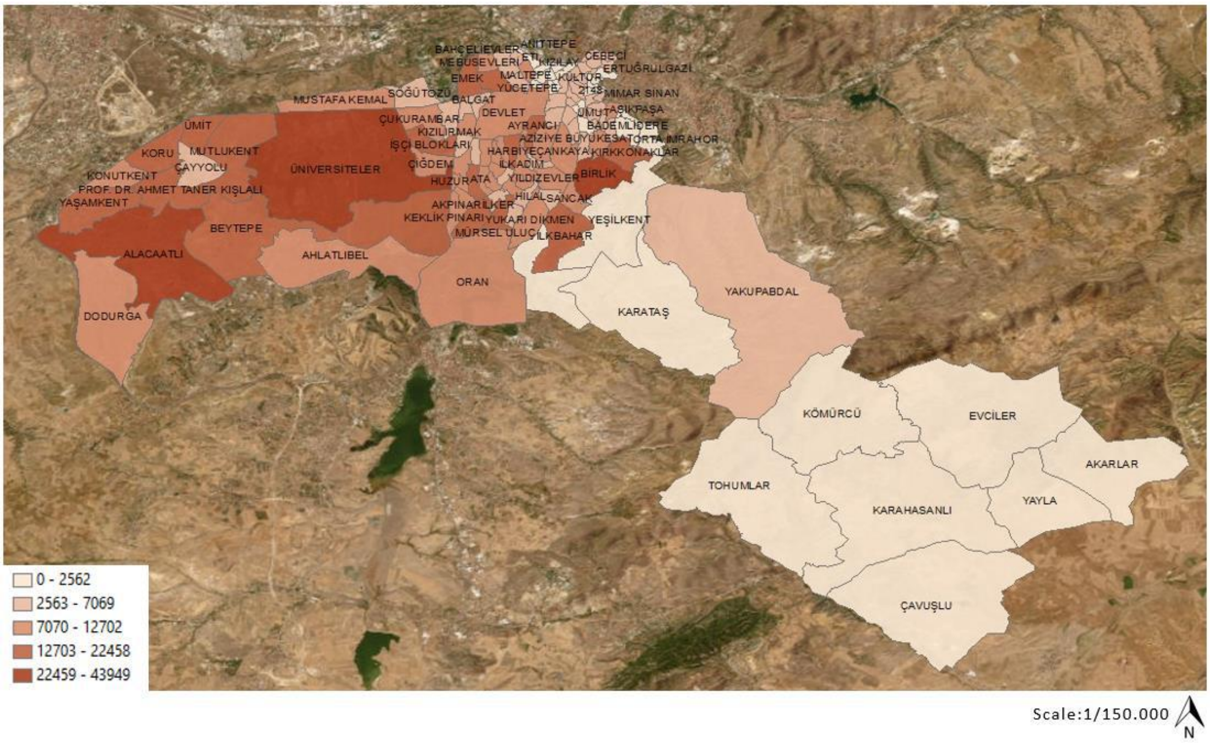

Figure 5.19 Neighborhood-Level 2023 Population Data for Çankaya District
(Thematic maps were created in GIS using 2024 data from TÜİK.)

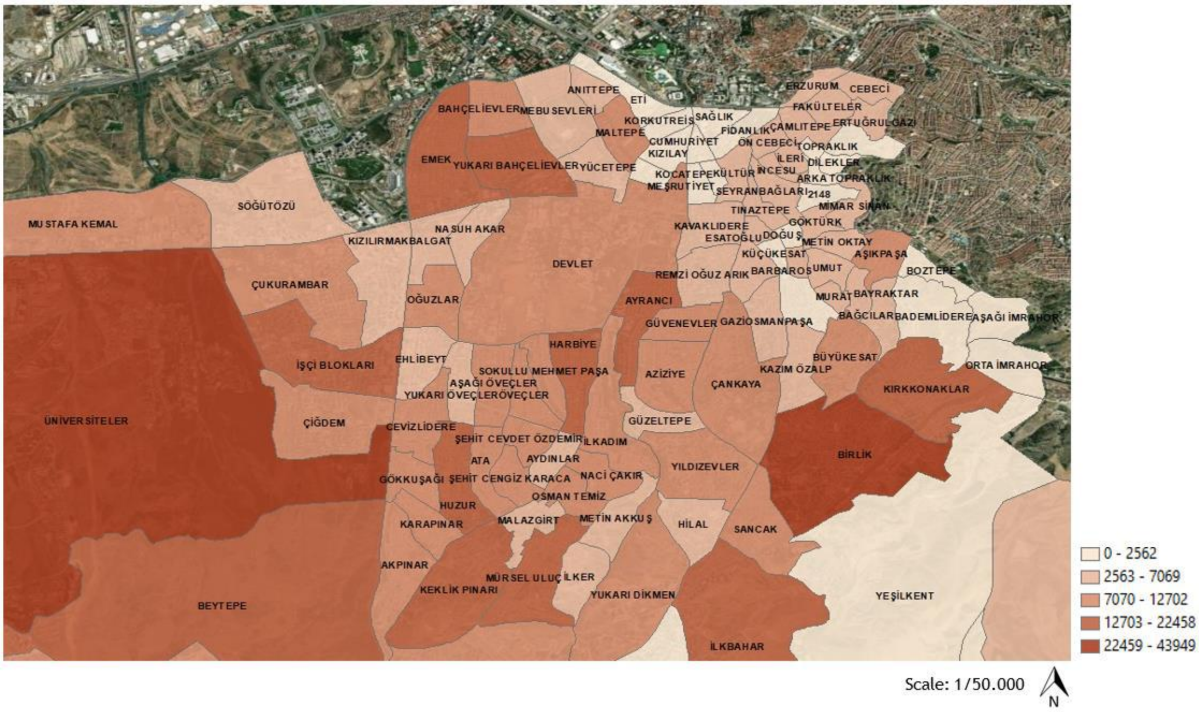

Figure 5.20 Zoomed-In Neighborhood-Level 2023 Population Data for Çankaya District
(Thematic maps were created in GIS using 2024 data from TÜİK.)

When looking at the district as a whole, it has been identified that the neighborhoods of Alacaatlı, Üniversiteler, and Birlik have the highest populations. In contrast, the neighborhoods with the lowest populations are clustered in the southeastern and northern outskirts of the district. Among these are Karahasanlı, Tohumlar, Yeşilkent, and Yayla. In the central neighborhoods, population figures generally range between 10,000 and 20,000 people.

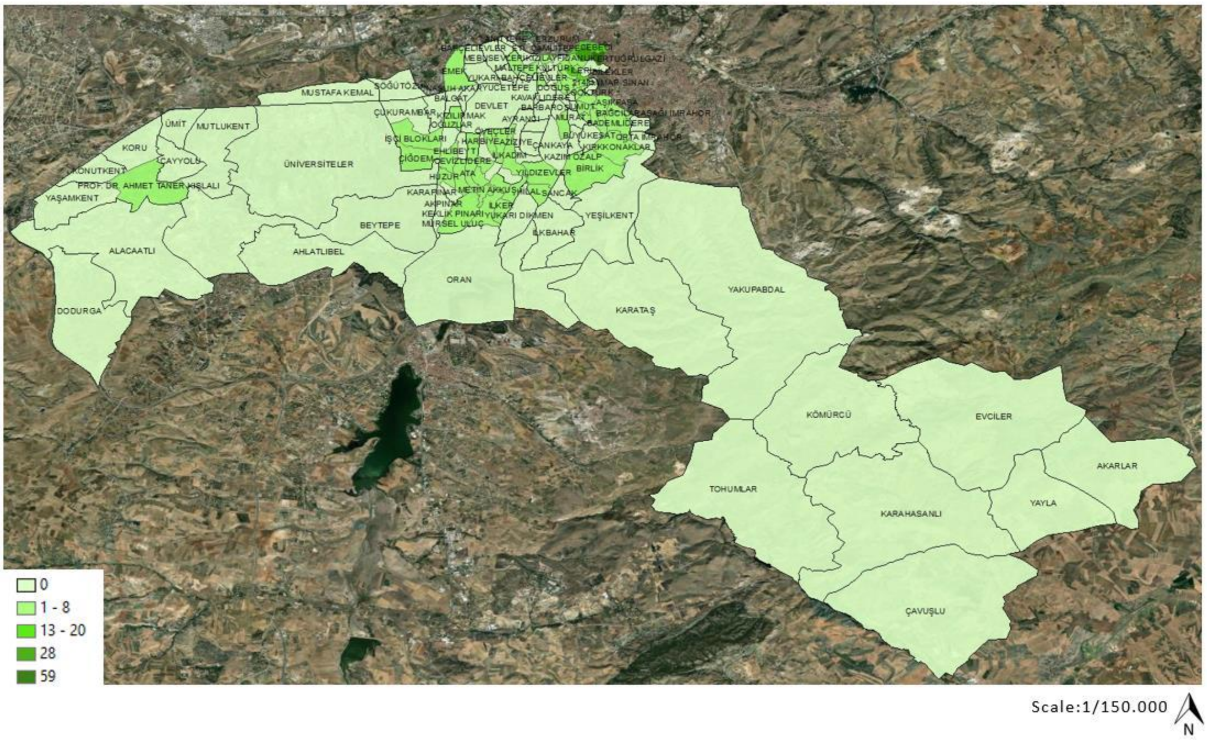

Figure 5.21 Neighborhood-Level Migrant Population in Çankaya District (Thematic maps were created in GIS using 2024 data from Ankara Metropolitan Municipality Department of Social Services.)

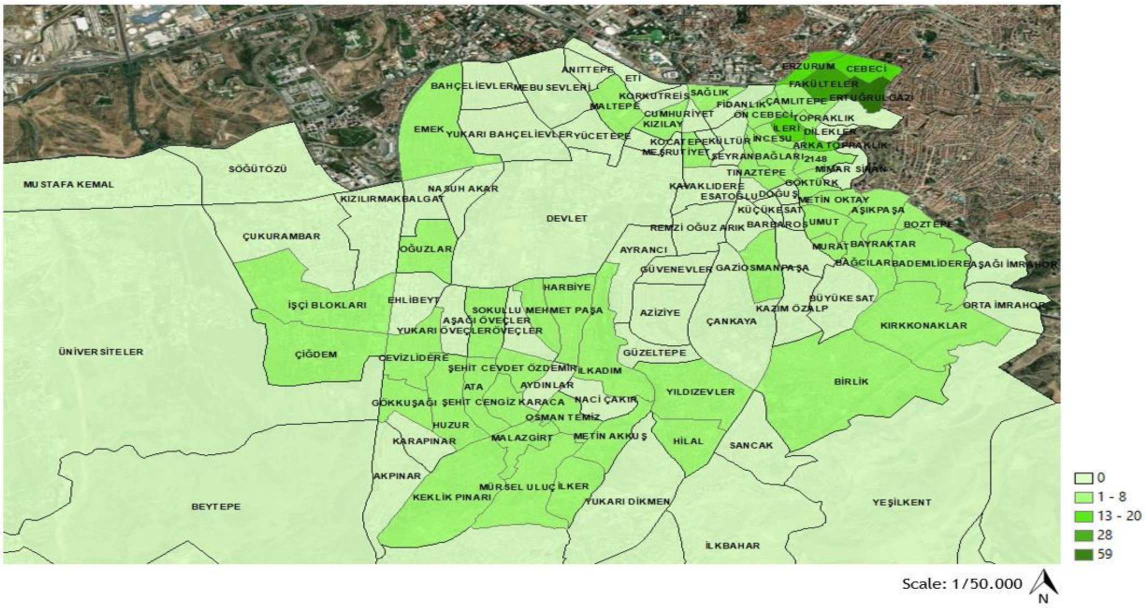

Figure 5.22 Zoomed-In Neighborhood-Level Migrant Population in Çankaya District
(Thematic maps were created in GIS using 2024 data from Ankara Metropolitan Municipality Department of Social Services.)

It has been identified that there is a concentration of migrants in the northern periphery of the Çankaya District. Ertuğrulgazi Neighborhood stands out in particular, followed by its adjacent Fakülteler Neighborhood. Ertuğrulgazi has a population of 6,485, with 59 registered migrants, while Fakülteler has a population of 5,619 and 58 registered migrants. Additionally, the neighborhoods of Erzurum, Cebeci, İleri, and Arka Topraklık also follow in terms of migrant population numbers. Although a clustering is observed in the northern part of the district, a general assessment of Çankaya indicates that the majority of the migrant population resides in the central neighborhoods.

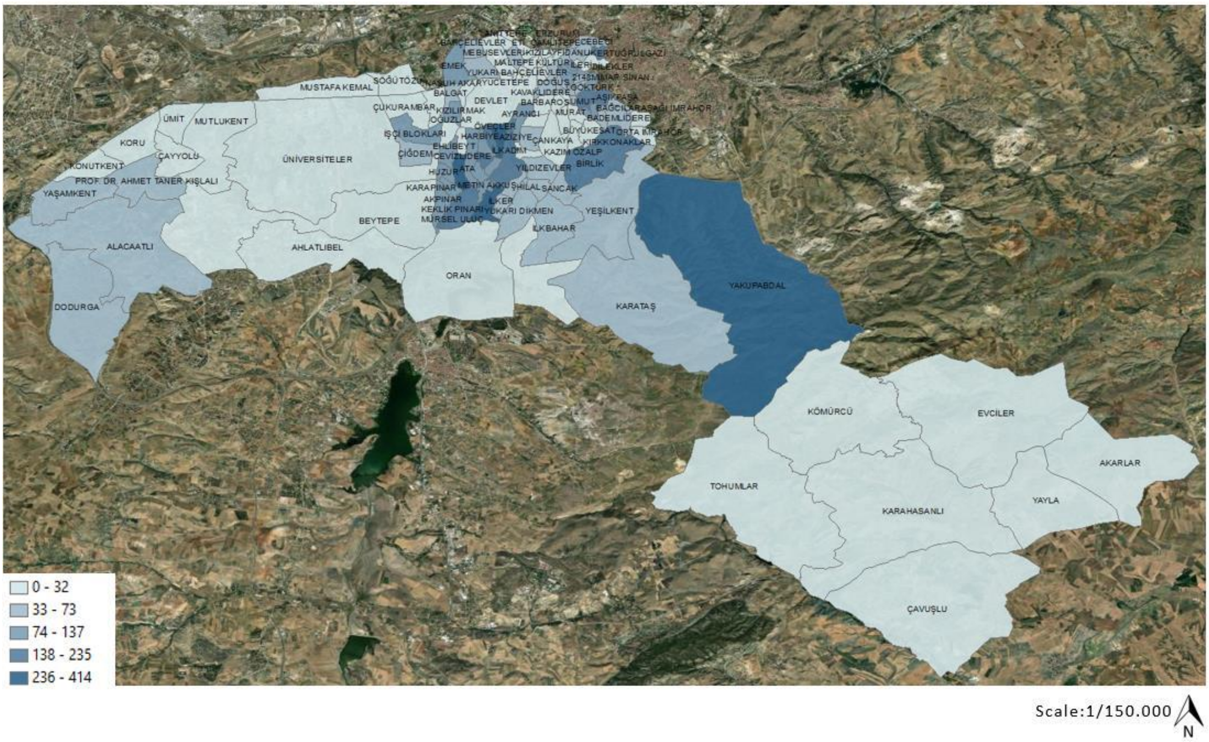

Figure 5.23 Neighborhood-Level Number of Households Receiving Social Assistance in Çankaya District (Thematic maps were created in GIS using 2024 data from the Ankara Metropolitan Municipality Department of Social Services)

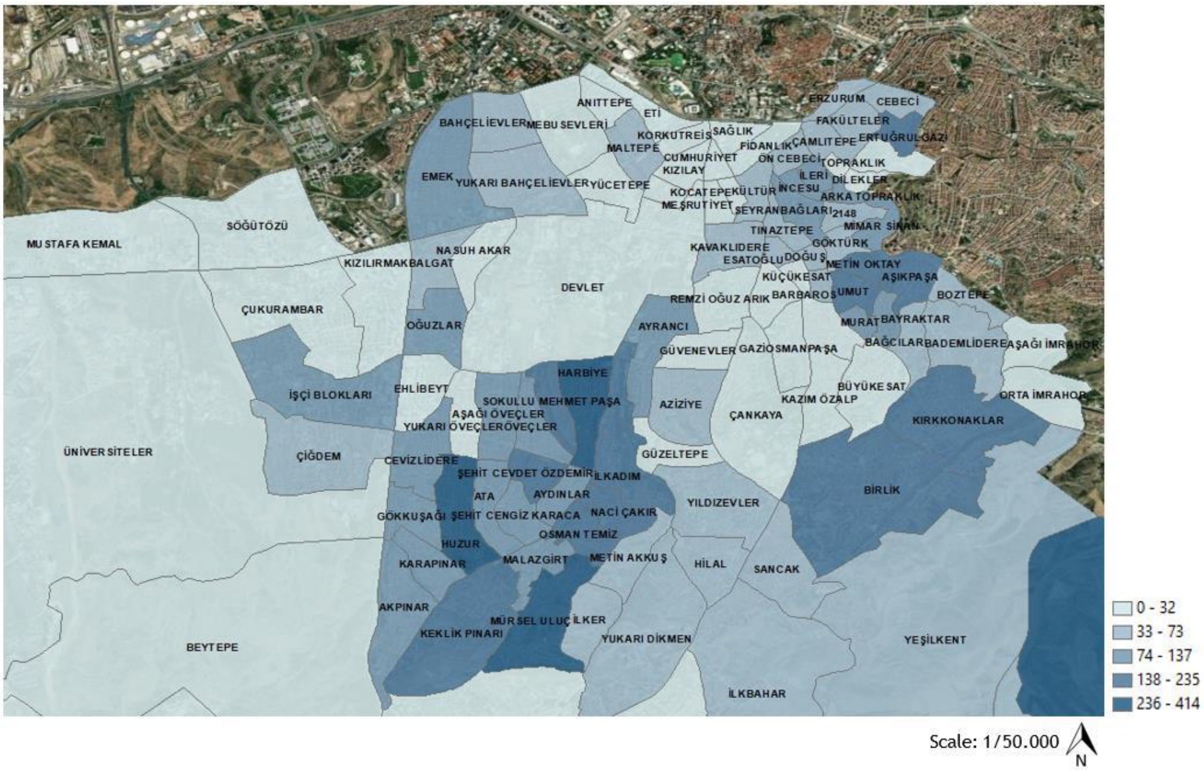

Figure 5.24 Zoomed-In Neighborhood-Level Number of Households Receiving Social Assistance in Çankaya District (Thematic maps were created in GIS using 2024 data from the Ankara Metropolitan Municipality Department of Social Services)

According to the classification based on the number of households receiving social assistance, the highest number of aid recipients was recorded in Mürsel Uluç Neighborhood, with 414 households receiving assistance. As of 2023, the population of this neighborhood was 17,746. It is followed by Yakupabdal Neighborhood, which has a population of 3,889 and 391 households receiving aid. Huzur and Harbiye neighborhoods are also among those receiving the most social assistance, with 290 and 279 beneficiary households, respectively. A particular vulnerability has been identified in the southern part of the central district, while the eastern and western parts of the district show relatively low numbers of households receiving assistance.

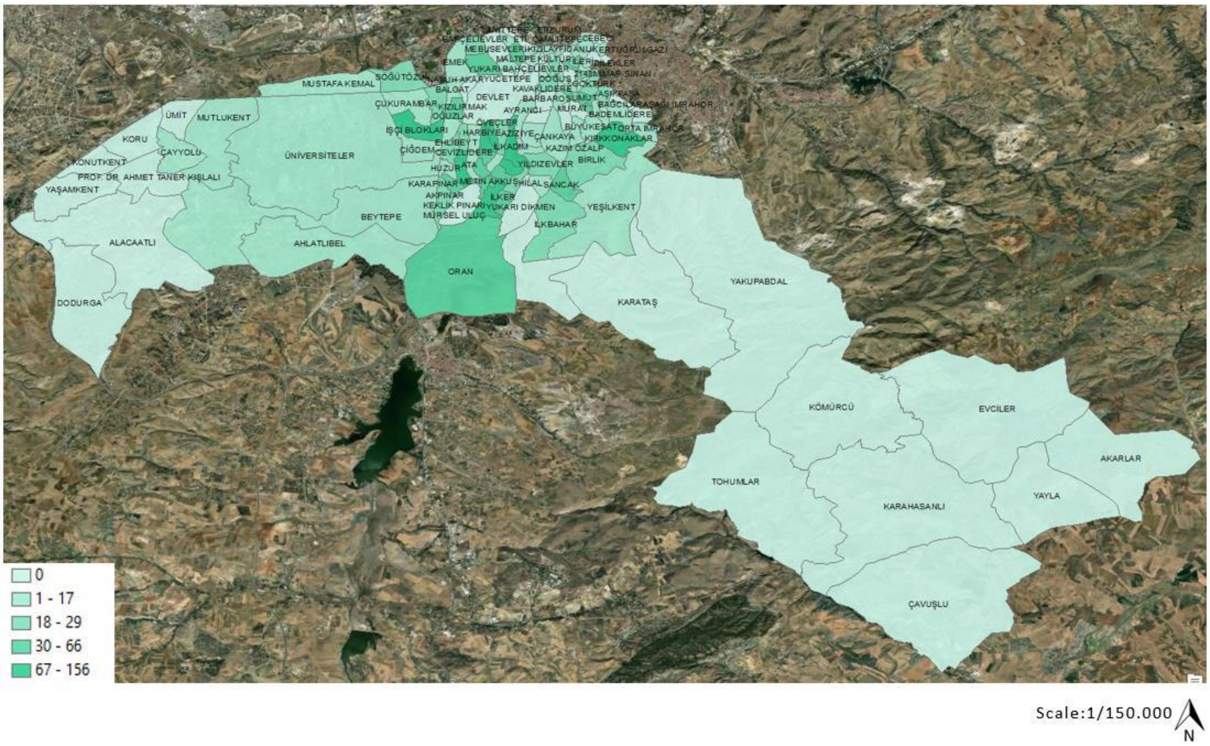

Figure 5.25 Neighborhood-Level Number of Persons with Disabilities of Çankaya District (Thematic maps were created in GIS using 2024 data from the Ankara Metropolitan Municipality Department of Social Services.)

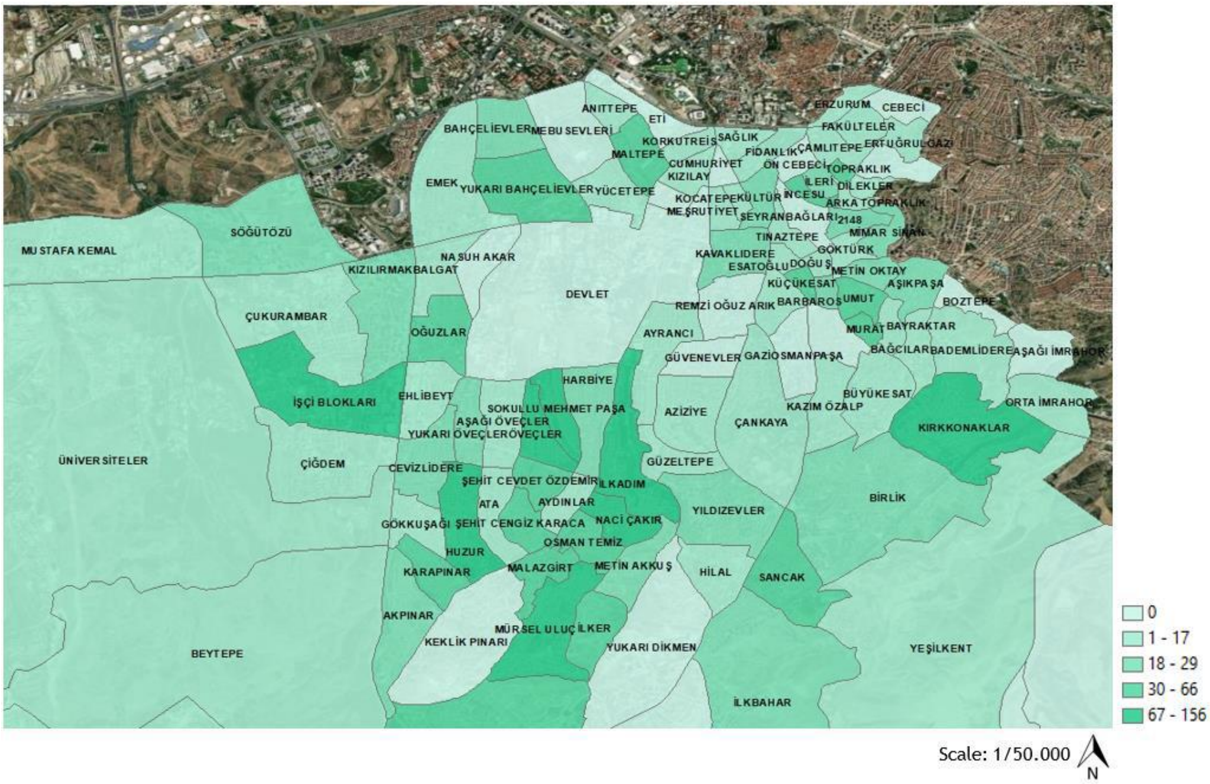

Figure 5.26 Neighborhood-Level Number of Persons with Disabilities in Central Neighborhoods of Çankaya District (Thematic maps were created in GIS using 2024 data from the Ankara Metropolitan Municipality Department of Social Services.)

An analysis of the number of persons with disabilities in the district reveals a concentration in the central neighborhoods of Çankaya. Among these, Öveçler Neighborhood has the highest number, with 156 individuals with disabilities and a population of 8,634 as of 2023. It is followed by Mürsel Uluç, which has a population of 17,746 and 128 individuals with disabilities. Huzur Neighborhood, with a population of 16,808 and 112 individuals with disabilities, also ranks among the neighborhoods with the highest figures. In contrast, it was identified that no persons with disabilities were recorded in the neighborhoods located in the eastern part of Çankaya.

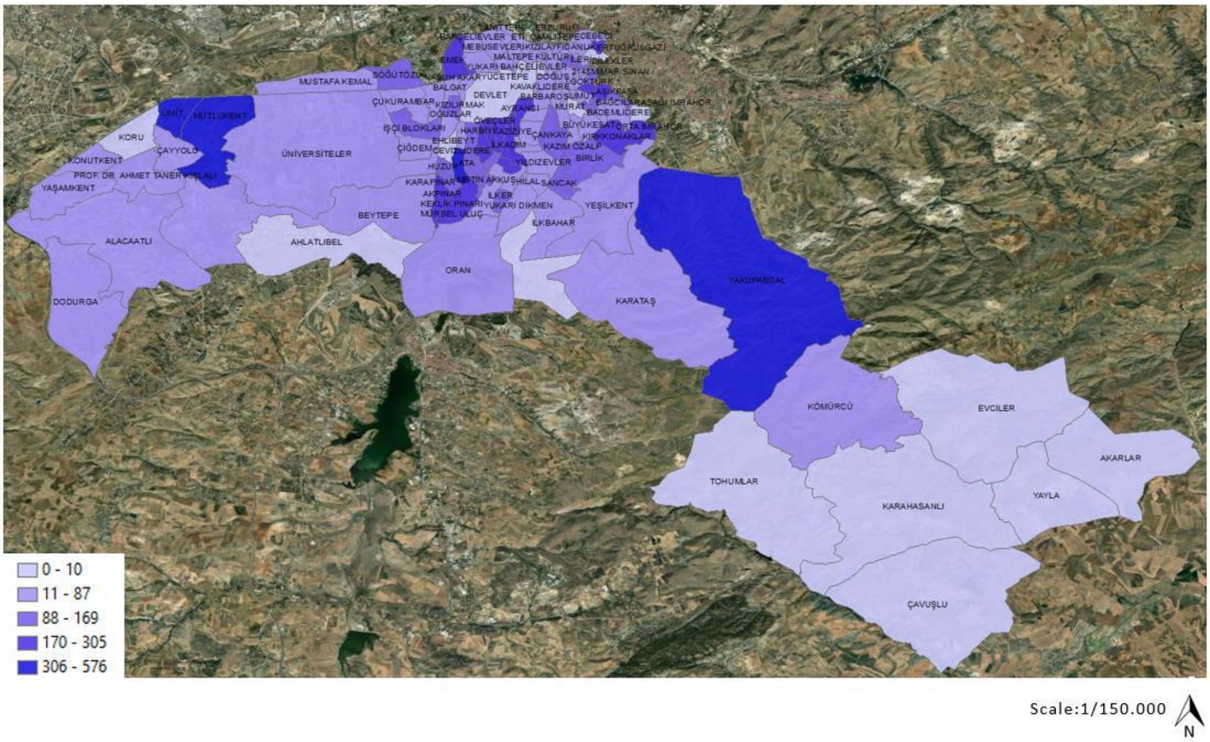

Figure 5.27 Neighborhood-Level Number of Food Assistance Cards of Çankaya District
(Thematic maps were created in GIS using 2024 data from the Ankara Metropolitan Municipality Department of Social Services.)

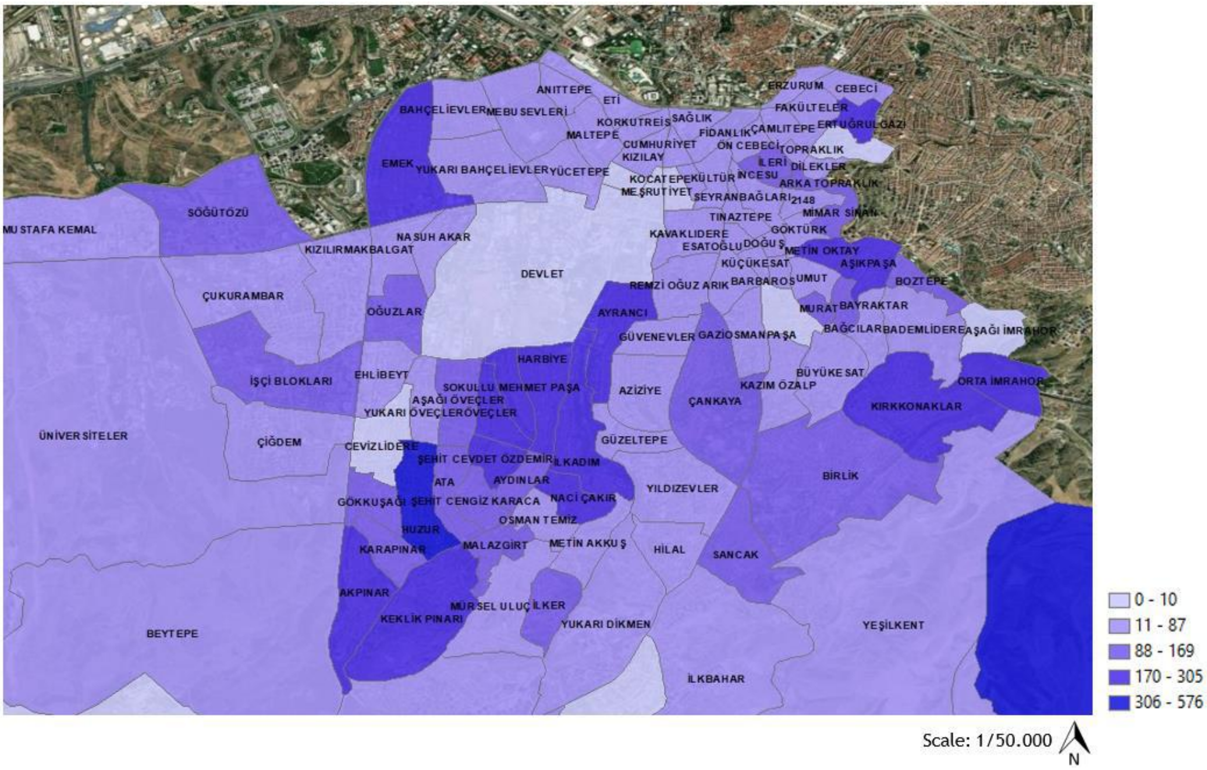

Figure 5.28 Neighborhood-Level Number of Food Assistance Cards in Central Neighborhoods of Çankaya District (Thematic maps were created in GIS using 2024 data from the Ankara Metropolitan Municipality Department of Social Services.)

The neighborhoods most vulnerable in terms of food access—based on the number of food assistance card recipients—are Mutlukent, Ümit, Yakupabdal, and Huzur, in that order. In Mutlukent, which had a population of 20,001 in 2023, 576 individuals received food assistance cards. In Ümit, Yakupabdal, and Huzur, the number of recipients was 395, 386, and 381 respectively, with 2023 populations of 13,961, 3,889, and 16,808. Additionally, food assistance card recipients are mostly concentrated in the central neighborhoods, while the eastern neighborhoods of the district appear to experience the least difficulty in accessing food.

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6. Greenhouse Gas Inventory and Mitigation Actions

6.1. Greenhouse Gas Inventory Results

Within the scope of this study, the sectoral breakdown of greenhouse gas emissions within the boundaries of Çankaya District for the calendar year 2023 is presented in Table 6.1.

According to the results, the largest source of emissions are public buildings (excluding municipal buildings) and commercial buildings, accounting for 39% of total emissions. These are followed by private passenger and commercial vehicles (28% of total emissions) and residential buildings (20% of total emissions). Together, these three sectors are responsible for approximately 90% of the total emissions.

Table 6.1 Distribution of Greenhouse Gas Emissions in Çankaya District by Sector

SECTOR	Greenhouse Gas Emission (tCO_2e)	Share in Sector (%)	Share in Total (%)
BUILDINGS, FACILITIES, AND INDUSTRY			
Çankaya Municipality Buildings	8,335	0.3%	0.2%
Çankaya Municipality Affiliates	159	0.01%	0.003%
Energy Use in Public Lighting	27,008	1%	1%
Public Buildings, excluding Commercial and Municipality Buildings	1,828,317	**62%**	**39%**
Residential Buildings	934,492	32%	**20%**
Industry	156,190	5%	3%
Subtotal	2,954,500		**63%**
TRANSPORTATION			
Municipally Owned Public Transport Vehicles	34,279	2%	1%
Municipal Construction Equipment	11,579	1%	0.2%
Municipally Owned Light Commercial Vehicles	351	0.03%	0.01%
Municipally Owned or Leased Passenger Cars	833	0.1%	0.02%
Private Public Transport Vehicles	7,830	1%	0.2%
Private Commercial and Passenger Vehicles	1,326,303	**96%**	**28%**
Subtotal	1,381,175		**29%**
OTHERS			
Agricultural Irrigation	57,911	15%	1%
Solid Waste Management	265,886	68%	6%
Wastewater Management	67,497	17%	1%

Fertilizer Use (Parks and Gardens)	143	0.04%	0.003%
Subtotal	391,437		8%
GRAND TOTAL	**4,727,112**		

Within the scope of this study, the sectoral breakdown of greenhouse gas emissions resulting from Çankaya Municipality's operational activities for the calendar year 2023 is presented in Table 6.2s.

According to the results, the largest source of emissions is fuel consumption from BELPET fuel sales, accounting for 28% of total municipal emissions. Other major emission sources include fuel consumption by municipal construction equipment (21%), fuel consumption by municipal waste collection vehicles (18%), and electricity consumption in municipal buildings and facilities (15%).

Table 6.2 Distribution of Greenhouse Gas Emissions in Çankaya Municipality by Operational Sources

GREENHOUSE GAS EMISSIONS IN ÇANKAYA MUNICIPALITY BY OPERATIONAL SOURCES	Greenhouse Gas Emission (tCO2e)	Share in Total (%)
MUNICIPALITY BUILDINGS		
Electricity Consumption in Çankaya Municipality Buildings (excluding lighting, cooling, and irrigation—includes electric motors, etc.)	4,564	15%
Electricity Consumption in Çankaya Municipality Subsidiaries (excluding lighting, cooling, and irrigation—includes electric motors, etc.)	98	0.3%
Electricity Consumption for Park and Garden Irrigation (consumed by electric motors)	113	0.4%
Natural Gas Consumption in Çankaya Municipality Buildings	3,771	13%
Natural Gas Consumption in Çankaya Municipality Subsidiaries	61	0.2%
TRANSPORTATION		
BELPET Fuel Sales (Excluding Municipal Vehicles)	8,200	28%
Diesel Consumption by Municipal Construction Equipment	6,315	21%
Diesel Consumption by Municipal Waste Collection Vehicles	5,264	18%
Diesel and Gasoline Consumption by Municipal Light Commercial Vehicles	351	1%
Diesel and Gasoline Consumption by Municipality-Owned or Leased Passenger Vehicles	833	3%

OTHERS		
Fertilizer Use (Parks and Gardens)	143	0.5%
GRAND TOTAL	**29.711**	**100,0%**

6.2. Mitigation Actions

As part of the Sustainable Energy and Climate Action Plan (SECAP), the designed emission reduction actions are expected to achieve a 55% reduction in emissions by 2030, based on baseline emissions from the 2023 calendar year. At this point, emission reduction actions should be examined under two main categories:

1. the reduction of emissions within the boundaries of Çankaya District, and
2. the reduction of emissions stemming from the operational activities under the control of Çankaya Municipality.

It should be noted that emission reductions at the district level are largely beyond the direct control of the municipal authority and will instead depend on national-level policies and provincial-scale decarbonization strategies shaped by those policies. In other words, the 55% emission reduction target for which Çankaya Municipality may be held accountable has been studied in relation to emissions that fall under the municipality's operational control.

In addition, emissions that could potentially be reduced in the buildings and transportation sectors have also been estimated, based on relevant and up-to-date national-level studies. In the following sections of this document, emissions projections for the entire district are first presented based on national policy documents, followed by a list of recommended actions that could achieve a 55% reduction in emissions from municipal operations under the direct control of Çankaya Municipality.

6.2.1. Emission Reduction Measures in Buildings Across the District

According to 2023 calendar year greenhouse gas emissions within the boundaries of Çankaya Municipality, two sectors stand out in particular.

In December 2023, the Ministry of Environment, Urbanization and Climate Change of the Republic of Türkiye published a study titled **"Decarbonization Roadmap for the Building Sector in Türkiye."** The report outlines the current state, assumptions, and various projection analyses for the period 2021–2053. As clearly stated in the report, Türkiye currently lacks a comprehensive and up-to-date building inventory. There are no official statistics regarding the total size or geographic distribution of the existing building stock.

The last building census conducted by the Turkish Statistical Institute (TÜİK) dates to the year 2000, and subsequent estimates have relied on assumptions. Another available data source is TÜİK's dataset on construction permits issued between 2000 and 2022.

The Decarbonization Roadmap describes the status of the building stock using parameters such as:

- Number of buildings
- Total usable floor area
- Floor area distribution by building typology
- Number and classification of Energy Performance Certificates (EPCs)
- Estimated demolition rates due to urban transformation.

As the most up-to-date national-level reference on buildings, this study is used as a key source for emission reduction projections in this document. The main mitigation assumptions presented in that study can be summarized as follows:

- Between **2023–2032**, all new residential and non-residential buildings will be constructed as **Nearly Zero-Energy Buildings (NZEBs)**.
- Between **2033–2042**, new buildings will comply with **EPC Class A** standards.
- Between **2043–2053**, new buildings will become **Net Zero Operational Carbon Buildings**, meaning that their annual operational emissions will be balanced by renewable energy sources.
  - In addition, pre-2000 buildings will be gradually demolished and replaced, and 5% of buildings constructed between 2000–2010 will undergo deep energy renovations annually (until 2043) to achieve NZEB standards (**operational carbon mitigation measures**).
- Starting from **2023**, inefficient appliances such as refrigerators, washing machines, and dishwashers in residential buildings will be replaced with energy-efficient alternatives at a pace of 10% per year until 2033 (**operational carbon mitigation measures**).

Based on these assumptions, it is projected that **operational GHG emissions** from new residential and non-residential reinforced concrete buildings will be reduced by **30% by 2033** and by **100% by 2053**, relative to 2023 levels.

Since this roadmap represents a national-level public policy, it is assumed that the same principles can be applied to buildings located within the Çankaya Municipality, including residential, commercial, public, and industrial facilities.

In the table below, the portion of Çankaya's 2023 greenhouse gas emissions associated with the **building sector** is presented under both the **baseline** and **mitigation scenarios**. The mitigation scenario reflects the assumptions stated above. In the next stages of this study, more detailed analyses and roadmaps will be developed specifically for buildings owned or leased by Çankaya Municipality, to explore further reduction opportunities for its infrastructure and building assets

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Table 6.3 Baseline Scenario and Mitigation Scenario Projections within the Boundaries of Çankaya Municipality

Sector: Buildings	Reduction Amount tCO_2e							Projected Emission Reductions from Mitigation Scenario by 2030 (tCO2e)	Expected Emission Quantities by Category in 2030 under the SECAP Framework	The Difference Between the Targeted Emission Amount in 2030 under the SECAP Framework and the 2030 Reduction Scenario Projections (tCO2e)	2023 Base Year Inventory Data (tCO2e)	The Additional Reduction Rate Required within the SECAP Framework Compared to the National Scale Reduction Projections
	2024	2025	2026	2027	2028	2029	2030					
32% Energy Efficiency in Public and Commercial Buildings by 2030	82,505	173,748	274,421	385,268	507,084	640,720	839,559	1,784,063	1,005,574	778,489	1,828,317	43%
32% Energy Efficiency in Residential Buildings by 2030	42,170	88,806	140,262	196,919	259,182	327,486	429,117	911,873	513,971	397,902	934,492	
32% Energy Efficiency in Buildings Owned by Çankaya Municipality	383	807	1,275	1,790	2,356	2,977	3,900	8,288	4,672	3,617	8,494	
Total	125,059	263,361	415,958	583,977	768,622	971,183	1,272,576	2,704,224	1,524,217	1,180,007	2,771,303	

6.2.2. Emission Reduction Studies in the Transportation Sector throughout the District

In the transportation sector, the most effective methods for emission reduction would be to prioritize public transportation options over individual passenger vehicles and to increase the use of electric vehicles (EVs), whose numbers are steadily rising in traffic. However, it should be noted that in cases where the electricity used by vehicles has a high emission factor, the use of electric vehicles may not contribute sufficiently to emission reduction.

However, with the growing capacity of renewable energy sources in Turkey, which is continuously increasing each year, the national grid's emission factor is expected to decline. This decline makes it easy to state that electric vehicles have a positive impact on reducing emissions from road transportation and logistics activities.

In the later sections of this document, national-scale projections and forecasts related to the number of electric vehicles and charging infrastructure, as prepared by the Energy Market Regulatory Authority (EPDK), will be taken into account. The impact on emission reduction within the boundaries of Çankaya District, assuming these projections materialize, will be analyzed. Additionally, as mentioned in the previous section on buildings, Çankaya Municipality's control over transportation vehicles it does not own is limited by regulations. Therefore, it is believed that the municipality can contribute to mitigation efforts for these vehicles through various incentive services.

One of the most recent projection studies on the number of electric vehicles was conducted by EPDK on April 8, 2024, titled "Electric Vehicle and Charging Infrastructure Projection." This study considers the rapid increase in the number of electric vehicles and the corresponding growth in charging points as a positive step for the development of the e-mobility ecosystem.

The study presents projections for the increase in the number of electric vehicles in Turkey under three scenarios: low, medium, and high. According to this, it is projected that:

- In 2025, the number of electric vehicles will reach: 202,030 in the low scenario; 269,154 in the medium scenario; 361,893 in the high scenario.
- In 2030, the number of electric vehicles will reach: 776,362 in the low scenario; 1,321,932 in the medium scenario; 1,679,600 in the high scenario.

Table 6.4 Projections for the Number of Electric Vehicles in Çankaya District (Source: EPDK, 2024)

Year	**Number of Electric Vehicles (EVs)**		
	Low Scenario	*Medium Scenario*	*High Scenario*
2025	202,030	269,154	361,893
2030	776,362	1,321,932	1,679,600

Table 6.5 Distribution of Registered Cars by Fuel Type, 2021-2023

Year	Total	Petrol	Diesel	LPG	Hybrid [(2)]	Electric
2021	**13 706 065**	3 495 172	5 158 803	4 923 275	86 682	6 267
2022	**14 269 352**	3 817 104	5 261 876	5 005 563	134 662	14 552
2023[(1)]	**14 350 770**	**3 866 580**	**5 280 291**	**5 011 448**	**140 639**	**16 233**

According to TURKSTAT data, in 2023, the number of electric vehicles in Turkey accounted for 0.1% of the total vehicle fleet, with a total of 16,233 vehicles. When comparing this data with EPDK figures, it is projected that the number of electric vehicles will increase by about 100 times by 2030, according to the high reduction scenario. However, assuming that the total number of vehicles on the road will also increase by 2030, it is difficult to predict the exact share of electric vehicles in the total vehicle fleet. Nevertheless, with a rough estimate, if the share of electric vehicles increases by 100 times compared to 2023, their proportion in the total vehicle fleet is expected to be at least around 10%. Since the electric vehicle sector is progressing rapidly, it is also possible that the share of electric vehicles in the total vehicle fleet in 2030 could exceed 10%. This share, if the electricity source is renewable, indicates a potential to reduce transportation-related emissions by approximately 10%. In the later stages of this study, more detailed data and projections will be sought to further develop the current draft-level analyses. However, in summary, in addition to individual vehicles, the emission reduction potential of vehicles owned by the Çankaya Municipality will be addressed separately as part of the municipal institutional inventory, with reduction options above 10% being evaluated.

6.2.3. Emission Reduction Strategies of Çankaya Municipality's Operational Activities

The emission reduction strategies stemming from Çankaya Municipality's operational activities have been examined under three main categories, as outlined below:

- Municipal buildings and facilities
- Municipal transportation, logistics activities, and construction equipment
- Energy, water, and fertilizer efficiency practices in parks and gardens under municipal control

In developing emission reduction strategies under these categories, two different scenarios (Scenario 1 and Scenario 2) have been prepared. The main distinguishing factors between Scenario 1 and Scenario 2 are summarized below. However, in both scenarios, it appears feasible to achieve the SECAP target of reducing 2030 emissions by 55% compared to the 2023 baseline.
Key differentiators include:

- Use of solar energy for electricity generation in municipal buildings and facilities
- Electrification of construction equipment and waste collection vehicles
- Fuel efficiency through route optimization in waste collection operations

The assumptions and detailed emission outputs for Scenarios 1 and 2 are presented in the following sub-sections.

6.2.3.1. Emission Reduction Strategies for Çankaya Municipality's Operational Activities – Scenario 1

The mitigation actions considered under Scenario 1 are listed as follows:

Buildings and Facilities

- Ensuring that all new constructions starting from 2025 meet the “A” energy efficiency class
- Conducting energy efficiency audits and implementing upgrades in pre-2025 buildings, including insulation, cooling systems, and centralized energy consumption monitoring
- Installing solar power systems (PV) on rooftops of municipal buildings, facilities, and marketplaces, with on-site use of the generated energy

Transportation, Logistics, and Construction Equipment

- Electrification of municipal or leased passenger vehicles
- Electrification of construction equipment and waste collection vehicles
- Gradual reduction of fossil fuel supply at municipal fuel stations and expansion of electric vehicle charging infrastructure
- Optimization of household solid waste collection systems

Efficiency Practices in Parks and Gardens

- Transition to automated/smart irrigation systems and replacement of lawns with drought-tolerant vegetation
- Replacement of chemical fertilizers with compost or organic fertilizers

If the above-listed actions under Scenario 1 are implemented during the 2026–2030 period, the estimated emission reduction by 2030—relative to the 2023 baseline—is projected to be **56%**. The projected emission values for 2030 resulting from these mitigation efforts are detailed in **Section 3.4.5** of this document.

Table 6.6 Emission Reduction Strategies for Çankaya Municipality's Operational Activities – Scenario 1

EMISSIONS FROM ÇANKAYA MUNICIPALITY OPERATIONS BETWEEN 2023 AND 2030 – MITIGATION SCENARIO 1 (TCO_2E/YEAR)								
MUNICIPALITY BUILDINGS	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Electricity Consumption in Çankaya Municipality Buildings (excluding lighting, cooling, and irrigation—includes electric motors, etc.)	4,564	4,649	4,735	4,534	4,323	4,103	3,874	3,634
Electricity Consumption in Çankaya Municipality Subsidiaries (excluding lighting, cooling, and irrigation—includes electric motors, etc.)	98	100	102	97	93	88	83	78
Electricity Consumption for Park and Garden Irrigation (consumed by electric motors)	113	115	117	99	81	62	43	22
Natural Gas Consumption in Çankaya Municipality Buildings	3,771	3,841	3,913	3,746	3,573	3,391	3,201	3,003
Natural Gas Consumption in Çankaya Municipality Subsidiaries	61	62	63	60	57	55	51	48
TRANSPORTATION								
BELPET Fuel Sales (Excluding Municipal Vehicles)	8,200	8,352	8,507	7,469	6,390	5,268	4,102	2,890
Diesel Consumption by Municipal Construction Equipment	6,315	6,432	6,552	5,772	4,962	4,119	3,243	2,333
Diesel Consumption by Municipal Waste Collection Vehicles	5,264	5,362	5,462	4,610	3,725	2,805	1,850	858
Diesel and Gasoline Consumption by Municipal Light Commercial Vehicles	351	357	364	317	267	216	163	108

Diesel and Gasoline Consumption by Municipality-Owned or Leased Passenger Vehicles	833	848	864	738	606	470	328	181
OTHERS								
Fertilizer Use (Parks and Gardens)	143	146	148	125	101	77	51	24
GRAND TOTAL	**29,711**	30,264	30,826	27,568	24,178	20,653	16,988	**13,180**

According to the data presented in Table 6.7, significant reductions in emission levels have been achieved over the years across all operational areas of Çankaya Municipality as a result of implemented mitigation policies. Emissions from transportation and construction machinery have been reduced by over 80%, while emissions related to electricity and natural gas consumption in municipal buildings have decreased by approximately 30%. Notably, a remarkable 85% reduction has been achieved in the use of chemical fertilizers in parks and gardens. This indicates that priority interventions have been made in areas with the highest carbon impact.

Table 6.7. Cumulative Emission Reduction Rates (%) by Category and Year from Çankaya Municipality's Operations – Scenario 1

2023–2030 CUMULATIVE EMISSION REDUCTION RATES (%) FROM ÇANKAYA MUNICIPALITY OPERATIONS – Scenario 1 – By Category and Year					
MUNICIPAL BUILDINGS	**2026**	**2027**	**2028**	**2029**	**2030**
Electricity Consumption in Çankaya Municipality Buildings (excluding lighting, cooling, irrigation – e.g., electric motors)	6%	12%	18%	24%	30%
Electricity Consumption in Subsidiary Buildings (same scope)	6%	12%	18%	24%	30%
Electricity Consumption for Irrigation in Parks and Gardens (electric motors)	17%	33%	50%	66%	83%
Natural Gas Consumption in Municipality Buildings	6%	12%	18%	24%	30%
Natural Gas Consumption in Subsidiary Buildings	6%	12%	18%	24%	30%
TRANSPORTATION, LOGISTICS, AND CONSTRUCTION MACHINERY					
BELPET Fuel Sales (excluding municipal vehicles)	14%	28%	41%	55%	69%
Diesel Consumption in Municipal Construction Machinery	14%	27%	41%	54%	68%
Diesel Consumption in Municipal Waste Collection Vehicles	17%	34%	51%	69%	86%

Fuel Consumption in Municipal Light Commercial Vehicles (diesel & gasoline)	15%	29%	44%	58%	73%
Fuel Consumption in Municipal and Leased Passenger Vehicles (diesel & gasoline)	16%	32%	49%	65%	81%
OTHER					
Chemical Fertilizer Use in Parks and Gardens	17%	34%	51%	68%	85%
TOTAL REDUCTION	12%	24%	37%	49%	61%

Table 6.8 presents the cumulative greenhouse gas emission reductions achieved over the years under Scenario 1, expressed in metric tons of CO_2 equivalent (tCO_2e). The total reduction amount, which was 3,831 tons in 2026, increased to 20,620 tons by 2030, representing an approximately 5.4-fold increase. The highest reduction amounts were recorded in categories with intensive fuel consumption, such as BELPET fuel sales (6,438 tCO_2e), construction machinery (4,851 tCO_2e), and waste collection vehicles (5,131 tCO_2e). This table demonstrates that the municipality's strategies focusing on energy and fuel efficiency have been particularly successful in reducing transportation-related emissions.

Table 6.8. Cumulative Greenhouse Gas Emission Reductions from Çankaya Municipality Operations between 2023–2030 – Scenario 1 – By Category and Year (tCO_2e)

2023–2030 CUMULATIVE GREENHOUSE GAS EMISSION REDUCTIONS FROM ÇANKAYA MUNICIPALITY OPERATIONS – Scenario 1 – Cumulative Reduction Amounts by Category and Year (tCO_2e)					
MUNICIPAL BUILDINGS	**2026**	**2027**	**2028**	**2029**	**2030**
Electricity Consumption in Çankaya Municipality Buildings (excluding lighting, cooling, irrigation – e.g., electric motors)	772	1.572	2.402	3.262	4.153
Electricity Consumption in Subsidiary Buildings (same scope)	17	34	52	70	89
Electricity Consumption for Irrigation in Parks and Gardens (electric motors)	20	40	61	83	106
Natural Gas Consumption in Municipality Buildings	239	487	744	1.011	1.287
Natural Gas Consumption in Subsidiary Buildings	4	8	12	16	21

TRANSPORTATION, LOGISTICS, AND CONSTRUCTION MACHINERY					
BELPET Fuel Sales (excluding municipal vehicles)	1.196	2.437	3.723	5.056	6.438
Diesel Consumption in Municipal Construction Machinery	901	1.836	2.806	3.810	4.851
Diesel Consumption in Municipal Waste Collection Vehicles	953	1.942	2.967	4.030	5.131
Fuel Consumption in Municipal Light Commercial Vehicles (diesel & gasoline)	54	110	168	228	291
Fuel Consumption in Municipal and Leased Passenger Vehicles (diesel & gasoline)	142	290	443	602	767
OTHER					
Chemical Fertilizer Use in Parks and Gardens	26	52	80	109	139
TOTAL REDUCTION	3.831	7.805	11.925	16.195	20.620

Figure 6.1 visually presents the annual cumulative greenhouse gas reduction rates between 2026 and 2030 achieved by Çankaya Municipality under Scenario 1. Starting at 12% in 2026, the cumulative reduction rate increases steadily each year, reaching 61% by 2030. The graph illustrates a step-by-step progression toward emission reduction targets, revealing that an additional 49% reduction was achieved over the five-year period. This upward trend indicates that the implemented policies have been applied consistently and have yielded effective results.

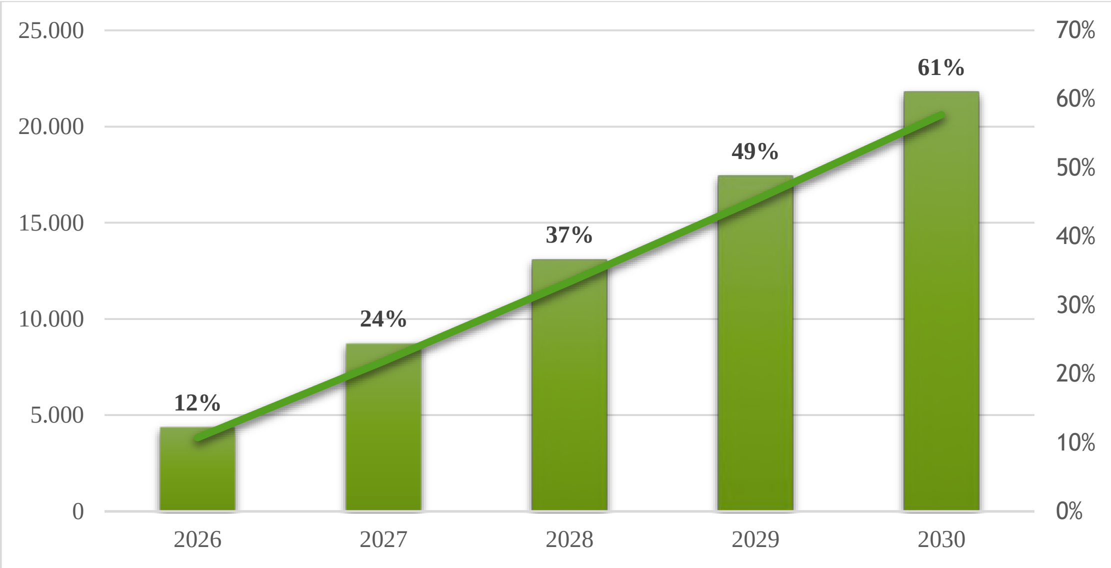


Figure 6.1. 2023–2030 Cumulative Emission Reduction Rates From Çankaya Municipality Operations – Scenario 1 – Yearly Trends by Category

6.2.3.2. Emission Reduction Strategies for Çankaya Municipality's Operational Activities – Scenario 2

The mitigation actions considered under Scenario 2 are listed below:

Buildings and Facilities

- From 2025 onward, all new constructions are to meet **"A" energy efficiency class** (over 55% energy efficiency improvement compared to Class C)
- Between 2026 and 2030, energy efficiency audits and retrofitting works, including insulation improvements, cooling systems upgrades, and centralized energy monitoring—will be implemented in buildings constructed before 2025 (up to **30% energy efficiency gain**)
- By 2030, **50% of the electricity** used in buildings and facilities will be sourced from **renewable energy**

Transportation, Logistics, Construction Equipment, and Waste Management

- Gradual **100% electrification** of municipal or leased passenger vehicles between 2026 and 2030

- Gradual **50% electrification** of construction equipment and waste collection vehicles between 2026 and 2030
- **25% fuel savings** through the optimization of the household solid waste collection system
- Gradual reduction in fossil fuel supply at municipal fuel stations between 2026 and 2030, with a complete transition to **electric charging stations** by 2030

Efficiency Measures in Parks and Gardens

- Transition to **automated/smart irrigation systems** and replacement of lawns with high water-retention plant species
- Use of **compost/organic fertilizers** instead of chemical fertilizers in parks and gardens

If the above-listed actions under **Mitigation Scenario 2** are implemented between 2026 and 2030, it is estimated that greenhouse gas emissions in 2030 can be reduced by **56%** compared to the 2023 baseline. The projected emission values for 2030, resulting from these reduction measures, are presented in **Section 3.4.5** of this document.

Table 6.9 Emission Reduction Strategies for Çankaya Municipality's Operational Activities – Scenario 2

EMISSIONS FROM ÇANKAYA MUNICIPALITY OPERATIONS BETWEEN 2023 AND 2030 – MITIGATION SCENARIO 2 (TCO_2E/YEAR)								
MUNICIPALITY BUILDINGS	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Electricity Consumption in Çankaya Municipality Buildings (excluding lighting, cooling, and irrigation—includes electric motors, etc.)	4,564	4,649	4,735	4,051	3,341	2,602	1,835	1,038
Electricity Consumption in Çankaya Municipality Subsidiaries (excluding lighting, cooling, and irrigation—includes electric motors, etc.)	98	100	102	87	72	56	39	22
Electricity Consumption for Park and Garden Irrigation (consumed by electric motors)	113	115	117	99	81	62	43	22
Natural Gas Consumption in Çankaya Municipality Buildings	3,771	3,841	3,913	3,746	3,573	3,391	3,201	3,003
Natural Gas Consumption in Çankaya Municipality Subsidiaries	61	62	63	60	57	55	51	48
TRANSPORTATION	0	0	0	0	0	0	0	0

BELPET Fuel Sales (Excluding Municipal Vehicles)	8,200	8,352	8,507	7,469	6,390	5,268	4,102	2,890
Diesel Consumption by Municipal Construction Equipment	6,315	6,432	6,552	5,772	4,962	4,119	3,243	2,333
Diesel Consumption by Municipal Waste Collection Vehicles	5,264	5,362	5,462	5,087	4,696	4,288	3,864	3,423
Diesel and Gasoline Consumption by Municipal Light Commercial Vehicles	351	357	364	317	267	216	163	108
Diesel and Gasoline Consumption by Municipality-Owned or Leased Passenger Vehicles	833	848	864	738	606	470	328	181
OTHERS	0	0	0	0	0	0	0	0
Fertilizer Use (Parks and Gardens)	143	146	148	125	101	77	51	24
GRAND TOTAL	**29,711**	30,264	30,826	27,552	24,146	20,603	16,920	**13,094**

Table 6.10 presents the emission reduction targets of the municipality on a category basis under Scenario 2. In particular, a reduction of up to 80% is targeted in emissions originating from electricity consumption in municipal buildings; this rate is considerably higher than in Scenario 1. In contrast, a more modest reduction of 30% is foreseen in emissions originating from natural gas consumption. A lower target (43%) is determined for garbage collection vehicles compared to Scenario 1. This table reveals that Scenario 2 is a scenario that focuses more on emissions originating from buildings and electricity, whereas a more limited improvement is targeted in emissions originating from transportation.

Table 6.10. Cumulative Emission Reduction Rates (%) by Category and Year from Çankaya Municipality's Operations – Scenario 1

2023–2030 CUMULATIVE EMISSION REDUCTION RATES (%) FROM ÇANKAYA MUNICIPALITY OPERATIONS – Scenario 2 – By Category and Year					
MUNICIPAL BUILDINGS	**2026**	**2027**	**2028**	**2029**	**2030**
Electricity Consumption in Çankaya Municipality Buildings (excluding lighting, cooling, irrigation – e.g., electric motors)	16%	32%	48%	64%	80%
Electricity Consumption in Subsidiary Buildings (same scope)	16%	32%	48%	64%	80%
Electricity Consumption for Irrigation in Parks and Gardens (electric motors)	17%	33%	50%	66%	83%
Natural Gas Consumption in Municipality Buildings	6%	12%	18%	24%	30%
Natural Gas Consumption in Subsidiary Buildings	6%	12%	18%	24%	30%

TRANSPORTATION, LOGISTICS, AND CONSTRUCTION MACHINERY					
BELPET Fuel Sales (excluding municipal vehicles)	14%	28%	41%	55%	69%
Diesel Consumption in Municipal Construction Machinery	14%	27%	41%	54%	68%
Diesel Consumption in Municipal Waste Collection Vehicles	9%	17%	26%	34%	43%
Fuel Consumption in Municipal Light Commercial Vehicles (diesel & gasoline)	15%	29%	44%	58%	73%
Fuel Consumption in Municipal and Leased Passenger Vehicles (diesel & gasoline)	16%	32%	49%	65%	81%
OTHER					
Chemical Fertilizer Use in Parks and Gardens	17%	34%	51%	68%	85%
TOTAL REDUCTION	12%	25%	37%	49%	61%

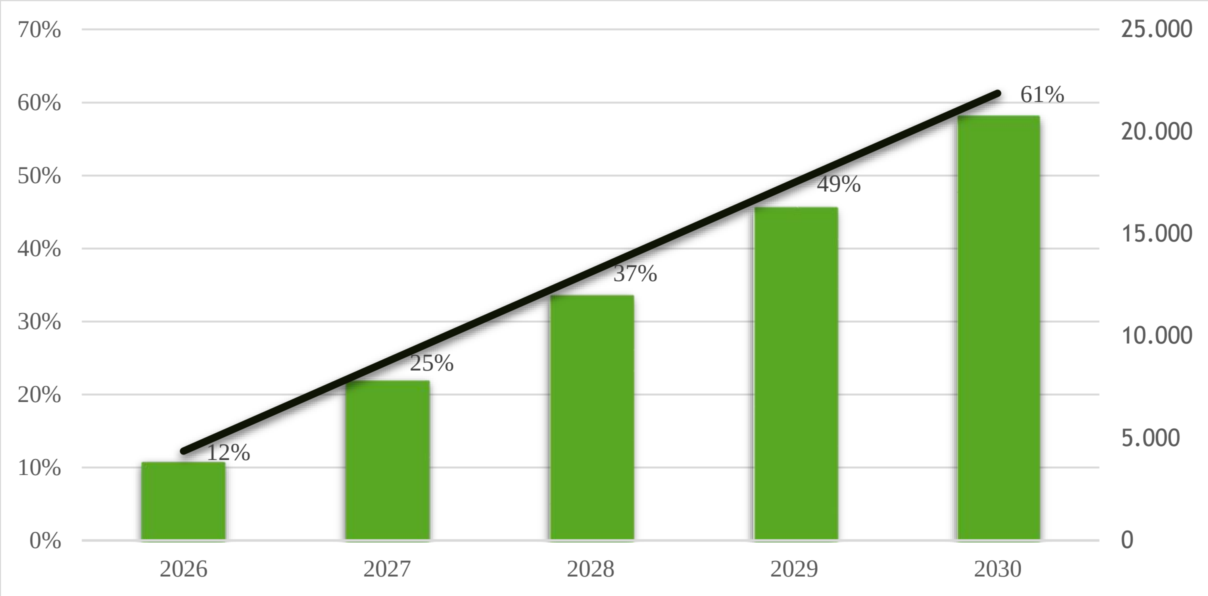
Table 6.13 shows the total greenhouse gas emission reductions projected to be realized by year under Scenario 2 in terms of tCO_2e (carbon dioxide equivalent). The reduction, which was 3,847 tons in 2026, reaches 20,707 tons in 2030, increasing by approximately 5.4 times. Thanks to the improvements made in electricity consumption, a significant reduction has been achieved in building-related emissions; the reduction caused by the electricity consumption of Çankaya Municipality buildings alone is projected as 4,153 tCO_2e for 2030. On the other hand, it is seen that lower reductions are targeted in transportation items such as garbage collection vehicles compared to Scenario 1. In general, the table shows that Scenario 2 is a building-focused, energy-efficient scenario.

Table 6.11. Cumulative Greenhouse Gas Emission Reductions from Çankaya Municipality Operations between 2023–2030 – Scenario 2 – By Category and Year (tCO_2e)

2023–2030 CUMULATIVE GREENHOUSE GAS EMISSION REDUCTIONS FROM ÇANKAYA MUNICIPALITY OPERATIONS – Scenario 1 – Cumulative Reduction Amounts by Category and Year (tCO_2e)					
MUNICIPAL BUILDINGS	**2026**	**2027**	**2028**	**2029**	**2030**
Electricity Consumption in Çankaya Municipality Buildings (excluding lighting, cooling, irrigation – e.g., electric motors)	289	590	901	1,223	1,558
Electricity Consumption in Subsidiary Buildings (same scope)	6	13	19	26	33

Electricity Consumption for Irrigation in Parks and Gardens (electric motors)	20	40	61	83	106
Natural Gas Consumption in Municipality Buildings	239	487	744	1,011	1,287
Natural Gas Consumption in Subsidiary Buildings	4	8	12	16	21
TRANSPORTATION, LOGISTICS, AND CONSTRUCTION MACHINERY					
BELPET Fuel Sales (excluding municipal vehicles)	1,196	2,437	3,723	5,056	6,438
Diesel Consumption in Municipal Construction Machinery	901	1,836	2,806	3,810	4,851
Diesel Consumption in Municipal Waste Collection Vehicles	953	1,942	2,967	4,030	5,131
Fuel Consumption in Municipal Light Commercial Vehicles (diesel & gasoline)	54	110	168	228	291
Fuel Consumption in Municipal and Leased Passenger Vehicles (diesel & gasoline)	142	290	443	602	767
OTHER					
Chemical Fertilizer Use in Parks and Gardens	26	52	80	109	139
TOTAL REDUCTION	3,831	7,805	11,975	16,195	20,620

Figure 6.2 shows the change in operational greenhouse gas emission reduction rates of Çankaya Municipality between 2026 and 2030 under Scenario 2. The cumulative reduction rate, which was 12% in 2026, increased to 61% by 2030. The graph shows that the targeted emission reduction levels are being approached with determined steps in the five-year period. The linear trend of the increase reveals that the strategies are planned annually, and their applicability is high.



Şekil 6.1 Emissions from Çankaya Municipality Operations between 2023 and 2030 - Scenario 2 - Change in cumulative reduction rates by category and year over the years.

6.2.4. Emission Reduction Actions from Çankaya Municipality's Operational Activities

Table 6.12 Mitigation Actions

Sector	Strategy	Action	Relevant Departments in Çankaya Municipality	Timeline	Barriers
Buildings	Energy Efficiency	Conduct energy efficiency audits in municipal buildings; develop and apply rapid screening methods to determine energy classes	Directorate of Zoning and Urban Planning, Directorate of Support Services, Directorate of Public Works	Short-term	Convincing stakeholders, additional financing needed
Water and Wastewater	Water Efficiency	Install rainwater harvesting systems	Directorate of Support Services	Short-term	Convincing stakeholders, additional

		in municipal buildings			financing needed
Buildings	Energy Efficiency	Install solar energy systems (PV) on municipal rooftops	Directorate of Support Services, Public Works, Parks and Gardens, BELPET, Municipal Police, Machinery Maintenance, Cleaning Services	Medium-term	Convincing stakeholders, additional financing needed
Transport	Energy Efficiency	Replace fossil-fuel municipal/passenger vehicles with electric vehicles	Directorate of Support Services, Public Works, Parks and Gardens, BELPET, Municipal Police, Machinery Maintenance, Cleaning Services	Medium-term	Convincing stakeholders, additional financing needed
Transport	Energy Efficiency	Switch municipal light commercial vehicles to electric models	Directorate of Support Services, Public Works, Parks and Gardens, BELPET, Municipal Police, Machinery Maintenance, Cleaning Services	Medium-term	High cost, lack of charging infrastructure, need for technical knowledge
Transport	Energy Efficiency	Convert garbage trucks from fossil fuel to electric	Directorate of Cleaning Services	Medium-term	High cost, lack of charging infrastructure, need for technical knowledge

Buildings	Energy Efficiency	Implement insulation improvements in municipal buildings	Directorate of Support Services	Medium-term	Structural incompatibility of existing buildings, high implementation cost
Buildings	Energy Efficiency	Replace IE1 and IE2 motors with more efficient IE3 and IE4 models	Directorate of Public Works	Short-term	Lack of technical knowledge, long procurement times
Transport	Energy Efficiency	Transition of applicable construction machinery to electrification	Directorate of Public Works, Parks and Gardens	Long-term	Convincing stakeholders, additional financing needed
Buildings	Energy Efficiency	Regularly monitor performance indicators in asphalt and concrete production (e.g., m^2 asphalt/kWh)	Directorate of Public Works	Short-term	Lack of data collection and analysis systems
Other	Energy Efficiency	Use low-emission fertilizers in parks and gardens	Directorate of Parks and Gardens	Medium-term	Convincing stakeholders, additional financing needed
Transport	Energy Efficiency	Convert municipal fuel stations into electric vehicle charging stations	BELPET	Long-term	Convincing stakeholders, additional financing needed
Other	Waste Management	Optimize waste collection systems for efficiency	Directorate of Cleaning Services	Medium-term	Need to restructure existing system, staff training required
Other	Waste Management	Produce compost from organic waste collected from markets and parks	Directorate of Cleaning Services, Parks and Gardens	Medium-term	Convincing stakeholders, additional financing needed

Other	Waste Management	Collect suitable non-park organic waste for pellet production	Directorate of Cleaning Services	Medium-term	Convincing stakeholders, additional financing needed
Other	Water Efficiency	Replace grass with drought-tolerant plants and convert irrigation systems to automated ones in parks	Directorate of Parks and Gardens	Short to Medium-term	Resistance to changing landscaping habits, difficulty in plant supply
Other	Waste Management	Produce pellets and biochar from park and garden waste	Directorate of Parks and Gardens	Medium-term	Lack of technical infrastructure, cost, market demand uncertainty
Other	Water Efficiency	Monitor irrigation water consumption in each park annually in proportion to park area	Directorate of Parks and Gardens	Short-term	Lack of data collection systems, need for staff training

6.2.4.1. Mitigation Actions in the Buildings Category

The objectives and descriptions of mitigation actions listed under the buildings category in Table 6.12 are detailed below.

- **Mitigation Action Name: Energy Audit and Energy Class Assessment of Buildings**

Objective:
It is proposed to analyze the current situation in all public buildings owned by Çankaya Municipality to improve energy efficiency, identify energy consumption points, determine the energy classes of buildings, and develop targeted improvement strategies accordingly.

Action Description:

It is recommended to systematically record and monitor the energy performance of municipal service buildings, cultural centers, nurseries, and social facilities. This approach will help prioritize future investments aimed at enhancing energy efficiency.
As an initial step, it is advised to conduct energy audits for all buildings owned by Çankaya

Municipality. The audits should include detailed analysis of building envelopes (walls, roofs, windows, etc.), HVAC systems, lighting equipment, and user behavior. For each building, an Energy Performance Certificate (EPC) should be prepared in accordance with national regulations, and energy classes should be determined.

- **Mitigation Action Name: Insulation of Buildings**

Objective:
It is recommended to reduce energy losses in municipal buildings by expanding thermal insulation practices, thereby decreasing energy consumption for heating and cooling and reducing greenhouse gas emissions.

Action Description:

Lack of insulation in buildings increases energy consumption, especially during the winter months, resulting in higher costs and carbon emissions. Moreover, the absence of information about current insulation conditions makes it difficult to prioritize interventions. Therefore, the first step should be to establish an inventory of the thermal insulation status of municipal buildings. This includes:

- Identifying and recording the current insulation thickness and material types of buildings,
- Prioritizing buildings with high potential for energy loss,
- Conducting preliminary cost-benefit analyses for insulation investments.

- **Mitigation Action Name: Centralized Monitoring of Energy Consumption**

Objective:
It is recommended to monitor electricity, natural gas, and water consumption in municipal buildings via a centralized platform to analyze consumption behaviors and prevent unnecessary use, thereby improving energy efficiency.

Action Description:

Currently, energy consumption data in most municipal service buildings are monitored manually, based on invoices or at the facility level. This makes comparative analysis, real-time anomaly detection, and behavioral trend monitoring difficult.
It is therefore proposed to integrate electricity, gas, and water meters in all municipal buildings into a centralized data platform and establish automatic data transfer systems. Through smart meter systems, consumption data can be tracked in real time, anomalies can be detected early,

and savings measures can be implemented promptly. The action includes:

- Creating an inventory of energy and water consumption meters for all buildings,
- Replacing incompatible meters with digital systems,
- Integrating all consumption data into a centralized software system.

- **Mitigation Action Name: Inventory of Refrigerant Gases Used in Air Conditioning and Fire Extinguishing Equipment and Evaluation of Low Global Warming Potential (GWP) Alternatives**

Objective:
To reduce greenhouse gas emissions by identifying and inventorying high global warming potential (GWP) gases used in air conditioning and fire safety systems in municipal buildings and evaluating the replacement of these gases with low-GWP alternatives.

Action Description:

Equipment such as air conditioning systems, refrigerators, and fire extinguishers may cause significant greenhouse gas emissions due to the fluorinated gases they contain. As shown in Table 6.13, commonly used refrigerants in various air conditioning systems—such as R134a, R404a, R410a, and R407a—have GWP values ranging from 1,300 to 3,943. The release of these gases into the atmosphere can result in a climate impact equivalent to thousands of tons of CO_2 per ton of gas.

Table 6.13. Global Warming Potential (GWP) Values of Refrigerant Gases[5]

Application Area/Equipment	Recommended Gases	GWP (Global Warming Potential tCO_2/t)	Currently Used Possible Gas Types	GWP (Global Warming Potential tCO_2/t)	Reduction Potential (%)

[5] https://climate.ec.europa.eu/eu-action/fluorinated-greenhouse-gases/climate-friendly-alternatives-hfcs_en

Multi-split / Variable Refrigerant Flow (VRF)	R290 (Propane)	3	R407A, R410A	1923-1924	
	R1234yf R1234ze	4-7	R407A, R410A	1923-1925	
Single-split fixed and portable air conditioning systems	R290 (Propane)	3	R407A, R410A	1923-1926	
Refrigerators, freezers, and similar appliances	R600a (Isobutane)	3	R134a	1300	**~%100**
Central systems	R290 (Propane) R717 (Ammonia) R744 (CO2)	1-3	R134a, R404A, R407A	1923-3943	
Industrial applications	R290 (Propane) R717 (Ammonia) R744 (CO2) R1270 (Propane)	1-3	R134a, R404A, R407A R134a, R404A,	1300-3943	

As part of this action:

- An inventory of all air conditioning, cooling, and fire extinguishing systems used in municipal buildings should be created.
- The type of gas used, its quantity, and the type of equipment for each device should be recorded.
- A priority replacement list should be developed based on the GWP values of the gases currently in use.
- The use of low-GWP alternatives such as R290 (propane), R600a (isobutane), R1234yf, R744 (CO_2), and R717 (ammonia) should be considered.

- **Mitigation Action Name: Rooftop Solar PV (Photovoltaic) System Installation**

Objective:

The aim is to meet electricity consumption from renewable sources and reduce greenhouse gas emissions with solar energy systems to be installed on the roofs of municipal service buildings.

Action Description:

Energy consumption in Çankaya Municipality's service buildings constitutes a significant source of emissions. The fact that electricity needs are largely provided by the national grid operating on fossil fuels increases the carbon footprint. Therefore, it is recommended to install solar panels on suitable roof areas of municipal buildings. With the GES systems, on-site renewable energy production will be realized, both carbon emissions will be reduced and energy costs will be reduced in the long term.

In addition, this application will set an awareness-raising example for citizens and will contribute to the municipality's sustainability goals.

Within the scope of the action:

- The roof areas of all service buildings owned by the municipality should be analyzed in terms of potential GES installation,
- Buildings prioritized according to technical suitability criteria should be determined,
- Engineering projects should be prepared for GES systems and installations should be carried out,
- After the GES systems are installed, production data should be monitored, and performance evaluations should be carried out regularly.

6.2.4.2. Mitigation Actions in the Transportation Category

The objectives and descriptions of the mitigation actions listed under the transportation category in Table 6.13 are detailed below.

1. **Mitigation Action Name: Replacement of Fossil Fuel Passenger Vehicles Owned or Leased by Çankaya Municipality with Electric Vehicles**

Objective:
To eliminate fossil fuel use in the municipality’s passenger vehicle fleet, reduce greenhouse gas emissions, and support sustainable transportation infrastructure.

Action Description:

The current passenger vehicle fleet of Çankaya Municipality consumes 280,827 liters of diesel and 43,997 liters of gasoline annually, resulting in 833 tons of CO_2e emissions. Replacing all of these vehicles with electric models—even under the assumption that electricity is sourced from the grid—would result in an annual reduction of 674 tons of CO_2e emissions. This transition corresponds to an 81% reduction in emissions within this specific category and would contribute to a 16% reduction in the municipality's total emissions.

According to emission factors, the values are as follows:

- Diesel: **0.00025 $tCO_2e/kWh \cdot km$**
- Gasoline: **0.00024 $tCO_2e/kWh \cdot km$**
- Electricity: **0.00008 $tCO_2e/kWh \cdot km$**

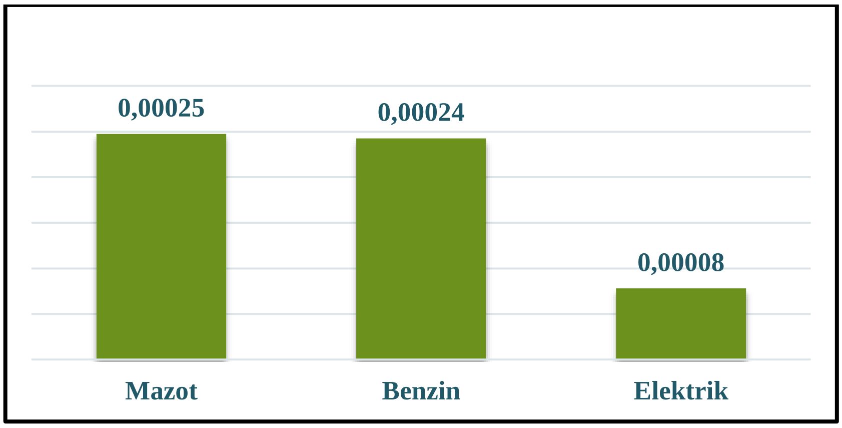


*Figure 6.2 Emission Factors for Passenger Vehicles (tCO2e/ kWh*km)*

These figures clearly demonstrate the environmental advantages of electric vehicles. Potential electric alternatives considered for the municipal fleet include models such as the Renault Zoe E-Tech, TOGG T10X, Citroën ë-C4, Dacia Spring Electric, and Hyundai Kona Electric.

The electrification of the municipality's passenger vehicle fleet would not only reduce greenhouse gas emissions but also enhance long-term energy efficiency and lower fuel costs. This action represents a key component of Çankaya Municipality's sustainable transportation strategy, playing a pivotal role in fulfilling its environmental responsibilities.

Based on preliminary cost assessments, the full electrification of the municipality's passenger vehicle fleet is expected to require a total investment in the range of **USD 2.5M – 11.5M**.

This budget includes the procurement of electric vehicles, installation of charging infrastructure, decommissioning of existing vehicles, adaptation of maintenance and spare parts systems, and training of relevant personnel. The total cost may vary depending on the selected vehicle models, the number of vehicles to be replaced, and the scale of infrastructure upgrades needed.

Table 6.14 Emission Scenario for Passenger Vehicles

Description	GHG Emissions (tCO_2e)
Emissions from Fuel (Diesel/Gasoline) Consumption by Municipality-Owned Passenger Vehicles	833
Emission Reduction from Full Electrification of Municipality-Owned Passenger Vehicles (Using Grid Electricity)	674
Emission Reduction Rate from Full Electrification of Municipality-Owned Passenger Vehicles (Using Grid Electricity)	%81

- **Mitigation Action Name: Conversion of Çankaya Municipality's Owned/Leased Light Commercial Vehicle Fleet to Electric Alternatives**

Objective:
To reduce carbon emissions by replacing fossil-fueled vehicles used in commercial services with electric alternatives.

Action Description:

Çankaya Municipality's fleet of light and heavy commercial vehicles consumes 128,786 liters of diesel and 6,677 liters of gasoline annually, resulting in 351 tons of CO_2e emissions. Transitioning to electric models would achieve a reduction of 256 tons of CO_2e emissions, lowering total emissions in this category by **73%** compared to current levels. This action would contribute to a **15%** reduction in the municipality's overall emissions.

When comparing emission factors:

- Diesel: **0.00017 $tCO_2e/kWh \cdot km$**
- Gasoline: **0.00020 $tCO_2e/kWh \cdot km$**

- Electricity: **0.00008 $tCO_2e/kWh \cdot km$**

These significantly lower emission values for electric vehicles clearly highlight the environmental benefit of the transition.

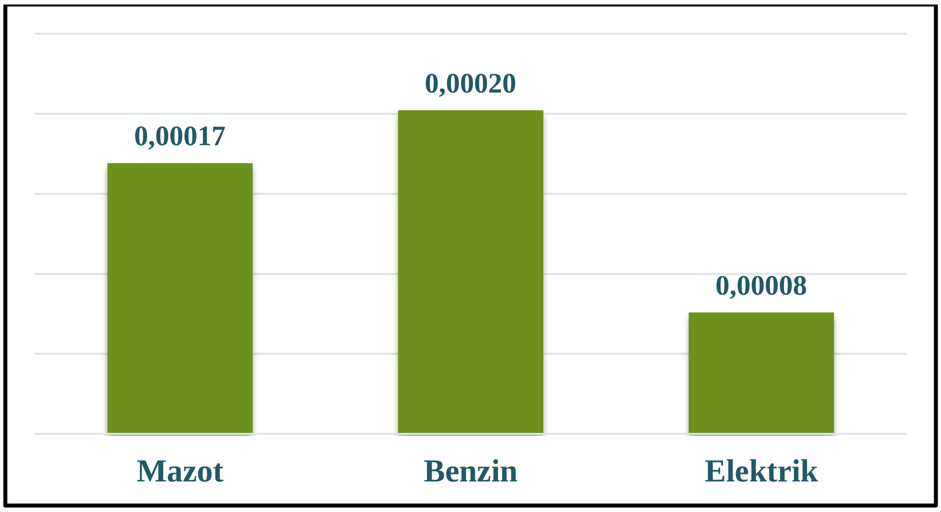


Figure 6.3. Emission Factor for Light Commercial Vehicles ($tCO_2e/kWh \cdot km$)

Electric light commercial vehicle models that can replace the existing fleet include Ford E-Transit, Renault Master E-Tech, Peugeot e-Expert, and GAZelle e-NN.

By implementing this vehicle transition, the municipality will not only achieve a significant reduction in carbon emissions but also benefit from improved energy efficiency and reduced long-term operational costs. This action will be considered a strategic step toward achieving the municipality's sustainability goals.

According to preliminary cost assessments, the total investment required for the electrification of Çankaya Municipality's owned or leased light commercial vehicle fleet is estimated to range between **USD 5M – 7M**.

This budget covers the procurement of electric light commercial vehicles, installation of charging infrastructure, decommissioning of existing vehicles, restructuring of maintenance operations, and training of personnel. The overall cost may vary depending on the vehicle models selected, the number of vehicles, and the required infrastructure.

Table 6.15. Emission Scenario for Light Commercial Vehicles

	GHG (tCO2e)
Emissions from Fuel (Diesel/Gasoline) Use in Light and Heavy Commercial Vehicles Owned by Çankaya Municipality	351
Emission Reduction Amount from Full Conversion of Light and Heavy Commercial Vehicles to Electric Models (Assuming Grid Electricity Use)	256
Emission Reduction Rate from Full Conversion of Light and Heavy Commercial Vehicles to Electric Models (Assuming Grid Electricity Use)	%73

- **Mitigation Action Name: Replacement of Waste Collection Vehicles with Electric Models**

Objective:
To reduce the carbon footprint of vehicles used in the municipality's waste collection services and promote the use of quiet, environmentally friendly vehicles.

Action Description:

The annual diesel consumption of waste collection vehicles owned or leased by the municipality is 2,081,809 liters, resulting in 5,264 tons of CO_2e emissions. Switching to electric models would reduce emissions by **4,510 tons of CO_2e per year**, representing an **83% reduction** in emissions within this category compared to the current situation. According to Scenario 1 outlined in Section 6.2.3, this action would contribute to a **17%** reduction in Çankaya Municipality's total emissions, while under Scenario 2, it would provide a **9%** reduction.

When examining the emission factors, diesel-powered vehicles reach a value of **0.0002 $tCO_2e/kWh \cdot km$**, while electric vehicles reach **0.0001 $tCO_2e/kWh \cdot km$**. This difference clearly highlights the environmental advantages of electric waste collecting vehicles.

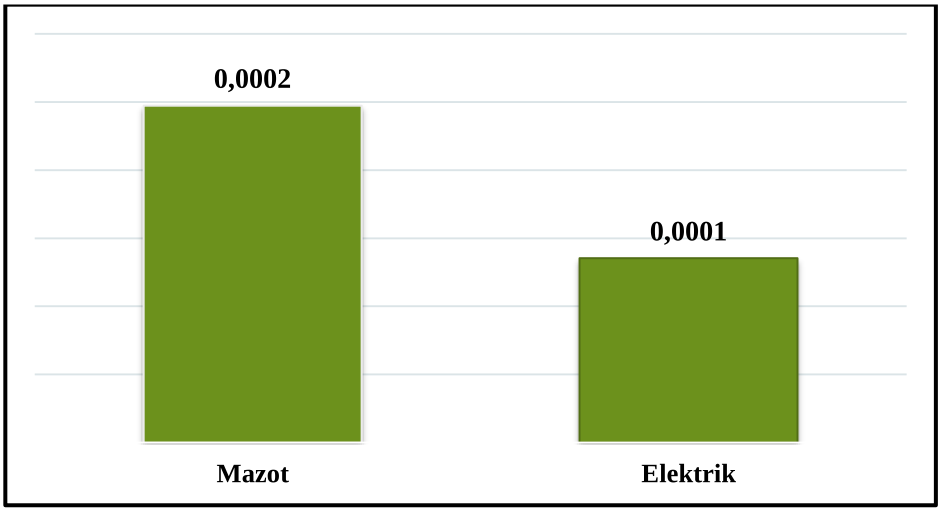


Figure 6.4. Emission Factor for Waste Collection Vehicles ($tCO_2e/kWh{\cdot}km$)

Electric alternatives that can be used in the municipal vehicle fleet include models such as the Mack LR Electric, Peterbilt Model 520EV, BYD 8R Electric Refuse Truck, Heil RevAMP Electric Side Loader, and McNeilus Volterra ZSL™ Electric Side Loader.

This transition not only represents a concrete step toward reducing the municipality's carbon footprint but also brings numerous operational benefits such as lower fuel costs, reduced maintenance requirements, and quieter, more environmentally friendly service delivery. Implementing this action is of great importance in line with environmental sustainability goals.

According to the cost analysis, the total investment required to replace the municipality's waste collection vehicles with electric models is estimated to range between **USD 20M – 40M**.

This budget includes the procurement of electric waste collection vehicles, installation of high-capacity charging infrastructure, decommissioning of existing diesel vehicles, updates to fleet management software, and personnel training. The total cost may vary depending on the selected vehicle models, the number of vehicles, and the intensity of service areas.

Table 6.16. Emission Scenario for Waste Collection Vehicles

	GHG (tCO2e)
Emissions from Fuel (Diesel/Gasoline) Use in Waste Collection Vehicles Owned or Leased by Çankaya Municipality	5,264

Emission Reduction Amount from Full Electrification of Waste Collection Vehicles Owned or Leased by Çankaya Municipality (Assuming Grid Electricity Use)	4,510
Emission Reduction Rate from Fuel Use in Waste Collection Vehicles Owned or Leased by Çankaya Municipality (Assuming Grid Electricity Use)	%83

- **Mitigation Action Name: Transition to Electrification Technology in Construction Machinery**

Objective:

To eliminate fossil fuel consumption in construction machinery used by the municipality and improve operational energy efficiency.

Action Description:

The annual consumption of 1,977,423 liters of diesel and 17,129 liters of gasoline results in 5,289 tons of CO_2e emissions. By transitioning to electric models, emissions in this category could be reduced by **81%** compared to the current situation. This action would result in a **14%** reduction in Çankaya Municipality's total emissions.

Considering the emission factors, the following values stand out:

- 0.0008 $tCO_2e/kWh \cdot km$ for diesel-powered construction machinery,
- 0.0009 $tCO_2e/kWh \cdot km$ for gasoline-powered models, and
- 0.0006 $tCO_2e/kWh \cdot km$ for electric models.

These values clearly demonstrate that electric construction machinery significantly reduces the carbon footprint.

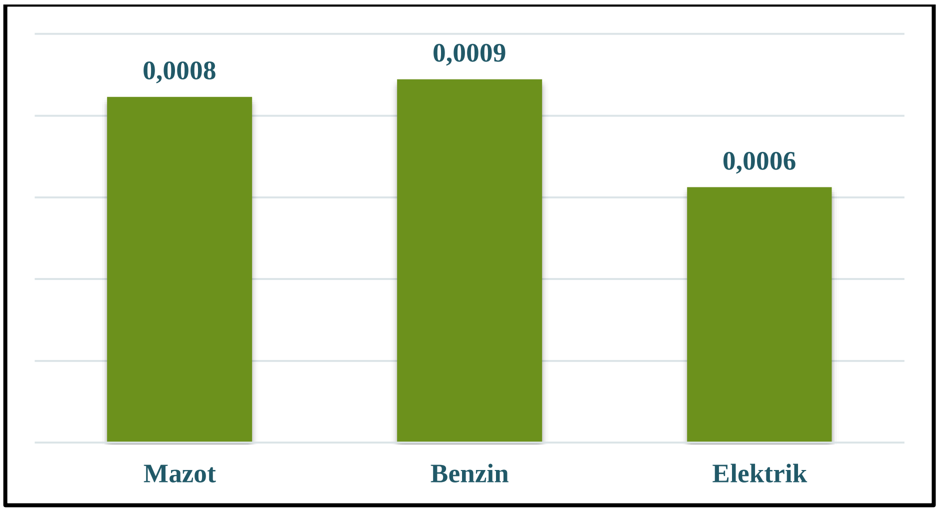


Figure 6.5. Emission Factor for Machinery and Equipment ($tCO_2e/kWh \cdot km$)

Among the high-performance and environmentally friendly electric models that can replace existing machinery are the HEVI Gel (Loader), Toyota Core Electric Forklift, Toyota Large Electric Forklift, Volvo FMX Electric Concrete Mixer, Lightning eMotors ZEV4 Dump Truck, Ford F-150 Lightning, and Alke ATX ED Double Cab.

The electrification of construction machinery not only contributes to reducing carbon emissions, but also helps decrease noise pollution, lower fuel costs, and reduce maintenance requirements. This action is of great importance in fulfilling the municipality’s environmental responsibilities and setting an example as a public institution in the fight against climate change.

According to preliminary cost analyses, the total investment required for electrifying the municipality's construction and industrial equipment is estimated to be between **USD 4M – 8M**.

This budget includes the procurement of electric machinery, installation of charging infrastructure, decommissioning of current fossil fuel-powered equipment, training of operators, and updating of maintenance systems. Costs may vary depending on the type of electric models selected, operational intensity, and infrastructure needs.

Table 6.17. Emission Scenario for Machinery and Equipment

	GHG (tCO2e)
Emissions from Fuel (Diesel/Gasoline) Use in Construction Machinery Owned by Çankaya Municipality	5,289
Emission Reduction Amount from Full Electrification of Construction Machinery Owned by Çankaya Municipality (Assuming Grid Electricity Use)	4,264

Emission Reduction Rate from Full Electrification of Construction Machinery Owned by Çankaya Municipality (Assuming Grid Electricity Use)	%81

- **Mitigation Action Name:** Conversion of Fuel Stations Owned by Çankaya Municipality into Electric Vehicle Charging Stations for Passenger Cars

Objective:

To transform the municipality's fossil fuel distribution infrastructure into a system that supports climate-friendly transportation.

Action Description:

Fuel consumption provided by BELPET—**2,668,148 liters of gasoline**, **3,996,126 liters of diesel**, **214,375 liters of fuel oil**, and **523,329 liters of LPG**—results in a total of **8,200 tons of CO_2e emissions**. Transitioning to an electric vehicle charging infrastructure is projected to achieve a 5,659-ton CO_2e reduction, equivalent to a 69% decrease within this category compared to the current situation. This action has the potential to contribute to a **14% reduction** in the total emissions of Çankaya Municipality.

When comparing emission factors, the following values are used:

- 0.00025 tCO_2e/kWh·km for diesel and fuel oil,
- 0.00024 tCO_2e/kWh·km for gasoline,
- 0.00048 tCO_2e/kWh·km for LPG, and
- only 0.00008 tCO_2e/kWh·km for electricity.

These figures clearly demonstrate the environmental advantages of electric vehicle use.

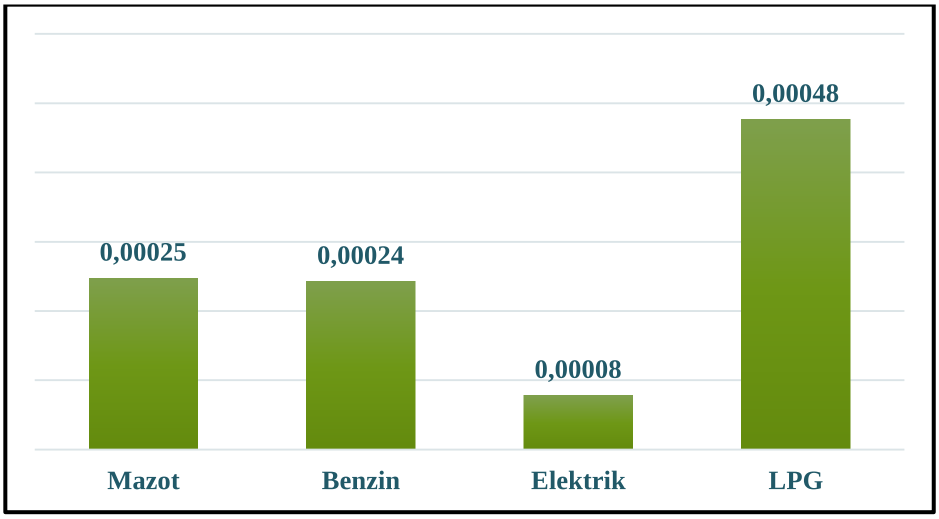


Figure 6.6. Emission Factor for Fuels ($tCO_2e/kWh·km$)

BELPET's transition from a traditional fuel station model to an electric vehicle charging infrastructure will not only reduce carbon emissions but also encourage the use of electric vehicles throughout the city, thereby helping to mitigate the environmental impacts of private vehicle use. This transformation represents a significant step toward achieving the municipality's carbon neutrality targets and developing an urban policy that supports clean transportation.

Table 6.18. Emission Scenario for Fuel Sales

	GHG (tCO2e)
Emissions from BELPET Fuel Sales (Excluding Municipal Vehicles)	8,200
Emission Reduction Amount Resulting from the Transition to Electric Charging Stations Instead of Fossil-Based Fuels (Assuming Grid Electricity Use)	5,659
Emission Reduction Rate Resulting from the Transition to Electric Charging Stations Instead of Fossil-Based Fuels (Assuming Grid Electricity Use)	%69

2. 6.4.2.3. Mitigation Actions in the Other Category

The objectives and descriptions of the mitigation actions listed under the "Other" category in Table 6.11 are detailed below.

- **Mitigation Action Name: Use of Drought-Tolerant Plants Instead of Grass and Transition to Automatic Irrigation Systems in Parks**

Objective:
To increase water efficiency in green space management and reduce carbon emissions from irrigation.

Action Description:

Current grass and inefficient irrigation systems use 865,747 m^3 of water annually and result in 113 tons of CO_2e emissions. By transitioning to automatic systems, water consumption can be reduced to 616,257 m^3, and the implementation of drought-tolerant plants can save an additional 99,796 m^3 of water and reduce 13 tons of CO_2e. This action can result in an overall 83% emission reduction with a total reduction of 93 tons of CO_2e compared to the current situation in this category. If this action is implemented alongside the next action of using compost as an organic fertilizer, it would contribute to a 17% reduction in the total emissions of Çankaya Municipality.

The implementation of smart irrigation infrastructure and vegetation optimization in parks and gardens will not only contribute to the conservation of water resources but also help reduce energy consumption resulting from irrigation activities. This approach supports the municipality's goal of developing nature-based solutions integrated into its fight against climate change. The proposal for this action is detailed in Section 7.8.

Based on the cost analysis conducted for the implementation of this mitigation action, the total investment is estimated to be in the range of **USD 12M – 15M**.

This budget includes the procurement of drought-tolerant plants and landscape design, installation of automated irrigation systems, infrastructure works, acquisition of sensors and control equipment, maintenance and repair operations, as well as personnel training. Costs may vary depending on the scale of implementation and the spatial distribution of park areas. Nevertheless, the long-term benefits in terms of water savings, energy efficiency, and emission reduction make this a strategic investment with substantial environmental and economic returns.

- **Mitigation Action Name: Production of Compost from Organic Waste Collected from Marketplaces and Parks/Gardens**

Objective:
To reduce the use of chemical fertilizers and minimize greenhouse gas emissions and environmental impacts.

Action Description:

The annual use of **165 tons of chemical fertilizers** in parks and gardens results in approximately **144 tons of CO_2e emissions**. This amount can be reduced to **22 tons** with the use of compost. The emission factor for compost is **0.13 tCO_2e/ton**, while for chemical fertilizers, this value is **0.86 tCO_2e/ton**. This action will achieve an **85% reduction** compared to the current situation in this category. If implemented alongside the previous action of using drought-tolerant plants and transitioning to automatic irrigation systems in parks, this action would contribute to a **17% reduction** in Çankaya Municipality's total emissions.

When evaluated in terms of emission factors, the emission value for chemical fertilizers is **0.86 tCO_2e/ton**, while for compost, this value is only **0.13 tCO_2e/ton**. This difference clearly highlights the environmental advantages of compost. This mitigation action aims to reduce external dependence on organic fertilizer procurement while creating an ecological resource for both waste management and urban agriculture/green space maintenance activities. Specifically, in the management of vegetable and fruit waste generated from marketplaces, it is recommended to shift from the traditional collection-transport-composting cycle to an on-site conversion system using mobile compost production units. These units will be selected based on the waste production capacity of each marketplace and strategically positioned at suitable locations to:

- Eliminate the need to transport organic waste to distant locations,
- Reduce emissions and costs associated with transportation,
- Increase compost yield by rapidly processing fresh waste,
- Enable direct use of compost in parks, gardens, or urban farms.

Mobile compost units, especially in permanent marketplace areas or fixed locations where weekly markets are held, should be capable of quickly converting waste collected at the end of the day. On-site conversion will make it easy to distribute the resulting compost within the same area, simplifying municipal service processes. Additionally, the system will allow high-quality compost production by blending pruning waste, leaves, and grass clippings collected from parks and gardens. In this way, urban waste will nourish the city's green spaces without the need for chemical fertilizers.

Based on preliminary feasibility studies, the estimated total cost for the implementation of this mitigation action is projected to be in the range of **USD 350,000 – 600,000**.

This budget covers the procurement of mobile composting units, site selection, infrastructure setup, staff training, and logistical support. The overall cost may vary depending on the scale of implementation and the density of market areas. However, in the long term, the reduction in chemical fertilizer usage, lower waste transportation costs, and minimized environmental impacts are expected to ensure a rapid return on investment.

- **Mitigation Action Name: Optimization of the Waste Collection System Based on Efficiency**

Objective:
To reduce fuel consumption and emissions by transitioning waste collection operations to data-driven management.

Action Description:

Waste collection vehicles owned or leased by Çankaya Municipality consume approximately 2,081,809 liters of diesel annually, resulting in 5,264 tons of CO_2e emissions. A significant portion of these high emissions stems from unplanned and inefficient waste collection operations. Not only can emissions be reduced by switching to electric vehicles, but substantial emission reductions can also be achieved by digitizing and optimizing the waste collection system.

Çankaya Municipally owned or leased waste collection vehicles in Çankaya Municipality consume approximately 2,081,809 liters of diesel per year, resulting in 5,264 tons of CO_2e emissions. A significant portion of these high emissions stems from unplanned and inefficient waste collection operations. Substantial emission reductions can be achieved not only through the adoption of electric vehicles but also by digitizing and optimizing the waste collection system.

The proposed optimization strategy is based on four core technologies:

- **Route Optimization**: Waste collection routes should be planned to cover the shortest distances, minimize stop-and-go movements, and only target full containers. Decision-support systems such as Google OR-Tools or ArcGIS Network Analyst are recommended for this purpose, as they offer route analyses that directly reduce fuel consumption and carbon emissions.
- **Smart Container Systems (IoT):** By integrating ultrasonic or weight-based fill-level sensors into waste containers, only full containers are collected. This prevents

unnecessary trips to empty containers, minimizing fuel use. The use of local technologies such as the Evreka Smart Waste System both supports domestic production and enables rapid deployment.

- **Real-Time Data Usage:** Integrating vehicle location data with container fill-level information allows for real-time monitoring of the system. This makes it possible to dynamically update routes by factoring in traffic conditions or road closures, making the collection system more agile and fuel-efficient.
- **Artificial Intelligence-Based Forecasting:** By analyzing waste generation patterns, it becomes possible to predict when and where waste will accumulate. Over time, machine learning algorithms enable further optimization of routes and collection frequencies, thereby reducing both fuel consumption and vehicle density.

The methods that can be implemented to reduce fuel consumption include route planning, smart container systems, real-time data usage, and AI- and machine learning-based decision support systems. These approaches make it possible to optimize collection frequency and minimize unnecessary fuel use by vehicles.

This improvement not only reduces carbon emissions, but also increases labor efficiency, reduces traffic load, and contributes to municipal cost savings. In this context, the digitization and data-driven management of household waste collection operations is of critical importance for climate-friendly municipal practices.

7. Risk Reduction and Adaptation Actions

In this section of the report, risk reduction and adaptation actions will be presented through a list of strategies developed based on the sectoral impacts of key hazard categories, along with the actions planned for implementation to realize these strategies.

7.1. Adaptation Actions Related to Buildings

Risk categories, target sectors, brief descriptions, justifications, and responsible institutions for adaptation actions related to buildings are summarized in Table 7.1

Table 7.1 Adaptation Actions for Buildings

Risk Category	**Sector**	**Strategy**	**Justification for the Proposed Action (1–2 sentences)**	**Brief Description of the Action (1–2 sentences)**	**Responsible Institution(s)**
Vulnerability to Extreme Heat and Cold Waves	Buildings	Reducing the vulnerability of buildings to extreme heat and cold waves	To mitigate the impacts of climate change in urban areas and enhance overall quality of life	Identify pilot projects for rooftop gardens on municipal buildings; collaborate with universities to conduct R&D projects for implementing this practice on both newly constructed buildings (including post-urban transformation projects) and existing building rooftops, and scale up the initiative based on results	Çankaya Municipality Directorate of Support Services
Flood and Inundation Risk	Buildings	Risk reduction strategy	To prevent potential loss of life and property in high-risk buildings	Identify residents living in basement-level units below ground elevation and implement early warning and evacuation protocols to prevent casualties during possible flooding events	Çankaya Municipality Directorate of Building Control, AKOM, Directorate of Disaster Affairs, Turkish State Meteorological Service, AFAD
Disaster Risk	Buildings	Risk reduction strategy	To prevent potential loss of life and property	Prioritize 17 identified high-risk buildings across Çankaya district that are vulnerable to hazards such as floods and	Çankaya Municipality Directorate of Building Control

			in high-risk buildings	landslides, and implement evacuation or restoration/strengthening measures accordingly	
Drought and Water Scarcity	Buildings	Enhancing resilience against disasters such as drought and water scarcity	To promote more efficient use of water resources	Redesign the surface materials and storage systems of open parking areas within building parcels to allow for rainwater harvesting and storage when needed	Çankaya Municipality Directorate of Support Services
Fire Risk	Buildings	Risk reduction strategy	To prevent potential loss of life and property in high-risk buildings	Map fire risks not only for individual enterprises but also for the entire buildings where they are located, by processing fire safety compliance reports as spatial data (GIS)	Çankaya Municipality Directorate of Disaster Affairs, AFAD
Disaster Risk	Buildings	Enhancing resilience against potential disasters	Between 2012 and 2025, 196 buildings in Emek, 121 in Yukarı Bahçelievler, 117 in Boztepe, and 85 in Bahçelievler were demolished due to being classified as high-risk structures	Conduct detailed risk assessments of buildings in Emek, Yukarı Bahçelievler, Bahçelievler, and Boztepe neighborhoods and develop evacuation plans accordingly. Given the high population density in these areas, phased implementation of risk analysis and evacuation procedures should begin. Urban redevelopment plans should also consider green spaces, open areas, and evacuation routes.	Çankaya Municipality Directorates of Disaster Affairs and Zoning (Urban Planning)
Disaster Risk	Buildings	Enhancing resilience against potential disasters	Between 2023 and 2025, 23 risky buildings were demolished in Bahçelievler and Emek neighborhoods, 19 in Boztepe, and 15 in Yukarı Bahçelievler.	Conduct detailed risk assessments for buildings in Emek, Yukarı Bahçelievler, Bahçelievler, Boztepe, and Mebusevleri neighborhoods and develop evacuation plans for high-risk structures. Given the dense populations of these neighborhoods, phased implementation of	Çankaya Municipality Directorates of Disaster Affairs and Zoning (Urban Planning)

			These figures indicate that the same neighborhoods remain vulnerable today.	risk analysis and evacuation processes should be initiated. Urban renewal and reconstruction efforts should incorporate planning for green spaces, open areas, and evacuation routes.	
Vulnerability to Extreme Heat and Cold Waves	Buildings	Reducing the vulnerability of buildings to extreme heat and cold waves	Reducing the impacts of climate change in cities and improving quality of life	In all urban transformation and construction projects planned by the municipality, additional measures should be taken to improve energy efficiency, promote renewable energy production, and ensure energy and water savings, while also implementing new climate adaptation standards	Çankaya Municipality Departments of Disaster Affairs and Urban Planning, and Support Services
Vulnerability to Extreme Heat and Cold Waves	Buildings	Reducing the vulnerability of buildings to extreme heat and cold waves	Raising awareness among employees about changing climate conditions	Providing training on climate adaptation standards for relevant stakeholders, including consumers, professionals, and municipal staff	Çankaya Municipality
Vulnerability to Network Failures during Extreme Weather Events	Buildings	Reducing vulnerability to network-related issues caused by extreme weather events	Transitioning to renewable energy sources and ensuring energy efficiency	Gradually converting water heating systems in municipal buildings into solar-assisted systems through pilot projects	Çankaya Municipality Support Services Directorate
Vulnerability to Extreme Heat and Cold Waves	Buildings	Reducing vulnerability to network-related issues caused by extreme weather events	Transitioning to renewable energy sources and ensuring energy efficiency	Implementation of white roofs and walls, green roofs, and shading elements to reduce excessive urban heat and avoid sharp increases in energy demand	Çankaya Municipality Support Services Directorate

Adaptation Action Title:

Identifying pilot projects for rooftop gardens on municipal buildings, implementing these especially in newly constructed buildings (including those rebuilt through urban transformation), and carrying out R&D projects in collaboration with universities for applications on older buildings, with the aim of broader dissemination.

Objective:
The general purpose of rooftop gardens is to support climate change adaptation by reducing the urban heat island effect, improving rainwater management, increasing energy efficiency, and contributing to the urban ecosystem. In parallel, the goal is to enhance public health and quality of life by promoting green infrastructure solutions.

Action Description:

Within this action, suitable public buildings owned by the municipality will be identified for rooftop garden applications. Pilot projects will be implemented on selected buildings, and the environmental and structural impacts of rooftop gardens will be monitored and assessed.

In newly constructed buildings (especially those developed after urban transformation, including residential and public structures), rooftop garden applications will be encouraged or integrated into planning decisions.

In addition, R&D projects will be developed in collaboration with universities and research institutions to assess the technical feasibility and cost-effectiveness of rooftop gardens for existing building roofs. Based on the results of these projects, implementation guidelines will be prepared, and dissemination efforts will be carried out. This process will also include educational and promotional activities aimed at increasing public awareness.

A study conducted in Ottawa compared traditional roofs with green roof applications: the average daily energy consumption needed to stabilize indoor temperature was measured at 6–7.5 kWh/day for traditional roofs, while this value dropped to 1.5 kWh/day for green roofs. The results demonstrated that green roofs provided up to **75%[6] energy savings**.

[6] Aras, B. B. (2019). Kentsel Sürdürülebilirlik Kapsamında Yeşil Çatı Uygulamaları. MANAS Sosyal Araştırmalar Dergisi, 8(1), 469-504. https://doi.org/10.33206/mjss.474314

The construction cost of rooftop gardens ranges from approximately **$50 to $100 per square[7] meter**. However, these costs are offset over time thanks to the energy efficiency they provide, while also offering significant contributions to environmental sustainability.

7.2. Adaptation Actions Related to Energy

The risk categories, target sectors, brief descriptions, justifications, and responsible institutions for the energy-related adaptation actions are presented in Table 7.2.

Table 7.2 Adaptation Actions for Energy

Risk Category	Sector	Strategy	Justification for the Proposed Action (1–2 sentences)	Brief Description of the Action (1–2 sentences)	Responsible Institution(s)
Vulnerability to Extreme Heat and Cold Waves	Energy	Reducing vulnerability to network-related issues caused by extreme weather events	Reducing vulnerability to potential grid problems caused by extreme weather events	Relocate overhead electricity distribution lines underground and ensure electricity and natural gas infrastructure is protected against flood risks	Çankaya Municipality and energy distribution companies
Vulnerability to Extreme Heat and Cold Waves	Energy	Reducing vulnerability to network-related issues caused by extreme weather events	Reducing vulnerability to potential grid problems caused by extreme weather events	Develop islanding plans for licensed and unlicensed energy and renewable energy producers within the district to safely supply power during national grid disruptions	Energy distribution companies
Vulnerability to Extreme Heat and Cold Waves	Energy	Reducing vulnerability to network-related issues caused by extreme weather events	Reducing vulnerability to potential grid problems caused by extreme weather events	Protect natural gas distribution networks and meters against climate-related threats such as flooding	Gas distribution companies

[7] https://www.toddhaimanlandscapedesign.com/blog/how-much-does-a-roof-garden-rooftop-garden-or-terrace-cost

7.3. Adaptation Actions Related to the Transport Sector

The risk categories, target sectors, brief descriptions, justifications, and responsible institutions for the adaptation actions related to the transportation sector are presented in Table 7.3.

Table 7.3 Adaptation Actions for Transport Sectors

Risk Category	Sector	Strategy	Justification for the Proposed Action (1–2 sentences)	Brief Description of the Action (1–2 sentences)	Responsible Institution(s)
Extreme Heat and Heavy Rainfall	Transport	Reducing the urban heat island effect	Raising public awareness about changing climate conditions	Conduct awareness campaigns to influence citizens' mobility behavior, aiming to reduce the share of individual car use in urban transportation	Çankaya Municipality
Extreme Heat	Transport	Reducing the urban heat island effect	Preservation of ecological balance	To reduce the urban heat island effect, major streets and boulevards will be afforested; existing trees will be preserved and properly pruned with the support of Faculties of Landscape Architecture and Agriculture	Çankaya Municipality, relevant universities
Heavy Rainfall	Transport	Protecting transport infrastructure against environmental impacts	Increasing resilience against potential disasters	Construct missing stormwater drainage systems and strengthen existing ones along transport routes and corridors	Çankaya Municipality, ASKİ, State Hydraulic Works (DSİ)
Extreme Heat	Transport	Reducing the urban heat island effect	Sustainability strategy	Implement greening and shading initiatives, and establish or retrofit “cool” sidewalks and bus stops to mitigate the urban heat island effect	Çankaya Municipality Directorate of Technical Affairs
Heavy Rainfall	Transport	Protecting transport infrastructure against	Sustainability strategy	Construct permeable pavements using materials that do not retain rainwater to	Çankaya Municipality Directorate of Technical Affairs

		environmental impacts		reduce surface runoff and enhance drainage	
Extreme Heat and Heavy Rainfall	Transport	Protecting transport infrastructure against environmental impacts	Sustainability strategy	Enhance the frequency and quality of road maintenance activities to ensure infrastructure resilience under extreme weather conditions	Çankaya Municipality Directorate of Technical Affairs, General Directorate of Highways (KGM)
Extreme Heat and Heavy Rainfall	Transport	Promoting behavior change in transport preferences	Raising public awareness about changing climate conditions	Organize various events during European Mobility Week to raise awareness of the environmental impacts of transport	Çankaya Municipality, NGOs, Union of Chambers of Turkish Engineers and Architects (TMMOB)

7.4. Adaptation Actions Related to Disaster Management

Risk categories, target sectors, brief descriptions, justifications, and responsible institutions for adaptation actions related to disaster management are presented in Table 7.4.

Table 7.4. Adaptation Actions for Disaster Management

Risk Category	**Sector**	**Strategy**	**Justification for the Proposed Action (1–2 sentences)**	**Brief Description of the Action (1–2 sentences)**	**Responsible Institution(s)**
Extreme Heat, Health Risk	Disaster Management	Informing citizens about changing climate conditions	To reduce the impacts of heat-related illnesses by increasing public awareness	Publish a “Heat Illness Prevention Guide” to inform citizens and help mitigate health risks associated with extreme temperatures	Çankaya Municipality
Food Security Risk	Disaster Management	Preserving ecological balance	To promote ecological adaptation to changing climate conditions	Apply precision agriculture techniques and Integrated Pest Management (IPM) strategies in pest control activities carried out in parks and green areas	Çankaya Municipality Directorate of Parks and Gardens and Directorate of Veterinary Services

Disaster Risk	Disaster Management	Sustainability strategy	To raise awareness for adapting to changing climate conditions	Organize awareness-raising workshops, competitions, and events for different age groups	Çankaya Municipality
Disaster Risk	Disaster Management	Enhancing resilience against potential disasters	To raise awareness for adapting to changing climate conditions	Increase public awareness through various hazard simulations	Çankaya Municipality Directorate of Disaster Affairs, Ankara Metropolitan Municipality Directorate of Disaster Affairs, AFAD
Disaster Risk	Disaster Management	Raising public awareness about changing climate conditions	To raise awareness for adapting to changing climate conditions	Foster cooperation and increase joint initiatives with neighboring municipalities and external stakeholders within the boundaries of Çankaya Municipality	Çankaya Municipality, NGOs
Vulnerability to Extreme Heat and Cold Waves	Disaster Management	Informing citizens about changing climate conditions	To support adaptation to changing climate conditions	Actively share data through the municipality's website to warn citizens about potential impacts of climate change	Çankaya Municipality
Disaster Risk	Disaster Management	Informing citizens about changing climate conditions	To raise awareness for adapting to changing climate conditions	Increase public visibility and awareness through brochures, meetings, short films, and other promotional materials	Çankaya Municipality
Disaster Risk	Disaster Management	Risk reduction strategy	To support adaptation to changing climate conditions	Transition rapidly to an electronic archive system and complete the mapping of data sets relevant to adaptation	Çankaya Municipality

Flood and Inundation Risk	Disaster Management	Preserving ecological balance	To adapt to changing climate conditions, heavy rainfall reduces the effectiveness of medications	Identify potential links between changing meteorological conditions and infectious animal diseases, and develop preventive measures	Çankaya Municipality Directorate of Veterinary Services
Flood and Inundation Risk	Disaster Management	Risk reduction strategy	To prevent loss of life and property in high-risk facilities	Assess the animal rehabilitation center/shelter near Mühye village by Lake Eymir for potential flood and landslide risks	Çankaya Municipality Directorate of Veterinary Services
Food Security Risk	Disaster Management	Preserving ecological balance	To enable ecological adaptation to changing climate conditions	Compost organic waste generated at marketplaces and use it as fertilizer in various gardens	Çankaya Municipality Directorate of Parks and Gardens
Disaster Risk	Disaster Management	Informing citizens about changing climate conditions	To raise awareness for adapting to changing climate conditions	Plan and launch joint educational activities on disaster and climate change in coordination with Ankara Metropolitan Municipality Directorate of Disaster Affairs and Ankara Provincial AFAD Directorate	Çankaya Municipality Directorate of Daycare Centers, Ankara Metropolitan Municipality Directorate of Disaster Affairs, Ankara Provincial AFAD Directorate
Disaster Risk	Disaster Management	Informing children about changing climate conditions	To raise awareness for adapting to changing climate conditions	Plan and implement coordinated educational programs specifically for children in collaboration with Ankara Metropolitan Municipality Directorate of Disaster Affairs and Ankara Provincial AFAD Directorate	Çankaya Municipality Directorate of Daycare Centers, Ankara Metropolitan Municipality Directorate of Disaster Affairs, Ankara Provincial AFAD Directorate

Disaster Risk	Disaster Management	Informing children about changing climate conditions	To raise awareness for adapting to changing climate conditions	Develop educational materials with a focus on climate change for children's learning environments	Çankaya Municipality Directorate of Daycare Centers
Vulnerability to Extreme Heat and Cold Waves	Disaster Management	Informing children about changing climate conditions	To raise awareness for adapting to changing climate conditions and ensure a safer environment during harsh weather	Use pruning waste from daycare gardens to produce shade canopies to protect children from extreme heat or rainfall	Çankaya Municipality Directorate of Daycare Centers
Disaster Risk	Disaster Management	Risk reduction strategy	To take precautions against potential disaster risks	Prepare a joint data inventory among Ankara AFAD Provincial Directorate, Ankara Metropolitan Municipality Directorate of Disaster Affairs, Ankara Fire Department, and Çankaya Municipality Directorate of Disaster Affairs, and develop inter-institutional coordination plans to avoid operational overlaps during disasters	Ankara AFAD Provincial Directorate, Ankara Metropolitan Municipality Directorate of Disaster Affairs, Ankara Fire Department, Çankaya Municipality Directorate of Disaster Affairs
Disaster Risk	Disaster Management	Enhancing resilience against potential disasters	To raise awareness for adapting to changing climate conditions	Ensure that disaster affairs personnel receive training on the relationship between climate change and disasters to improve institutional capacity	Ankara AFAD Provincial Directorate, Ankara Metropolitan Municipality Directorate of Disaster Affairs, Ankara Fire Department, Çankaya Municipality

					Directorate of Disaster Affairs
Flood and Inundation Risk	Disaster Management	Enhancing resilience against potential disasters	To take precautions against potential disaster risks	Based on analysis conducted between 2017 and 2023, frequent flood and inundation events have been identified in the neighborhoods of Sağlık, Harbiye, İncesu, Kırkkonaklar, Birlik, Emek, Maltepe, Bahçelievler, and Mutlukent. The sources of these events should be identified, mitigation actions initiated, and necessary infrastructure investments accelerated.	Çankaya Municipality Directorate of Disaster Affairs, AFAD, State Hydraulic Works (DSİ), Ankara Metropolitan Municipality (ASKİ)
Flood and Inundation Risk	Disaster Management	Enhancing social resilience against vulnerability	To strengthen resilience against disasters such as droughts, floods, and water scarcity, with a focus on socially vulnerable and disadvantaged groups	Since Kırkkonaklar and Mutlukent neighborhoods are vulnerable both in terms of flood risk and social fragility, risk assessments should be conducted and necessary interventions implemented accordingly	Çankaya Municipality Directorates of Social Assistance, Family and Social Services, and Disaster Affairs
Flood and Inundation Risk	Disaster Management	Enhancing resilience against potential disasters	To take precautions against potential disaster risks	In Birlik Neighborhood, due to both flood threats and high population density contributing to disaster vulnerability, risk prioritization and intervention planning should be carried out	Çankaya Municipality Directorate of Disaster Affairs

7.4.1. Adaptation Actions in the Disaster Management Category

The objectives and descriptions of selected adaptation actions under the disaster management category listed in Table 7.4 are detailed below.

Adaptation Action Title:

Implementation of precision agriculture techniques and Integrated Pest Management (IPM) strategies in pest control practices in parks and gardens

Objective:

Due to rising temperatures associated with climate change, the types of pests found in parks and gardens are changing, and existing pesticide treatments are becoming less effective. Therefore, the goal is to apply sustainable and environmentally friendly pest control methods in urban green spaces, reduce pesticide use, protect public health, and promote a management approach that preserves ecological balance.

Action Description:

This action aims to apply a combination of precision agriculture techniques and Integrated Pest Management (IPM) strategies in parks, gardens, and urban agriculture areas owned by the municipality to enhance environmental sustainability and adapt to changing climate conditions[8].

The IPM approach involves the integrated use of biological, physical, and chemical methods in pest control, with the goal of minimizing pesticide use while protecting ecosystem health. For instance, as seen in areas like Silivri, Çatalca, and Arnavutköy in Istanbul, green and agricultural areas can be analyzed in detail using GPS-supported systems and satellite imagery[9].

Additionally, integrating smart irrigation systems, sensor-based monitoring infrastructure, and biological pest control methods will help manage pest populations while conserving water and preserving soil health.

According to studies, pesticide use per hectare is reduced in gardens or farms applying IPM, and pesticide-related costs decrease by 1.21% while overall production costs drop by 5%, making the method economically viable as well[10].

Through these practices, the environmental impact of pesticide use will be reduced, local biodiversity will be supported, and a more climate-resilient, nature-based urban management approach will be promoted.

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[8] Srinivasarao, Mathukumalli & Mani, M. & Prasad, Y. & Prabhakar, M. & Sridhar, V. & Vennila, Sengottaiyan & Singh, Vinod. (2022). Climate Change and Pest Management Strategies in Horticultural and Agricultural Ecosystems. 10.1007/978-981-19-0343-4_3

[9] https://farmonaut.com/europe/istanbulda-modern-tarim-teknikleri-genc-ciftcilerin-bugday-ve-arpa-uretiminde-surdurulebilir-uygulamalari/

[10] Gül, M., Akpinar, M. G., Demircan, V., Yilmaz, H., Bal, T., Arici, Ş. E., Polat, M., Şan, B., Eraslan, F., Örmeci Kart, M. Ç., Gurbuz, D., & Yilmaz, Ş. G. (2016). Economic Analysis of Integrated Pest Management Adoption in Apple Cultivation: a Turkish Case Study. *Erwerbs-Obstbau*, 58(4), 147–154

Adaptation Action Title: Increasing awareness through multi-hazard simulations

Objective:

The aim is to raise public awareness of disaster risks, impacts on climate change, and related precautionary measures through visual and experiential methods, thereby strengthening disaster and climate literacy across all segments of society. This also targets enhancing individual and institutional preparedness levels.

Action Description:

Under this action, the municipality will regularly organize hazard-specific simulations (e.g., earthquakes, floods, fires, extreme weather events), mobile training units, virtual reality (VR) applications, or drills. For example, the ClimateGAN[11] project uses Generative Adversarial Networks (GANs) to simulate flood scenarios in familiar environments with photorealistic visuals. This helps transform abstract climate projections into personalized visual experiences, making future risks more tangible. Visualizing potential climate impacts in well-known locations makes the threat feel closer and prompts action. Expanding the number of disaster education centers—like the one currently operated by AFAD[12] in Bursa—and enriching them with locally relevant scenarios such as these would further strengthen and expand awareness and educational efforts.

7.5. Adaptation of Actions Related to Urban Planning

Risk categories of adaptation actions related to urban planning, the sector in which the action will be implemented, short description, justification and responsible institutions are given in Table 7.5.

Table 7.5 Adaptation Actions Related to Urban Planning

Risk Category	Sector	Strategy	Justification of Action Recommendation (1-2 sentences)	Brief Description of Action (1-2 sentences)	Responsible Organization(s)
Flood and inundation risk	Urban Planning	Risk mitigation strategy	To mitigate the impacts of climate change in urban areas	Conducting studies on permeable asphalt types and their	Çankaya Municipality Directorate of Technical Affairs

[11] Schmidt, V., Luccioni, A., Teng, M., Zhang, T., Reynaud, A., Raghupathi, S., Cosne, G., Juraver, A., Vardanyan, V., Hernandez-Garcia, A., & Bengio, Y. (2021). *ClimateGAN: Raising climate change awareness by generating images of floods* [Preprint]. arXiv. https://doi.org/10.48550/arXiv.2110.02871

[12] https://bursa.afad.gov.tr/afet-egitim-merkezi

			and enhance quality of life.	application in flood-prone areas.	
Heatwave and flood risk	Urban Planning	Urban protection and sustainability strategy	To mitigate the impacts of climate change in urban areas and enhance quality of life.	Increasing the number of open and green spaces within urban areas and strictly preserving existing green spaces.	Çankaya Municipality Directorate of Zoning and Urban Planning
Heatwave and flood risk	Urban Planning	Urban protection and sustainability strategy	To mitigate the impacts of climate change in urban areas and enhance quality of life.	Establishing continuous corridors of open and green spaces aligned with dominant wind directions within the city.	Çankaya Municipality Directorate of Zoning and Urban Planning
Risks of loss of life, property damage, and health issues due to heatwaves	Urban Planning	Urban transformation strategy	To mitigate the impacts of climate change in urban areas and enhance quality of life.	Developing urban transformation projects to enhance the climate resilience of existing structures and provide necessary amenities for climate adaptation.	Çankaya Municipality Directorate of Zoning and Urban Planning
Risks of loss of life, property damage, and health issues due to heatwaves	Urban Planning	Urban transformation strategy	Taking preventive measures against potential disaster risks	Prioritizing urban transformation projects in city development plans and renewing old and high-risk urban areas.	Çankaya Municipality, Ministry of Environment, Urbanization and Climate Change
Flood risk	Urban Planning	Urban risk reduction strategy	Taking preventive measures against potential disaster risks	Developing and implementing technical and nature-based risk mitigation measures in flood-prone areas.	Çankaya Municipality, Ministry of Environment, Urbanization and Climate Change, State Hydraulic Works (DSİ), General Directorate of Water Management

7.5.1. Adaptation Actions in the Urban Planning Category

The objectives and descriptions of selected adaptation actions under the urban planning category listed in Table 7.5 are detailed below.

Adaptation Action Title:

Investigation of permeable asphalt types and conducting studies for their use in flood-prone areas

Objective:

To reduce the impacts of climate change in cities and improve quality of life

Action Description:

This action focuses on the use of permeable materials for road construction, allowing excess surface water to infiltrate beneath the road and be stored through stormwater harvesting systems. These systems are particularly suitable for main roads frequently affected by sudden flooding and should first be implemented as pilot applications. Based on performance evaluations, such systems can then be expanded in the future.

Although the construction and maintenance of such systems can be costly, local production is expected to reduce costs. For example, in Japan, it is reported that permeable road materials cost approximately 1.7 times more than conventional materials[13].

7.6. Adaptation Actions Related to Water & Wastewater and Waste Management

Risk categories of adaptation actions related to urban planning, the sector in which the action will be implemented, short description, justification and responsible institutions are given in Table 7.6.

[13]https://www.japanfs.org/en/news/archives/news_id024989.html#:~:text=A%20new%20type%20of%20pavement,yen%20(about%20U.S.%2454%2C000).

Table 7.6 Adaptation Actions for Water& Wastewater, Waste

Risk Category	Sector	Strategy	Justification of Action Recommendation (1-2 sentences)	Brief Description of Action (1-2 sentences)	Responsible Organization(s)
Drought and water scarcity	Water and Wastewater	Enhancing resilience against potential disasters such as drought and water scarcity	To use water resources more effectively.	Implementation of rainwater harvesting systems in municipal buildings.	Çankaya Municipality Directorate of Support Services, State Hydraulic Works (DSİ)
Drought and water scarcity	Water and Wastewater	Enhancing resilience against potential disasters such as drought and water scarcity	To use water resources more effectively.	Integration of rainwater harvesting systems into designated parks and gardens within the municipality.	Çankaya Municipality Directorate of Parks and Gardens, DSİ
Drought and water scarcity	Water and Wastewater	Enhancing resilience against potential disasters such as drought and water scarcity	To use water resources more effectively.	Application of environmentally friendly landscaping practices using "Xeriscape" methods for efficient water use in parks and gardens.	Çankaya Municipality Directorate of Parks and Gardens
Drought and water scarcity	Water and Wastewater	Enhancing resilience against potential disasters such as drought and water scarcity	To use water resources more effectively.	GIS-based mapping of locations (streets, neighborhoods, etc.) within Çankaya Municipality boundaries where combined stormwater and sewage systems still exist.	Çankaya Municipality Directorate of Technical Affairs, ASKİ, Ankara Metropolitan Municipality (ABB)
Drought and water scarcity	Water and Wastewater	Preservation of ecological balance	To use water resources more effectively.	Cultivation and use of climate-resilient plant species suitable for Ankara’s climate (such as Lavender, Yarrow, Wild	Çankaya Municipality Directorate of Parks and Gardens

				Thyme, Lamb's Ear, Sage, Immortelle) for sustainable landscaping in parks.	
Drought and water scarcity	Water and Wastewater	Preservation of ecological balance	To use water resources more effectively.	Replacing traditional grass with alternative plant covers (such as Festuca glauca or Yarrow) that significantly reduce water consumption in parks.	Çankaya Municipality Directorate of Parks and Gardens
Drought and water scarcity	Water and Wastewater	Enhancing resilience against potential disasters such as drought and water scarcity	To use water resources more effectively.	Evaluation of the rainwater harvesting pilot project initiated at Bademli Park and implementation across other parks within Çankaya Municipality.	Çankaya Municipality Directorate of Parks and Gardens
Drought and water scarcity	Water and Wastewater	Enhancing resilience against potential disasters such as drought and water scarcity	To use water resources more effectively.	Transition to smart irrigation systems in parks and gardens.	Çankaya Municipality Directorate of Parks and Gardens
Drought and water scarcity	Water and Wastewater	Enhancing resilience against potential disasters such as drought and water scarcity	To use water resources more effectively.	Monitoring of irrigation water consumption in parks throughout the year relative to the park area.	Çankaya Municipality Directorate of Parks and Gardens
Drought and water scarcity	Water and Wastewater	Enhancing resilience against potential disasters such as drought and water scarcity	To use water resources more effectively.	Ensuring regular cleaning of stormwater drains, especially during the autumn season.	Çankaya Municipality Directorate of Sanitation

Extreme rainfall and flooding	Water and Wastewater	Enhancing resilience against extreme meteorological events	Taking preventive measures against potential disaster risks	Conducting risk-based studies and provision of portable flood barriers at critical locations.	Çankaya Municipality Directorate of Technical Affairs, Ministry of Environment, Urbanization and Climate Change (MoEUCC), Disaster and Emergency Management Authority (AFAD)
Extreme rainfall, flooding, and heatwave risk	Water and Wastewater	Enhancing resilience against extreme meteorological events and promoting urban sustainability	Sustainability strategy	Expanding urban waterways and establishing blue-green infrastructure corridors.	Çankaya Municipality Directorate of Zoning and Urban Planning, State Hydraulic Works (DSİ)
Extreme rainfall and flooding	Water and Wastewater	Enhancing resilience against extreme meteorological events	Reducing the impacts of climate change in cities and improving quality of life	Requiring water drainage structures in new building permits, reinforcing cisterns, gardens, and roofs, and mandating light-colored roofing.	Çankaya Municipality Directorate of Technical Affairs, Ministry of Environment, Urbanization and Climate Change (MoEUCC)
Extreme rainfall and flooding	Water and Wastewater	Enhancing resilience against extreme meteorological events	Taking preventive measures against potential disaster risks	Procurement of equipment (such as pumps, ladders, and screwdrivers) anticipated to be increasingly necessary during heavy rainfall for water drainage.	Çankaya Municipality, Governorship
Extreme rainfall and flooding	Water and Wastewater	Enhancing resilience against extreme meteorological events	Taking preventive measures against potential disaster risks	Preference for permeable surfaces in open parking areas.	Çankaya Municipality Directorate of Technical Affairs

Drought and water scarcity	Water and Wastewater	Enhancing resilience against potential disasters such as drought and water scarcity	Using water resources more efficiently	Implementing measures to reduce non-revenue water and distribution network losses.	Çankaya Municipality Directorate of Technical Affairs, Ankara Water and Sewerage Administration (ASKİ)
Drought and water scarcity	Water and Wastewater	Enhancing water efficiency	Using water resources more efficiently	Implementing deterrent water pricing for businesses with high water consumption; differentiated water pricing for summer and winter months.	Çankaya Municipality Directorate of Technical Affairs
Increased rainfall	Waste	Integrated Solid Waste Management Strategy	Taking preventive measures against potential disaster risks	Conducting flood and inundation risk assessments for all waste disposal sites, prioritizing uncontrolled landfill areas.	Çankaya Municipality
Temperature increase	Waste	Integrated Solid Waste Management Strategy	Reducing the impacts of climate change in cities and improving quality of life	Reviewing and revising design parameters of waste management facilities (such as compost and landfill gas recovery plants) according to anticipated temperature increases.	Çankaya Municipality and Operating Company
Increased rainfall	Waste	Integrated Solid Waste Management Strategy	Taking preventive measures against potential disaster risks	Evaluating alternatives for relocating or protecting waste transfer stations against flood risks.	Çankaya Municipality

7.6.1. Adaptation Actions in the Water & Wastewater Category

The objectives and descriptions of selected adaptation actions under the water and wastewater category listed in Table 7.6 are detailed below.

Adaptation Action Title: Rainwater harvesting in municipal buildings

Objective:

With the increasing risk of drought and decreasing freshwater resources due to climate change, alternative urban water management solutions have become essential. The objective of this action is to establish rainwater harvesting systems in municipal buildings to save water, reduce pressure on infrastructure systems, mitigate flood risks, and strengthen climate resilience.

Action Description:

Rainwater will be collected from roofs and impermeable surfaces of public buildings owned by the municipality, filtered, and reused through dedicated systems. Collected water will serve as an alternative to potable water from the municipal network, particularly for purposes such as landscape irrigation, cleaning, and toilet flushing. This approach will contribute to water conservation and alleviate pressure on freshwater resources[14]. In a study conducted on the Colombes municipal building in Paris, it was estimated that rainwater harvesting could lead to a **10% reduction** in potable water consumption[15].

To implement this in Çankaya Municipality, pilot buildings will be selected for the initial phase. These buildings will be equipped with rainwater storage tanks, filtration systems, piping infrastructure, and basic treatment units. Technical performance (e.g., volume collected, usage efficiency, maintenance needs) will be monitored, and a broader implementation plan will be developed accordingly.

Installation costs may vary depending on factors such as building size, function, and age. Studies indicate the cost of installing a rainwater harvesting system in a single building range

[14] https://www.energy.gov/femp/rainwater-harvesting-systems-technology-review#:~:text=Rainwater%20harvesting%20captures%2C%20diverts%2C%20and,and%20toilet%20and%20urinal%20flushing.

[15] Belmeziti, A., Coutard, O., & De Gouvello, B. (2013). A New Methodology for Evaluating Potential for Potable Water Savings (PPWS) by Using Rainwater Harvesting at the Urban Level: The Case of the Municipality of Colombes (Paris Region). Water, 5(1), 312-326. https://doi.org/10.3390/w5010312

between **$1,000 and $3,500**[16]. Over time, reduced water consumption and environmental benefits make this investment economically and environmentally viable, contributing to sustainable urban water management.

Adaptation Action Title:

Integration of rainwater harvesting systems in designated municipal parks and gardens

Objective:
To reduce urban water consumption, improve the efficient use of water resources, and promote sustainable infrastructure in line with climate adaptation strategies by encouraging the use of alternative water sources in parks and gardens.

Action Description:

Rainwater harvesting systems will be integrated into municipal parks and gardens. Water collected from landscape surfaces will be filtered and treated for reuse in green space irrigation and cleaning activities. This will reduce dependence on the municipal water supply, especially during dry summer months, and ease the burden on infrastructure while mitigating flood risks caused by surface runoff.

An exemplary case is **Brimbank Park** in Melbourne, where approximately 1.7 hectares of asphalt parking area serve as the main rainwater collection zone. A **2,000 m^3 underground storage tank** and a **600 m^2 bioretention/filtration system** were designed to treat the collected water. The system achieved **95% volumetric reliability**, indicating that the majority of irrigation needs could be met through harvested rainwater. The installation cost was calculated at **$98 per square meter**[17]. Applying a similar system in Çankaya's parks is projected to offer long-term economic and environmental benefits.

Adaptation Action Title:

Eco-friendly landscaping practices using the "Xeriscape" method for efficient water use in parks and gardens

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[16] https://www.fixr.com/costs/rainwater-collection-system

[17] Day, J., & Sharma, A. (2020). *Stormwater harvesting infrastructure systems design for urban park irrigation: Brimbank Park, Melbourne case study*. *Journal of Water Supply: Research and Technology-Aqua, 69*(7), 791–805. https://doi.org/10.2166/aqua.2020.047

Objective:

Increasing temperatures and diminishing water resources have emphasized the importance of sustainable and low-water-use landscaping in urban areas. This action aims to implement water-saving, low-maintenance, and ecologically adaptive landscaping practices in municipal parks and green spaces.

Action Description:

Xeriscaping is a landscaping approach focused on efficient water use. It is particularly relevant in arid and semi-arid regions, where it creates climate-resilient spaces by prioritizing water conservation in design. The method involves zoning the area into sections with tailored irrigation strategies, thus enabling water control. Studies have shown that Xeriscaping can contribute up to **50% water savings**[18].

Implementation will begin with soil improvement, the use of mulch, selection of native and drought-tolerant plants, installation of drip irrigation systems, and reduction of turf areas. This will not only lower water consumption but also reduce maintenance needs. Additionally, this method supports biodiversity and reduces the urban heat island effect.

Installation costs range between **$5 and $20 per square meterfoot**[19], depending on scale and design. Due to its low cost and eco-friendly nature, integrating Xeriscape landscaping into Çankaya Municipality's parks and gardens is expected to enhance water efficiency while supporting adaptation to changing climate conditions.

7.7. Adaptation Actions Related to Community Planning

The risk categories, target sectors, brief descriptions, justifications, and responsible institutions for the adaptation actions related to social planning are presented in Table 7.7.

[18] Çorbacı, Ö. L., Özyavuz, M., & Yazgan, M. E. (2011). Water-wise in Landscape Architacture: Xeriscape. Reserach Journal of Agricultural Sciences(1), 25-31

[19] https://lawnlove.com/blog/xeriscaping-cost/

Table 7.7 Adaptation Actions for Community Planning

Risk Category	Sector	Strategy	Justification of Action Recommendation (1-2 sentences)	Brief Description of Action (1-2 sentences)	Responsible Organization(s)
Social Vulnerability	Community Planning	Enhancing community resilience against social vulnerability	To prioritize socially vulnerable and disadvantaged groups.	Providing targeted assistance based on social vulnerability assessments in the neighborhoods of Huzur, Kırkkonaklar, Yakupabdal, Sokullu Mehmet Paşa, Öveçler, Harbiye, İlkadım, Ertuğrulgazi, Aşıkpaşa, Metin Oktay, Keklik Pınarı, Akpınar, Mürsel Uluç, Mutlukent, and Ümit to mitigate disadvantages.	Çankaya Municipality Directorates of Social Assistance Affairs, Family and Social Affairs, Disaster Affairs
Social Vulnerability	Community Planning	Enhancing community resilience against social vulnerability	To prioritize socially vulnerable and disadvantaged groups.	Identifying and providing food assistance to those experiencing difficulties accessing food in Yakupabdal, Huzur, Mutlukent, and Ümit neighborhoods.	Çankaya Municipality Directorates of Social Assistance Affairs, Family and Social Affairs, Disaster Affairs
Social Vulnerability	Community Planning	Enhancing community resilience against social vulnerability	To prioritize socially vulnerable and disadvantaged groups.	Urban planning aimed at creating accessible living environments for disabled individuals in İşçi Blokları, Huzur, Öveçler, Sokullu Mehmet Paşa, İlkadım, Naci Çakır, Mürsel Uluç, Oran, and Kırkkonaklar neighborhoods.	Çankaya Municipality Directorates of Social Assistance Affairs, Family and Social Affairs, Disaster Affairs
Social Vulnerability	Community Planning	Enhancing community resilience	To prioritize socially vulnerable and disadvantaged groups.	Providing targeted social aid to families receiving social assistance in Yakupabdal, Mürsel	Çankaya Municipality Directorates of Social Assistance Affairs, Family and

		against social vulnerability		Uluç, Huzur, and Harbiye neighborhoods.	Social Affairs, Disaster Affairs
Social Vulnerability	Community Planning	Enhancing community resilience against social vulnerability	To prioritize socially vulnerable and disadvantaged groups.	Identifying vulnerable migrant groups in Ertuğrulgazi, Fakülteler, Cebeci, İleri, and Erzurum neighborhoods and providing social assistance, as well as project support aimed at risk reduction investments.	Çankaya Municipality Directorates of Social Assistance Affairs, Family and Social Affairs, Disaster Affairs

7.8. Highlighted Adaptation Actions Based on Stakeholder Consultations

The following adaptation actions were identified during stakeholder consultations described in Section 8 and can be independently implemented by Çankaya Municipality without requiring partnerships or external collaboration:

- **Adaptation Action Title: Adjusting Pest Control Practices to Changing Meteorological Conditions**

Objective:

Due to increasing temperatures, shifting seasonal transitions, and extended pest breeding periods linked to climate change, the existing pest control calendar is becoming ineffective. This action aims to maintain effective pest control efforts in Çankaya to protect public health and quality of life.

Action Description:

Rising temperatures, changes in precipitation patterns, and prolonged spring-summer seasons are increasingly impacting urban life. In densely populated areas like Çankaya, these changes have led to increased pest populations and reduced effectiveness of traditional pest control measures.

Early and prolonged summers have extended the breeding periods of pests such as mosquitoes, flies, and cockroaches, increasing the number of generations per year and rendering calendar-based pesticide applications insufficient. Additionally, warmer temperatures promote the migration of new pest species or increased aggressiveness of existing ones.

Pest control processes must be redesigned with a climate-adaptive approach. Dynamic pest control calendars should be developed based on local meteorological and phenological data, allowing for early detection and timely intervention.

Academic studies support this approach. For instance, research with vegetable producers in Beypazari found that climate change directly affects pest types and outbreak frequency, forcing producers to adapt to their control strategies[20]. Reports from the Ministry of Agriculture and Forestry[21] confirm that rising temperatures expand the geographical spread of pests and increase survival rates of overwintering species.

The IPCC also warns that vector-borne risks will threaten urban areas as well as agricultural zones[22].

The pest control activities carried out by Çankaya Municipality's Parks and Gardens Directorate and Veterinary Directorate should be restructured to account for climate change. Key recommendations include:

- Establishing dynamic pest control schedules based on climate data.
- Regular monitoring of meteorological and phenological indicators.
- Creating a decision support system integrating biological observations and public complaints.
- Adding flexible intervention periods as needed throughout the year.

- **Adaptation Action Title: Replacing Turf Grass with Drought-Resilient Plant Species in Urban Green Areas**

Objective:
Rising temperatures, erratic rainfall, and increasing droughts due to climate change have intensified pressure on water resources. To ensure water conservation and sustainability of green spaces in densely populated areas like Çankaya, turf grass should be replaced with low-water, native, and climate-resilient plant species.

Action Description:

Urban green areas in Çankaya are increasingly exposed to drought. Extended hot summers and reduced rainfall make maintaining turf grass difficult and increase irrigation costs.

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[20] Aydın, A., & Fawole, P. (2021). *Impact of Climate Change on Pest Control Decisions: A Case Study from Beypazarı and Sierra Leone.*

[21] T.C. Tarım ve Orman Bakanlığı (2020). *İklim Değişikliği ve Tarım Değerlendirme Raporu.*

[22] IPCC (2022). *Sixth Assessment Report (AR6): Impacts, Adaptation and Vulnerability.*

Xeriscape landscaping, which uses native and drought-tolerant species, is an effective climate adaptation strategy, providing 30–60% water savings along with reduced maintenance and chemical use (Corbaci & Ozyavuz, 2024).

In a previous project titled “Climate-Friendly Parks with Native Plants,” Çankaya Municipality successfully implemented drought-tolerant native species such as *Genista sessilifolia*, *Colutea cilicica*, *Cotoneaster numularia*, and *Rhus coriaria*.

Integrating xeriscaping with rainwater harvesting and permeable surfaces helps retain water in the soil, enhancing nature-based water cycles. Recommended actions include:

- Using native, drought-resistant species in new green spaces instead of turf.
- Launching pilot projects to convert existing turf areas and assess water consumption.
- Combining xeriscaping with rainwater harvesting and permeable infrastructure.
- Redesigning parks based on xeriscaping principles (planning, plant selection, mulching, efficient irrigation).
- Conducting public education and awareness programs to ensure social acceptance.

- **Adaptation Action Title: Installing Shade Structures in Nursery Gardens and Reusing Woody Waste**

Objective:
Increased heatwaves linked to climate change pose risks to children's health. Providing shaded outdoor play areas in municipal nurseries is essential for health and comfort. This action also promotes circular economy principles through the reuse of woody waste from municipal pruning operations.

Action Description:

Outdoor activity areas in municipal nurseries are exposed to direct sunlight, increasing heat stress and UV risks. Rising average temperatures and heatwaves will exacerbate this issue.

It is proposed that wooden pergolas, canopies, or shade structures be installed using woody waste (e.g., branches, trunk sections) generated by the Parks and Gardens Directorate.

Expected benefits include:

- Reducing heat island exposure in nursery outdoor spaces.
- Supporting circular economy by reusing pruning waste as building materials.
- Lowering emissions and costs through use of locally produced wood.

- **Adaptation Action Title: Identifying Links Between Changing Weather Conditions and Infectious Animal Diseases, and Planning Preventive Actions**

Objective:
Climate change affects the spread of pathogens and vectors through variables such as temperature and humidity, posing threats to animal health. This action aims to identify these relationships and develop tailored preventive strategies for the Çankaya district.

Action Description:

Rising temperatures, irregular rainfall, and humidity fluctuations have led to an increase in vector-borne diseases like tick-related illnesses and zoonoses (e.g., anthrax, leptospirosis, brucellosis).

These diseases pose public health risks for both pets and stray animals, requiring updated municipal veterinary services.

The action will be coordinated by the Çankaya Municipality Veterinary Directorate and will include:

- Analyzing meteorological data and animal disease records.
- Classifying common local diseases by climate vulnerability.
- Developing early warning systems, updating vaccination schedules, and adapting treatment measures accordingly.

- **Adaptation Action Title: Reducing Impervious Surfaces and Promoting Permeable Infrastructure Systems**

Objective:
Short, intense rainfall events have increased due to climate change, raising surface runoff and flood risks in urban areas. Impervious surfaces prevent water infiltration, deplete groundwater, and intensify urban heat islands. This action aims to replace such surfaces with permeable, climate-friendly infrastructure across Çankaya.

Action Description:

Existing roads, sidewalks, parking areas, and pedestrian zones in Çankaya mostly consist of impervious materials. These surfaces cause rapid runoff, increase flood risks, and disrupt natural water cycles. They also trap and release heat, exacerbating the urban heat island effect.

Key recommendations:

- Mapping current impervious surfaces under municipal control.

- Preparing phased replacement plans using permeable surfaces (e.g., permeable concrete, interlocking pavers, gravel-soil mixes).
- Requiring permeable infrastructure in all new roads, sidewalks, and parking areas.

8. Stakeholder Meetings

As part of the Çankaya Municipality SECAP (Sustainable Energy and Climate Action Plan) efforts, an Internal Stakeholder Meeting was held on October 26, 2024, and an External Stakeholder Meeting was held on December 4, 2024. In addition, within the scope of the project, a total of 22 stakeholder interviews were conducted—both online and in person—with internal and external stakeholders who participated in these meetings.

8.1. Internal Stakeholder Meeting

The Internal Stakeholder Meeting, held on October 26, 2024, at the Çankaya Municipality Main Building, was attended by a wide range of participants from various departments within the Çankaya Municipality. The list of participants is shared in the **Annex**.

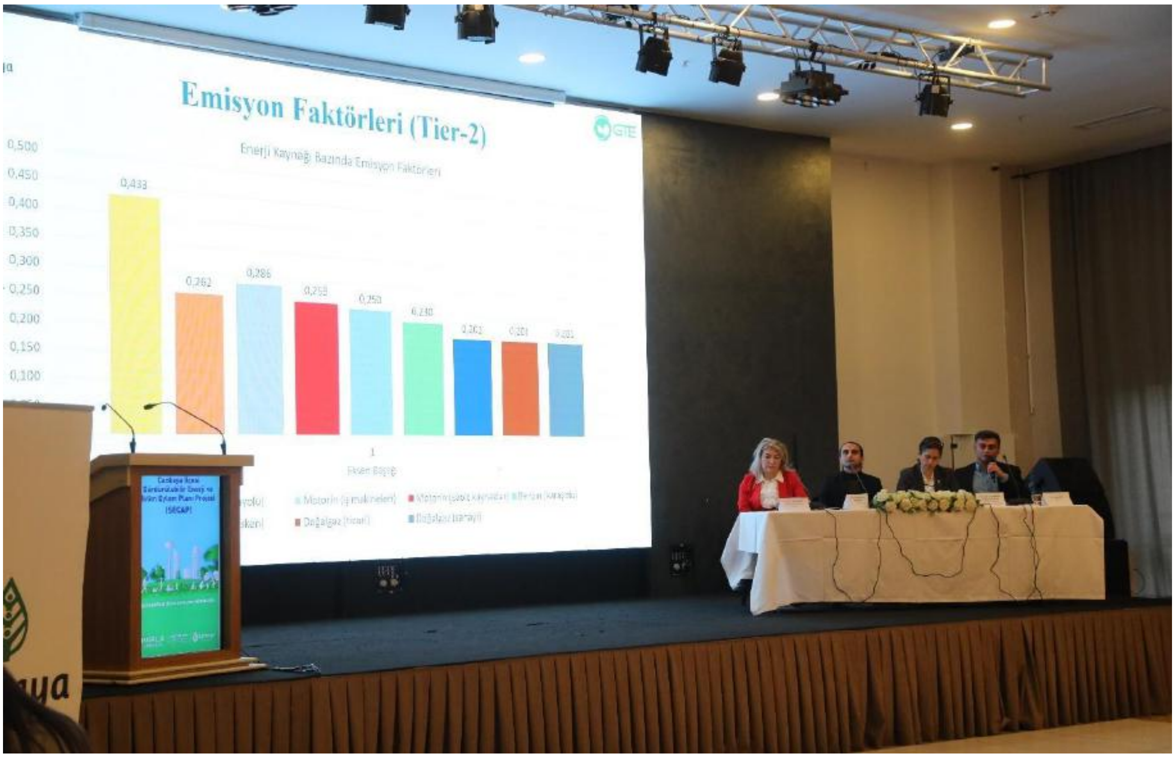

Çankaya
BELEDİYESİ
İklim Projeksiyonları

The meeting discussed the municipality's current situation analysis, carbon emission reduction targets, and strategies that can be implemented to combat climate change. The departments within the municipality presented the challenges they face in their daily operations and suggestions for making existing processes more sustainable. Furthermore, areas for improvement within the municipality's internal processes, such as energy efficiency, the use of renewable energy sources, and waste management, were discussed. The meeting served as an important platform to determine how different units could collaborate to achieve common goals within the SECAP framework.

8.2. External Stakeholder Meeting

The External Stakeholder Meeting, held on December 4, 2024, was organized with the participation of public institutions, non-governmental organizations (NGOs), various municipalities, and private sector representatives. The list of participants is shared in the Appendices.


Çankaya İlçesi
Sürdürülebilir Enerji Ve
İklim Değişikliği Eylem
Planı
(SECAP)


Emisyon Faktörleri (Tier-2)

The meeting shared the goals of Çankaya Municipality in combating climate change and promoting sustainable energy, along with the strategies to achieve these goals. Participants detailed the roles their institutions could play in this process and potential areas for collaboration with Çankaya Municipality. Additionally, public-private partnerships, projects to raise climate awareness in the community, and innovative approaches to promote environmental sustainability were discussed.

8.3. Stakeholder Consultations

Between February 3 and April 25, 2025, stakeholder consultations were held with the participation of Çankaya Municipality branch directorates and external stakeholders.

The topics discussed during the consultations are summarized in the table below. Photos and screenshots related to the meetings are shared in the Annex.

Table 8.1 Topics Discussed

	Topics Discussed
1	Working hour arrangements and environmental condition briefings for outdoor employees
2	Preparations for protecting living beings against climate change impacts
3	Developing a database for vulnerable groups at risk
4	Energy efficiency in buildings
5	Developing a database and public awareness activities for cultural assets potentially vulnerable to risks

6	Awareness and education activities on mitigation and adaptation in municipal kindergartens
7	Fuel transition/energy efficiency in machinery and equipment used
8	Developing a database for groups at high risk of climate vulnerability
9	Green area projection, rainwater harvesting, composting, etc.
10	Working hour arrangements and environmental condition briefings for outdoor employees
11	Improving spatial data for use in adaptation efforts
12	Electric vehicle charging stations at fuel stations
13	Exchanges of ideas on actions for groups highly vulnerable to risk

During the consultations, it was observed that various departments of the municipality carry out different levels of work on climate change, energy efficiency, environmental management, and urban adaptation. While awareness of environmental impacts is increasing in most departments, lack of data, institutional coordination challenges, and infrastructure deficiencies stand out as key barriers.

Urban Structures and Transformation: The urban transformation process is largely shaped by citizen demand, and overlapping responsibilities are observed. Key issues in the identification and intervention processes for risky buildings include lack of information, a high number of unregistered structures, and insufficient data digitization. Efforts are underway to collect data on energy classes and building characteristics, but the need for central coordination continues.

Energy Consumption and Efficiency: There is room for improvement in the monitoring and management of energy consumption in municipal service buildings. Electricity and natural gas consumption is mostly monitored manually, but energy efficiency measures such as LED conversion have been initiated. Projects like solar power system installations, electric vehicles, and charging stations are in the planning stage.

Transportation and Vehicle Fleet: Fossil fuel consumption is very high in the vehicle inventory. Planning for transition to electric vehicles is largely lacking. Waste collection operations are not optimized and are currently carried out manually. However, there is openness to suggestions such as route planning, smart containers, and AI-supported systems.

Green Areas and Park Management: Irrigation systems are largely manual and result in high water consumption. Developing smart irrigation systems and automatic drip irrigation infrastructure is a key recommendation. Compost production is not yet widespread, but there is potential for utilizing organic waste. Improvements can be made in plant species selection, landscaping, and afforestation.

Education, Public Participation, and Awareness: Various educational activities are organized for children, youth, and communities. Awareness programs related to the environment and climate are implemented in kindergartens, but structural issues (e.g., shading, temperature control) are open to improvement. It is recommended to establish a platform for information sharing between departments and for improving digital access.

Disaster and Adaptation Planning: Awareness of disaster risks (floods, heat islands, etc.) has increased, and various interventions are being planned. Studies are ongoing regarding the mapping of disaster risk areas, designation of gathering areas, and development of early warning systems.

Waste Management and BELPET: Fuel consumption and distribution are mostly managed centrally. There are plans to switch to electric charging infrastructure. Data deficiency, inefficiency of containers, and insufficient workforce are major limitations in waste collection processes. It was recommended to compost organic waste, make use of marketplace waste, and evaluate rooftop areas for solar power installations.

8.4. Closing Meeting

The Closing Meeting held on April 22, 2025, at the Zübeyde Hanim Social Facilities was held with the broad participation of different directorates operating within the Çankaya Municipality and external stakeholders who provided support throughout the project.

At the closing meeting, the output obtained during the project and the adaptation and compliance actions aimed at increasing the municipality's resistance capacity against climate change were shared with the public. The actions presented attracted attention as applicable solution proposals shaped in line with local conditions and stakeholder views.


Çankaya İlçesi Sürdürülebilir Enerji ve İklim
Eylem Planı Proje Kapanış Toplantısı
İKLİM DEĞİŞİKLİĞİ VE SIFIR ATIK MÜDÜRLÜĞÜ


Dış Paydaş Çalıştayı
Çankaya


SECAP
Kapanış Toplantısı
Çankaya Belediyesi
İKLİM DEĞİŞİKLİĞİ VE SIFIR ATIK MÜDÜRLÜĞÜ
DR. FİLİZ AYDIN
Çankaya


Çankaya İlçesi
Sürdürülebilir Enerji ve
İklim Eylem Planı Projesi
(SECAP)

9. Annex

INTERNAL STAKEHOLDER PARTICIPANT LIST	
Name of Directorate	**Number of Participant**
Disaster Affairs Directorate	1
Information Technology Directorate	2
Foreign Relations Directorate	3
Real Estate and Expropriation Directorate	2
Youth and Sports Directorate	2
Public Relations Directorate	2
Legal Affairs Directorate	1
Internal Audit Unit	1
Human Resources and Training Directorate	1
Operations Directorate	1
Women and Family Services Directorate	1
Culture and Social Affairs Directorate	1
Nursery Directorate	2
Machinery Supply, Maintenance, and Repair Directorate	2
Parks and Gardens Directorate	2
Social Assistance Affairs Directorate	2

Strategy Development Directorate	1
Inspection Board Directorate	3
Cleaning Affairs Directorate	2
Building Control Directorate	1
Secretariat Affairs Directorate	1
Climate Change and Zero Waste Directorate	20
Municipal Police Directorate	4
Support Services Directorate	1
Veterinary Affairs Directorate	1

EXTERNAL STAKEHOLDER PARTICIPANT LIST	
Name of Organizaiton	**Number of Participant**
Ministry of Environment, Urbanization, and Climate Change / Climate Change Directorate	1
Human Rights and Equality Institution of Türkiye	1
Ankara Bar Association / Ankara Bar Association Urban and Environmental Center Board Members	2
Provincial Health Directorate / Public Health Services Department	2
European Union External Action Service	1
Ankara Metropolitan Municipality / Climate Change and Zero Waste Department	4
Ankara Metropolitan Municipality / Transportation Department	2

Ankara Metropolitan Municipality / Zoning Department	2
Ankara Metropolitan Municipality / Disaster Department	3
Ankara Metropolitan Municipality / Strategy Development Department	1
Akyurt Municipality	3
Etimesgut Municipality	3
Kahramankazan Municipality	2
Keçiören Municipality	2
Kızılcahamam Municipality	1
Yenimahalle Municipality	1
ASKI General Directorate	2
ASKİ Environmental Protection and Water Basins Department / Water Basins Branch Directorate	3
State Hydraulic Works 5th Regional Directorate	2
Ankara Development Agency	1
TEMA	1
HBV University	1
ÇİĞDEMİM Association	1
Chamber of Environmental Engineers Ankara Branch	5
Chamber of Geological Engineers	1
Chamber of Chemical Engineers	1

Chamber of Landscape Architects	1
Ankara Chamber of Commerce (ATO)	1
Chamber of Mechanical Engineers ne Mühendisleri Odası	1
Başkent Youth Center	1
TED University Social Innovation Center	1
TED University Entrepreneurship Office	1
Youth Organizations Forum (Gofor)	1
Master Studient	1
Master Studient	1