Czech University of Life Sciences Prague
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Master's Thesis

ECONOMIC EFFECTS OF GLOBAL CLIMATE CHANGE ON THE AGRICULTURE SECTOR IN TURKEY

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Thesis title

ECONOMIC EFFECTS OF GLOBAL CLIMATE CHANGE ON AGRICULTURE SECTOR IN TURKEY

Objectives of thesis

The aim of this study is to investigate the economic effects of global climate change on the agriculture sector in Turkey, with a focus on understanding the potential impacts on crop yields, land use, and production costs. Based on the findings of the quantitative analyses, policy recommendations will be developed.

Methodology

Existing literature on the economic impacts of global climate change on the agricultural sector in Turkey will be comprehensively reviewed.

Data will be collected on climate models, crop yields, production costs and other relevant variables from secondary sources such as the Turkish Statistical Institute, Ministry of Agriculture and Forestry, and other relevant sources.

Interviews with stakeholders in the agricultural sector in Turkey will be conducted to gain a deeper understanding of the potential economic impacts.

The proposed extent of the thesis

70 – 90 pages

Keywords

global climate change, agriculture, Turkey, crop, land, economic impacts, climate

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Recommended information sources

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Declaration

I declare that I have worked on my master's thesis titled " Economic Effects of Global Climate Change on Agriculture Sector in Turkey " by myself and I have used only the sources mentioned at the end of the thesis. As the author of the master's thesis, I declare that the thesis does not break any copyrights.

In Prague on 31.03.2024 ______________________________

Esra MORAN UNLU

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I would like to thank my supervisor Ing. Pavel Kotyza, Ph.D. for his advice and support. I would like to thank my family for their suggestions and mental support.

Economic Effects of Global Climate Change on the Agriculture Sector in Turkey

Abstract

Climate change is a concept that affects the lives of all living things in the world and poses a great threat to the vital cycle in the world if precautions are not taken. Naturally, one of its biggest effects is on the economies of countries. However, the biggest impact of climate change is undoubtedly on the agricultural sector. This is because temperature changes or natural disasters, which are one of the biggest consequences of climate change, have a great impact on agriculture. In this study, the impact of climate change on agriculture was examined economically. In the study, the relationship between annual average precipitation, temperature and CO2 emission variables and the share of Turkey's agricultural GDP in total GDP was analyzed. As a result of the analysis, a negative and significant relationship was detected between agricultural GDP and CO2 emissions, but no significant relationship was found between temperature and precipitation variables with agricultural GDP.

Keywords: Climate Change, Agriculture, Turkey, Economics

Ekonomické dopady globální změny klimatu na zemědělský sektor v Turecku

Abstrakt

Změna klimatu je koncept, který ovlivňuje životy všech živých věcí na světě a představuje velkou hrozbu pro životní cyklus ve světě, pokud nebudou přijata preventivní opatření. Jeden z jeho největších dopadů má přirozeně na ekonomiky zemí. Největší dopad změny klimatu má však bezesporu na sektor zemědělství. Na zemědělství totiž mají velký vliv teplotní změny nebo přírodní katastrofy, které jsou jedním z největších důsledků klimatických změn. V této studii byl z ekonomického hlediska zkoumán dopad změny klimatu na zemědělství. Ve studii byl analyzován vztah mezi ročními průměrnými srážkami, teplotou a proměnnými emisemi CO2 a podílem zemědělského HDP Turecka na celkovém HDP. Výsledkem analýzy byl negativní a významný vztah mezi zemědělským HDP a emisemi CO2, ale nebyl nalezen žádný významný vztah mezi teplotními a srážkovými proměnnými a zemědělským HDP.

Klíčová slova: Změna klimatu, zemědělství, Turecko, ekonomika

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Introduction

It is known that the geographical features of the world have changed several times since the first periods of human existence. Disturbances in the world's natural balance have also caused significant changes in climate conditions. The world was covered with glaciers, glacial and interglacial periods occurred, and with these changes, changes occurred in the world's climate and natural balance. However, all these changes also occurred naturally. On the other hand, rapid developments in human history since the 19th century have led to increased human contribution to the changes in the world's natural balance. Today, it is accepted by almost all climate scientists that there is a deterioration in the world climate system. It is clearly stated that if people's various activities, which cause the deterioration of the natural balance, continue without taking the necessary precautions, these deteriorations in the climate will increase, and climate changes due to global warming will occur, the consequences of which may be very harmful. Because due to human reasons, the increase in greenhouse gas accumulation and particles in the atmosphere, the destruction of the natural environment, and the thinning of the ozone layer will cause a global temperature increase (Zhong & Huang, 2019).

Changes in climate and weather conditions affect many areas, from meeting people's nutritional needs to various habits such as travel and recreation. The economic effects of a critical and multi-dimensional environmental problem such as global warming will also arise in this context. Moreover, these effects are much more severe in underdeveloped and developing countries. According to research, the potential economic effects of doubling CO_2 emissions will correspond to 1% to 2.5% of the world's gross domestic product(DeCanio, 1997).

Within its complex climate structure, Turkey is one of the countries that will be most affected by climate change, mainly due to global warming. Naturally, different regions of Turkey are affected by climate change in different ways and to different extents due to being surrounded by seas on three sides and having faulty topography and geographic features. As the impact of climate change increases, the Eastern Anatolia and Central Anatolia regions of Turkey, which have arid and semi-arid climate characteristics, face a threat such as desertification. At the same time, water shortages may occur in semi-humid regions such as the Aegean and Mediterranean regions (Sen et al., 2013).

The aim of this study is to investigate the economic effects of global climate change on Turkey’s agricultural sector, with a focus on understanding the potential impacts on crop yields, land use, and production costs. In this context, in the second part of the thesis, a comprehensive literature review will be conducted based on climate change, the economic effects of climate change, and the effects of climate change in Turkey. In the third part of the thesis, the practical part, a quantitative analysis will be included that reveals the impact of Turkey's climate change on the country's agricultural indicators. In the fourth and fifth chapters, the findings were obtained from the analysis, and the results obtained from the findings will be evaluated.

1 Objectives and Methodology

1.1 Objectives

This thesis investigates the effects of climate change on Turkey's agriculture, focusing on three primary objectives:

- Analyzing the relationship between climate change and Turkey' agriculture GDP,
- Evaluating the current mitigation measures within Turkey,
- Proposing potential strategies for inclusion in the National Plan to reduce climate change impacts.

This thesis seeks to answer the following research questions:

- How has climate change impacted the agricultural GDP of Turkey over the last two decades?
- What mitigation measures are currently employed within Turkey's agricultural sector to combat the effects of climate change, and how effective have these measures been?
- Considering the current and projected impacts of climate change, what innovative strategies could be integrated into the National Plan to enhance the resilience of Turkey's agricultural sector?

1.2 Methodology

The research methodology for investigating the impact of climate change on Turkey's agriculture employs a deductive approach, chosen for its capacity to formulate hypotheses from empirical data. This contrasts with the inductive method, which generates theories from prior observations and is more aligned with qualitative research. The deductive strategy, fitting for quantitative studies, enables the analysis of time series data through statistical tools to test hypotheses, aligning with the study's goal to empirically explore the climate-economy relationship.

Research methodologies encompass qualitative, quantitative, and mixed methods, selected based on the study's objectives. Qualitative research relies on non-numerical data to uncover meanings and patterns, using tools such as interviews and observations. Quantitative research, chosen for this study, involves statistical analysis of numerical data to test hypotheses and understand cause-effect dynamics, particularly between climate changes and Turkey's agriculture. Mixed methods combine qualitative and quantitative approaches to leverage both's strengths.

The study will analyze the interplay between climate change indicators (annual temperature, precipitation averages, and population) and Turkey’s GDP, using data from 1991-2020 sourced from the World Bank and Turkey official statistics. This period was selected to ensure a comprehensive data set for a thorough analysis.

For the purpose of quantitative analysis, economic and statistical indicators between 1991 and 2020 will be analyzed by econometric model (Multiple Regression Model using the Ordinary Least Squares (OLS) method). The relationship between Turkey's precipitation, temperature and CO2 emission data, and agricultural GDP variables between 1991-2022 with econometric model.

Dependent Variable: Agricultural GDP

Independent Variable: CO2 emissions, temperature, precipitation

In this method, the amount of precipitation, temperature and CO2 variables show the dimensions of climate change in Turkey, while agricultural GDP represents the agricultural development in the country.

The data will be collected from Turkey Meteorological Station and Turkish Statistical Institute.

2 Literature Review

In this section, the conceptual framework of the thesis will be drawn under the headings of climate change, the economic effects of climate change, the impact of climate change on the agricultural sector, climate change, and agriculture in Turkey.

2.1 Climate Change

Many changes have occurred in the climate system since the formation of the Earth. The main human-based factor that reveals the concept of climate change is the increasing carbon dioxide emissions since the Industrial Revolution. With the increase in the use of machinery and the start of mass production with the Industrial Revolution, the use of fossil fuels in production, and the increasing consumption level due to population growth, carbon dioxide emission values have increased to visible levels until today. In this section, we will not focus on the natural factors that cause climate change; instead, human-based factors will be considered and examined.

The main problems caused by human factors are the increasing amount of carbon dioxide due to fossil fuels, the destruction of forests and forest fires, wrong land use, and wrong agricultural practices. Although the cause of climate change dates to the Industrial Revolution, it became evident, especially after the Second World War (1939-1945), with the rapid increase in production and consumption. Since factories generally produce using fossil fuels, carbon dioxide emissions have increased in recent years (Skendžić et al., 2021).

The increasing carbon dioxide emissions of countries cannot be absorbed at the same rate by living things on Earth. Therefore, the amount of carbon dioxide in the air increases with increased production. The amount of carbon dioxide that cannot be reduced by living things through photosynthesis creates an increasing greenhouse effect on the world. This greenhouse effect triggers global warming when CO_2, especially CH_4, N_2O, and CFC5, which started to accumulate in the atmosphere during the industrial revolution and after, cannot be absorbed sufficiently in the earth; the natural greenhouse effect is replaced by the strengthened greenhouse effect (Mathioudakis et al., 2020).

When trees cannot absorb the carbon dioxide produced due to increased production at the same level, it increases the greenhouse effect. Forest fires, illegal tree felling, and unconscious or conscious damage to forests reduce carbon dioxide absorption.

Among the human factors that cause climate change, the most important are the destruction of forests and forest fires. Deforestation and forest fires cause forests to decrease, which reduces carbon absorption over time. One of the most dangerous events that can happen to the world can be considered among the main reasons that directly affect climate change while setting out to establish a settlement or develop the wood industry. Forests indiscriminately destroyed by humans can trigger global warming, cause climate change, damage existing biodiversity, and cause the extinction of many plant and animal species. While the biological diversity of forests decreased due to the drought in the Mediterranean region in the 1970s and onwards, today, many plant and animal species are losing their lives due to forest fires, which increase exponentially every year, as well as drought. As a result of fires, regions suffer heavy losses (Abbass et al., 2022; Charlson et al., 2022).

Forests regulate the level of carbon dioxide in the soil and atmosphere by photosynthesis, allowing global warming and climate change to be slowed down. Unconscious cutting of forests is one of the most important factors that causes an increase in the amount of carbon dioxide in the world and, therefore, an increase in global temperatures and climate change. Forest fires have been seen in many regions and countries, especially recently. Significant forest fires occurred in 2019-2020, especially in Australia. These fires spread over large areas, causing vegetation to burn and the extinction of living things in Southern and Eastern Australia. As a result of the fires, the arid regions become even more arid, which poses a greater danger for fires that will occur in the coming years. As a result of the fires, many species have come to extinction. Strategies should be developed to eliminate this situation and to ensure plant and animal vitality in re-burned areas(Fitzmaurice, 2021). The regions will be revitalized thanks to environmental policies implemented by developing strategic suggestions to ensure the recovery of plants and animals after the fire. It is also essential to identify the situations that caused the fire and to punish those responsible to prevent this disaster from occurring again. These previously burned areas should be given greater importance and sensitivity in the future (Malhi et al., 2020).

According to the interim report titled "Australia's 2019 2020 Bushfires: The Wildlife Toll", as a result of the fires in Australia, approximately 3 billion animals lost their lives, and 11.46 million hectares of forest area were destroyed. Of these animals, 143 million are mammals, 2.46 billion are reptiles, 180 million are birds, and 51 million are frogs. Carbon dioxide emissions caused by fires also negatively affect the fight against climate change and pave the way for temperature increases on the Earth (Short & Farmer, 2021).

Another human factor that causes climate change is incorrect land use and faulty agricultural practices. Losses in agricultural production will reduce the yield and quality of planted products and cause significant changes in harvest periods. Since the stems of plants from agricultural production are used as animal food, loss of efficiency and quality in production will also reduce the quality of animal production and animal food(El Bilali et al., 2020).

Wrong land use means that the climatic condition of the agricultural land in the region is not well determined, and a product suitable for the current climatic conditions is not planted. If the product suitable for the region is not planted, the product will not be able to come out of the ground or grow less than expected. This will cause losses in product efficiency. In addition, choosing the wrong product depending on the location of the land and choosing fertile lands for housing construction are also among the reasons for incorrect land use. Improper land use also makes it challenging to combat climate change. Using wrong irrigation techniques, excessive or careless use of artificial fertilizers, and planting the same product on the same land yearly can cause climate change. However, excessive and careless use of nitrogen-containing products causes N_2O gas, which triggers climate change. The methods and products used in agricultural production are the most significant cause of N_2O emissions from the agricultural sector. N_2O emission figures from agriculture have been constantly increasing over the years. One of the most important sources of this situation is the fertilization management used to increase productivity in agriculture. There is a constant increase in the amount of N_2O gas due to the amount of fertilizer used unnecessarily to increase agricultural product yield and quality. However, burning agricultural waste also causes the emergence of N_2O gas.

One of the consequences of increasing global warming is the melting of glaciers due to temperatures. With the melting of glaciers, sea and ocean levels rise, and this increase confronts the creatures living in the oceans and seas with adverse situations. While the increase in water temperatures does not cause any problems if the creatures immediately adapt to the region they live in, if they cannot adapt, it causes sea creatures to migrate. Apart from global warming, some human practices that negatively affect aquatic creatures are trawling, mining waste, oil and natural gas extraction, and seabed mining (Fitzmaurice, 2021). While overfishing causes the extinction of many marine creatures, it also disrupts the environmental balance.

Deterioration of environmental balance also means deterioration of biological diversity. Biodiversity is a term that expresses that all living things are compatible and suitable for the environments they live in. Biological diversity includes genetic differences, differences between species, and differences in the ecosystem, and all these differences combine to form a whole. Biological diversity, vital for the world's continuity, creates a livable space for humans, who are a part of nature, by restoring disturbed balances (Fitzmaurice, 2021). Biological diversity allows living things worldwide to live in an orderly balance. The emergence of any change in the world ecosystem creates the need for biological diversity to rebalance spontaneously. In this case, it takes time for the balance to be restored. However, there are such imbalances that reversal is not possible. In other words, there is no certainty that the system will regain balance after every imbalance. The smooth operation of the system that ensures balance in living life on Earth is the most fundamental element for living life. Due to the imbalances created by climate change in the ecological system, global problems in food production may arise, and as a result of these problems, more poverty and disease may arise. Again, disruptions in biological diversity may lead to an increase in infectious diseases that harm the lives of some harmful species (Malhi et al., 2020).

Climate change has many direct or indirect effects on human health. Direct effects are factors that affect the continuity of human health and life. Direct effects: Sudden temperature fluctuations, increasing amounts of carbon dioxide in the air, hurricanes, storms, floods, and fires. If severe, factors such as hurricanes, floods, and fires can cause death, loss of limbs, and forced migration. Indirect effects result from direct effects. These are infectious diseases-infections transmitted from animals, epidemics, water- and food-borne diseases, respiratory diseases, and allergic diseases caused by air pollution (Abbass et al., 2022).

Due to climate change, particles suspended in the air directly affect the respiratory tract, resulting in death. Some upper respiratory tract diseases such as flu, sinusitis-migraine, asthma, and bronchitis increase in regions with high levels of polluted air. In this context, countries need to implement the policies they have planned and make these practices simultaneously, replace their investments with environmentally friendly practices, and expand the practices for healthy production and consumption, especially with innovative technologies (Charlson et al., 2022).

The concept of climate change is often confused with the concept of global warming. However, climate change occurs due to the negative situations of global warming. Global warming is defined as the temperature on Earth rising above average temperatures and continuously rising in these temperatures. Gases that create a natural greenhouse effect and other gases (H_2O, CO_2, CH_4, and N2O) have increased significantly since the Industrial Revolution (1750 and later) compared to the pre-industrial revolution periods. In the 1990s, CO_2 (30%), CH_4 (145%) and N_2O (15%) increased. The main reason for this increase is human-induced activities. This increase in greenhouse gases has disrupted the world's temperature balance and caused climate change. There was an increase of approximately 0.6°C in the world's average temperature from the late 19th century to the 1990s (IPCC, 1995). Following this increase in the 1990s, it was stated that global warming will increase by approximately 1.1°C in 2022, according to the Intergovernmental Panel on Climate Change - IPCC report. As a result of the continuous increase of these gases in the atmosphere, temperatures have increased over time. If these temperature increases continue, seasonal temperatures worldwide will rise above average and cause many balances in the world to change (Charlson et al., 2022).

With the addition of human factor gases to the existing gases in the atmosphere, the natural greenhouse effect is replaced by the strengthened greenhouse effect. Negative situations will occur on Earth as a result of global warming. It is expected that the melting of glaciers, the rise of sea levels, the emergence of precipitation differences, the occurrence of extraordinary weather events, and the likelihood of drought, desertification, water shortage, floods, and floods will increase. These adverse situations in the natural environment reveal risk factors for living things. With global warming, the balance of water vapor in the air changes, and excessive precipitation may occur. This situation can cause floods and overflows and endanger the lives of living things (Mathioudakis et al., 2020). Due to the increase in temperature due to global warming, there are differences in weather phenomena such as cloudiness, wind, humidity, and water vapor. A moisture change that may occur in the soil changes the amount of water consumption required for plants to survive, and this causes agricultural activities to be negatively affected (DeCanio, 1997).

As a result of temperature increases, evaporation will also increase. The increase in the amount of evaporation will reduce the soil’s moisture. The diversity of plants, animals, and microorganisms accustomed to living in humid environments will vary in such an environment. Failure of living things to adapt to the environment under changing climatic conditions due to environmental factors will directly affect the natural environmental order (Zittis et al., 2022). Maintaining harmony is as essential for marine life as for land life. Warming in sea and ocean water may cause fragile marine creatures to fail to adapt and cause species to decline or disappear. While the adaptable ones continue their lives, creatures that find a suitable environment in nearby areas will migrate to areas with suitable living conditions (Skendžić et al., 2021).

2.2 Factors Causing Climate Changes

2.2.1 Natural Greenhouse Effect

The atmosphere, which is an indispensable environment for all life forms on earth, consists of a mixture of many gases. The main gases that make up the atmosphere are nitrogen (78.08%), oxygen (20.95%) and argon (0.93%). The fourth important gas, although with a smaller proportion, is carbon dioxide (0.03%). These many other gases, whose accumulation in the atmosphere is very small, constitute the remaining part of the atmosphere (Marazziti et al., 2021a).

The greenhouse effect is one of the most important natural factors for the climate system. The greenhouse effect can be simplified and explained as follows: In cloudless and clear weather, a significant part of the short-wave solar radiation passes through the atmosphere and reaches the earth and is absorbed there. However, a portion of the long-wave terrestrial radiation emitted from the Earth's hot surface is absorbed and then re-emitted by numerous radiatively active trace gases (greenhouse gases) in the upper levels of the atmosphere before escaping into space. The most important of the natural greenhouse gases are the ones that make the biggest contribution. They are water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrogen monoxide (N_2O), and ozone (O3) gases found in the troposphere and stratosphere (S. Islam, 2020).

The formation of the natural greenhouse effect, the most important process in establishing the Earth's temperature balance, depends on the atmosphere's tendency to transmit short-wave solar radiation while absorbing or retaining long-wave earth radiation. The net output of infrared ground radiation must balance the net input of solar radiation (235 Wm-2). Approximately two-thirds (168 Wm-2) of the incoming solar radiation (342 Wm-2) is absorbed by the surface and one-third (67 Wm-2) is absorbed by the atmosphere. Greenhouse gases and clouds absorb a significant part of the outgoing infrared radiation. The greenhouse effect makes the earth approximately 33 C^0 warmer than in ambient conditions without this process. This natural process, which causes the Earth to warm up more than expected and regulates the heat balance, is called the greenhouse effect (Sharma, 2016a)

2.2.2 Strengthened Greenhouse Effect

The increase in anthropogenic (human-induced) greenhouse gas accumulation in the atmosphere since the industrial revolution continues. CO_2 stands out among these greenhouse gases, especially when its accumulation in the atmosphere and its lifetime are taken into consideration.

Therefore, the atmospheric carbon dioxide monitoring program at the Mauna Loa (Hawaii) Observatory forms the basis of global warming studies. Mauna Loa measurements, made since 1958, show that the accumulation of CO_2 in the Earth's atmosphere is rapidly increasing. These increases in greenhouse gas accumulation weaken the Earth's cooling efficiency through long-wave radiation, creating a positive radiative forcing that tends to warm it further. This positive contribution to the energy balance of the earth/atmosphere system is called the strengthened greenhouse effect (Jung et al., 2018)

The magnitude of global warming resulting from the strengthened greenhouse effect depends on the extent of the increase in the accumulation of each greenhouse gas, the radiative properties of these gases, their atmospheric lifetime, and the accumulation of other greenhouse gases that continue to exist in the atmosphere.

People knowingly or unknowingly apply various radioactive substances to the atmosphere. Some of these have a cooling effect on the earth. However, the warming effect is mostly more dominant. Although all these effects are not yet understood, they are known to cause global warming and sea level (Jung et al., 2018).

2.2.3 Effects of Sulfate Parasols on Global Climate

Human-induced aerosols (small volatile particles) in the troposphere, and especially sulfate particles from sulfur dioxide (SO_2) resulting from the combustion of fossil fuels, capture solar radiation before it reaches the earth and reflect it into space. Changes in volatile particle accumulations can change the cloud amount and reflectivity of the cloud. In general, observed increases in particles in the troposphere create a negative radiative forcing that tends to cool the climate. The lifetime of greenhouse gases varies from decades to centuries, whereas the lifetime of volatile particles remains between a few days and a few weeks. Therefore, their accumulation in the atmosphere can respond much more quickly to changes in emissions. On the other hand, ash particles released due to volcanic activities can also cause the earth and the troposphere to cool (Alhendi & Salameh, 2023)

2.2.4 Changes in Solar Radiation

Direct changes in solar energy occur in well-known 11-year cycles and longer-term changes. The contribution of changes in the 11-year solar cycles is estimated to be as small as 0.1%. The slow change in the Earth's axis, which takes place on a time scale ranging from decades to millennia, directs the temporal (seasonal) and generational (across latitudes) changes of solar radiation on a long-time scale. These changes played an important role in forming and controlling climate changes in the Earth's geological past, such as the ice ages in the Quaternary (Marazziti et al., 2021)

2.3 Possible Effects of Climate Changes

Depending on the increases in global temperatures, it is expected that there will be significant changes that will directly affect ecological systems and human life, such as significant changes in the hydrological cycle on a world scale, melting of land and sea glaciers, sea level rise, displacement of climate zones and increase in epidemic diseases (Marazziti et al., 2021)

The effects of climate change due to global warming are not only global, but also not limited to these. As with past climate changes, regional and temporal differences may occur. For example, in some parts of the world in the future, there will be an increase in the intensity and frequency of meteorological disasters such as hurricanes, heavy rains and floods, while long-term and severe droughts and associated widespread desertification events may be more effective in some regions (Sharma, 2016).

As a result of climate changes and global warming, it will be affected by the predicted negative aspects, especially the weakening of water resources, forest fires, drought and desertification and their associated ecological degradation. XXI century due to the increase in greenhouse gas accumulation in the atmosphere. The environmental and socioeconomic effects that a climate change that may occur in the century are as follows (Estok, 2023):

- Depending on the increase in the length and severity of the hot and dry period, the frequency, impact area and duration of forest fires may increase.
- Agricultural production potential may change (this change may be an increase or decrease depending on the species, with regional and seasonal differences).
- Natural terrestrial ecosystems and agricultural production systems may be damaged by increases in pests and diseases.
- Human pressure on sensitive mountain and valley-canyon ecosystems will increase.
- New water resources problems will be added to the water resources problems in arid and semi-arid areas, especially in cities; Water requirements for agricultural and drinking purposes may increase further.
- In addition to the expansion of arid and semi-arid areas, increases in the duration and severity of summer drought will support desertification processes, salinization and erosion.
- Increases in the higher values of the statistical distribution and especially in the frequency of limited hot days may affect human health and biological productivity.
- With the contribution of the urban heat island effect, night temperatures in the hot period will increase significantly, especially in large cities; This may lead to increased energy consumption for ventilation and cooling purposes.
- Infections resulting from changes in water availability and heat stress can increase health problems, especially in big cities.

- Although the effects on renewable energy sources such as wind and sun will vary by region, the number and strength of wind blowing, and the duration and intensity of sunshine may vary.
- There may be some changes in sea currents and marine ecosystems that may also cause significant socioeconomic problems in terms of their consequences.
- Due to sea level rise, coastal tourism areas, low flood-delta coastal plains and estuary and ria type coasts may be flooded.
- Changes in the CO2 retention and release capacities of forests and seas may cause the weakening of natural reservoirs and sinks.
- The area covered by seasonal snow and permanent snow-ice cover and the length of the snow-covered period may decrease; Sudden snow melts and snow avalanches may increase.
- Changes in the timing and volume of runoff resulting from snowmelt can impact water resources, agriculture, transportation, and recreation sectors.

2.4 The Economic Effects of Climate Change

The first effects of climate change appear with temperature increases and fluctuations in the precipitation regime. Extremes in these climate elements increase the frequency and severity of climate-related natural disasters such as drought, flood, and storm, causing severe economic losses. Approximately 87% of the natural disasters experienced in the 1980-2012 period were climate-related natural disasters. 44% of these natural disasters are storms, floods cause 41%, and 15% by droughts. The economic loss caused by these natural disasters in the same period is approximately 2.8 trillion dollars. When examined on an annual basis, it is seen that this figure corresponds to $85 billion. It is predicted that these economic losses caused by climate change will be around 1 trillion dollars annually on average in the 2050s (Faria et al., 2020).

Agriculture, tourism, and energy sectors, essential for economies, are intensely exposed to the effects of climate change. Among these sectors, agriculture and tourism directly depend on the climate, while energy indirectly depends on the climate. Although moderate climate change is expected to have an initial positive impact on agriculture and tourism in some regions, its net effect on a global scale will be negative. Undoubtedly, this situation will negatively affect the employment level. All these developments will have some effects on economic growth, which is an indicator of the success of economies (Tol, 2009).

Considering that climate change will continue in the future, it is expected that some countries that are not currently affected by climate change or benefit from it will be negatively affected. Although there is no consensus in practice and theory on the mechanism that explains the effects of climate change on the economy, some indicators can play a leading role in determining the magnitude of these effects. The share of climate-sensitive sectors in the economy and the indirect effects of climate change on non-climate-sensitive sectors are some of these (Nelson et al., 2014)

According to the report of IPCC, a regional temperature increase of 1-3C^0 in middle and high latitudes is expected to affect agricultural production positively. On the other hand, it is estimated that a regional temperature increase of 1-2C^0 in low latitudes will negatively affect agricultural production. In addition, the agricultural sector may be negatively affected in all countries due to extreme fluctuations in temperature and precipitation. Cline (2007) found in his study that the average land temperature will increase by 4.5-5 ^{0}C in the 2080s, and the productivity in the agricultural sector will decrease worldwide.

Increasing air and water temperatures due to climate change, changes in precipitation regimes decreases in water levels in some regions depending on temperature and precipitation regimes, increasing frequency and severity of storms and floods, and increases in seawater levels can also significantly affect energy supply and demand. In addition to affecting energy supply and demand, climate change can directly affect energy resources, facilities, and transfer. Hydroelectric production facilities may be negatively affected by climate change, on the one hand, due to the decreasing water level as a result of changes in the precipitation regime, and on the other hand, due to the increasing ambient and water temperature reducing the cooling efficiency of the water ((M. M. Islam et al., 2022).

Cayan et al. (2006), in their study on hydroelectric production in California, found that under a four ^{0}C temperature increase scenario, there would be a 28% decrease in stream flows towards the end of the century, and this would reduce energy production by 30%. On the other hand, decreases in hydroelectricity production due to decreases in water levels may impose an additional burden on the balance of payments of countries dependent on foreign energy sources, such as Turkey. Namely, countries with insufficient energy supply choose to meet the additional supply gap arising from the decrease in their current energy production capacity by importing energy. This process negatively affects the current account balance of these countries.

The cost of climate-related natural disasters is increasing day by day and has begun to create a significant burden on country economies. For example, in the EU region in 1999, the cost of storms reached €13 billion and the cost of floods in 2002 reached €13 billion. The heat wave in Europe in 2003, which killed 27,000 people, cost €10 billion. It is stated that this heat wave is the highest temperature in 1000 years, and the probability of similar heat waves occurring is predicted to be more than 100 times in the next 10 years. In the EU region, the annual cost of climate-related disasters has doubled in the last 20 years, reaching €8 billion. In the UK, the annual cost of floods is €1.5 billion and it is estimated that by 2070, the annual cost of floods could increase 20-fold. In 2005, the total cost of disasters in the world was $230 billion, and Hurricane Katrina had the highest total damage at $135 billion (Rogers et al, 2019).

Considering the direct and indirect effects of climate change in every field, it is inevitable that climate change will negatively affect both developing countries and developed country economies, and therefore the global economy. Current calculations show that the estimated economic impacts of just 1 degree Celsius of global warming could reach $2 trillion by 2050, and at least $300 billion each year before then. According to research, in order to avoid being exposed to the environmental costs of global warming, which varies between 5% and 20% of the world's gross national product after 2050, the methods required to reduce greenhouse gas emissions by 2050 will be equal to 1% of the world's annual economic output. The necessity of making an investment is emphasized (Davis et al., 2007).

Today, the ratio of the cost caused by the negative impact of climate change on labor productivity to world GDP is approximately 0.5% and is around 300 billion dollars annually. The countries most affected by the decline in labor productivity are countries with developing economies such as China, India, Indonesia and Mexico. The decline in productivity in these countries alone causes an annual loss of 200 billion dollars, affecting the development potential of these countries. In 2030, this loss is expected to be approximately half a trillion dollars for each country in China and India. On the other hand, under the assumption that the temperature will increase by 0.6°C, the global cost caused by the decrease in labor productivity is estimated to be around 2.5 trillion dollars in 2030 (DARA, 2012).

2.5 The Effects of Climate Change on Agriculture

Climate change undoubtedly affects many sectors from different perspectives. However, it has a direct impact, especially on the agricultural sector. When we look at the direct effects of climate change on the agricultural sector, we see that increases in temperatures, changes in precipitation patterns, increases in dry areas, and forest fires directly affect agriculture. In addition, the occurrence of tornadoes and storms due to climate change, which did not occur before, also directly impacts the agricultural sector (Hernández-Rodríguez et al., 2023).

Depending on temperature increases, there will be changes in the variety of vegetables and fruits produced in a certain region, and the products produced in that region will begin to be produced in different places. In addition, a change in the rain pattern will cause the crops to face extreme drought or to be damaged by floods (Unachukwu et al., 2022). The emergence of disasters such as temperature increases, changes in precipitation regimes, and floods resulting from climate change will reduce the quantities, yields, and quality of planted products. As a result of climate change, there will be a decrease in precipitation, population growth, and unplanned urbanization, which will cause the amount of water used in production and consumption to change in the coming years. Since less rainfall will not be sufficient throughout the year, combating drought will create difficulties, especially in summer and areas where irrigated agriculture is common (Ali et al., 2021).

When agricultural products do not have access to sufficient water, situations such as drying the products, failure to grow the product, or failure to bloom will be encountered. In this case, since the products produced within the country will not be sufficient, agricultural products will have to be imported if needed. Therefore, one aspect of the fight against climate change is the fight against drought (Arnell & Freeman, 2021). As a result of drought, product losses and decreases in yield and quality will occur. Drought will fundamentally affect large, small, and poultry breeding and significantly affect animal product access. For example, in a region that does not receive sufficient snowfall during the winter months, plants such as hay, clover, and oats will not grow sufficiently, and the number of crops planted on the land will decrease during harvest periods. In such a case, the farmer who does not have enough product will supply the missing part of the product from different places by paying higher prices, and the farmers' costs will increase (Micu et al., 2022).

Temperature increases are also a crucial factor affecting the productivity of plants. Grain products such as rice, chickpeas, and wheat are vulnerable to temperature increases during growth. Therefore, temperature increases will cause significant decreases in crop yields. Thus, in the long term, temperature increases will increase productivity losses in agricultural production, reduce the number of agricultural products available in the country, and negatively affect access to basic food for living things (Onyeneke et al., 2021).

Fires are one of the natural disasters that occur due to climate change. Fires cause significant damage to forests and agricultural lands. Overheating of the weather during the summer months and fires caused consciously or unconsciously by people cause damage to the lands where many agricultural products are planted. Forest fires that occur in a short period take a very long time to recover. It takes many years for nature to revive after fires. Natural disasters, such as fires, floods, and landslides, also damage trees and the ecosystems of plants and animals in the forest (Belford et al., 2023). Forest fires are also an essential agenda item for biodiversity.

In Turkey, farmers should be given the necessary training on the emergence, growth, and prevention of fires by experts appointed by the General Directorate of Forestry. In this regard, significant progress will be made in preventing and responding to forest fires quickly. The training should be repeated at regular intervals, and attention will be drawn to preventing forest fires through advertisements on television and the internet so that people in the city can be informed. Awareness should be created about forest fires and the damages they cause by instilling environmental awareness in nurseries, kindergartens, and primary school levels. In order to prevent forest fires, priority should be given to farmers and forest workers in all areas.

Natural meadows have a very high capacity to retain carbon emissions. However, the conversion of pasture lands into agricultural lands will cause the captured carbon emissions to be released into the atmosphere. Pasture areas are closely related to the livestock sector. Animals roaming the pasture are healthier than animals tied up in the barn, and at the same time, it will also reduce the costs for the farmer as the animal that goes to the pasture collects and eats the products it eats itself. Improvements in pasture areas will increase the quantity and quality of the products farmers obtain from livestock and dairy animals (Vannasinh Souvannasouk et al., 2021).

Since there will be no return from the effects of climate change in the short term, the first precaution to be taken is planting products compatible with changing climate conditions. In order to adapt to changing climatic conditions in agricultural production, the production of drought, rain, and frost-resistant varieties has become very important. For this reason, countries need to develop irrigation systems, attach importance to combating diseases, pests, and weeds, and develop the necessary infrastructure and research activities in these areas (Mohanty, 2021).

While non-agricultural use of existing lands in countries causes decreases in the production of agricultural products, the sustainability of the machinery and equipment used in production will lead to an increase in the productivity of products and soil quality (Mohanty, 2021). Safe and controlled agricultural practices can also ensure soil quality. While natural resources will be better protected through safe and controlled agricultural practices, access to healthy food will become more accessible (Belford et al., 2023)

For the agricultural sector to be compatible with climate change, decision-makers may need to change agricultural policies. In order to adapt to climate change, farmers may have to change planting and sowing decisions and harvest crops at an earlier period or a later date. Mitigation or adaptation policies to be determined by policymakers are essential for farmers in terms of healthy and feasible agricultural production. The fact that the new systems were developed and are to be developed first supported by the state is a practice that may be to the farmer's advantage in the long term (Onyeneke et al., 2021). New systems to be developed for agricultural production must be environmentally friendly and not beyond the farmer's purchasing power. Otherwise, farmers will be likely to be left out in the struggle.

The agricultural sector has a dual interaction with climate change. The agricultural sector, which has a strategic position regarding climate change, is most affected by the slightest seasonal change. On the other hand, it is known that some practices in the agricultural sector cause an increase in climate change. Situations such as machinery and equipment used during soil processing, pesticides, and artificial fertilization processes that will harm the natural environment, rice cultivation, burning of fields in the autumn period, and animals expelling the digested food as CH_4 increase greenhouse gas emissions. Thus, the agricultural sector is a sector that is both affected by and affected by climate (Micu et al., 2022).

The annual change in Turkey's total greenhouse gas emissions by sector between 1990 and 2019 is shown in Table 1. This table shows that the sector that causes the highest greenhouse gas emissions in Turkey is the energy sector. The sector with the second highest emissions is the agriculture sector. The basis of greenhouse gas emissions in the agricultural sector is human-induced factors.

Table 1. CO2 Emissions by Sectors in Turkey Between 1990-2019

Years	Total	Change compared to 1990	Energy	Industrial Processes and Product Use	Agriculture	Waste
1991	227,0	3,4	144,0	24,7	46,9	11,3
1992	233,2	6,2	150,3	24,3	47,0	11,5
1993	240,5	9,5	156,8	24,5	47,4	11,8
1994	234,5	6,8	153,3	24.2	44,8	12,0
1995	248,0	12,9	166,3	25,2	44,1	12,3
1996	267,6	21,9	184,0	26,2	44,8	12,7
2000	299,0	36,1	216,0	26.3	42,3	14,3
2005	337,0	53,4	244,4	33,7	42,4	16,4
2010	398,7	814	287,8	49,0	444	17,4
2012	447,6	103,8	320,5	S5,1	52,7	19,4
2013	439,7	100,3	307,5	58,1	S5,8	18,2
2014	459,0	109,0	325,8	58,7	56,2	18,3
2015	473,3	115,6	340,9	57,2	56,1	19,0
2016	498,9	127,2	359,7	61,4	S8,8	19,0

2017	525,0	139,1	379,9	64	63,3	17,8
2018	522,5	138,0	373,1	65,9	65,3	18,1
2019	506,1	130,5	364,4	56,4	68,0	17,2
2020	523,9	138,4	367,6	66.8	73,2	16,4

Source: Turkish Statistics Institute, 2024.

Greenhouse gas emissions arising in the agricultural sector consist of gases such as carbon dioxide (CO_2), methane (CH_4), nitrogen monoxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). There are many agricultural reasons for the emergence of these gases. These reasons include greenhouse gases arising in agricultural production and land use, soil management, rice production, emissions that occur during animal digestion (enteric fermentation), and emissions from drugs and nitrogenous fertilizers that accelerate the growth and development of plants used in agricultural production.

The CO_2 equivalent of CO_2, CH_4, and N_2O gases, which cause greenhouse gas emissions, is given in Table 2. While CO_2 causes the highest emission, it can be said that CH_4 gas also causes a significant emission. The primary greenhouse gases that occur during production in the agricultural sector and directly affect agricultural production are N_2O and CH_4 gases. Among agricultural activities, N_2O emissions resulting from artificial fertilization constitute the most essential and most considerable agricultural-related emissions. CH4 gas, also released during cattle and sheep farming and rice production, creates other greenhouse gases from agriculture and agricultural production. Farm animals, especially cattle and sheep, cause the greenhouse effect by releasing CH_4 gas as a result of their digestion(Belford et al., 2023).

Table 2. CO2 Emissions in Turkey between 1990-2019.

Years	Total	CO_2	CH_4	N_2O
1990	216,6	151,5	42,5	25,0
1991	227,0	158,0	43,4	24,7
I992	233,2	163,6	43,3	25,3
1983	240,5	171,0	43,1	26,0
1994	234,5	167,4	428	23,6
1995	248,0	180,9	42,6	23,9
1996	267,6	199,5	43,0	24,5
2000	299,0	229,9	43,7	24,8
2005	337,0	264,8	45,2	25,3
2010	398,7	3l6,0	51,6	27,4
2012	447,6	353,7	57,1	32,1
2013	439,7	345,2	55,5	34,1
2014	456,0	36î,7	57,5	34,6
2015	473,3	381,3	51,6	35,4
2016	498,9	401,2	54,5	37,7
2017	525,0	425,3	54,8	39, 1
2018	522,5	419,4	58,1	39,3
2019	508,1	399,3	60,3	40,2
2020	523,9	413,4	64,0	40,5

Source: Turkish Statistics Institution,2024

Performing the wrong procedure during soil management and fertilization can lead to productivity or product loss in the soil. First of all, mineral analysis in the soil must be done. As a result of the analysis, the necessary fertilizer application should be made. The amount of fertilizer to be used must be determined carefully. The use of natural fertilizers, chemical pesticides, and nitrogen-containing artificial fertilizers used to increase the efficiency of products also has an essential place in greenhouse gas emissions (Micu et al., 2022)

In order to plant land for agricultural production, it must first be plowed and harrowed. For this purpose, agricultural production operations are carried out with the help of tractors and tractor-like vehicles. These vehicles used in agricultural production run on fossil fuels. While the CO_2 emissions of tractors used today are expected to be high during all these processes, thanks to the new generation technologies developed, it has become possible to reduce the emissions of harmful substances released into nature.

The study examining climate change's impact on the agricultural sector on a global scale between 1960 and 2000 determined that temperature and precipitation changes caused changes between 0.05% loss and 0.9% gain in agricultural income. Adaptation measures that can be taken against climate change are also included in the analysis, thanks to the model used in the study, which calculates the effects of climate on agriculture with temperature, precipitation, and carbon dioxide indicators using the Global Impact Model (GIM). In the study, drawing attention to the differences in climate change between latitudes, it is estimated that 4-7% of agricultural growth, especially in countries in middle and high latitudes, is due to climate change. In contrast, in countries at lower latitudes, this contribution to climate change is estimated to be between 0.6% and 3% (Mendelsohn, 2007).

A similar result is encountered in the study conducted by Rosenzweig and Parry (1994), in which the potential effects of climate change on the world food supply are evaluated on a global scale. This study focuses only on the grain group among agricultural products. Potential changes in the yield of grain products were calculated using temperature, precipitation, and solar radiation data representing climate change and projections in different scenarios under the General Circulation Model (GCM) until 2060, and the economic consequences of these changes were determined using the World Food Trade Model (WFTM). According to the results obtained, while climate change positively affects the grain production number of developed countries in middle and high latitudes, it harms the grain production amount of developing countries in low latitudes. Adaptation measures taken on a farm basis have little effect in reducing the large gap between countries in middle and high latitudes (developed countries) and countries in low latitudes (developing countries). In contrast, developing countries are predicted to suffer significant losses due to climate change. Therefore, while some countries in temperate regions may benefit from climate change, many countries in tropical and sub-tropical regions appear to be more vulnerable to the potential effects of global warming (Rosenzweig & Parry, 1994).

Zabel et al. (2015) showed that temperature and precipitation change in regions at high latitudes. It claims that the agriculturally suitable areas of regions located mainly in semi-arid regions will change. This study determined that the global production potential could be increased by 50% when the maximum number of harvests possible per year is used under current conditions. It was concluded that another 20% increase in the global production potential could be achieved by optimizing the spatial distribution of crops within agricultural production systems according to their profitability(Zabel et al., 2015).

Lobell et al. (2011) examined the impact of climate change on the agricultural sector worldwide, on four agricultural products (corn, wheat, rice, and soybeans) and by taking into account the standard deviations in temperature and precipitation trends between 1980 and 2008, found that the harmful climate effects of climate change. They found that wheat production in Russia, Turkey, and Mexico and corn production in China accounted for much of the total yield gains. In the study, it was determined that the increase in temperature in high-latitude regions positively increased rice production. At the same time, it was observed that there were no significant differences between latitudes for other products (Lobell et al., 2011).

A study examining the impact of climate change on the productivity of agricultural products was included in the 2010 World Bank Development Report. The study focuses on productivity with wheat, rice, corn, millet, field sugar beet, sweet potato, soybeans, peanuts, and sunflower products. The parameters of temperature, precipitation, and cloudiness represent climate change. As a result of the study, in which each of 3 different emission scenarios was applied to 5 different General Circulation Models between 1950-2055, the changes in agricultural production between the periods 1996-2005 and 2046-2055 are presented,, and these changes represent the average agricultural productivity of the years 2000 and 2050. While climate changes are expected to increase agricultural productivity in countries located at middle and high latitudes, it is estimated that it will significantly reduce agricultural productivity in most developing countries. As a result, global agricultural productivity averages will decrease. In these studies, conducted on a global scale, representing the world in general, countries in middle and high latitudes are generally referred to as developed countries, and countries in low latitudes are considered undeveloped or developing countries. In these studies, examining the effect of climate change on agricultural production, it can be said that while climate change is expected to positively affect the agricultural production of countries located in middle and high latitudes, the agricultural production amounts of countries located in low latitudes will be negatively affected by climate change. Nevertheless, the effects of climate change on developing countries are poorly understood because very few studies have been conducted in this field (Mendelsohn et al., 2001).

In addition, in some studies on a global scale, when agricultural production amounts are considered, it is seen that climate change will cause different effects on the hemispheres. In the study conducted by Adams, which examined the effect of climate change on the amount of change in agricultural areas, it was concluded that northern latitudes were less affected than southern latitudes (Adams, 1989). In addition to studies on a global basis, the literature generally addresses the impact of climate change on agricultural production regionally, mainly on a country-specific basis.

Taking the Asian continent, Mendelsohn examined the effects of climate change on the Asian agricultural sector between 1960 and 1990 through the Ricardian model, which he widely used in his studies. As a result of the study, in which the climate is represented by temperature and precipitation variables, it is estimated that a 1.5-degree temperature increase in the Asian continent will cause a 13% decrease in net product income per year and a 3-degree temperature increase will cause a 28% decrease in net product income. It has been concluded that climate change will adversely affect the Asian agricultural sector. In addition, while agricultural income is expected to decrease across the continent because of climate change, Afghanistan, Brunei Darussalam, North Korea, Japan, Kyrgyzstan, South Korea, and Tajikistan are among the countries in the continent where agricultural income is expected to increase as a result of climate change (Mendelsohn, 2014).

In the study conducted by Blanc, which aimed to estimate the effect of climate change on the yields of the four most grown agricultural products in Sub-Saharan Africa (SSA), millet, corn, sorghum (a type of millet), and cassava, the yield was determined by standard weather variables such as temperature and precipitation. A panel data approach correlated sophisticated weather measures such as evapotranspiration and standardized precipitation index (SPI) (2012). The created model was calculated using data for the period 1961-2002 for 37 countries, and the crop yields obtained until 2100 were estimated by combining estimates from panel analysis with climate change estimates from general circulation models (GCMs). As a result of the study, compared to a case without climate change, yield changes in 2100 for these four crops grown in sub-Saharan Africa were approximately zero for cassava, from -19% to +6% for maize and -38% for millet. It was concluded that it varied from -13% to -13% for sorghum and from -47% to -7% (Blanc, 2012).

The impact of climate change on the agricultural sector has been studied on a global, regional, and continental basis, as well as on countries and even states. In their study, Wang et al. (2009) examined the effects of the expected change in climate on Chinese agriculture with precipitation and temperature indicators and concluded that the net effects of climate change on China would first appear at a mild level, and the size of the damage will gradually increase. Another result that has been determined is that global warming will negatively affect China's grain-fed agricultural lands but will positively affect irrigated agricultural lands. Therefore, the effects will vary according to various regions of the country (Wang et al., 2009).

In another study examining the effects of warming on Chinese agriculture using Ricardian analysis, it was concluded that as the temperature increases, the average net agricultural income will increase rather than decrease (Liu et al., 2004).

In the study examining the impact of climate change on the Israeli agricultural sector, in addition to annual temperature and precipitation variables, irrigation water amount data for each farm was also included in the model to measure the response of the farms to climate change. When irrigation water is excluded from the model, the model predicts that climate change will benefit the Israeli agricultural sector, while in the model with irrigation water included, it predicts that moderate climate changes will be beneficial and severe climate change will be detrimental in the long run. In addition, in the study, predictions made using Atmosphere-Ocean General Circulation Models (AOGCM) scenarios predict that climate change will cause an increase in Israel's net agricultural income (Fleischer et al., 2008)

In the study, which examined the effects of climate change on the agricultural sector of Argentina between 1941 and 2010, it was found that the semi-arid and semi-humid regime that dominated at the beginning of the 70-year series under discussion changed significantly until the end of the twentieth century to create a more humid environment, significantly affecting the current development level of agriculture. It is undergoing a positive climate change (de la Casa & Ovando, 2014). In most of the studies dealing with climate, it is found that temperature and precipitation variables, which are the most used climate change indicators, affect agricultural products in different magnitudes and/or directions.

Similarly, in the study conducted by Ochieng et al. (2016), where the effects of climate diversity and change on corn and tea production were examined based on small-scale farmers in Kenya, climate change was represented only by temperature and precipitation parameters. In the study, micro-scale socioeconomic variables such as household size, gender, and education of farmers were controlled. It has been concluded that temperature has a more significant impact on product production than precipitation and that climate change will negatively affect agriculture in 2020, 2030, and 2040, leaving greater impacts, especially on the tea industry (Ochieng et al., 2016).

In the study, which aims to measure the effects of climate change on the Sri Lankan agricultural sector using the Ricardian method, the model created estimates the net income per hectare of tea, rubber, coconut, and rice, four critical products in the country. In the study, where only the thirty-year average values of temperature and precipitation variables were used to represent the climate, the limited range of temperature data allowed only a simple test to measure the effect of temperature on agriculture. In contrast, the distribution of precipitation data over a wide range allowed a more complex investigation of the precipitation effect on the country, and climate effects were to be observed under five different AOGCM scenarios. As a result of the study, the regions with an arid climate of a country such as Sri Lanka, which is in the tropical region and experiences two monsoon seasons, will primarily lose their agricultural areas. In contrast, the agricultural output of the regions with a cold climate may remain at the same level or increase slightly. In short, the temperature increase will affect Sri Lanka. It has been observed that the increase in precipitation will have a detrimental effect on the agricultural sector, while the increase in precipitation will have a beneficial effect (Seo et al., 2005). This study also supports the view, widely expressed in the literature, that the damages caused by climate change on developing countries located in the tropical region will be greater than in other countries.

By choosing two regions with entirely different climates in America, the relationship between climate variations and corn and soybean production was tried to be estimated by simple linear regression using temperature, precipitation, and solar radiation variables between 1982 and 1998, and each degree increase in seasonal temperatures resulted in the highest production in the world. It was concluded that it caused a 17% decrease in the production of corn and soybeans, which are the most common products (Lobell & Asner, 2003).

Another study examining the impact of climate change on the American agricultural sector measures the economic impact of climate change on US farmland by estimating the impact of random annual variation in temperature and precipitation on agricultural profits. As a result of the study conducted by Deschênes and Greenstone (2007), using panel data on a state basis in America between 1970 and 2000, agricultural production, soil quality, temperature and precipitation data, and Hadley long-term climate change forecasts, it was found that climate change will reduce annual agricultural sector profits by 4%. It was estimated to increase by 1.3 billion dollars at 2002 prices (2007). In addition, analysis shows that projected increases in temperature and precipitation will have virtually no impact on yields of the most important crops (corn and soybeans). While it is stated in the study that the impact of climate change will be small for America, it is also noted that the levels of states' impact from climate change will differ. The state that will suffer the most from climate change is expected to be California, which will lose 15% of its current annual profit and lose 750 million dollars, Nebraska with 670 million dollars, and North Carolina, with 650 million dollars, constitutes the top three states most damaged by climate change. The states where climate change is expected to affect the agricultural sectors positively are South Dakota, with a profit of 720 million dollars, and Georgia, with a profit of 540 million dollars (Deschênes & Greenstone, 2007). As this study shows, climate change affects regions across latitudes at different levels and countries and even states within a country in different directions and magnitudes.

The tourism sector, like the agricultural sector, depends on climatic change. Many tourism activities are done outdoors. In addition, a clean environment and favorable weather conditions are crucial to tourist satisfaction and the continuity of the tourism region. In this regard, the tourism sector and regions are extremely sensitive to climate variability and change. In many places, environmental conditions are closely related to tourism regions (Tol, 2009). Natural resources that have significant impacts on tourism activities, such as winter conditions, productivity of wildlife, biodiversity, water level, and quality, are affected by climate and climate change. On the other hand, situations such as the risk of infectious diseases caused by climate change, forest fires, harmful insects, and the invasion of the seas and nature by pests may negatively affect the decisions of tourists and the tourism sector. Tourism activities help individuals improve their quality of life by providing holiday opportunities and producing critical economic results. Namely, tourism plays a vital role in the redistribution of wealth from rich countries to poor countries, from urban areas to rural areas, and from north to south. In addition, tourism revenues are of excellent importance, especially in the balance of payments between developed countries and developing countries. 46 of 50 underdeveloped countries obtain foreign exchange income from the tourism sector. In this regard, tourism offers essential employment opportunities and poverty prevention potential in developing countries. As an income-generating activity, tourism also encourages the preservation of the world's natural beauty and cultural heritage (Tol, 2009).

Tourism activities not only help individuals improve their quality of life by providing holiday opportunities, but also produce important economic results. Namely, tourism plays an important role in the redistribution of wealth from rich countries to poor countries, from urban areas to rural areas and from north to south. In addition, tourism revenues are of great importance especially for the balance of payments of island countries and developing countries. 46 of 50 underdeveloped countries obtain their foreign exchange income from the tourism sector. In this regard, tourism in developing countries offers significant employment opportunities and poverty prevention potential. As an income-generating activity, tourism also encourages the preservation of the world's natural beauties and cultural heritage.

However, climate change has many negative effects on both summer and winter tourism. For example, while 20,000 people visited Bali Barat National Park in 2000, this number has increased to around 3,100 annually in recent years. Desertification is expected to increase in Sub-Saharan Africa and also in Central Asia, where there is water scarcity and irregular supply. Lake Nakuru in Kenya, where tourists go to observe the bird population, is exposed to water stress. Desertification and decline in forests threaten wildlife. The population of lions, elephants and rhinos in Africa has decreased significantly and negatively affects safari tourism. Tropical forests are disappearing in tropical Africa, South America and Southeast Asia due to the effects of climate change, as well as other human-induced factors. Tropical forest cover decreased by around 3% between 2004 and 2007. At the same time, 13 hectares of forest area the size of Greece is damaged every year due to increasing fires. While this situation contributes to climate change, on the other hand, it negatively affects such tourism activities by damaging wildlife and natural vegetation (UNWTO, 2007).

Winter and winter sports tourism are at great risk due to climate change. Tourism demand in regions where winter tourism is carried out may decrease significantly. Due to increasing temperatures, the season will shorten and demand will shift to higher latitudes (UNWTO, 2003). As a matter of fact, it is estimated that a temperature increase of less than 2 °C will cause the snow cover in the Northern Alps to be unusable for 40 days in a 5-month period and 60% of the winter sports potential in the Bavarian Alps of Germany will be lost (UNWTO, 2007).

The effects of climate change on the tourism sector may trigger many economic and social developments. The decrease in tourism demand may lead to sectoral unemployment due to the decrease in labor demand in decreasing regions. Additionally, there may be decreases in investments such as construction, infrastructure facilities and transportation network. This chain effect may create wider economic and social impacts, for example, by affecting the tourism sector's demand for agricultural products, regional handcrafted products, and regional small businesses (UNWTO, 2003).

2.6 Climate Change in Turkey

In order to find solutions to an important problem with many different dimensions, such as global warming and climate change, which requires a joint effort across the world, the factors causing this problem must be thoroughly analyzed, and the necessary precautions must be taken. In this context, one of the most important points to consider is the countries' development levels and economic structures. Since the energy resources, energy use amounts and intensities, populations, and development levels of countries are different, the amount of emission reduction that may occur because of the tools that can be applied and the measures taken in each country will also be different. Realistic situation assessments need to be made to determine the appropriate tools and measures to ensure success in global warming for Turkey, a country in developing countries, considering the economic growth trend it has recently achieved.

At this stage, one of the most important guiding documents is the National Greenhouse Gas Emission Inventory, which every country that has signed the FCCC must prepare and submit to the FCCC Secretariat every year. This document reveals critical analyses such as the countries' greenhouse gas emission amounts, sources, and sectoral distributions (Mateo-Márquez et al., 2020).

The Framework Convention on Climate Change (FCCC), which was adopted in 1992 and entered into force on 21 March 1994, to prevent the adverse effects of greenhouse gas emissions, which have reached dangerous levels in the atmosphere today, on climate systems and to keep them at a certain level, is one of the first steps taken internationally within the framework of global warming. It constitutes one of them. In order to achieve the objectives of the FCCC, which was adopted at the United Nations Conference on Environment and Development held in Rio in 1992 and came into force with the approval of 50 countries, developed countries should reduce greenhouse gas emissions in 2000 to 1990 levels and provide technological and financial assistance to developing countries. They are made liable. The basic principles contained in the Agreement can be listed as follows(Kocabas, 2013):

- Protecting the climate system based on equity by the common but differentiated area of responsibility,
- Considering the needs and special conditions of developing countries that will be affected by climate change,
- Carrying out the measures to prevent climate change effectively and at the least possible cost,
- Supporting sustainable development and integrating the policies to be implemented and the measures to be taken into development programs,
- The countermeasures taken should not be arbitrary, unfair, discriminatory, or a hidden international trade restriction.

The primary purpose of the FCCC is to keep greenhouse gas accumulations in the atmosphere at a level that will prevent dangerous anthropogenic effects on the climate system. For this purpose, two additional country groups have been defined within the scope of the Convention. ANNEX II list consists of countries that became OECD members in 1992 and European Union countries. These countries are Germany, the United States, France, Switzerland, Norway, Australia, the Netherlands, Italy, Portugal, Austria, England, Iceland, Turkey, Belgium, Ireland, Japan, New Zealand, Denmark, Spain, Canada, and Greece(Vardar et al., 2022).

ANNEX I list, in addition to the countries in the ANNEX II list, consists of countries in the process of transition to a market economy (Russian Federation, Croatia, Slovakia, Lithuania, Ukraine, Hungary, Latvia, Poland, Slovenia, Romania, Bulgaria, Belarus, Czech Republic and Estonia). Since Turkey is a member of the OECD, it is included in the Annex I countries, which are primarily responsible for reducing greenhouse gas emissions, and in Annex II countries, which will provide financial and technical support to reduce the emissions of underdeveloped countries. As a developing country, Turkey's energy production and consumption are behind those of other OECD countries. In addition, the level of socioeconomic development is lower than in other Annex II countries. Thereupon, although Turkey was optimistic in principle, it did not sign the FCCC at the 1992 Rio Conference because it could not fulfill its obligations under these conditions. Legal obligations to reduce greenhouse gas emissions after 2000 are in Chapter III, designed to achieve and observe the FCHS targets and in which all parties have a say. It is included in the outcome of the Conference of the Parties. The Conference held in Kyoto, Japan, in 1997 has particular importance because it revealed in more detail the obligations to reduce greenhouse gas emissions that cause climate change and created various mechanisms that can be implemented(Vardar et al., 2022).

According to the Kyoto Protocol, which was opened for signature on 16 March 1998, countries included in the Annex I group are required to reduce their greenhouse gas emissions by 5% below 1990 levels between 2008 and 2012. This target in the protocol is considered one of the most critical steps taken internationally in limiting greenhouse gas emissions. Annex I countries responsible for at least 55% of the total CO2 emissions 1990 are among the 55 countries. The Kyoto Protocol, which could not come into force because the United States of America, which has a share of approximately 36%, did not sign the protocol for a long time, was signed by the Russian Federation, which has a share of 17%, on 18 November 2004, and was signed on 16 February 2005, was implemented on. Turkey expressed its desire to be removed from both annexes of the FCCC during the COP3 process in 1997; since this request was not fulfilled, it did not become a party to the Kyoto Protocol. Turkey's attitude towards the FCCC shows significant differences between 1992 and 1997, from Rio to Kyoto, and after 1997(Maizer, 2022).

Until Kyoto, the Third Conference of the Parties, Turkey's general attitude was to become a party to the FCCC if both annexes were removed and facilities were provided, considering the country's unique conditions. After 1997, it adopted a more moderate approach, searching for concrete ways to participate in the FCCC process. In this context, at the sixth meeting of the Conference of the Parties held in The Hague in 2000, Turkey stated that it could become a party to the FCCC as an Annex I country, provided that it was removed from Annex II and benefited from the facilities provided to former socialist countries. Depending on the decision taken at the Hague Conference, at the Marake Conference, which was the 7th Conference of the Parties, it was decided that "Turkey, which is in a different position from other countries in the Annex I list of the Convention, should be recognized in its special conditions and its name should remain in the Annex II and be deleted from the Annex II." It has been accepted to be removed from Annex II (UNFCCC, 2001). Following these developments, the draft law declaring that it was appropriate for Turkey to participate in the Framework Convention on Climate Change was submitted to the General Assembly of the Turkish Grand National Assembly in 1996 and signed on 24 May 2004. In addition, Turkey has officially become a party to the Framework Convention on Climate Change as the 189th country. The Grand National Assembly accepted the law regarding Turkey's participation in the Kyoto Protocol on 5 February 2009, and Turkey officially became a party to the Protocol on 26 August 2006. Turkey, which was not a UNFCCC party at the date of adoption of the Protocol, was not included in the Protocol Annex-B list, where the quantified emission limitation or reduction obligations of the Annex Parties are defined. Therefore, Turkey has no emission limitation or reduction obligations in the first obligation period of the Protocol, covering 2008-2012 (Maizer, 2022).

In the Mediterranean basin, Turkey is anticipated to face significant repercussions from climate change. The country's agricultural production is highly susceptible to temperature variations, with abrupt increases during spring and summer posing critical risks. Alongside temperature shifts, alterations in precipitation patterns present vulnerabilities for crop production. In Turkey, 20% of agricultural land is irrigated, utilizing 70% of water resources (Dellal & Unuvar, 2019)

Rainfall and irrigation are crucial in cultivating staple crops such as wheat, barley, and corn. Consequently, water scarcity, resulting from climate-induced precipitation decreases, will impede crop production nationwide. Fujihara et al. (2008) predict a 160 mm annual reduction in precipitation in Turkey's Seyhan River Basin (Fujihara et al., 2008). Turkey's diverse crop production, vital for domestic consumption and exports, includes wheat grown in arid and semi-arid regions. Wheat cultivation heavily relies on irrigation, making water scarcity a limiting factor due to decreased precipitation. Tonkaz et al. (2007) reported a 30% decline in wheat production with a 6℃ increase in minimum and maximum temperatures in Turkey(Tonkaz et al., 2007).

Barley, another significant crop in Turkey, is cultivated in regions like wheat but exhibits greater tolerance to irrigation shortages. Soylu and Sade (2012) observed a comparatively minor reduction in barley production than wheat during dry years in Central Anatolia (Soylu & Sade, 2012). Maize, crucial for animal feed in Turkey, faces climate predictions of substantial temperature increases and precipitation decreases in regions with a Mediterranean climate. Additionally, maize growth is constrained when the maximum temperature exceeds 41℃ (Challinor et al., 2014). The Şanlıurfa Basin has already experienced temperatures beyond this threshold, making maize particularly sensitive to further temperature increases.

Sunflower production, critical for Turkey's oil production, historically concentrated in Northwest Anatolia, has rapidly expanded to Central Anatolia. Sunflower cultivation in Central Anatolia relies on irrigation and sufficient precipitation for optimal growth. Climate change affects agricultural production globally, but Turkey, located in the Mediterranean Basin, faces heightened risks. The agricultural sector confronts three significant challenges: meeting increased food demand due to population growth, mitigating the negative impacts of climate change on crops, and contributing to global emission reduction targets outlined in the Paris Agreement (Dellal & Unuvar, 2019).

Addressing these challenges necessitates global collaboration. Despite ongoing disagreements, the 23rd COP established the Koronovia Joint Work on Agriculture (KJWA), a UNFCCC platform discussing agricultural issues. While focusing on agriculture's potential in combating climate change, KJWA also considers socioeconomic and food security dimensions. Adopted at COP23 in 2017, KJWA continues its efforts. COP26 in 2021 emphasized the transition towards sustainable and climate-resilient food systems (Directorate-General for Agriculture and Rural Development, 2021).

Growing global awareness of climate change's impact on agricultural productivity, crop production, and food security underscores the need to quantify these effects for effective mitigation and adaptation policies. Literature extensively covers climate impacts on agriculture, with an increasing focus on economic analyses of agricultural production in the past decade.

2.7 Agriculture in Turkey

Due to Turkey's physical conditions, lands, soil fertility, and climate conditions, agricultural production always has great potential, and its contribution to the economy is great. The importance of the agricultural sector in the economy stems from the expected contribution from production. While 46% of the total number of workers in Turkey was working in the agricultural sector in 1990, currently 24.7% is employed in the agricultural sector. The agricultural sector's share of employment has declined by approximately 50% in the last 20 years. However, even in this case, 25% of the population is employed in agricultural production. During periods of economic distress experienced by Turkey, the downsizing of working areas causes increased employment in the agricultural sector. Meeting the nutritional needs of the people, providing raw materials to the industrial sector, creating demand for industrial products, and contributing to national income and exports are the main contributions of the agricultural sector to the country's economy (Hayran et al., 2018).

The agricultural sector does not need a large share in the GNP to make these contributions. It is possible to show the place and importance of the agricultural sector in the economy with data. The first thing that comes to mind is the share of agriculture in GNP. When the average of the last three years is taken in Turkey, the contribution of agriculture to the GNP is 50 billion dollars according to data, and 8.2% on a rate basis (Turker& Anac, 2022).

While the production volume of agriculture increases in quantity with financial developments, the income of the agricultural sector increases, and with this situation, the share of agricultural income in the country's income decreases. This situation is due to the demand for agricultural products and the low-income level. In particular, the fact that the income elasticity of the demand for plant products is less than one and that of non-agricultural goods is greater than one results in the growth rate of other sectors being higher than the agricultural sector. In the report titled "Where is Turkish Agriculture Going", it is noted that the share of agriculture in GNP was around 26% until 1980, but this rate decreased to 17 percent in 1998; it is stated that "The share of agriculture in exports has decreased over the years; While the agricultural sector constituted 80 percent of the revenues from exports in 1980, it is stated that this rate decreased to 10 percent in 1998." It was stated that there was a decrease in the total employment rates of employment in the agricultural sector between 1980 and 1999, and these rates decreased from 56 percent to 57 percent. The report stated that the agricultural sector's added value constituted 15.9 percent of GNP and 44.9 percent of total employment in the 1990-1998 ((Baran et al., 2019)).

By the 1980s, Turkey was largely an exporter in the import and export of agricultural and animal production. While agricultural production exports increased 1.5 times between 1980 and 1999, imports increased 36 times. In the early 2000s, it was seen that Turkey's agricultural sector increased significantly in terms of imports. The country was an importer of agricultural products in the three years between 1995 and 1999 (Hayran et al., 2018).

In Turkey, the inclusion of agricultural income into the Income Tax system became possible with the Income Tax Law No. 193 issued in 1960. However, the provisions of this law regarding agricultural income (earnings) could only be implemented in 1962. In Article 52 of the code, "the concept of agricultural activity; The production, hunting, protection, transportation, sale or use of plants, forests, animals, fish, and their products by planting, planting, maintenance, production, cultivation, and improvement in land, seas, lakes and rivers, or by directly benefiting from nature, by hunters and breeders, or It refers to using these products in another way." Agricultural income (earnings) is the income obtained from agricultural production(Yılmaz et al., 2019).

The income earned by farmers who operate their own land personally, as sharecroppers, or as tenants is included in the scope of agricultural income. However, the income of people who earn income by renting out agricultural enterprises is not included in the definition of agricultural income. People involved in agricultural production, whether taxable or not, are defined as "farmers," and the products produced as a result of these practices are defined as "crops." "According to law, collective companies, ordinary limited companies, and limited partnership companies with shares are not considered farmers even if they engage in agricultural activities, and the income they earn is not agricultural, but commercial income." For this reason, it is necessary to be a real person for farming. Enterprises in which agricultural activities are carried out are called "agricultural enterprises."(Yılmaz et al., 2019)

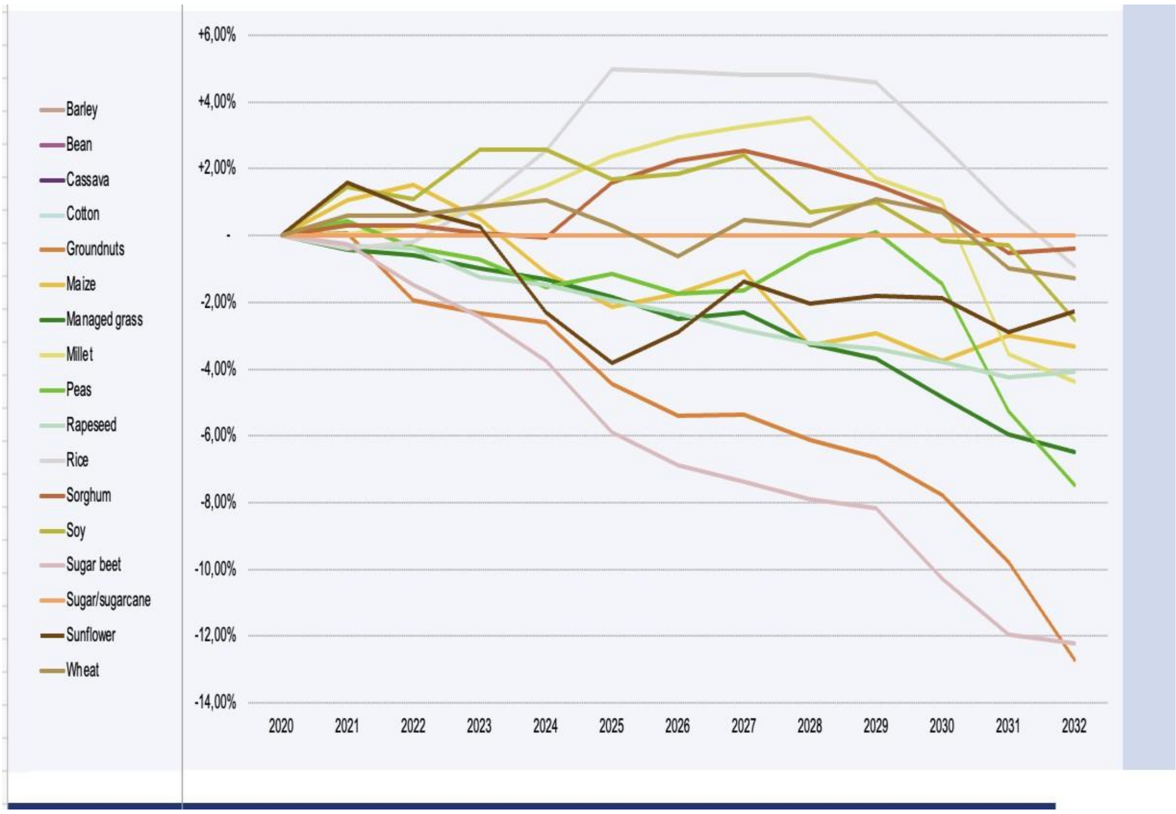
As in the rest of the world, agriculture in Turkey is one of the sectors that will be most affected by climate change. Due to the economic and social importance of the agricultural sector in the country, it can be said that Turkey is one of the sensitive countries in terms of the effects of climate change on the agricultural sector. The fact that Turkey is a semi-arid country located in the Mediterranean basin also increases this sensitivity. The agricultural sector in Turkey is an important sector in terms of food supply, raw material supply to agriculture-based industry, GDP, exports and employment. 9% of GDP and exports and 24% of employment come from agriculture. In this regard, changes in agricultural production that may occur due to climate change may have significant repercussions on the economic and social structure of those who earn their living from agriculture, as well as on the country's economy (Ministry of Environment, Urbanization and Climate, 2012).

In Turkey's First National Declaration on Climate Change prepared in 2007; The effects of climate change on Turkey; It is stated that these will be in the form of increasing summer temperatures, decreasing winter precipitation in western provinces, loss of surface water, increasing frequency of drought, soil degradation, coastal erosion and floods. This situation; It is expected that it will have negative effects on water and land resources, which are essential for food production and security, and development prospects in rural areas, and that the severity of these effects will gradually increase (Ministry of Environment, Urbanization and Climate, 2012).

The area cultivated for agricultural production activities in Turkey is 24.3 million hectares. Only 5.1 million hectares of the cultivated area is irrigated. Dry farming is done in approximately 80% of the total agricultural land. In other words, agricultural production directly depends on rainfall. Due to climate change, decreases in precipitation are expected across Turkey. The decrease in precipitation will significantly affect agricultural production and productivity when considered together with temperature increases. Decreases in production will cause upward pressure on the prices of agricultural and agricultural products (Ministry of Environment, Urbanization and Climate, 2012).

The figure for the forecast in the production of agricultural products for Turkey made by IFAD is shown below for the 2020-2032 period.

Figure 1. IFAD Change Forecast in Turkey Agricultural Production (2020-2032)



Source: IFAD, 2024

When the figure above is examined, according to IFAD predictions, although there will be production increases in some of Turkey's products until 2030, there will be decreases in the production of all products, even the most important products such as cotton and wheat, as of 2030.

3 PRACTICAL PART

In this study, the possible effects of climate change on the agricultural sector were examined with the help of multivariate regression analysis. The variables included as percentage changes in the model created for this purpose consist of annual data covering the period 1991-2020. The variables in the regression model and the databases from which they are provided are shown in detail below.

Table 3. The Information of Variables

AGDP	Agriculture (%GDP)	WDI	2015 Constant US$	Annual
PREC	Precipitation	Turkish Meteorological Directorate	Millimeter	Annual
TEMP	Temperature	Turkish Meteorological Directorate	C^0	Annual
CO_2	Carbon dioxide	WDI	Kt	Annual

First of all, Turkey's situation in terms of precipitation, temperature, CO2 and agricultural GDP between 1991 and 2020 will be examined and the changes of individual variables between these years will be examined.

The table showing Turkey's share of agriculture in GDP between 1991-2020 is given below.

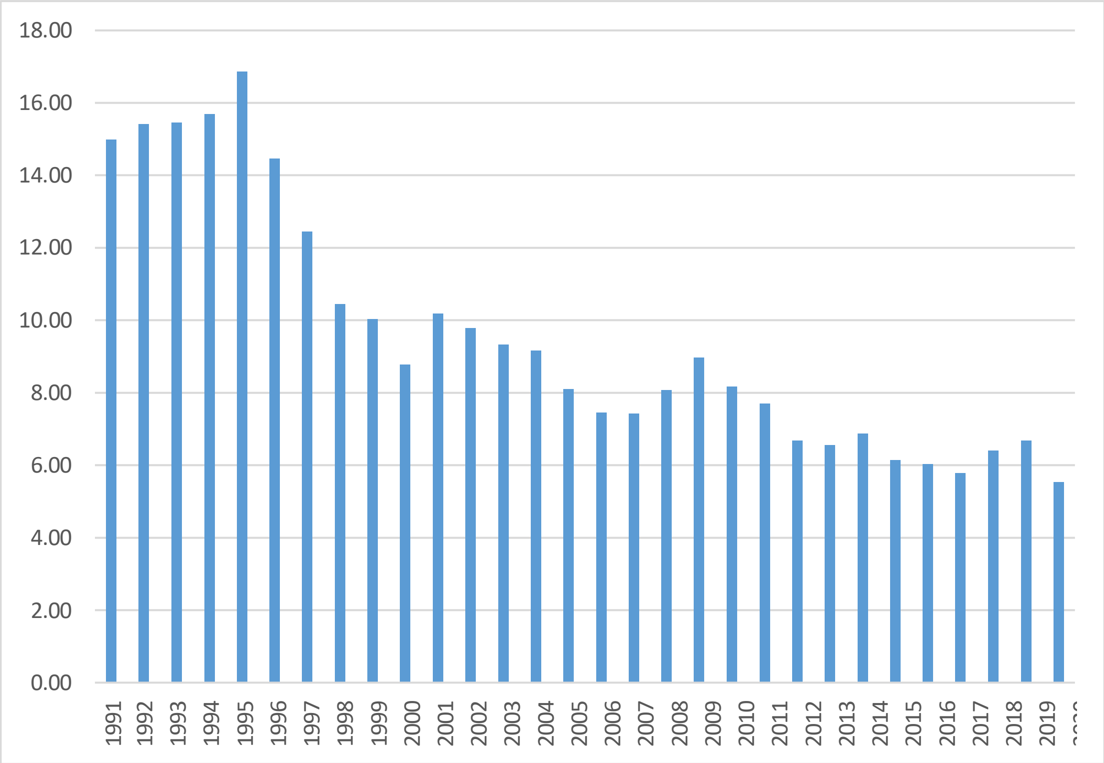
Table 4. The Agriculture, Forestry, and Fishing, value added (% of GDP) – Turkey

Years	Agriculture (%GDP)
1991	14.98
1992	15.42
1993	15.46
1994	15.69
1995	16.85
1996	14.46
1997	12.45
1998	10.46
1999	10.03
2000	8.79
2001	10.19
2002	9.80
2003	9.33
2004	9.17
2005	8.09
2006	7.46
2007	7.42
2008	8.07
2009	8.97
2010	8.17
2011	7.69
2012	6.68
2013	6.56
2014	6.87
2015	6.14
2016	6.04
2017	5.79
2018	6.40
2019	6.67
2020	5.53

Source: WDI, The World Bank, 2024

As seen in the table above, while the share of agriculture in GDP was over 10% in the 90s, this share entered a serious downward trend since 2001 and decreased to 5.53% in 2020. Below, in order to better see the trend of the share of agriculture in GDP, the share of agriculture in GDP between 1991 and 2020 is given as a figure.

Figure 2. The Change of The Agriculture, Forestry, and Fishing, value added (% of GDP) – Turkey



Source: WDI, The World Bank, 2024

As can be seen from the figure above, agriculture started to lose its share in GDP since 1995 and the downward trend continued for 20 years.

The data of the annual average temperature variable, one of the independent variables used in the study, between 1991 and 2020 is given below in a table.

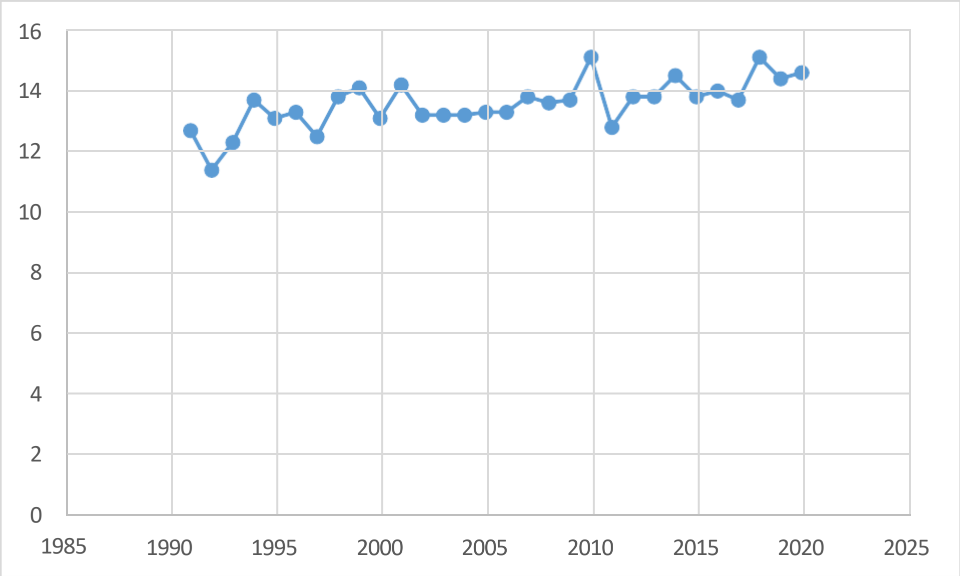
Table 5. Annual Temperature Averages of Turkey (1991-2020)

Years	Temperature(C^0)
1991	12.7
1992	11.4
1993	12.3
1994	13.7
1995	13.1
1996	13.3
1997	12.5
1998	13.8
1999	14.1
2000	13.1
2001	14.2
2002	13.2
2003	13.2
2004	13.2
2005	13.3
2006	13.3
2007	13.8
2008	13.6
2009	13.7
2010	15.1
2011	12.8
2012	13.8
2013	13.8
2014	14.5
2015	13.8
2016	14
2017	13.7
2018	15.1
2019	14.4
2020	14.6

Source: Turkish Statistics Institute, 2024

As seen in the table above, Turkey's average annual temperature between 1991 and 2020 was the lowest at 11.4 C0 and the highest at 15.1 C0. It is seen that the average remained high in the last 3 years and remained in the range of 13-14 C0 in the remaining years. The figure is given below to better see the change between these years.

Figure 3. The Change of Annual Temperature Averages of Turkey (1991-2020)



Source: Turkish Statistics Institute, 2024

When Turkey's annual temperature averages are examined using the figure above, it is evident that the temperature averages are in an increasing trend. It is seen that the average temperature, which was in the range of 11-12 C0 in 1991-1992, remained in the range of 14-15 C0 in 2020.

Another independent variable used in analysis is Turkey's annual precipitation averages. Turkey's annual precipitation averages between 1991-2020 are given in the table below.

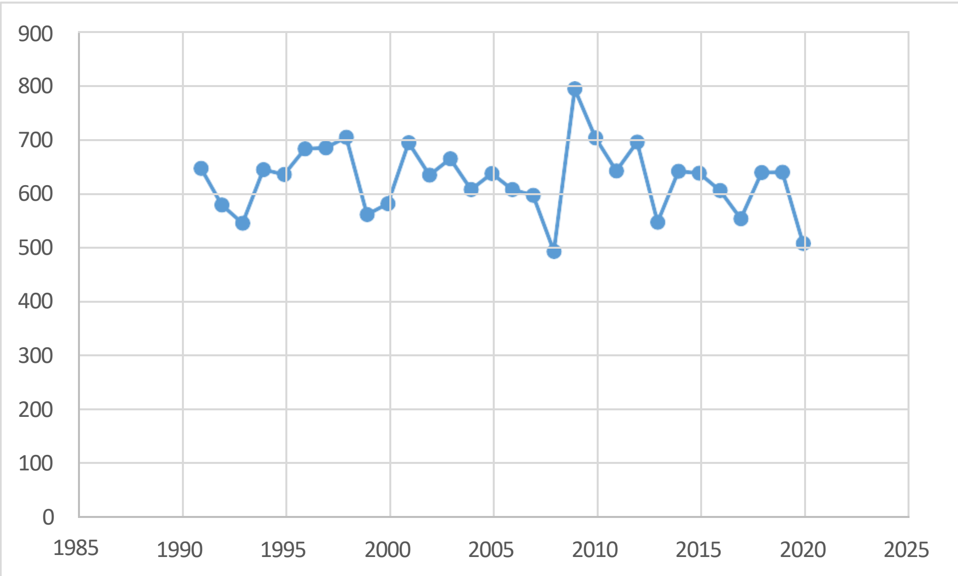
Table 6. Annual Precipitation Averages of Turkey (1991-2020)

Years	Precipitation (mm)
1991	646.5
1992	578.8
1993	545.2
1994	644.3
1995	635.7
1996	682.8
1997	684.5
1998	704.3
1999	561.4
2000	581.4
2001	694.2
2002	634
2003	664.4
2004	607.4
2005	637.2
2006	607.4
2007	596.7
2008	493.1
2009	793.8
2010	703
2011	642.2
2012	695.2
2013	547
2014	641.6
2015	637.8
2016	605.7
2017	553.4
2018	639.2
2019	639.7
2020	507.6

Source: Turkish Statistics Institute, 2024

As seen in the table above, Turkey's average annual rainfall between 1991 and 2020 is the lowest at 493.1 mm. while the highest is 793.8 mm. has happened. While it is seen that there has been no major change in the last 30 years, the average has remained in the range of 500-700 mm. The figure is given below to better see the change between these years.

Figure 4. The Change of Annual Precipitation Averages of Turkey (1991-2020)



Source: Turkish Statistics Institute, 2024

When the figure above is examined, it is seen that the average annual precipitation in Turkey does not show an increase or an increasing trend, and its lowest values are in 2008 and 2020.

The table showing the data between 1991 and 2020 on the CO2 emission value, another independent variable used in the analysis, is shown below.

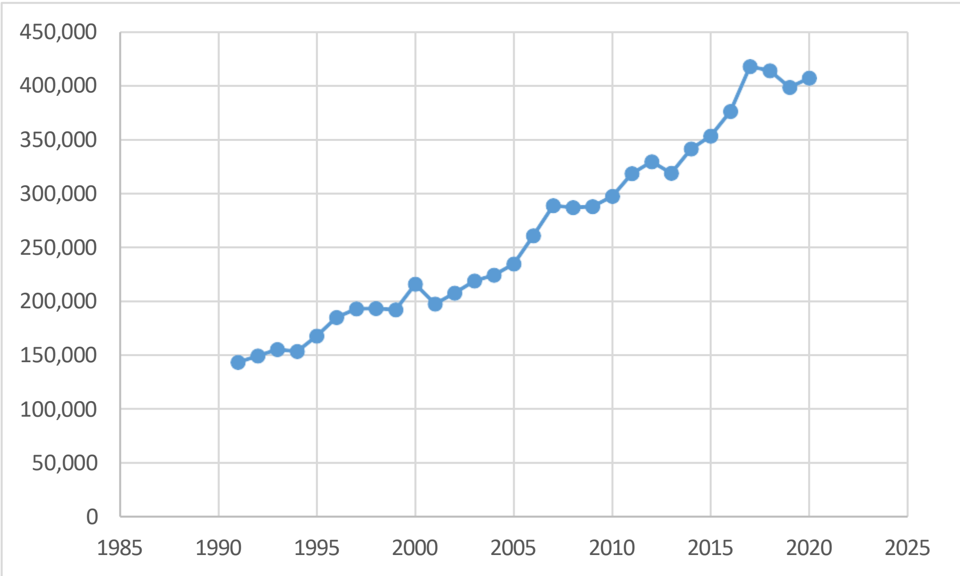
Table 7. Annual CO2 Emissions of Turkey (1991-2020)

Years	**CO_2 Emissions (kt)**
1991	143,796
1992	149,797
1993	155,580
1994	153,823
1995	168,151
1996	185,338
1997	193,428
1998	193,688
1999	192,651
2000	216,397
2001	197,771
2002	208,108
2003	219,159
2004	224,601
2005	235,003
2006	261,084
2007	288,968
2008	287,205
2009	288,307
2010	297,814
2011	318,641
2012	329,798
2013	319,089
2014	341,672
2015	353,414
2016	376,399
2017	418,098
2018	414,112
2019	398,773
2020	407,406

Source: WDI, The World Bank, 2024

As seen in the table above, it is noticeable that there was a significant increase in Turkey's CO_2 emissions between 1991 and 2020. CO_2 emissions, which were 143,796 kt in 1991, reached 407,406 kt in 2020. This change is given as a figure below.

Figure 5. The Change of Annual CO_2 Emissions of Turkey (1991-2020)



Source: Turkish Statistics Institute, 2024

When the figure above is examined, it is seen that CO_2 emissions in Turkey have increased significantly in the last 30 years, and this trend continues. It is noteworthy that CO_2 emissions increased nearly three times between these years.

Descriptive statistics of the variables used in the study are presented in the table below. The table shows the averages of the series, their standard errors, their highest and lowest values, and the years in which these values were obtained.

Table 8. Descriptive Statistics

	AGDP	CO2	PREC	TEMP
Mean	9,52	264602	626,85	13,57
St.Deviation	3,43	87270,62	64,29	0,79
Maximum	16,85	418098,2	793,8	15,1
Minimum	5,53	143796,1	493,1	11,4
Observation	30	30	30	30

Source: Own Calculations

Correlation Analysis

Correlation analysis is one of the methods used to determine the direction, degree or strength of the linear relationship between two variables. The findings obtained from this analysis, in which there is no distinction between dependent and independent variables, provide important preliminary information about the extent of the relationship between variables. The correlation matrix created by the variables used in the study according to Pearson correlation analysis is shown below.

Table 9. Correlation Analysis

	AGDP	CO2	PREC	TEMP
AGDP	1,000000			
CO2	-0,865224	1,000000		
PREC	0,1329146	-0,155290	1,000000	
TEMP	-0,619264	0,6465878	0,1141383	1,000000

Source: Own Calculations

When the results given above are examined, it can be seen that although there is a strong correlation between temperature and CO2 variables and agricultural GDP, the effect of precipitation is very limited. However, while the relationship between both CO2 and temperature with agricultural GDP is negative, the relationship between precipitation and agricultural GDP is positive.

The concept of stationarity is of great importance in time series analysis. In order to obtain econometrically meaningful relationships between variables, the analyzed series must be stationary. If the nature of the stochastic process changes over time, that is, if the series is not stationary, it will not be possible to express the past and future structure of the series with a simple algebraic model. If the stochastic process is constant over time, a coefficient model of the series can be obtained by using the historical values of the series. In a stationary time series, the difference between two consecutive values in a series does not arise from time itself but only from the time interval. The practical consequence of this relationship in a stationary series is that the mean of the series will not change over time. If the series is not stationary, the autocorrelations deviate significantly from zero and move away from zero as the lags increase, or a spurious sample emerges(Choi, 2001; Herranz, 2017)

The concept of stationarity can be used for a probabilistic process that mean and variance do not change over time and whose common variance between two periods depends only on the distance between the two periods, not on the period in which this common variance is calculated (Herranz, 2017). The simplest definition of the concept of stationarity of a time series. This can be done by ensuring that the series' mean, variance, and covariance are constant and that the higher-degree moments do not change depending on time.

Stationary series fluctuate around the mean within a certain range, and the time required to return to the mean is almost constant. As the delay time in these series increases, the correlogram gradually approaches and becomes zero. If only the arithmetic means of any time series change independently of time, there is first-degree stationarity; if the mean and variance-covariance change independently of time, there is second-degree stationarity or weak stationarity. A non-stationary series' mean and/or variance are independent over time. Unlike a stationary series, it does not have a long-term average to reverse the series, and the variance is independent of time. It approaches infinity as time extends to infinity, and finally, theoretical autocorrelations do not decrease and fade out. However, in finite samples, the sample correlograms fade out slowly and disappear. Trying to eliminate the trend effect in a time series or taking the first difference is a common practice. If a trendless time series is not calculated with truly random progressions, the series in question will resemble a structure that does not actually exist. However, if the first-degree difference is taken in a time series where the real trend is stationary, it will be seen that the series forms a unit root that moving averages can represent. The process that has a deterministic trend effect and where stationarity is achieved by removing the trend is defined as a trend stationary process. If the difference is a stationary process, it is made stationary by taking the difference, and it has a stochastic trend effect. Various unit root tests have been developed to distinguish whether a series is stationary, differenced, or detrended (Choi, 2001). Below are the results of the Augmented Dickey-Fuller Test used in the study.

Table 10. Augmented Dickey-Fuller Unit Root Test

	Level Form			Difference Form		
Variables	**T statistics**	**Prob**		**T statistics**	**Prob**	
AGDP	-1,156245	0,6792	Non-Stationary	-4,262010	0,0025	Stationary
PREC	-5,149581	0,0002	Stationary	-6,245424	0,0000	Stationary
CO2	0,083276	0,9588	Non-stationary	-5,232162	0,0002	Stationary
TEMP	-3,540961	0,0139	Stationary	-6,351318	0,0000	Stationary

Source: Own Calculations

Augmented Dickey Fuller Test results of the variables are shown above. According to these results, the precipitation and temperature average variables are stationary at the level, while the agricultural GDP and CO2 variables become stationary after the first level differences are taken.

Linear regression model estimation is one of econometric analysis's most frequently used estimation methods. Multivariate regression analysis is used to determine the relationship between a dependent variable and one or more independent variables. One of the most important features of the multivariate regression model is that it allows for defining the effects of a series of dependent variables on the independent variable. In this study, the following regression model was created to determine the effects of climate change on the agricultural sector in Turkey.

TRMt=α0+ α1N+ α2YGS+ α3SCK+ α4OÖ+ εt (1)

The coefficients and related statistics obtained as a result of estimating equation (1) using the Least Squares (LS) method are presented below.

Table 11. Least Square Test Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGCO2	-0.909486	0.085605	-10.62427	0.0000
LOGPREC	0.249697	0.210354	1.187033	0.2459
LOGTEMP	-0.225393	0.481032	-0.468562	0.6433
C	12.48417	1.619138	7.710384	0.0000

R-squared	0.899539	Mean dependent var	2.196658
Adjusted R-squared	0.887947	S.D. dependent var	0.335702
S.E. of regression	0.112374	Akaike info criterion	-1.410401
Sum squared resid	0.328326	Schwarz criterion	-1.223575
Log likelihood	25.15601	Hannan-Quinn criter.	-1.350634
F-statistic	77.60196	Durbin-Watson stat	0.522842
Prob(F-statistic)	0.000000		

When the table given above is examined, a relationship was detected between the dependent variable, agricultural GDP, and CO2 only at a 1% significance level, and no significant relationship was found between temperature and precipitation averages and agricultural GDP. The relationship between agricultural GDP and CO2 appears to be negative. Accordingly, a 1 unit increase in CO2 value causes a 0.9% decrease in agricultural GDP.

It is thought that the reason for not finding a significant relationship between precipitation and temperature variables and agricultural GDP is that there is no significant change in temperature and precipitation variables in the selected year range. Since the change of climatic variables such as temperature and precipitation is quite slow, its effect on agricultural GDP was not found to be significant in the selected time period.

4 RESULTS AND DISCUSSION

Although climate change affects many sectors, it is clear that it affects the agricultural sector, which is the cornerstone of the economy and production, more. The agricultural sector is one of the most sensitive and vulnerable sectors affected by climate change, as temperature, precipitation, intensity of weather events, sea level rise, and CO_2 levels in the atmosphere have a direct impact on agricultural products and livestock. Climate change has a greater impact on the agricultural sector, especially in underdeveloped countries that have inadequate technology in agriculture, as in many areas. As a result, agricultural production and the share of agriculture in GDP are decreasing in these countries.

The effects of climate change, which is a global phenomenon, vary by country, region, location, sector and community. Poor and rural communities in developing or underdeveloped countries are disproportionately affected by climate change because they do not have access to production resources and the capacity to adapt to production. For this reason, the communities most vulnerable to climate change are poor communities whose livelihoods depend significantly on the natural environment and are engaged in agricultural production. Agriculture is an important source of income, especially for rural communities, and is more affected by climate change because it is a source of livelihood for poor rural people. Therefore, this situation causes economic development problems in these countries.

The agricultural sector is both affected by and caused by climate change. Agricultural lands, fertilization, tillage, pesticide application and energy consumption cause climate change by affecting carbon emissions. Climate changes caused by carbon emissions or CO_2, which include climate change can affect the growth and productivity of plants and animals productivity, and as a result of sea level rises, agricultural areas may be submerged under water, causing a loss of agricultural production. On the other hand, humid weather, increased carbon dioxide levels in the atmosphere and increased temperatures can lead to weeds, diseases and insects in agricultural areas. Lack of rainfall and high temperatures prevent the crops from growing. Although there is a danger of agricultural products not being able to be grown as a result of dehydration of agricultural lands due to drought, there is a high probability of agricultural costs resulting from a decrease in agricultural areas as a result of avalanche disaster due to snowfall, flood disaster as a result of excessive precipitation, and forest fires due to high temperatures.

In the study, the relationship between annual average precipitation, temperature and CO_2 emission variables and the share of Turkey's agricultural GDP in total GDP was analyzed. As a result of the analysis, a negative and significant relationship was detected between agricultural GDP and CO_2 emissions, but no significant relationship was found between temperature and precipitation variables with agricultural GDP. The correlation between rising CO_2 emissions and a decline in agricultural GDP in Turkey is evident, with a nearly threefold increase in CO_2 emissions over the past 30 years paralleled by a significant reduction in agricultural GDP. This outcome aligns with expectations regarding the environmental impact on agricultural productivity.

5 CONCLUSION

The increase in greenhouse gas emissions due to the use of fossil fuels after the industrial revolution, as well as the increase in the greenhouse gas process due to natural occurrence as well as human activities, has paved the way for the problem of climate change, and has become an important problem faced by all countries, from underdeveloped countries to developed countries at the global level. Climate change, which affects many sectors such as agriculture, health, tourism, fisheries, forestry, animal husbandry, foreign trade, construction, finance and logistics, affects the agricultural sector the most negatively, as it is directly affected by weather events and climatic conditions.

In this study, a significant and negative relationship was found between Turkey's CO2 emissions and agricultural GDP. Accordingly, it is understood that as CO2 emissions increase, there will be a decrease in agricultural GDP. This result is expected. There has been a nearly 3-fold increase in Turkey's CO2 emissions in the last 30 years, along with a serious decrease in its agricultural GDP.

Since climate change reduces the productivity of the agricultural sector and causes the share of agriculture in GDP to decrease, policies to prevent the negative effects of climate change should be implemented. In this context, it is important for countries to develop adaptation policies to climate change. In order to minimize the negative impact of climate changes resulting from the increase in greenhouse gas emissions in the agricultural sector, measures must be taken to reduce greenhouse gas emissions. For this, the use of fossil fuels must be reduced. In order to eliminate the negative effects of climate change, governments of all countries, from underdeveloped countries to developed countries, organizations such as private and public sectors, and development agencies should attach importance to implementing policies and strategies for agriculture. Problems related to agriculture should be examined by universities and research institutions and new agricultural techniques should be developed against climate change. In order to eliminate the negative effects of climate change on the agricultural sector, strategies to combat climate change must be created. Additionally, employees in the agricultural sector should be made aware of climate change, and employees should be trained.

It is seen that legal steps have begun to be taken in Turkey to combat climate change, especially with the accession process to the European Union. However, as in many other countries, it appears that the steps taken legally have not succeeded in stopping or slowing down climate change. The biggest indicator of this is that greenhouse gas emissions, one of the biggest causes of climate change, continue to increase. It will be better understood that Turkey needs these measures greatly, especially considering that the tourism and agriculture sectors, which are the most important sources of income for the country's economy, are the sectors most affected by climate change. For this reason, it is essential to monitor these measures as well as legal measures and to take some measures that will minimize the economic effects of climate change. In order to minimize weather-related problems, greenhouse farming activities should be supported throughout the country and R&D activities should be continued to make greenhouses more durable. Thanks to logical and complementary policies followed in this direction, agricultural areas will minimize the impact of weather-related problems brought about by climatic changes. In addition, the widespread use of various agricultural practices that do not depend on soil throughout the country will increase the resilience of the agricultural sector against climate changes.

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