

Evaluation of Climate Change in the Scope of Agriculture and Food

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ABSTRACT

Global climate change is increasingly manifesting its effects day by day, and Turkey is also facing various adverse influences such as temperature fluctuations, excessive rainfall, drought, and storms. Each region within Turkey's borders has its own unique soil structure, contributing to agricultural diversity. Climate change complicates the cultivation of agricultural products, affecting both product quality and yield, and impacts agricultural labor. Furthermore, it can exert pressure on agriculture by causing social and economic issues. An interdisciplinary approach is essential to examine the effects of meteorological events resulting from climate change. Given the direct impact of climate change on agricultural and food security, it is crucial to analyze its root causes in this field. Measures must be taken to monitor indicators, understand the extent of their effects, and provide explanations accordingly. Evaluating the problems caused by meteorological disasters stemming from climate change on agricultural and food production, along with analyzing soil-economic impacts, is vital for developing solution-oriented recommendations. First, studies aimed at identifying the adversities caused by climate change and formulating scenarios to mitigate them should be planned. Subsequently, strategies should be developed to minimize the negative impacts.

Keywords: Climate change, Agriculture, Food

Tarım ve Gıda Kapsamında İklim Değişikliğinin Değerlendirilmesi

ÖZ

Küresel iklim değişikliği, her geçen gün etkilerini daha fazla hissettirmekte ve Türkiye de sıcaklık dalgalanmaları, aşırı yağışlar, kuraklık ve fırtınalar gibi çeşitli olumsuz etkilerle karşı karşıya kalmaktadır. Türkiye sınırları içindeki her bölgenin kendine özgü toprak yapısı, tarımsal çeşitliliğe katkıda bulunmaktadır. İklim değişikliği, tarımsal ürünlerin yetiştirilmesini karmaşık hale getirerek hem ürün kalitesini hem de verimi etkilemekte ve tarımsal iş gücünü de etkilemektedir. Ayrıca, sosyal ve ekonomik sorunlara yol açarak tarım üzerinde baskı oluşturabilir. İklim değişikliği kaynaklı meteorolojik olayların etkilerini incelemek için disiplinler arası bir yaklaşım gereklidir. İklim değişikliğinin tarımsal ve gıda güvenliği üzerindeki doğrudan etkisi göz önüne alındığında, bu alandaki sorunun kök nedenlerini analiz etmek hayati önem taşımaktadır. Göstergelerin izlenmesi, etkilerinin boyutunun anlaşılması ve buna göre açıklamalar sağlanması için önlemler alınmalıdır. İklim değişikliğinden kaynaklanan meteorolojik felaketlerin tarımsal ve gıda üretimi üzerindeki sorunlarını değerlendirmek ve toprak-ekonomik etkileri analiz etmek, çözüm odaklı önerilerin geliştirilmesi için hayati öneme sahiptir. Öncelikle, iklim değişikliğinin neden olduğu olumsuzlukları belirlemeye yönelik çalışmalar planlanmalı ve bunları hafifletmek için senaryolar oluşturulmalıdır. Ardından, olumsuz etkileri en aza indirmek için stratejiler geliştirilmelidir.

Anahtar Kelimeler: İklim değişikliği, Tarım, Gıda

INTRODUCTION

Climate change is a phenomenon addressed within the context of chronic rather than acute events. Its impacts are observed across all aspects of life due to its potential to cause emergencies and disasters. Among the chronic problem areas that directly affect the agriculture sector are pollution, global warming, excessive population growth, depletion of natural resources, waste, climate change, loss of biodiversity, deforestation, acid rain, water pollution, and harms caused by genetically modified foods [1]. According to the Global Risk Report published by the World Economic Forum in 2023, natural disasters and extreme weather events rank second among short-term risks, while among long-term risks, they rank third, following biological diversity loss and ecosystem disruption, respectively [2]. In this context, climate change can be considered a chronic issue, while the emergency and disaster events it generates can be seen as acute problems [1, 13].

Seasonal dynamics required for agricultural production, climatic conditions, product quality, and production quantity are crucial in agricultural production. Vulnerability to climate change is defined as the physical geography-related ecological or socio-economic impact of climate change stress and pressure on a community or system [3]. Changes in temperature, precipitation type and amount, drought, storms, and tornado events due to climate change deeply affect agricultural products, producers, actors involved in the delivery of these products to final markets, and exporting companies. Economic losses due to drought, floods, storms, and related events in 2022 have increased compared to the 2002-2021 average [4]. Meteorological, climatological, and hydrological disasters related to weather, climate, and water are generally categorized under the umbrella term of hydrometeorological disasters in studies [5-7].

CLIMATE CHANGE PROBLEM AREAS

The World Meteorological Organization defines disasters occurring due to weather, climate, and water as hydrometeorological disasters [8]. These disasters include rainfall, severe local storms, tropical storms, storm surges, severe winter conditions, hail, and frost. Forest fires, agricultural pests, drought, lake and sea level rises, avalanches, and floods are natural disasters closely related to weather conditions. All natural disasters directly or indirectly associated with meteorological conditions are known as meteorological disasters or meteorology-related natural disasters. Floods and droughts can also be referred to as hydrological or hydrometeorological disasters (Table 1) [9-11].

Due to climate change, there has been an increase in the frequency and intensity of such disasters. Data from

the General Directorate of Meteorology indicate that average humidity in Turkey has decreased compared to the 1970s, with a tendency for evaporation to also decrease. Turkey is generally facing a climate characterized by higher temperatures, less rainfall, and higher evaporation rates. Projections developed by the General Directorate of Meteorology for the period 2016-2099 involve three different global models. For instance, according to the first scenario, it is expected that Turkey's annual average temperatures will increase by 1.5 to 2.6°C during the period 2016-2099. Although a general decrease in rainfall is expected, there is no continuous trend of increase or decrease in precipitation, but rather an increase in precipitation irregularities is anticipated. Similarly, during the period 2016-2099, it is expected that Turkey's annual total precipitation anomaly will decrease by an average of 3% to 6%; the average change in precipitation anomaly is projected to be between 1% and 6% in the first half of the century and between 5% and 6% in the second half [13].

By predicting sudden-onset natural disasters such as floods, flash floods, and storms, as well as slow-onset disasters like drought and deforestation beforehand, effective disaster management practices can be implemented to prevent and mitigate damage. This would enable the implementation of activities to reduce the impacts on affected sectors, minimize loss of life and property, and reduce the vulnerability of agricultural products, producers, and the economy as a whole, thus enhancing resilience from humanitarian, economic, and social perspectives. In Europe, a project aimed at investigating the effects of extreme weather events, reducing vulnerability, and developing risk communication strategies has been conducted to disseminate risk reduction, prevention, and cooperation efforts [14]. Analyzing the effects of climate change specifically on fig production, a strategic agricultural product with significant production and export share in the Aegean region, from the perspectives of producers, agricultural workers, and exporting companies constitutes the unique value of the project.

When considering the insufficiency of rainfall as a limiting factor for agricultural production, the importance of necessary policies and strategies to increase sustainable food production and water resources becomes evident. Striking indicators and findings mentioned in the Climate Change and Sustainability in Agriculture Report of the Federation of Food and Beverage Associations of Turkey [15]. point to the need for scientific research in this area. The report particularly highlights expected significant decreases in rainfall amounts in the Aegean and Mediterranean coasts, as well as in the Southeastern and Eastern regions of Turkey, leading to rainfall shortages, reduced frequency of frost events, milder winters, but hotter, drier, and shorter-duration summer seasons.

Table 1. Potential effects of hydrometeorological disasters [12]

Hydrometeorological Hazards/Disasters	Potential Effects
Hail	Damage to all field crops, property damage, injuries to humans and animals, transportation problems
Strong Winds and Storms	Property damage, transportation issues, crop damage, forest damage, tree damage, indirect impact on human and animal safety, increased existing security vulnerabilities (forest and other fires, environmental disasters, disruption of rescue operations)
Drought	Significant losses in agricultural production, water supply issues, river transportation, problems in operation of hydroelectric power plants
Spring and Autumn Frosts	Damage to fruits, vegetables, and other agricultural products
Flooding and Floods	Dangers for human and animal habitats, loss and property damage in all weather-related sectors
Fires	Forest damage, endangerment of human and animal lives, significant threat to environment, industry, and other vegetation
Extreme Cold	Endangerment of human and animal lives, thermal and electricity supply issues, road and river traffic issues, forestry damages, agricultural losses, and damages in other economic sectors dependent on weather conditions
Extreme Heat	Endangerment of human and animal lives, problems in electricity supply, traffic issues, favorable conditions for forest and other fires
Heavy and Extreme Rainfall	Flooding and sudden flash floods, risk of mudslides and landslides, disruption of planned agricultural activities, endangerment of human and animal lives, property damage
Prolonged Rainfall	Flooding, problems in all agricultural production activities, traffic issues, risk of landslides and mudslides
Freezing Rain and Ice	Traffic issues (possible traffic blockages), problems in electricity supply - possible major damages in electricity transmission systems, pedestrian injuries
Snow	Traffic and other communication problems, issues in electricity supply
Wet Snow	Traffic issues, issues in electricity supply - possible major damages in electricity transmission systems
Snowstorm	Increased traffic issues and partially or completely hindered rescue operations
Thunderstorms (Thunder and Lightning)	Risk of severe winds and sudden flash floods, along with the risk of thunderstorms, problems in operation for all electrical devices, risk of fire outbreak, telecommunication issues
Fog and Low Clouds	Increased traffic issues and partially or completely hindered rescue operations
Deviation from Normal Climatological and Weather Patterns	Interruption of normal activities in water and food supply, thermal and electricity energy supply, possible adverse effects on tourism and commerce

According to the aforementioned report, given the socio-economic importance of the agriculture and food sectors, it is essential to evaluate the impact of future climate change on crop productivity and food security. Since agriculture and food are expected to be the sectors most affected by climate change in the future, it is important for preventive measures in agricultural production not only to ensure food security but also to avoid adverse effects on the Turkish economy. Recent unprecedented tornado and storm events in the Aegean and Mediterranean regions have resulted in not only loss of life but also significant economic losses [3].

The Turkish Climate Change Strategy [16] outlines short-term objectives such as promoting conscious fertilizer use; limiting emissions by using modern techniques in irrigation, soil tillage, and agricultural spraying; supporting and promoting organic farming and the production of drought-resistant plant species with certified seeds; identifying the current situation regarding deforestation and degradation of forest areas, and developing a strategy to solve these problems; conducting scientific research on the effects of climate

change on forest ecosystems and developing adaptation strategies based on these studies; and producing policies based on these researches.

Medium-term goals include implementing crisis management based on agricultural drought prediction; identifying drought-resistant tree species, especially in drought-prone and semi-arid areas, and afforestation with these species; and applying fertilization based on soil analysis requirements to reduce the adverse effects of climate change on soil and water resources and ensure conscious chemical fertilizer use." Long-term strategies emphasize "the planning and implementation of forest areas and forestry activities according to upper watershed management principles, which are of great importance for the conservation and sustainability of water resources.

In the short-term goals of Climate Change Adaptation strategies, efforts will be made to strengthen capacity to combat animal diseases and plant pests arising from climate change. Effective measures against potential pests such as insects, fungi, and others that may

increase in forest areas due to rising temperatures will be considered. Scientific studies on the sustainable use of natural resources will continue, considering the interaction between climate change and sectors. Efforts will be made to raise awareness, educate, and support scientific and social initiatives for climate change adaptation among local authorities, professionals, and the public. Policy and strategy development, international communication, and information transfer will also be pursued. Legislation related to disaster and risk effects will be reviewed with a focus on resettlement based on risk reduction. Educational activities will be conducted to increase societal awareness and participation regarding the potential disaster and risk effects of climate change. Local meetings, broadcasts, television programs, and similar events will be planned accordingly.

Similarly, a strategy exists for the detection of potential natural disasters such as floods, avalanches, and landslides, with efforts initiated using early warning systems to minimize their effects. This strategy aligns with the core focus of the project, aiming to shed light on the current situation of fig production and employment in the field. An analysis of the susceptibility to climate change will be conducted nationwide, evaluating its impacts on health and food security. Efforts will be made to accelerate the development of plant and animal species resistant to heat, drought, diseases, and pests.

In the long term, the goals of minimizing the impact of climate change-induced heatwaves, extreme cold, floods, storms, and droughts on public health will be monitored. Efforts will be made to ensure that the public health is minimally affected by these weather events. These objectives highlight the need for academic and scientific research to support efforts related to climate change and agricultural sustainability.

EFFECT of CLIMATE CHANGE on FOOD PRODUCTION

Agricultural food production is highly dependent on temperature and rainfall, making crops vulnerable to climate change. In a seminal assessment of the potential impacts of climate change on agriculture by Nelson (2009), it was concluded that while some regions may experience yield increases in certain crops, rising temperatures are expected to decrease crop yields and promote weeds and pests. Changes in rainfall patterns are likely to increase the likelihood of crop failures in the short term and lead to a decrease in production in the long term. Findings suggest that populations in developing countries, particularly those without food security and vulnerable to climate change, are likely to be disproportionately affected. The results of the analysis undeniably indicate that despite productivity gains in some regions, agriculture and human well-being will be adversely affected by climate change.

The impacts of climate change on agriculture and human welfare can be categorized into biological effects on crop yields, effects on prices, production, and consumption, and effects on per capita energy

consumption and child malnutrition. With climate change expected to adversely affect global food production, achieving sustainable food production in the future will become even more challenging, making climate change an increasingly critical issue [17].

CLIMATE CHANGE and FOOD SECURITY

There is a widespread consensus in the literature that anthropogenic greenhouse gas (GHG) emissions contribute to climate change. This will have a range of effects, including changes in food production and supply [18]. In the literature, much focus has been placed on the impacts of climate change on food security in the developing world. Findings suggest that climate change will exacerbate existing and anticipated food insecurity and malnutrition issues [19]. For example, by the end of this century, average summer temperatures are projected to exceed historical maximum values in tropical and subtropical regions, potentially affecting up to 50% of the population living in these regions and leading to serious consequences for food production [20].

Climate change is likely to have implications for food security in developed countries as well. Anthropogenic GHG emissions and natural climate forcings [21]. lead to climate change and specific environmental impacts affecting agriculture and food processing. The agricultural food industry will be affected by efforts to adapt to changing climates and to reduce GHG emissions associated with the food chain [22]. All these changes will result in alterations in the types of foods consumed, their nutritional content, and their safety.

FOOD PRICES and AVAILABILITY

Several studies have examined the potential impact of climate change on world food prices, with a particular focus on grains. [23] found that there was little change or a slight decrease in grain prices with a global temperature increase of up to 3°C, but prices began to rise as production declined. However, many assessments do not consider the likely increase in frequency of extreme weather events under climate change. Considering these assessments, Easterling. [23] (2007) concluded that crop prices are likely higher than what published assessments suggest.

As an example of the impact of current climate variability, extreme weather conditions in many parts of the world, particularly in the Murray-Darling Basin in Australia in 2006, led to a decrease in global cereal production. These declines in productivity can be partially attributed to the subsequent increase in global food prices [24]. Another example is the 25% decrease in French fruit harvests following the 2003 European heatwave [20].

CHANGING PRODUCTION METHODS

With climate change, food will be produced in different climatic conditions within changing ecosystems. Efforts through initiatives in the food industry can alter

conditions to mitigate climate change. Production, processing, transportation, storage, preparation, purchase, and consumption activities in the food sector account for 15-30% of global GHG emissions. Most greenhouse gas emissions from the food sector occur within agriculture (45%), food production (12%), and transportation (12%) [25]

Climate change can alter the number of pests and diseases with seasonal patterns that may affect pesticide use, including herbicides and fungicides. Examples of potential mechanisms that may increase under climate change include volatile and dust-associated contamination of air inputs, flooding, changing environments, and increased bioavailability of heavy metals due to soil characteristics [26]. Results may vary between products and geographical locations. For instance, Chen and McCarl [27] predicted an overall increase in pesticide use in the United States due to climate change. Climate change can also affect the transportation of pathogens and chemicals into food.

Mycotoxins, a significant public health issue, result from complex interactions between fungi and crops and are influenced by air and soil. A recent study showed that as temperature increases associated with climate change approach optimal levels for aflatoxin production, one of the most important mycotoxins for public health, mycotoxin problems have increased in some temperate regions of Europe and the United States. However, in other countries like Australia, temperatures may rise to levels sufficient to reduce fungal growth and mycotoxin production [28].

Climate change is expected to lead to changes in food production areas, indicating that future foods will be sourced from different regions of the world [23].

The source of food, different varieties grown, changing soil structure and cultivation conditions, varying harvesting methods, processing, and storage methods can affect the micro and macronutrient composition. An example of how geographical sources can affect food composition is selenium, which can be protective against various cancer types. The UK population obtains most of its selenium from grains. Between 1970 and 2000, there was a 50% decrease in selenium intake in the UK diet coinciding with the transition from grain imports from Canada to domestic production on selenium-poor soils in the UK [29]. There is evidence that daily selenium intake in the UK is below recommended levels [30].

In the European Union and many other countries (such as the UK), permissible levels of various contaminants (microbial, chemical, and radiation) in food are determined internationally through the FAO/WHO (2006) Codex Alimentarius Commission. Therefore, if levels of food contaminants exceed the established levels, such foods will not be allowed to enter the human food chain. Some food retailers ensure that their suppliers adhere to values below legal limits [31].

Processes allowed in agriculture and food businesses are tightly controlled to ensure food safety. Examples include EU Food Hygiene Regulations (European Parliament and Council of the European Union) and EU Plant Protection Product Regulations (European Parliament and Council of the European Union). Standards and regulations will help prevent food and safety issues arising from climate change.

IMPACT of CLIMATE CHANGE on AGRICULTURE in TÜRKİYE

The agricultural sector can be vulnerable, especially to natural events and disasters. This vulnerability stems from the fact that productivity in the agricultural sector largely depends on climatic conditions. Climate-related weather events can adversely affect agricultural production and incomes, leading to various risks in the short and long term [32]. Climate change affects crop production, markets, food prices, and supply chain infrastructure. It also has significant implications for global food security [33]. Predicting global and regional climate changes, reducing their potential impacts, and adapting to them are crucial. Consequently, climate change has become an increasingly important research topic among scientists. Extreme weather events have negative effects on crop and livestock production, forest ecosystems, rural production, and fishing. This leads to losses in productivity and employment [34]. For instance, Al-Amin and Ahmed [35] examined climate change adaptation and cost benefits using an experimental, dynamic, and adaptable general equilibrium model for Malaysia. They found that due to the effects of climate change, the food sustainability gap increased over time. Dawson [36], predicted that by 2050, if no adaptation or agricultural innovation is made based solely on projected changes in population and agricultural land use, 31% of the global population would be at risk of inadequate nutrition. Considering the effects of climate change, it is expected that 21% of the global population will be at risk of inadequate nutrition. Addressing future food security gaps requires an integrated food system approach rather than relying solely on technological advancements in agriculture [37].

The potential impacts of climate change on agriculture in Turkey have been a research topic, particularly since the 2000s. Studies focusing on the effects of climate change on fig cultivation are limited, with research on climate change and agriculture predominantly concentrated on grains. Kanber [38] investigated the effects of climate change on agriculture and predicted a significant decrease in rainfall. They also indicated that snowfall amounts and melting times would change, affecting the planting times and areas for certain crops (such as wheat) in Turkey. Dumrul and Kılıçarslan [39] empirically evaluated the effects of climate change on the Turkish agricultural sector for the period 1961-2013, finding that increasing temperatures and decreasing rainfall negatively affected agricultural gross domestic product. It has been observed that severe wind and tornado events in Turkey have had adverse effects on agricultural production, causing damage to crops,

greenhouses, and agricultural processing facilities, leading to economic losses [40]. For example, on January 24, 2019, a tornado originating from the sea caused significant damage to greenhouse areas in Kumluca, Antalya. The tornado, with a width of 50-100 meters and a length of 5 km, tore and carried away PVC greenhouse films, causing substantial damage. Additionally, it bent and partially dislodged the metal frames of many greenhouses, rendering them unusable. Glass greenhouses experienced broken glass panels, scattering glass shards across agricultural fields [41].

Increasing temperatures contribute to the exacerbation of water crises in agriculture and exert pressure on limited water resources. Dry and hot weather conditions lead to decreased crop yields, fallow arable land, and increased costs of water use. The cost of water creates an impact that will lead to cost inflation in agricultural crops and the food supply chain. In their study, Tellı [42] highlighted the combat against climate change and its socio-economic impacts as an analytical initiative aimed at integrating sustainable development principles into both macroeconomic and sectoral levels of national development planning and environmental policy objectives. However, such studies predominantly focus on the economic effects of environmental policies and environmental taxes across employment, labor force, producers, and exporting firms.

CONCLUSION

The inability to meet the world's food production needs due to factors such as declining agricultural areas, animals at risk, dwindling clean water sources, increasing pesticide use, rising production costs, and a growing global population is expected to become a major problem in the future. Food systems are highly sensitive to the adverse effects of climate change. Solutions aimed at promoting agroforestry, reducing waste, and adopting sustainable eating habits within food systems do not require high investment or technological processes compared to other industries. Additionally, implementing improvement processes will not only reduce emissions but also foster development in areas such as food security and biological diversity.

The impact of climate change on food production is geologically and temporally variable and highly complex. The effects of climate change on food production can be evaluated in two ways: direct and indirect effects. Agricultural and ecological impacts are considered indirect effects within the scope of direct effects, while economic growth and income distribution are considered indirect effects. Access to a sufficient level of safe food is a right that everyone should have to meet their daily needs and maintain a healthy life. Solutions and plans addressing the adverse effects of temperature changes and climate extremes on food production, the effects on freshwater resources, and changes in atmospheric gas ratios should be provided. It is known that adverse conditions arising from climate change will affect agricultural productivity, but it is possible to mitigate the resulting negative consequences in various ways. It is considered that raising awareness among producers

about new efficient technologies and directing them towards sustainable agricultural production are strong adaptive strategies. In short, failure to take urgent action will negatively affect many people, changing climate conditions will harm crops and animals, and destroy harvests. This process will lead to the emergence of a food crisis in addition to the climate crisis.

Increased temperatures due to climate change, changing climate seasons, extreme weather events, and disasters necessitate increased awareness-raising activities in agricultural production and animal husbandry related to food production, integration of insurance systems to prevent income losses, and emphasis on activities to prevent indiscriminate water use.

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