J. Int. Environmental Application & Science, Vol. 14(3): 97-103 (2019)

Research Paper

Impacts of Climate Change on Turkish Agriculture

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Received May 08, 2019; Accepted September 17, 2019

Abstract: The aim of this study was to review the effects of climate change on the agricultural sector of Turkey. The main policy documents and the literature related with climate change were used as main material in this study. According to the results, global average surface temperature had increased by 0.4-0.8 ºC since 1860s and it would increase by 1.4 to 5.8 ºC over the 1990-2100 period. In Turkey, it was estimated that the temperature would increase by 1.7 in 2050 and 5.1 in 2080. This climate estimation show also that the effects of climate change would occur severely in Turkey. Therefore, Turkey has tried to mitigate and adapt to the effects of climate change, its current actions could not be seen enough to meet the effects of future climate changes on the agricultural sector. Climate change in Turkey would cause considerable losses in the yield of crops at an increasing rate. Climate change should be an issue not only for the government and industry, but also for the scientists and farmers. Mitigation and adaptation strategies can help to minimize negative impacts of climate change and these need to be increased expenditures in research, technology, infrastructure, institutional innovation, data collection and policy support.

Keywords: *Climate change, impacts, agriculture, Turkey.*

Introduction

Global climate has changed especially since 1900s and it has been one of the most important challenges for global food security. As the world population grows to a projected 9 million by 2050, agricultural production must also increase by an estimated 70% (FAO, 2009). Climate change is defined by the Framework Convention on Climate Change as "*a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability over comparable time periods*" (Pielke, 2004). Climate volatility, more frequent extreme weather events and temperature changes increasingly threaten the viability of agriculture. By 2050, emissions should be reduced by 7% in order to keep the increase in global temperature below the crucial ceiling of 2 ºC. This can only be achieved with the contribution of the agriculture sectors (FAO, 2016) and global cooperation (Peker *et al.,* 2019).

Climate change may influence on crop production, markets, food prices and supply chain infrastructure (Gregory *et al*., 2005). The climate change is real, and it has led to significant impacts on the global food security. Forecasting the global and regional changes in the climate is very important to mitigate and to adapt with its possible future effects (Sen, 2018). Therefore, the issue of climate change has increasingly become a research topic among the scholars. Thus, Al-Amin and Ahmed (2016) examined climate change adaptation and its cost-benefits using an empirical dynamic commutable general equilibrium model for Malaysia and found that the food sustainability gap is rising over time due to climate change effects. Dawson *et al*. (2016) found that under no climate change scenario by 2050, based upon projected changes in population and agricultural land use only, 31% of the global population would be at risk of undernourishment if no adaptation or agricultural innovation is made in the intervening years. When climate change is considered, an additional 21% of the global population would be at risk of undernourishment. The future food security gap could not be solved via technological improvement in agriculture and this requires an integrated food system approach to adapting to additional threats on food security (Ericksen *et al*., 2009).

In Turkey, the possible effects of climate change on agriculture have been a research issue especially since 2000s. Kanber *et al*. (2008) investigated the impacts of climate change on the agriculture and estimated that precipitation would decrease significantly; the amount of snow and melting times would change; sowing or planting times and sown areas of some crops (wheat) would

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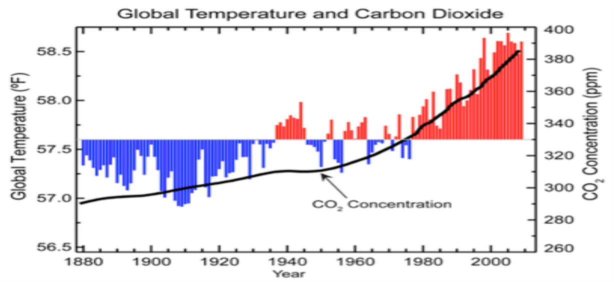
change in Turkey. Turkes (2006) evaluated the agreement of global climate change for Turkey. Kanat and Keskin (2018) evaluated the literature about climate change and stressed that there is a severe lack of data availability on climate change. There have been some empirical studies investigating the past period effects of climate change in Turkey. Thus, Dellal *et al*. (2011) assessed the yield and welfare effects of projected climate change on wheat, barley, corn, sunflower and cotton for Turkey. Akyuz and Atis (2017) investigated interaction between climate change and agriculture in Turkey. Bayrac and Dogan (2016) investigated the impacts of climate change on Turkish agricultural sector for a longer period (1980-2013) and stated that climate change negatively affected agricultural sector. Dumrul and Kilicarslan (2017) also evaluated empirically the effects of climate change on Turkish agricultural sector for the period of 1961-2013 and found that increase in temperature and decrease in precipitation negatively affected on agricultural gross domestic product and they recommended establishing necessary policies to mitigate and to adapt to climate change.

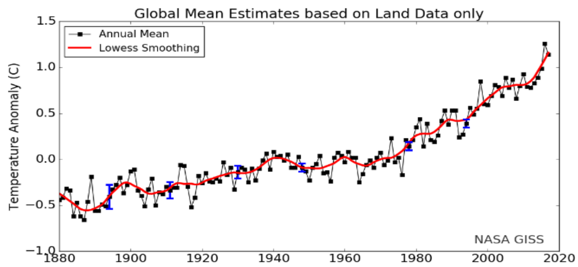
The aim of this study was to examine the possible effects of climate change on Turkish agricultural sector. The general concept of this study includes the evidences of climate change in the global and country-wide levels, the climate change policy of Turkey and the possible effects of climate change on Turkish agricultural sector.

The Evidences of Climate Change

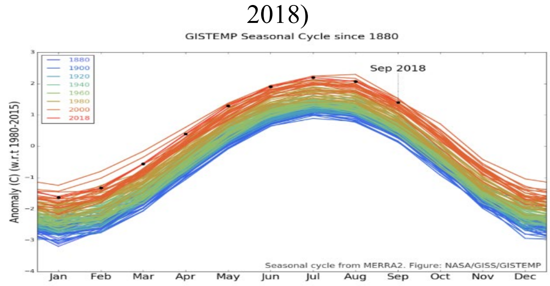
Observations show that the earth has indeed warmed as the atmospheric concentration of greenhouse gasses like CO_2 has increased. Figure 1a and 1b shows that there had been an upward trend in the global surface temperature anomalies since 1880s. Today, average temperature had increased by 0.4-0.8 ºC since 1860s. Figure 1c show that there had been about 1.5-2 ºC monthly or seasonal increase in global temperature during the period of 1880-2018. It was estimated that the global surface temperature would increase by 1.4 to 5.8 ºC over the 1990-2100 period. There have been evidences that other climate parameters such as rainfall distribution and extreme events have changed due to the activities of society and, particularly the combustion of fossil fuels. However, recent climate changes cannot be explained by natural causes alone. Unlike natural influences, human activities explain most observed warming especially since the mid-20th century (IPCC, 2013). Figure 1d also shows that global climate change has been caused by more human factors than natural phenomena.



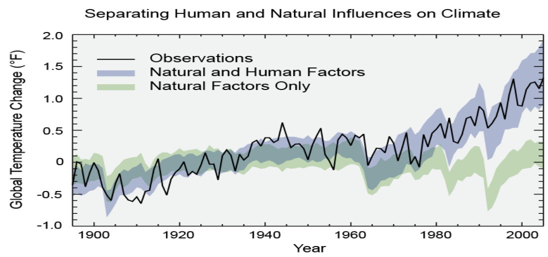
(a) Global CO_2 concentration and temperature (NOAA, 2018)



(b) The anomalies in the global temperature (NOAA, 2018)



(c). Global temperature seasonal anomaly (EPA, 2017a)



(d) Human and natural influences in climate (EPA, 2017b)

Figure 1. The annual anomalies in the land temperature and the human and natural influences

Figure 2 shows that, in Turkey, there had been a parallel trend in the temperature anomaly. While global trend seems to begin since 1980s, there had been an increasing trend in the temperature anomaly of Turkey since 1990s. Despite this delay, the temperature increase in Turkey was higher than the global temperature increase for the same period.

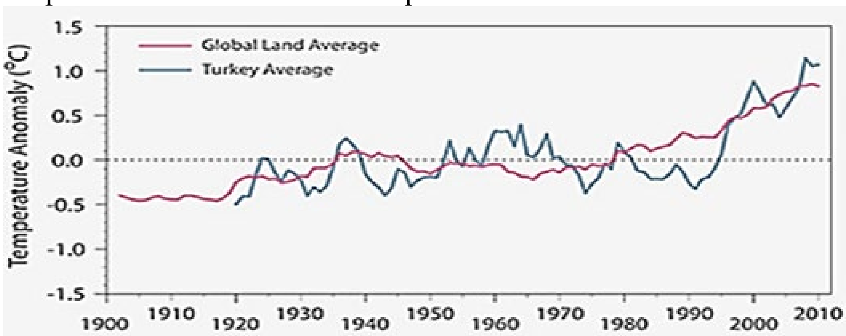
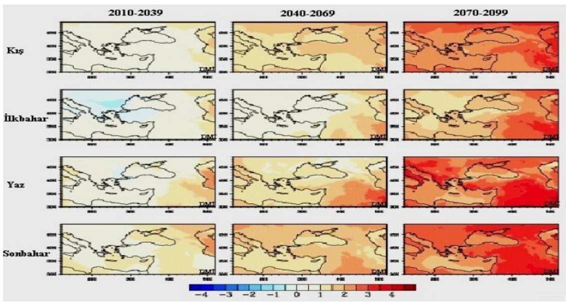
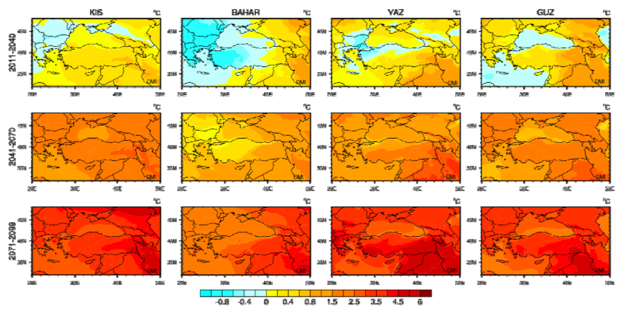


Figure 2. Developments in the average annual temperatures in Turkey (Sen, 2018).

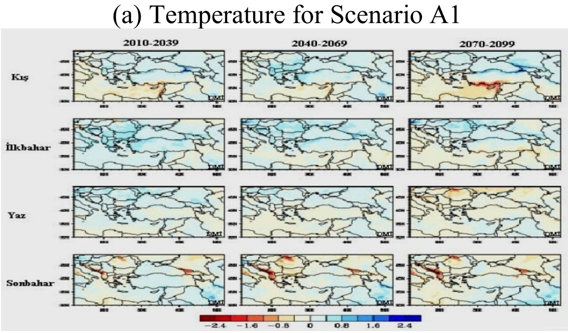
Figure 3 shows the estimated future changes in the annual temperature and precipitation of Turkey. Based on the average of 1961-1990, the estimated annual mean temperatures in Turkey for the periods of 2010-2039, 2040-2069 and 2070-2099 show that the temperature will increase in all over Turkey. The temperature increase from 1960s or 1970s to the 2000s was close to 1.5 ^{0}C. By 2050, it was estimated that while annual mean temperature would increase by 1.5°C and precipitation would decrease by 1.5 mm. At the end of this century, it was expected that temperature would increase 1.8°C at the low emission scenario and 4 °C at the high emission scenario and the temperature increases would rise the sea level about 26 cm and 59 cm, respectively (IPCC, 2007). However, Cline (2007) projected that there would be 5 ^{0}C temperature increase in 2099 compared with the base period of 1961-1990 and average daily precipitation would decrease from 1.57 mm to 1.33 mm. The scenario A1 indicates that economic and social developments in the world will be better in the future, while the A2 scenario represents a more pessimistic approach especially for rapid population growth.



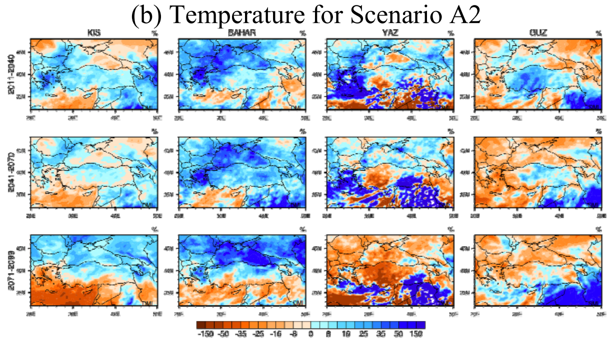
(a) Temperature for Scenario A1



(b) Temperature for Scenario A2



(a) Precipitation for Scenario A1



(b) Precipitation for Scenario A2

Figure 3. The estimated changes in annual temperature and precipitation in Turkey (MoFAL, 2018a)

The most drastic temperature change in the period of July and August was projected as 4.1°C for the Central Anatolia Region and 3-4 °C for the Mediterranean and Aegean regions. The least temperature change is projected as changing from 1.6 °C to 2.5 °C for the Black Sea Region. The highest and the least changes in precipitation were projected for the period of March and April in the Mediterranean Region and the South-eastern Anatolian Region, respectively (IPCC, 2007). The summer season would witness the largest temperature increase and the temperature increase would affect more the South East, Central Anatolia, Aegean and Mediterranean regions. While the temperature would further increase, there would not be a single trend regarding prospective changes in precipitation patterns. Still the primary factors that shape the climate of Turkey can give us hints about prospective changes in precipitation patterns. Above estimation results show clearly that climate change will be intensified more in the future and Turkey will be one of the most effected country.

The Policy and Action of Climate Change in Turkey

Turkey has tried to mitigate and adapt to the effects of climate change through the programs and projects. International agreement and national legislation or strategic or action plan documents set out the main policy objectives and strategies of Turkey about mitigation and adaptation to the global climate change. First, Turkey has participated in the Climate Change Convention of United Nation in 2004. Constitution 1982 of Turkey, 10th Development Plan (2014-2018), Medium Term Program (2014-2018), Climate Change National Action Plan (2011-220), Turkey's Climate Change Strategy Document (2010-2023) the Strategic Plan of Ministry of Food Agriculture and Livestock (2018-2022), and National Rural Development Strategy (2014-2020) has consisted of the main climate change policy documents of Turkey.

According to the article 45 of 1982 Constitution, the government is responsible to prevent unintended use and destruction of agricultural lands and pastures (TBMM, 2011). The **s**trategic objectives of Turkey's Climate Change Adaptation Strategy and Action Plan are to integrate climate change adaptation into the agricultural sector and food security policies, to determine natural disaster risks and the effects of climate change on agriculture, to protect soil and biodiversity, to plan sustainability of agricultural water use, to develop institutional capacity and inter-institutional cooperation or coordination, to improve information, monitoring and evaluation systems for decision-making processes and R&D capacity, to strengthen the management of intervention mechanisms, to organize education, information and public awareness activities and to improve mitigation and adaptation capacity of climate change (MoEU, 2012).

The Medium-Term Program has envisaged to develop tax policies for combating with climate change (OGoTR, 2018). National Rural Development Strategy (OGoTR, 2015) has objected to improve rural environment and to sustain natural resources in Turkey. This strategy has foreseen some measures such as promoting environmentally friendly agricultural practices, improving organic agriculture, preventing environmental pollution caused by agricultural activities and improving pastures in order to ensure the sustainability of soil and water resources. However, the strategy also aims to develop irrigation infrastructure and income generating activities in the protected areas, to promote land consolidation and its surroundings in order to ensure efficiency of agricultural land use.

The Strategic Plan of MFAL emphasized that there has been decrease in water resources due to climate change whereas water demand has increased and, this is a significant threat for the sustainability of agriculture sector. The main strategic aims of the Strategic Plan of MoFAL are to determine the possible impacts of climate change on agricultural systems and to develop the measurements for monitoring-mapping droughts and yield estimation models and to develop strategies (MoFAL, 2018b).

The MoFAL have implemented some agricultural programs and projects to mitigate and adapt to the negative effects of climate change. Within this scope, the farms have supported by the programs of land consolidation, organic agriculture and good agricultural practices, and environmental protection of agricultural lands. The interest-free loans for five years have been provided to the farmers in order to protect the water resources and to ensure modernization of irrigation facilities and systems. However, Provincial Crisis Centres of Agricultural Drought were established within the scope of drought management strategy to fight with the droughts. The government has subsidized the insurance premium at a rate of 50% in order to compensate meteorological disasters such as frost, hoses, floods etc. MFAL has carried out agricultural R&D activities to mitigate and adapt with climate change such as reduction of energy use in agriculture, sustainable use of resources, development and rehabilitation of drought-resistant plants, improvement of degraded irrigation methods and tools in dry periods, development of land-processing methods and tools fixed carbon retention into the soil (MoFAL, 2018b). All these policy precautions are important and effective in terms of adaptation and mitigation to climate change, they could not achieve the targeted effects due to some problems and impossibilities (Akyuz and Atis, 2016).

The Effects of Climate Change on the Agricultural Sector

Table 1 shows the possible effects of climate change and vulnerable sectors in Turkey. Thus, the climate change in Turkey will have a medium decreasing impact on surface waters and agricultural productivity (Mediterranean, Aegean), whereas this medium impact would be as increase in forest fires (West Anatolia), shortage of usage water (Afyon, Izmir, Kayseri, Mugla, Manisa), floods (Black Sea, Southeast Anatolia) and landlessness or loss of soil (Southwest Anatolia). However, climate change would have a low decreasing impact in disruption of marine ecosystem (Mediterranean, Black Sea and Aegean) and seafood production (Mediterranean), whereas this low impact would be as increase in river or basin regime changes (all regions), soil losses or salinity (Mediterranean, Black Sea and Aegean), migration of species and coastal erosion (Black Sea).

Climate change has been occurred as an increase in droughts, extreme rainfalls, floods and natural disasters. Therefore, in Turkey, the climate change would have an increase effect in deterioration of irrigation water quantity-quality, cost of water supply, degradation of agricultural ecosystem and pastures, plant diseases and pests, credit risk, unemployment, migration and risk of sustainability in the agricultural sector, whereas it will have a decrease effect in number of animal husbandry, quality and quantity of production or stocks of foods, incomes of farmers, tax revenues of the government, national economic growth and development.

Table 1. Impact levels of climate change on the regions and sectors in Turkey (MoEU, 2012)

Impacts	Severity	Region or Province	Sector or Theme
Declining of surface waters		West Anatolia	Agriculture, infrastructure of water distribution network
Forest fires		West Anatolia	Tourism, agriculture
Increase in shortage of usage water		Afyon, İzmir, Kayseri, Muğla, Manisa	Agriculture, industry, energy
Flood	Medium	Black Sea, Southeast Anatolia	Survival of farms, human health
Landlessness/loss of soil		Southwest Anatolia	Farms' survival, food security, shallow lakes and wetlands
Decrease in agricultural productivity		Mediterranean, Aegean	Agriculture (employment), food security
Change of river/basin regimes		All	Ecosystem services and biodiversity
Soil losses/salinity		Mediterranean, Black Sea, Aegean	Tourism, ecosystem services, biodiversity, seafood
Disruption of marine ecosystem	Low	Mediterranean, Black Sea, Aegean	Ecosystem services and biological diversity
Migration of species		Mediterranean	Tourism, agriculture, food security
Decrease in seafood production		Mediterranean	Agriculture, food security, water distribution network
Coastal erosion		Black Sea	Fishing, unemployment

Dellal *et al*. (2016) estimated that, with a decrease in precipitation, the average temperature in Turkey would increase 1.7 °C in 2020, 2.9 °C in 2050 and 5.1 °C in 2080 based on 1971-2000. The temperature rise and precipitation decrease would cause considerable yield losses in the yields of main grains. Thus, while yield decrease would change from 1.7% (cotton) to 7.3% (paddy) in 2020, the yield losses in grains would be higher as 3-12.5% in 2050. The yield losses would increase at the range of 5-15.8% in 2080. However, the decrease in milk production would be 4.3% in 2020 and 20.3% in 2080 (Figure 4). However, Cline (2007) also found that, in Turkey, the yield of main cereals (paddy, wheat, maize, and soybean) and oilseeds would be decreased 11.8% in 2080s.

However, climate change would also increase crops' prices. Climate change would have a global price increases as 32-37% for paddy, 52-55% for maize, 94-111% for wheat and 11-14% for soybean in 2050. If effective climate change measures are taken, these price increases would be expected to be less 10% (Nelson *et al*. 2009). However, Dellal *et al*. (2011) estimated that the prices increase in Turkey would be 12.6% for corn, 7.1% for barley, 6.3% for wheat and 0.1% for sunflower.

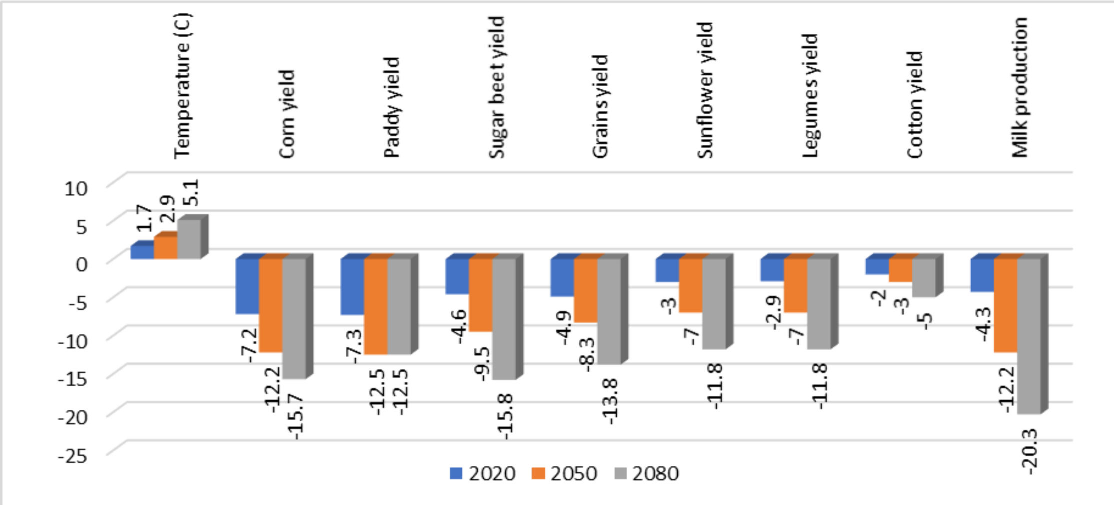


Figure 4. The climate change and its impacts on the yield of selected crops and milk production (Dellal *et al*, 2016)

Conclusions

Climate change is a reality and it is expected to continue. Thus, there has been increase in CO2, temperature, sea level, variability and extreme events such as floods and drought. Climate change will alter comparative advantages of the country and the direction and magnitudes of these changes should be investigated. Climate change should be the issue of farmers, industry, government and scientists in Turkey. Therefore, understanding of the interaction between climate change and agriculture should be a priority for all stakeholders. However, climate change impacts vary across the regions and this need region specific analysis and policy measures. Emissions of greenhouse gases should be reduced and alternative energy sources should be developed and used in the worldwide. Mitigation and adaptation strategies can help to minimize potential negative impacts of climate change and this need to increase expenditures in research, technology, infrastructure, institutional innovation, data collection and policy support. The measures such as changing of crop mixes from perennial plants to deep root ones, using of cultivation systems that leave residues reducing tillage and shifting land use from annual crops to perennial crops, pasture and forestry should be taken for the agricultural sector. However, regional drought action plans should be prepared and implemented. Water resources should be used efficiently and sustainably.

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