An Overview of the Impacts of Global Climate Change on Farmland in Turkey

Ayse Ozcan and Eric Strauss

***Abstract*—Turkey is a country located in a semi-arid climate. As a result of worldwide climate change, dry land farming will drift to the north, decreasing agricultural productivity. Currently in Turkey agriculture generates 7.2% of GDP, 11.3 % of exports, 21.5 % of employment and constitutes 34% of the land area. The amount of agricultural land has decreased 15% since 2000. Future projections for the country show an increase in temperature and a reduction in precipitation. This affects the type of crops grown and the use of water resources for irrigation and power production. Government policy must be specifically designed to positively deal with these specific impacts.**

***Index Terms*—Climate change, agriculture, water resources, GDP, Turkey.**

I. Introduction

It is expected that by the year 2030, the ratio of CO_2 in the atmosphere would increase about twice if we compare the period before the industrial revolution, global temperature is expected to rise between 2 to 5 degrees [1]. Signs of climate change such as temperature increases, sea-level rise, atmospheric events and significant changes occured with heavy rainfall affect the ecological balance in the world. It is also estimated that there are many environmental problems caused by the increase in world population and cause negative impacts on such issues as food security, water, energy, biodiversity and soil erosion depending on the climate change will be felt more and more.

From 1901 to 2005, Canada, Rusia, Atlantic Ocean, Indian Ocean, and Brazil are seen as the regions come to fore with 1,4-1,7 degrees temperature rise in the world. Data has been monitored that show the Atlantic Ocean, Indian Ocean and a large part of Australia have a temperature rise of between 1.1-1.4 degrees [2].

Agriculture is the most vulnerable sector that might be affected from climate changes in the economy. Although many technological and biological innovations have been developed in agriculture, it is still dependent on climate conditions. Climate change may impact agriculture in multiple ways. Changes in temperature and precipitation may affect the timing and length of growing seasons, as well as yields. These climatic changes may also affect water availability for agriculture. Increasing carbon dioxide concentrations, meanwhile, will have a positive effect on water use efficiency leading to higher yields for certain crops. Changes in climate variability, in particular changes in the intensity and/or frequency of floods, drought and storms, are also expected to significantly affect agricultural production. Regional yields are projected to increase up to 3℃ of warming in mid to high latitudes, while they are expected to decline in low latitudes for any increase in temperature [3], [4]. These effects can be summarized as follows:

- Herbal product efficiency and production cost: Agricultural loses increase when drought and excessive rainfall occur.
- The suitability of the soil for agricultural production: Soil productivity losses will occur with an increase in temperature. Temperature increases the microbial composition of soil and so it affects the soil nutrient elements as negative.
- Irrigation water supply.

The Intergovernmental Panel on Climate Change (IPCC) 2007 Report [5] projects that the climate could warm by as much as 5℃ over the next 100 years, and estimates that we have already seen a warming of about 0,7℃ since 1900. Agriculture will be the most affected sector from climate change, because it mostly depends on climate.

In this study the results of impact assessment of climate change on Turkish agriculture are discussed. The conclusion of this paper is that climate change has affected crop yields negatively in Turkish agriculture.

II. Methodology

As this study is based on a literature review, it includes the studies on the general sources discussing the impacts of climate change on farmland and farming policies in Turkey carried out by several private and state institutions. Internet sources, books and articles published abroad on these topics have also been used. The research methodology consists of interpreting previous studies, evaluating and synthesizing sources, identifying the impacts of climate change on farmland in Turkey. By this way, it has aimed to discuss the results of impact assessment of climate change on Turkish agriculture sector. The main method adopted has to evaluate, synthesize and establish relationships among the works form the relevant literature.

III. A Global Look

According to FAO data, in 2010, there were approximately 3.2 billion hectares of pasture and 1.5 billion hectares of cropland globally. Of course, the extent and proportion of

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total land area vary greatly across regions. Arable land per capita has decreased by 14.3% in developed countries and 40% in developing countries. Agricultural land per capita is 0,23 hectares and this value will decline by 15% in 2050 [6]-[8].

Farmland in the world covers an important area in Australia, China, Brazil, the United States and Saudi Arabia. Countries located in very arid climate zone (such as Algeria, Libya, Egypt, Saudi Arabia, Niger) and countries located in arid climate zone (such as Australia, Chile, South Africa, Iran, Kazakhstan, China) will be affected primarily by climate change. It is assumed that Turkey as a country located in semi-arid climate zone will also be affected primarily by climate change.

Agricultural production shortages and surpluses arising as a result of climate change greatly affect the economic balance. For example, the reduction of production could lead to increase in product prices. Therefore, consumers pay a higher price that can lead to an increase in imports and a decline in exports. It will have an impact on human health, livelihood assets, food production and distribution channels, as well as changing purchasing power and market flows. Its impacts will be both short term, resulting from more frequent and more intense extreme weather events as well as long term causing changing temperatures and precipitation patterns (see Fig.1).

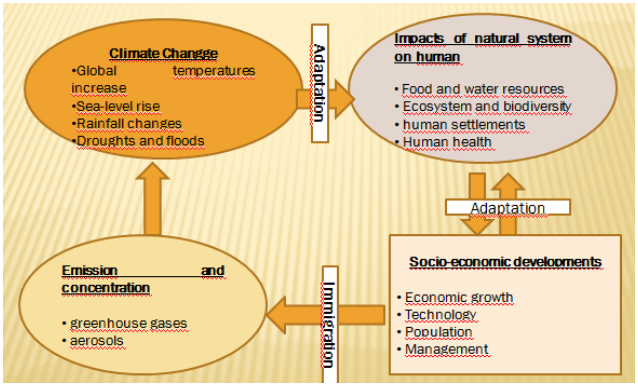


Fig. 1. Global climate change and its effects [9].

According to the most of the scientific studies on climate changes, it is estimated that dryland farming areas and cereals grown areas of the world will be shifted towards the North. In addition to this increase, the geographic shift is expected to decrease from 10 % to 50 % in yield [10]-[14]. Reference [11] examined climate change impact on world food supply. They projected global yield losses amounting to 16% for wheat and 20% for corn with a variation of 3% and 51% across countries. Reference [14] projects that the regional crop production impacts of climate change will be geographically uneven. Their findings show that cereal production increased in colder regions of Latin America (as 3.7%-14.9) and Former Soviet Union (as 4.9%-7%), but decreased production in all the other currently warmer and drier regions. Reference [10] draws together evidence from the IPCC and show Turkish agriculture may well be vulnerable.

While it is expected to decrease in crop productivity in the future due to climate change in some parts of the world according to various projections, some regions are expected to increase in productivity. It is predicted that agricultural crop production will be reduce from 15% to %25 in Turkey (see Fig. 2 and Fig. 3) [4], [13].

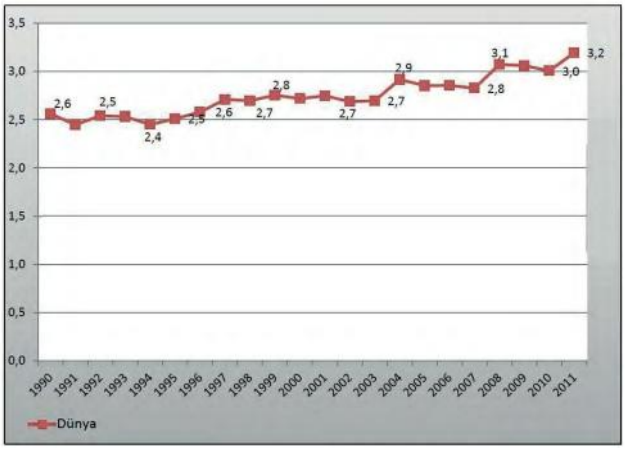


Fig. 2. World wheat production (ton/hectare), 1990-2011 [15].

According to the USDA data in the period between 2010-2011 wheat production decreased in US, Alaska and Iran. Canada, Russia, China, Kazakhstan and Australia have shown an increase in wheat production [16] (see Fig.3).

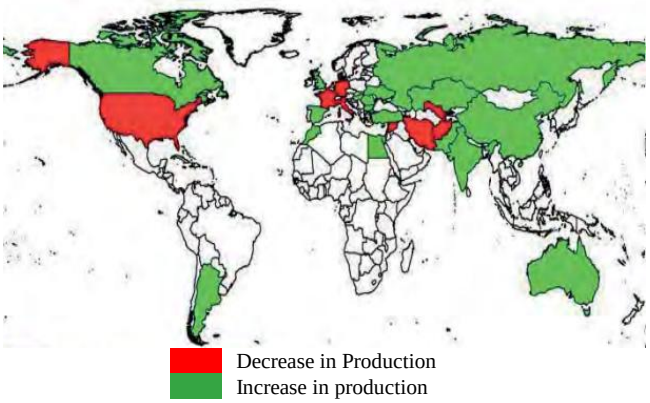


Fig. 3. Wheat production by country (2010-2011) [16].

IV. Climate Change and Turkey

A. General Situation of Agricultural Land in Turkey

37% of Turkey's population lives in rural areas. As of 2013, the share of Turkey's agriculture sector in GDP is 7.2% while agricultural employment is 21.5% in 2014. As of 2011 Turkey's total exports are 134.9 billion dollars and agricultural exports are 15.3 billion dollars. The share of agriculture sector including agriculture and forestry is 11.3 percent of total exports. The share of agricultural imports is 7.3 percent with a total value of 17.6 billion dollars in 2011 [17]-[20].

Agricultural areas constitute approximately 35% of the land of Turkey. Forest areas cover 26% of land and 16% of the land consists of meadow and pasture areas. As of 2010, the land used for agriculture is 24.3 million hectares, and about 20% of this area is dedicated to irrigated agriculture and the remaining 80% is used for dryland farming. Agricultural areas have declined steadily between 1990-2012 in Turkey.

As shown in Table I and Table II, the cultivated land areas making up the majority of agricultural land have been steadily decreasing since 2000. Sown field areas have shown a decrease in the rate of 14.3 percent. Fallow areas have

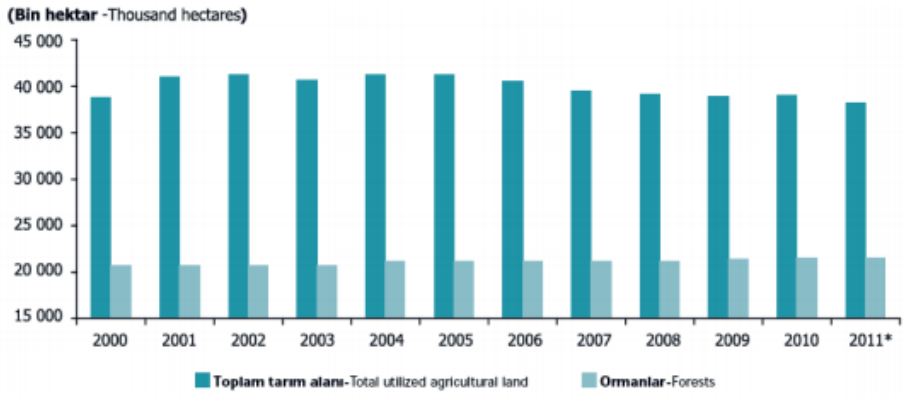
decreased since 2000. From 2000 to 2012 sown and fallow areas have been decreasing without fluctations.

TABLE I: AGRICULTURAL AREAS IN TURKEY (1990-2002) [21]

Area Type	1990 (1000 ha)	1990 (%)	2000 (1000 ha)	2000 (%)	2002 (1000 ha)	2002 (%)
Cultivated Area	18,868	67.7	18,207	69.0	18,123	68.2
Fallow	5,324	19.1	4,826	18.3	5,040	19.0
Area of Vegetable Gardens	635	2.3	793	3.0	831	3.1
Vineyards	580	2.1	535	2.0	530	2.0
Orchards	1,583	5.7	1,418	5.4	1,435	5.4
Olive Garden	866	3.1	600	2.3	620	2.3
Total	27,856	100	26,739	100	26,579	100

TABLE II: AGRICULTURAL AREAS IN TURKEY (1990-2002) [21]

Area Type	2006 (1000 ha)	2006 (%)	2009 (1000 ha)	2009 (%)	2010 (1000 ha)	2010 (%)
Cultivated Area	17,440	67.9	16,217	66.8	16,333	67.5
Fallow	4,691	18.1	4,323	17.8	4,249	17.1
Area of Vegetable Gardens	850	3.0	811	3.1	802	3.0
Vineyards	513	2.0	479	2.0	478	2.0
Orchards	1,670	6.3	1,686	6.9	1,748	7.2
Olive Garden	712	2.8	778	3.2	784	3.2
Total	25,876	100	24,294	100	24,394	100



Graph 1. Agriculture and forest areas in Turkey (2000-2012) [21].

The Turkish government has officially defined the types of agricultural land. The "Regulation for the implementations of the Law on soil protection and land use" dated December 15, 2005 has reclassified farmland areas and has established the legal framework about farmland classification. According to the Regulation farmland types include prime farmland, custom sewn product farmland, woodland, marginal farmland, protected farmland, greenhouses and other farmland plots that consist of 27, 510,751 hectares [22] (see Table III).

Changes in the use of farmland in Turkey were examined together with population growth. The data shows significant increases in the amount of land opened for agriculture. In 1928, 6.6 million hectares of agriculture were cultivated and there were 25.3 million hectares cultivated in 1950. The figure at the end of the 1980s reached the level of about 28 million hectares [23]. However farmland areas have been started to shrink since the beginning of the 1990s (see Table IV - Table VI). The causes of this decrease as follows: farmland use allocation for non-farm purposes, the small business land in the agriculture sector, non-farmland areas, incorrect agricultural activities, incorrect land use, and of course some extreme events depending on climate change.

Approximately 21.4 million hectares of the land used for agricultural production is total arable land, and 3 million hectares of the area covered with orchards and olive gardens. Total land under permanent meadows and pastures is about 14,6 million hectares. Therefore, as of 2014 the total land area used for agricultural purposes is 37.7 million hectares [22], [26]. According to the data given above, as of 2011 the total land used for agricultural purposes is 38.2 million hectares. In addition to this, as land usage amounts has varied from year to year, 18-22 percent of the cultivated area, which constitutes 4-5 million hectares of arable land, has been left as fallow area.

TABLE III: TURKEY'S TOTAL LAND WITHIN THE SCOPE OF FARMLAND CLASSIFICATION (HECTARES) [22]

Prime Farmland	Marginal Farmland	Woodland	Custom Sewn Product Farmland
11,613,090	12,135,961	2,883,105	78,594

TABLE IV: FARMLAND USE TYPES BY YEAR (1000 HECTARES) [15], [24], [25]

Year	Total Farmland (G=E+F)	Total Arable Land and Land Under Permanent Crops (E=C+D)
1990	42,033	27,856
1995*	39,212	26,834
2000	38,757	25,586
2005	41,223	25,657
2011**	38,231	22,800
2012	37,568	22,951
2013	37,640	23,023
2014***	37,752	23,135

TABLE V: TOTAL ARABLE LAND BY YEAR (1000 HECTARES) [15], [24], [25]

Year	Sown Area (A)	Fallow Land (B)	Total (C+A+B)
1990	18,868	5,324	24,827
1995*	18,464	5,124	24,373
2000	18,207	4,826	23,033
2005	18,005	4,876	22,881
2011**	15,692	4,017	19,709
2012	15,464	4,286	19,750
2013	15,613	4,188	19,791
2014***	15,789	4,108	19,897

TABLE VI: TOTAL LAND UNDER PERMANENT AGRICULTURE BY YEAR (1000 HECTARES) [15], [24], [25]

Year	Total Land Under Permanent Crops (D)	Land Under Permanent Meadows and Pastures (F)
1990	3,029	14,177
1995*	2,461	12,738
2000	2,553	12,738
2005	2,776	14,617
2011**	3,091	14,617
2012	3,201	14,617
2013	3,232	14,617
2014***	3,238	14,617

Note: Figures may not be equal to total due to rounding off.
*Data are grouped according to Statistical Classification of Products By Activity in European Economic Community (CPA 2002) since 1995.
Since 1995, only areas covered with fruit and olive are given, it is not included areas covered by scattered trees.
**Data have been compiled since 2011.
*** Data are provisional.

According to the results of agricultural land use ability scheme (AKKS in Turkish) it is seen that the share of land situated in the first four classes is %34,1 in total. Thus it can be understood that in 2014 Turkey has approximately 26,5 million hectares (total arable land and land under permanent crops-23,135 million hectares**)** including embroidered agriculture and permanent crops production. In contrast, agricultural production was made on a wide range of land –around 27,9 million hectares in total- between the years 1990-2011 [27]. The data indicates a loss of one million hectares of farmland within the last five years.

There are no reliable data relating to the amount of the missing part of the farmlands in Turkey. According to data of General Directorate for Rural Services (former), 17.043.482.000 m² farmland has been destroyed in between 1985-2003. The area first and second class non-agricultural lands are 1.781.843.000 m² [28]. After the General Directorate for Rural Services, detailed institutional inventories have not been performed for farmlands. Therefore contemporary data are unknown. According to Reference 25, 4.13.099.000 m² farmland has been destroyed in between 1991-2001. That is the important problem that how to configure an effective agricultural policy based upon these outdated data of Turkey.

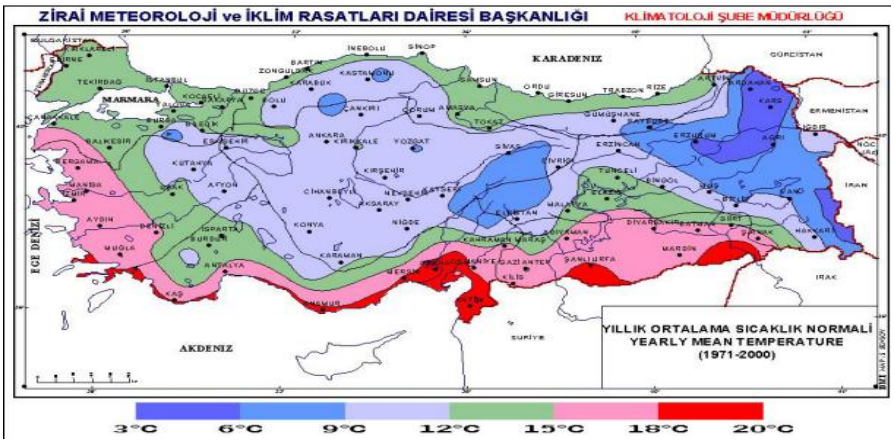
As of 2010, Turkey's total agricultural land is 24.21 million hectares and total cultivated area is 21.35 million hectares. Intensive farming is being done fully irrigated over 5.4 million hectares of land (22% of agricultural land) [20]. According to Reference 25 data 24.1% of total land is irrigated land while 75% of total land is not irrigated.

In Turkey arid and semi-humid land areas are located in a large portion of the Central Anatolia and Southeastern Anatolia Region and some parts of Central and Eastern Mediterranean Region and in the some east parts and west parts of Eastern Anatolia. Semi-arid climate is dominant especially in Igdır and Konya located in central and eastern Anatolia, and the total average annual precipitation is less than 400 mm for these regions. Turkey has arid areas prone to desertification especially in the terrestrial inner and Eastern Anatolia and Southeastern Regions [29].

B. General Situation of Agricultural Land in Turkey

Turkey lies in a region that is highly vulnerable to climate change. The future climate change projections agree on an increase in temperatures throughout the country as well as a reduction in precipitation in the southern half of the country. The IPCC Reports (for 4th and 5th Reports) and other national and international scientific modeling studies demonstrate that Turkey in near future will get hotter, more arid and unstable in terms of precipitation patterns. In the case of increases in the global temperature of up-to 2˚C; the expected impacts in the Mediterranean Basin which includes Turkey show the extent to which measures taken against the impacts of climate change need to be programmed [4], [30], [31].

In Reference 4 it is indicated that a 1˚C - 2˚C increase in temperatures in the Mediterranean Basin would be observed. This suggests that aridity will be felt in an even wider area, and heat waves and the number of very hot days will increase especially in inland regions. For Turkey, on the other hand, the average increase in temperatures is estimated to be around 2.5℃ - 4℃, reaching up to 5℃ in inner regions and up to 4℃ in the Aegean and Eastern Anatolia.



Map: Average temperature distribution (1971-2000) [33].

It is inevitable that for these changes to impact the country's water resources negatively by reducing the water potential in the southern basins. The projections that were based on the high emissions scenarios indicate water potential reductions up to 37% in the Mediterranean basins, up to 70% in Konya basin and up to 10% in the Euphrates and Tigris basins by the mid twenty first century [4], [32]. The decline in the water resources will, first and foremost, influence the agriculture, animal husbandry and related sectors. Hydroelectric energy production is another sector that will be negatively affected by the water potential reduction in Turkey. In addition, Turkey will be subjected to more droughts, heat waves and forest fires. The wider prevalence of Mediterranean climate in Turkey in the future (together with the expansion of warm summer period) will have positive effects in terms of both human life and tourism

The most sensitive and weak areas against heat and cold waves in Turkey are Central Anatolia and Eastern Anatolia region. The weakest and most sensitive areas in terms of Turkey's precipitation climatology are Central Anatolia Region, inner Aegean and Eastern Anatolia Region. Central Anatolia Region is also quite sensitive to temperature. All action plans and strategies for adaptation to climate change should be prepared in accordance with these data.

TABLE VII: TURKEY'S TOP TEN WARMEST YEAR [34]

Year	Average Temperature °C	Normal Temperatures (1971-2000)	Difference °C
2010	15.2	12.81	2.39
2001	14.22	12.81	1.41
1999	14.10	12.81	1.29
1998	13.80	12.81	0.99
2007	13.75	12.81	0.94
2009	13.70	12.81	0.89
2005	13.68	12.81	0.87
2006	13.59	12.81	0.78
2008	13.54	12.81	0.73
2004	13.40	12.81	0.59

V. CONCLUSION

Climate change in Turkey has manifested itself as temperature changes and lower amounts of precipitation. Coupled with the changes in CO2 concentrations, these developments have implications for crop and livestock productivity. The effect of climate change on production varies by crop. Yield effects vary with region. Yield improvement at higher latitudes has been found fairly consistently. On the other hand, crop yields in warmer, low latitude and semi-arid areas like the US South and Southwest often are found to be reduced by climate change. The analogy may be extended to Turkey. If the climate changes, yields can generally be enhanced by producer adaptations, aided by education and government programs.

Farmers may adapt by changing planting dates, substituting cultivars or crops, changing irrigation practices, and changing land allocations among crop production, pasture, and other uses [10].

Risk perceptions and disaster management planning for agriculture sector should be made to include these concerns. Long term climate trends should be made known to producers. Government programs that involve open space protection, tax policy and land use planning in the agricultural sector should involve issues of climate change.

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