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Dellal I., McCarl B.A.

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The economic impacts of drought on agriculture: The case of Turkey

İ. Dellal* and B.A. McCarl**

*Department of Agricultural Economics, Agricultural Faculty, Ankara University, Dışkapı, Ankara (Turkey)
**Department of Agricultural Economics, Texas A&M University, College Station, TX (USA)
e-mail: dellal@agri.ankara.edu.tr

Abstract. Agriculture is known to be the most affected sector from environmental threats due to its dependency to climate factors. Drought as one of the threats seen in recent years affects agricultural production. The effects of drought are based on frequency, severity, degree and on the vulnerability of the region and sectors. On the other hand climate change is one of the concerns of this century. According to climate projections, the impacts of climate change across the world are likely to vary: colder regions may benefit from warmer temperatures while warmer regions may suffer from increased heat and drought. Since Mediterranean countries are in arid and semi arid regions with low precipitation and high temperature in summer, they are vulnerable for drought. The aim of this study is to determine the economic impacts of drought on Turkish agricultural sector at regional and national levels. The analysis is carried out using Turkish Agricultural Sector Model focusing on the major crops in Turkey. This Model is based on 2008 conditions as existed across various agricultural production regions in Turkey to find out the effects of drought on economic indicators such as production, price, trade and welfare.

Keywords. Climate change – Drought – Economic effects – Agricultural sector model – Impact assessment.

Les impacts économiques de la sécheresse sur l'agriculture : Le cas de la Turquie

Résumé. *L'agriculture est connue pour être le secteur le plus touché par les aléas environnementaux en raison de sa dépendance des facteurs climatiques. La sécheresse est l'une des menaces perçues lors des années récentes, affectant la production agricole. Les effets de la sécheresse sont basés sur la fréquence, la sévérité, et le degré et la vulnérabilité de la région ou des secteurs. Par ailleurs le changement climatique est une des préoccupations de ce siècle. Selon les projections climatiques, les impacts du changement climatique à travers le monde sont susceptibles de varier : les régions les plus froides pouvant bénéficier de températures plus chaudes tandis que les régions les plus chaudes pourraient subir une chaleur et une sécheresse accrues. Vu que les pays méditerranéens sont situés dans des régions arides et semi-arides à faibles précipitations et fortes températures en été, ils sont vulnérables à la sécheresse. Le but de cette étude est de déterminer les impacts économiques de la sécheresse sur le secteur agricole turc au niveau régional et national. L'analyse est menée en utilisant un modèle pour le secteur agricole turc axé sur les principales cultures en Turquie. Ce modèle est basé sur les conditions existantes en 2008 pour plusieurs régions de production agricole en Turquie afin de mettre en relief les effets de la sécheresse sur des indicateurs économiques tels que production, les prix, le commerce et le bien-être.*

Mots-clés. *Changement climatique – Sécheresse – Effets économiques – Modèle du secteur agricole – Évaluation de l'impact.*

I – Introduction

The Intergovernmental Panel on Climate Change (IPCC) indicates that global average surface temperature has increased since 1861. Over the 20th century, the increase has been about 0.7°C globally, with the 1990s being the warmest decade and eleven of the twelve years in the period 1995-2006 rank among the top 12 warmest years in the instrumental record. IPCC report projects that the climate could warm by as much as 5°C over the next 100 years (IPCC, 2007). One of the results of climate change according to the scientific community is to increase

frequency and severity of the extrem events including droughts. Drought as one of the threats has been frequently seen in recent years, especially in Mediterranean countries. Since Mediterranean countries are in arid and semi arid regions with low precipitation and high temperature in summer, they are vulnerable for drought. Agriculture is known to be the most affected sector from environmental threats due to its dependency to climate factors so that yields, production, economic contribution to the country, etc., could be most affected.

The effects of drought are based on frequency, severity, degree and vulnerability of the region and sectors. The effects of drought on crop production might be annual and perennial crop losses, damage to crop quality, income loss for farmers due to reduced crop yields, reduced productivity of cropland, insect infestation, plant disease, increased irrigation costs, cost of new or supplemental water resource development (wells, dams, pipelines). Animal production might be affected and results as high cost/unavailability of feed for livestock, increased feed transportation costs, high livestock mortality rates, disruption of reproduction cycles (delayed breeding, more miscarriages), decreased stock weights, reduced productivity of rangeland, reduced production, forced reduction of foundation stock, limitation of public lands to grazing, high cost/unavailability of water for livestock, cost of new or supplemental water resource development (wells, dams, pipelines), increased predation, range fires. Drought has also economic effects such as income losses, loss to industries directly dependent on agricultural production, decreased land prices, unemployment from drought-related declines in production, strain on financial institutions (foreclosures, more credit risk, capital shortfalls), reduction of economic development, fewer agricultural producers (due to bankruptcies, new occupations), rural population loss (NDMC, 2010).

Turkey is located in the temperate zone of the Mediterranean basin, surrounded on three sides by seas – the Mediterranean, the Aegean and the Black. The total land area is 780,600 square kilometres. By climate, the Turkish agriculture operates in four broad classifications. A Mediterranean climate prevails in Turkey's Mediterranean and Western Anatolian parts; a temperate climate with high precipitation in every season along the Black Sea coast; a continental climate in the inland regions and a semi-arid climate in central and southeastern Anatolia. Country wide the average annual rainfall is 643 mm and most precipitation occurs in the winter months. Annual rainfall is least in the low-lying areas of eastern Anatolia (220 mm), and highest along the eastern Black Sea coast (2420 mm).

According to average climate change projections across the Global Circulation Models (GCMs) in IPCC (2007), by 2050 the annual mean temperature is expected to increase by 1.5°C and precipitation is to decrease by 1.5 mm. The most drastic change in temperature is projected in the July and August period: 4.1°C in Central Anatolia region and 3-4°C in the coastal regions (Mediterranean and Aegean). The lowest temperature change is projected in Black Sea region between 1.6-2.5°C. The highest precipitation change is projected in the Mediterranean region in the period of March-April, and the lowest change in Southeastern Anatolian region (IPCC, 2004).

One of the drought years in Turkey was 2007. The rainfall was lower than normal years in almost all regions. The temperature was higher than normal years average. Those changes affect crops yields and almost all crops had lower yields than previous year which was a normal year according to agricultural parameters (Figs 1 and 2).

Since agricultural production was down, the crop prices were increased as seen Fig. 3. Those have effects on agricultural growth rate in the national level which was minus 7% in 2007 (TURKSTAT, 2009).

The aim of this study is to determine the economic impacts of drought in a climate change context on Turkish agricultural sector at regional and national levels. The analysis is carried out using Turkish Agricultural Sector Model focusing on major crops in Turkey. Turkish Agricultural Sector Model is based on 2008 conditions as existed across various agricultural producing regions in

Turkey to find out the effects of drought on economic indicators such as production, price, trade and welfare.

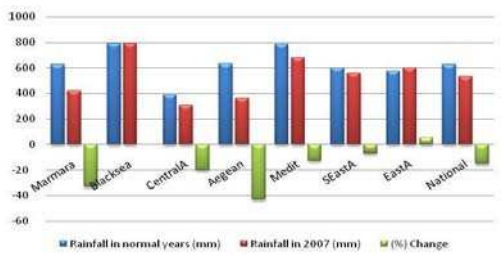

Fig. 1. Rainfall changes (mm) in 2007 in Turkey (for each Region: 1st bar: rainfall in normal years; 2nd bar: rainfall in 2007; 3rd bar: %change)

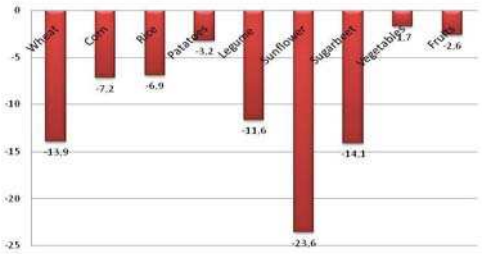

Fig. 2. Yield changes (%) in 2007 in Turkey.

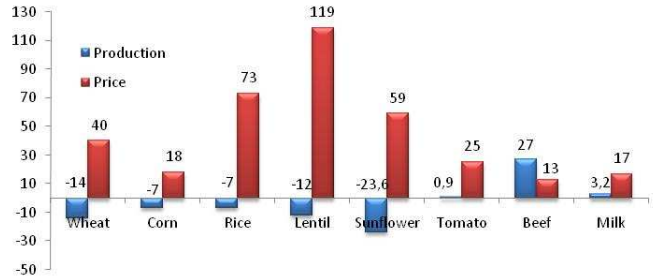

Fig. 3. Agricultural production and prices in 2007 in Turkey (for each crop: 1st bar: production; 2nd bar: prices).

II – Materials and methods

To study the economic impacts of drought in a climate change context in Turkey, we examined the effects on the main crops and how these effects translate into overall production and the market environment. The main crops of Turkey are wheat, barley, corn, cotton, and sunflower covering 85% of the total area sown.

To evaluate the economic impact of climate change on Turkish agriculture, an Agricultural Sector Model for Turkey was developed (TARSEM). TARSEM was designed to simulate competitive equilibrium solutions under a given set of demand and supply conditions following concepts developed by Samuelson (1952) and Takayama and Judge (1964) as reviewed by McCarl and Spreen (1980) and Norton and Schiefer (1980). The TARSEM objective function is the summation of all areas beneath the product demand curves minus the summation of all areas under the supply curves. The objective function represents social welfare which, within the limitations of consumers' and producers' surplus, measures the benefits of producers' and consumers' from producing and consuming commodities.

TARSEM simulates economic conditions in the Turkish agricultural sector including prices, production, and trade of the main crops (wheat, barley, corn, sunflower, cotton) based on 2008. The model is set up as a mathematical program.

In terms of geographic scale, TARSEM is a national level model that incorporates

agroecological diversity in the agriculture sector across seven geographical production regions, as shown in Fig. 4.

The model simulations provide results on production, consumption, trade, and prices of crops at regional and national levels. It also provides the impact of changes in the economic and biophysical environment of agriculture sector on producers' and consumers' benefits for engaging in production and consumption as estimated by producer and consumer surplus measures. Consumption and trade are conditional on prices (under a yield outcome) as determined in the domestic regional markets under fixed trade prices.

Fig. 4. Regions of Turkey.

To setup TARSEM, 21 years of area, production and yield data were obtained from Turkish Statistical Institute (TURKSTAT) by province level and aggregated to the regional level. The other supporting data based on 2008 conditions, trade, price, consumption were obtained from TURKSTAT.

III – Results and discussion

The changes in yield altered crop mixes and production levels that in turn would alter total supply, market prices, consumption and trade. We evaluate these impacts by changing yields in the TARSEM by drought year yield amount and then simulating crop area allocation and market decisions.

The production level of all crops was decreased as seen Fig. 5 from 4.5% to 15.3%.

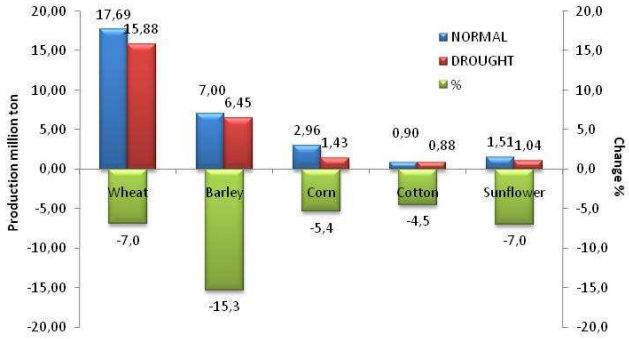

Fig. 5. Production changes of Turkey according to drought.

At the regional level area allocation changes are seen in Fig. 6 where only the changes in area sown are shown. Figure 6 shows that while wheat area increased by a small amount in the Black Sea, Marmara and Aegean regions, the area under wheat decreased in the Central Anatolia, East Anatolia and South Eastern Anatolia regions. On the other hand, Mediterranean and Marmara regions increased barley area, but Black Sea and Aegean regions decreased it. Black Sea, Marmara, Mediterranean Anatolia regions increased corn area, while Central, East and Southeast Anatolia decreased. Black Sea region decreased sunflower area while other regions increased. We do not find any noticeable change in cotton area across any region.

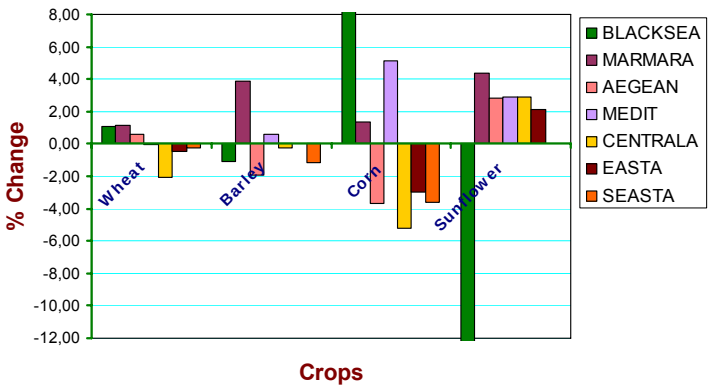

Fig. 6. Crop mix changes of Turkey.

As a result of the area and yield changes from climate change show that prices for all crops increased between 6.5 and 34.7% (Fig. 7).

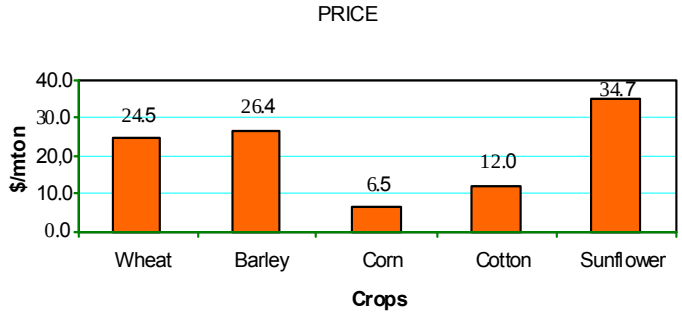

Fig. 7. Price changes of Turkey.

Climate change also induces consumers', producers' and total welfare changes. Climate induced market changes are harmful for consumers but are typically beneficial to producers. Results from the economic model of this study show that total welfare decreased by 1%, producer welfare increased by 8% and consumer welfare decreased by 2%.

IV – Conclusions

Turkish agriculture is sensitive to drought and climate change. In this study we examined under the effects of drought and we found that national and regional production are negatively affected

in the range of minus 4.5% to minus 15.3%. Significant crop mix changes occur as a result, with total crop production decreasing. National area sown for wheat and barley increased, corn and sunflower decreased and cotton area sown remain at the same level. Regionally there are even larger shifts. For example, in the Black Sea region we find that in reaction to climate change there is a shift from sunflower to corn. Trade is also affected: we found that climate change induces a drastic decrease in wheat exports and an increase in corn imports. Collectively we found that Turkey experienced a welfare loss derived from agriculture. However, we found that consumer lost, while with producers gained due to a rise in commodity prices.

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