# An Econometric Analysis of the Effects of Global Warming and Economic Factors to the Yield and Area Sown of Barley in Adana and Konya Provinces in Turkey

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## 1. Introduction

Barley is one of the major animal feed crops in Turkey. It occupies 27% of the total cereal production in Turkey. It can tolerate salinity, drought, and lower temperature better than wheat. Turkish nine million tons of barley production in 2004 gives the seventh largest barley producer position to Turkey in the world.

Concern over the potential effects of climatic change on agriculture has motivated a lot of research over the past decade. Most of studies have used crop growth models. This approach must utilize huge amount of data on plant growth, ET, water, temperature, soil, etc. The multiple regression analysis of the effect of monthly weather variables and economic variables to yield and area sown of barley in Adana and Konya, that was done in the current study does require much smaller amount of data than the plant growth model approach. Based on the results of the multiple regression analysis, we estimated the impacts of global warming to barley production in the two provinces. So far, there have not been any trials to utilize the results of short-run multiple regression analysis of the relation between weather and crop production for estimating the impact of global warming to crop production.

Time series data (1959 to 2002) for weather (monthly data), for price variables (annual data), and yield and area sown of barley (annual data) were used in this study. Our analysis was done in two stages. In the first stage, multiple regression analyses of the effects of heat damage, drought, rainfall and prices to the yield and area sown of barley for Adana and Konya were made. Then at the second stage, the pseudo-warming second run N2 data and the socio-economic sub-group basic scenario for prices were inserted into the corresponding variables of the regression equations in order to identify the impacts of global warming to yield, area sown and production of the barley in Konya and Adana.

## 2. Material and Methods

Two main agricultural regions (Adana and Konya) within Turkey were chosen (Figure 1) as a study area.


Figure 1. The study area, Konya (including Karaman) and Adana (including Osmaniye)

Adana is very important agricultural province in Turkey. It is mostly plain, very productive and irrigated land in the south-east part of the Turkey. Osmaniye was separated from Adana province and became a new province in 1997. to be consistent Osmaniye's data was added into Adana's data after the year 1997.

Konya is our second selected study area in the middle of Turkey, is a plain and mostly rainfed land. Karaman which was belongs to Konya province, separated from Konya and became a new province in 1989. In the analysis, to be consistent, we added Karaman's data into Konya's data after the year 1989.

The climatic variables used in this analysis were obtained from records of the Turkish State Meteorological Service. This data includes monthly observations of temperature (in degrees) and monthly precipitation (in units of millimeters per month) starting from 1950 to 2004. These long-term records offer the best view of what climate has been like and how it has already changed. Historical data (period of 1959 to 2002), related to the barley yield and area sown were obtained from records of State Institute of Statistics (SIS). In addition, necessary information's (such as crop pattern, planting and harvesting times of crop) obtained from Agricultural Services in each selected provinces. All the data used for the analysis was related to the period 1959-2002.

For economic analysis of the climate factors (drought effect, heat damage and cumulative rainfall) and economic factor (barley price) to the yield and area sown of barley were examined using by Multiple Regression Analysis (MRA). However, as inflation was very high after the late 1970s in Turkey, barley price modified by whole sale price index (1938=100).

In the MRA yield and area sown series of barley relating to 1959-2002 period were considered as dependent variables. The independent variables in the model were calculated separately for drought effect, heat damage, cumulative rainfall and crop price of barley in Adana and Konya province.

The selection and introduction of independent variables for regression equation were performed by using stepwise selection method. In the analysis, Standard software computer package program SPSS 11.0 was used.

After getting the regression equations for yield and area sown in Adana and Konya, PGW estimation was used to estimate future (2070-2079) yield and area sown.

## 3. Results

The climatic and economic variables were arranged to yield and area sown of the barley. All the data used for the analysis was related to the period 1959-2002. The results of the model were given below.

### 3.1. Barley Yield Model for Adana Province

The period of analysis is for 1959 to 2002, and linear function is used for the analysis. In the model, average barley yield in the year (t) in Adana province was used as a Dependent Variable.

Barley yield was 1,699 Kg/ha in 1959 and it reached 2,401 Kg/ha in 2002. In the research period, average barley yield was 2,328 Kg/ha.

The variable description for the analysis is shown in Table 1 below:

Table 1. Description of the Variables for Barley Yield in Adana

| | | |
|---|---|---|
| NPC | : | Nominal Price Change |
| DDDA(t)23 | : | Drought Effect in December in year (t) (1 if rain <= 23%, 0, otherwise) |
| DHDAA(t)18.9 | : | Heat damage in April in year (t) (1 if temperature >= 18.9 °C, 0, otherwise) |
| DHDMA(t)23.4 | : | Heat damage in May in year (t) (1 if temperature >= 23.4 °C, 0, otherwise) |

The MRA gave an R2 value of 0.254 and adjusted R2 value of 0.178. Durbin Watson statistic value was found 1.342 and there is no autocorrelation. Estimated parameters are highly significant and have theoretically expected signs. Farmers in Adana responded to increase their barley yield to the higher last year's Nominal Price Chance. Barley yield in Adana responded negatively to the drought and high temperature. Especially this result also tells us that barley yield in Adana declines when December rainfall become less than 23% and temperature become higher than 18.9 degree centigrade in April and 23.4 degree centigrade in May. This reflects heat damage and drought effect to barley in Adana (Table 2).

Table 2. Barley Yield Model for Adana

| | $R^2$= 0.254 | $AR^2$= 0.178 | DW= 1.342 |
|---|---|---|---|
| Variables | Coefficient | t-value | Significant |
| CONSTANT | 2128.75 | 31.18 | 0.00 |
| NPC | 1.95 | 1.84 | 0.07 |
| DDDA(t)23 | -423.78 | -1.90 | 0.07 |
| DHDAA(t)18.9 | -135.45 | -0.84 | 0.41 |
| DHDMA(t)23.4 | -375.13 | -1.42 | 0.16 |

### 3.2. Barley Area Sown Model for Adana Province

In the model, barley area sown in the year (t) in Adana province was used as a Dependent Variable.

Barley area sown was 50,381 ha in 1959

and it decreased to 14,917 ha in 2002. In the research period, average barley area sown was 14,779 ha.

The variable description for the analysis is shown in Table 3 below:

Table 3. Description of the Variables for Barley Area Sown in Adana

| | |
|---|---|
| RPBARLEY(t-1) | Real Farm Gate Price for Barley deflated by Whole Sale Price Index, 1938=100 |
| CRJAN(t-1)OCT(t-1) | Cumulative monthly rainfall from January in year (t-1) to October in year (t-1) |

Estimated model shows that farmers are responding to the higher last year's real farm gate barley price while they are investigating on production. Barley area sown in Adana responded positively to the higher cumulative rainfall between January to October. This demonstrate that if there is enough rainfall before harvesting and last year's real farm gate barley price is high, farmers are willing to plant more barley in Adana.

Table 4. Barley Area Sown Model for Adana

| | $R^2$= 0.208 | $AR^2$= 0.170 | DW= 0.347 |
|---|---|---|---|
| Variables | Coefficient | t-value | Significant |
| CONSTANT | -9912.30 | -0.84 | 0.41 |
| RPBARLEY(t-1) | 0.13 | 3.18 | 0.00 |
| CRJAN(t-1)OCT(t-1) | 15.44 | 1.11 | 0.28 |

### 3.3. Barley Yield Model for Konya Province

In the model, average barley yield in the year (t) in Konya province was used as a Dependent Variable.

Barley yield was 826 Kg/ha in 1959 and it reached 2,366 Kg/ha in 2002. In the research period, average maize yield was 2,178 Kg/ha. The variable description for the analysis is shown in Table 5 below:

Table 5. Description of the Variables for Barley Yield in Konya

| | |
|---|---|
| NPC | Nominal Price Change |
| CROCT(t-1)JUN(t) | Cumulative monthly rainfall from October in year (t-1) to June in year (t) |
| DDMK(t)17 | Dummy for drought in May, year (t) (1 if rain <= 17%, 0, otherwise) |
| DHDAK(t)13.7 | Dummy for heat damage in April, year (t) (1 if temperature >= 13.7 °C, 0, otherwise) |
| DHDMK(t)16.3 | Dummy for heat damage in May, year (t) (1 if temperature >= 16.3 °C, 0, otherwise) |

Table 6. Barley Yield Model for Konya

| | $R^2$= 0.533 | $AR^2$= 0.472 | DW= 1.384 |
|---|---|---|---|
| Variables | Coefficient | t-value | Significant |
| CONSTANT | 858.22 | 3.04 | 0.00 |
| NPC | 4.69 | 3.22 | 0.00 |
| CROCT(t-1)JUN(t) | 3.43 | 3.96 | 0.00 |
| DDMK(t)17 | -579.05 | -1.34 | 0.19 |
| DHDAK(t)13.7 | -505.21 | -1.71 | 0.09 |
| DHDMK(t)16.3 | -309.10 | -2.34 | 0.02 |

The result is good as the R2 is high and the estimated parameters are highly significant and have theoretically expected signs. Durbin-Watson statistic value was calculated to be 1.384 and there is no autocorrelation. Farmers in Konya also responded to increase their barley yield to the higher last year's Nominal Price Change. Cumulative rainfall for selected months (growing period) has positive effect on the barley yield in Konya.

Especially this result also tells us that Konya barley yield declines when May rainfall become 17% less than average.
In addition, barley yield declines if April temperature become higher than 13.7 degree centigrade and May temperature become higher than 16.3 degree centigrade. This reflects heat damage to barley in Konya.

### 3.4. Barley Area Sown Model for Konya Province

In the model, barley area sown in the year (t) in Konya province was used as a Dependent Variable.

Barley area sown was 345,000 ha in 1959 and it reached 468,761 ha in 2002. In the research period, average barley area sown was 587,142 ha.

The variable description for the analysis is shown in Table 7 below:

Table 7. Description of the Variables for Barley Area Sown in Konya

| | |
|---|---|
| RPBW(t-1) | Relative farm gate price between barley and wheat in year (t-1) |
| CROCT(t-2)SEP(t-1) | Cumulative monthly rainfall from October in year (t-1) to September in year (t-1) |

The result shows that farmers are responding to the higher last year's relative farm gate price between barley and wheat while they are investigating on production. Barley area sown in Konya also responded positively to the cumulative rainfall between January and October.

Table 8. Barley Area Sown Model for Adana

| | $R^2$= 0.114 | $AR^2$= 0.070 | DW= 0.277 |
|---|---|---|---|
| Variables | Coefficient | t-value | Significant |
| CONSTANT | 208247.40 | 1.67 | 0.10 |
| RPBW(t-1) | 290201.00 | 2.20 | 0.03 |
| CROCT(t-2)SEP(t-1) | 105.62 | 0.51 | 0.61 |

## 4. Future Estimation by Using Pseudo Global Warming (version 2_2, revised second run data)

So far we estimated barley yield and area sown models for Adana and Konya that related with barley price, drought damage, heat effect, cumulative rainfall etc. Using these models and 2070-79 pseudo-warming temperature and rainfall data, we estimated barley yield and area sown for Adana and Konya for 2070-79.

Then, multiplying yield and planted area data for 2070 we can predict wheat production in 2070-79.

According to PGW estimation, average monthly temperature will increase and rainfall will decrease in Adana and Konya.

As a result of our work, we found that barley yield will decrease 29.8% (from 2,328 kg/ha to 1,633 kg/ha) in 2070-79 in Adana. In contrast, barley area sown will increase 80.3% (from 14,779 ha to 26,644 ha) in Adana. We assume in the light of PGW estimation that Adana will get less rain and high temperature. This will cause low yield and since there will not more choice for the farmers in dry agricultural land and barley has resistance for drought, area sown will increase.

In case of Konya province, Konya will get dryer and hotter than nowadays. This will directly effect to yield and it will decrease 46.3% (from 2,178 kg/ha to 1,170 kg/ha). In addition, area sown will decrease also from 587,142 ha to 468,926 ha (20.1%), since Konya will not suitable place for barley production in the future.

On the other hand, most difficult part for the future estimation was predict future price of barley. In our future estimation we used average price of the period of 1935-2002. We assumed that price will be same as the last 68 years on average. But as it shown above, barley production will decrease in Turkey. Turkish barley consumption is expected to remain strong in the future because of improvement in animal husbandry and increase in population. Therefore, price is expected to increase.

Considering this possibility we were calculated three different cases, first if future price increase 25%, barley yield in Adana will decrease 29.2% and area sown will increase 108.8%. In Konya, yield will decrease 34.3% and area sown will decrease 8.6%. Second, if future price increase 35%, barley yield in Adana will decrease 28.9% and area sown will increase 130.0%. In Konya, yield will decrease 33.6% and area sown will decrease 4.7%. Third, if future price increase 50%, barley yield in Adana will decrease 28.5% and area sown will increase 161.8%. In Konya, yield will decrease 32.6% and area sown will increase 1.2%.

## 5. Conclusions

The relationship between climate change and its effects on agriculture has been investigated by many researchers. However, little research has been conducted MRA for estimating the effects of the climate change on agriculture.

Agriculture in Turkey highly depends on climate change. Our predictive model also shows that, Adana's and Konya's vulnerability to climate change is acute. The study concludes with the finding that Turkey may experience yield losses under the magnitude of climate change as projected by MRA and PGW estimations.

As a result of our econometric model, estimated parameters were significant and had theoretically expected signs in both Adana and Konya. Barley yield in Adana and Konya responded negatively to the drought and heat. Barley yield in certain year declined considerably when the temperature in the same year became higher than 18.9 degree centigrade in April and 23.4 degree centigrade in May in Adana. The same heat damage effect was found in Konya. When temperature in a certain year became higher than 13.7 degree centigrade in April and 16.3 degree centigrade in May barley yield there declined significantly in the same year.

On the other hand, if the rainfall decreased more than 23% of the long run average in December in Adana and more than 17% in May in Konya, significant drought affect on barley yield was found.

The pseudo-warming second run shows that Adana and Konya provinces will get less rain and higher temperature in 2070. Barley yield will decrease by 29.8% in Adana and by 46.3% in Konya in 2070. The total barley production will increase by 21.5% and will be 43,510 tons in 2070 (35,817 tons in 2002) in Adana because of the estimated increase in area sown. Total barley production will decrease by 49.5% in Konya in 2070. It was 1,109,095 tons in 2002, and it will be 548,643 tons in 2070.

This paper only examined barley yield and area sown that climate may affect in the future. It also needs to analyze the effects of the pseudo-warming to cropping system in Adana and Konya. Out next step for the future work is to estimate models for other important crops in Adana and Konya, considering the interdependences between these crops, integrate them and analyze the impacts of global warming to the farmers' behaviour concerning cropping pattern and land use.