Chapter 5 An Econometric and Agro-climatological Study of the Impacts of Global Warming and Prices to Production of Rain-fed Wheat and Barley in Konya and Adana

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1. Main conclusions of an econometric and agro-climatological study of the interactions among production of wheat and barley, weather variables, prices of wheat and other major crops, and climatic change in Konya and Adana

Research methodology of the Socio-economic sub-group of ICCAP follows the two methodological memos by H. Tsujii written in 2003 and 2004(Tsujii, H., 2003 & Tsujii, H., 2004). An English interim-report of the socio-economic team was published and distributed in February 2005 (Tsujii, H. ed., 2005).

In the rain-fed areas in Adana and Konya, an econometric study by Tsujii and Ufuk has found that the global warming under the case of no Turkey accession to the EU in 2070 will increase wheat and barley yields by 13% and 6% respectively, while it will decrease these yields in Konya by 18% and 17% respectively. This difference is probably caused by the fact that 2070 average temperature in Konya will increase by 21% of current climatic temperature, while the same temperature in Adana will increase by only 14%.

The impacts of global warming to area sown of wheat and barley in Adana and Konya in the case of no EU accession are all small negative percentages. Thus the total production of Adana wheat will be increased by 10%, while the total production of Adana barley will be reduced by 2% under global warming. Wheat and barley yields in Konya will be decreased by 18% and 17% respectively under global warming in no EU accession case. The area sown of wheat and barley will decrease a little under global warming in 2070. Consequently the total wheat and barley production will decrease by large amounts of 18% and 18%. This may imply a future decline of food security or wheat shortage in Turkey as Konya is a large and representative wheat producing area in Turkey.

These reductions of wheat and barley production caused by global warming can be intensified by the long run soil degradation perceived by most of the farmers surveyed in our farm surveys in Adana and Konya. Most of the surveyed farmers in Cesimilseville, Konya have told us that the inherent soil fertility of rain-fed wheat land has been degrading because of increasing chemical fertilizer application so

that fallow frequency has increased form once in three years to every other year. The surveyed farmers told us and have shown us that the grass of vast national grazing land has deteriorated to the dominance of thorny grass because of overgrazing, and animals can not eat these thorny grass.

Many farm surveys, the analyses of the data collected, and some methodologies for economic analysis of the interactions among farmers' perception of and their responses to climatic changes, technological changes and policy and institutional changes have been conducted in the research projects of Hiroshi Tsujii conducted in Nigeria, Tanzania, Indonesia, and Japan using the farm questionnaires similar to the one used in Turkey. About 10 English papers by Tsujii and others have been published by and have been accepted by international journals. (Chianu and Tsujii, 2006, Herianto and Tsujii, 2003)

2 The econometric and agro-climatological study of the impacts of global warming and price changes to wheat and barley in Konya and Adana.

This Tsujii and Ufuk econometric analysis, first estimated historical yield and area sown functions of wheat and barley in Adana and

Konya, incorporating the effects of very high

temperature, drought, soil moisture, and output prices. Secondly, combining the best estimated functions with the model bias adjusted projected monthly rainfall and temperature by the RCM of Dr. Kimura, and atmospheric CO2 concentration effects of global warming, yield, area sown, and total production of wheat and barley in Adana and Konya were predicted for 2070.

2.1 A result of the econometric analysis of the effects of very high temperature, drought, soil moisture, and output prices to wheat and barley production

This study follows the methodology used in the past econometric studies of H. Tsujii on the similar topic conducted for Japan and Thailand. Here we show in the following figures the results of our econometric study of wheat and barley for Adana, and Konya, and the impacts of global warming to the production of these crops in Adana and Konya. The period of analysis is for 1951 to 1998, and the linear function is used for the analysis. The variable description and for the wheat yield function for Adana is shown in Table 1 just below.

Table 1. Description of the Variables for the Wheat Yield Function for Adana

NPC	:	Nominal Price Change
DDMA(t)20	:	Drought Effect in May in year (t) (1 if rainfall <= 20%, 0, otherwise)
DHDAA(t)16.2	:	Heat damage in April in year (t) (1 if temperature >= 16.2 °C, 0, otherwise)
DHDMA(t)23.5	:	Heat damage in May in year (t) (1 if temperature >= 23.5 °C, 0, otherwise)

The estimated Adana wheat yield function is shown in the following table.

Table 2. The Estimated Wheat Yield Function for Adana

	R^2= 0.279	AR^2= 0.205	DW= 0.808
Variables	**Coefficients**	**t-value**	**Significance**
CONSTANT	2624.62	6.93	0.00
NPC	10.29	3.23	0.00
DDMA(t)20	-255.84	-1.61	0.26
DHDAA(t)16.2	-215.36	-0.63	0.53
DHDMA(t)23.5	-580.26	-0.77	0.44

The variable description and the estimated wheat area sown function for Adana are shown in Table 3 and 4.

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

NPC(t-1)/(t-2)	Nominal farm gate price Change from year (t-1) to year (t-2)
CRSEP(t-1)OCT(t-1)	Cumulative monthly rainfall from September in year (t-1) to October in year (t-1)

Table 4. The Estimated Wheat Area Sown Function for Adana

	R^2= 0.467	AR^2= 0.441	DW= 1.058
Variables	**Coefficient**	**t-value**	**Significant**
CONSTANT	199932.10	10.19	0.00
NPC(t-1)/(t-2)	1531.91	5.24	0.00
CRSEP(t-1)OCT(t-1)	535.42	2.12	0.04

The variable description and estimated functions of barley yield and area sown for Adana are presented in Table 5-8 below.

Table 5. Description of the Variables for the Barley Yield Function for Adana

NPC	:	Nominal Price Change
DDMA(t)35	:	Drought Effect in March in year (t) (1 if rainfall <= 35%, 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)

Table 6. The Estimated Barley Yield Function for Adana

	R^2= 0.190	AR^2= 0.107	DW= 1.239
Variables	**Coefficient**	**t-value**	**Significant**
CONSTANT	2106.94	28.94	0.00
NPC	2.30	2.06	0.05
DDMA(t)35	-51.29	-0.47	0.64
DHDAA(t)18.9	-83.83	-0.48	0.64
DHDMA(t)23.4	-420.48	-1.45	0.15

Table 7. 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)

Table 8. The Estimated Barley Area Sown Function 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

The estimated results of Konya wheat and barley yild and aera sown functions are shown in Table 9-16.

Table 9. Description of the Variables for the Wheat Yield Function for Konya

NPC	:	Nominal Price Change
CROCT(t-1)MAY(t)	:	Cumulative monthly rainfall from October in year (t-1) to May in year (t)
DDAK(t)20	:	Drought Effect in April in year (t) (1 if rainfall <= 20%, 0, otherwise)
DHDAK(t)12.8	:	Heat damage in April in year (t) (1 if temperature >= 12.8 °C, 0, otherwise)
DHDMK(t)16.3	:	Heat damage in May in year (t) (1 if temperature >= 16.3 °C, 0, otherwise)
DHDJK(t)20.7	:	Heat damage in June in year (t) (1 if temperature >= 20.7 °C, 0, otherwise)

Table 10. The Estimated Wheat Yield Function for Konya

	R^2= 0.579	AR^2= 0.511	DW= 1.120
Variables	**Coefficient**	**t-value**	**Significant**
CONSTANT	1400.67	4.98	0.00
NPC	5.07	3.33	0.00
CROCT(t-1)MAY(t)	1.32	1.61	0.12
DDAK(t)20	-318.90	-2.62	0.01
DHDAK(t)12.8	-205.46	-1.48	0.15
DHDMK(t)16.3	-171.30	-1.59	0.12
DHDJK(t)20.7	-267.22	-2.13	0.04

Table 11. Description of the Variables for Wheat Area Sown in Konya

RPWB(t-1)	Relative farm gate price between wheat and barley in year (t-1)
CRJAN(t-1)FEB(t-1)	Cumulative monthly rainfall from January in year (t-1) to February in year (t-1)

Table 12. The Estimated Wheat Area Sown Function for Konya

	R^2= 0.144	AR^2= 0.102	DW= 0.464
Variables	**Coefficient**	**t-value**	**Significant**
CONSTANT	701373.66	5.60	0.00
RPWB(t-1)	206883.04	2.01	0.05
CRJAN(t-1)FEB(t-1)	543.83	1.31	0.20

Table 13. Description of the Variables for Barley Yield Function for Konya

NPC	Nominal Price Change
CROCT(t-1)JUN(t)	Cumulative monthly rainfall from October in year (t-1) to June in year (t)
DDAK(t)15	Dummy for drought in April, year (t) (1 if rainfall <= 15%, 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 14. The Estimated Barley Yield function for Konya

	R^2= 0.595	AR^2= 0.542	DW= 1.349
Variables	**Coefficient**	**t-value**	**Significant**
CONSTANT	1415.21	4.14	0.00
NPC	4.91	3.67	0.00
CROCT(t-1)JUN(t)	2.13	2.22	0.03
DDAK(t)15	-408.93	-2.81	0.01
DHDAK(t)13.7	-312.07	-1.11	0.27
DHDMK(t)16.3	-284.87	-2.32	0.03

Table 15. 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)
CRJAN(t-1)APR(t-1)	Cumulative monthly rainfall from January in year (t-1) to April in year (t-1)

Table 16. The Estimated Function for Barley Area Sown in Konya

	R^2= 0.117	AR^2= 0.074	DW= 0.279
Variables	**Coefficient**	**t-value**	**Significant**
CONSTANT	199257.53	1.60	0.12
RPBW(t-1)	305464.40	2.30	0.03
CRJAN(t-1)APR(t-1)	245.75	0.66	0.52

The global warming effects to yield (a+c), area sown (b), and total production of Adana wheat and barley (a+b+c) are shown in the following Tables for no EU accession case.

WHEAT ADANA YIELD	Coeff.	Var. Value	Yield 2070's	Estimated Yield 1993-2002	a (%)	c (%)	a+c (%)
CONSTANT	2624,62	1,00	2624,62				
Nominal price change	10,29	73,20	753,23				
DDmay(t)%20	-255,84	0,00	0,00				
DHDApril(t)162	-215,36	1,00	-215,36				
DHDMay(t)235	-580,26	1,00	-580,26				
			2582,23	**3162,49**	**-18,35**	**31**	**12,65**

WHEAT ADANA AREA SOWN	Coeff.	Var. Value	Area Sown 2070's	Estimated Area Sown 1993-2002	b (%)
CONSTANT	199932,10	1,00	199932,10		
Nominal price change	1531,91	73,20	112135,81		
CRSEP(t-1)OCT(t-1)	535,42	43,31	23189,04		
			335256,95	**345713,70**	**-3,02**

	a+b+c (%)
The Total Impact to Adana wheat production	**9,63**

Notes:

1. O=Y*AS, Of=(1+a)*(1+c)*Y*(1+b)*AS=(1+c)*(1+(a+b)+a*b)*Y*AS≒(1+a+b+c)*Y*AS

Def.: Of=future producction. a=a rate of change in yield (Y) caused by weather changes of GW. b=a rate of change in area sown (AS) caused by GW. c=a rate of change in Y caused by CO2 concentration.

2. The values of real and relative prices and of nominal price change to be used for 2070's projection under the condition of no EU accsession are the averages of these corresponding price variables for the period of 1993 - 2002.

BARLEY ADANA YIELD	Coeff.	Var. Value	Yield 2070's	Estimated Yield 1993-2002	a (%)	c (%)	a+c (%)
CONSTANT	2106,94	1,00	2106,94				
Nominal price change	2,30	78,90	181,47				
DDMarch(t)35	-51,29	1,00	-51,29				
DHDApril(t)18,9	-83,83	1,00	-83,83				
DHDMay(t)23,4	-420,48	1,00	-420,48				
			1732,81	**2282,61**	**-24,09**	**30**	**5,91**

BARLEY ADANA AREA SOWN	Coeff.	Var. Value	Area Sown 2070's	Estimated Area Sown 1993-2002	b (%)
CONSTANT	-9912,30	1,00	-9912,30		
Real PriceBARLEY(t-1)	0,13	234646,10	30503,99		
CRJAN(t-1)OCT(t-1)	15,44	316,94	4893,56		
			25485,25	**27607,32**	**-7,69**

	a+b+c (%)
The Total Impact to Adana barley production	**- 1,8**

The global warming effects to yield (a+c) and area sown (b) of Konya wheat and barley are shown in the following Tables.

WHEAT KONYA YIELD	Coeff.	Var. Valu	Yield 2070's	Estimated Yield 1993-2002	a (%)	c (%)	a+c (%)
CONSTANT	1400,67	1,00	1400,67				
Nominal price change	5,07	73,20	371,27				
CROCT(t-1)MAY(t)	1,32	218,65	287,52				
DDApril(t) %20	-318,90	1,00	-318,90				
DHDApril(t)12,8	-205,46	1,00	-205,46				
DHDMay(t)16,3	-171,30	1,00	-171,30				
DHDJune(t)20,7	-267,22	1,00	-267,22				
			1096,59	**2130,70**	**-48,53**	**31**	**-17,53**

WHEAT KONYA AREA SOWN	Coeff.	Var. Valu	Area Sown 2070's	Estimated Area Sown 1993-2002	b (%)
CONSTANT	701373,66	1,00	701373,66		
relativePriceWB(t-1)	206883,04	1,20	248259,65		
CRJAN(t-1)FEB(t-1)	543,83	50,99	27729,79		
			977363,10	**982284,74**	**-0,50**

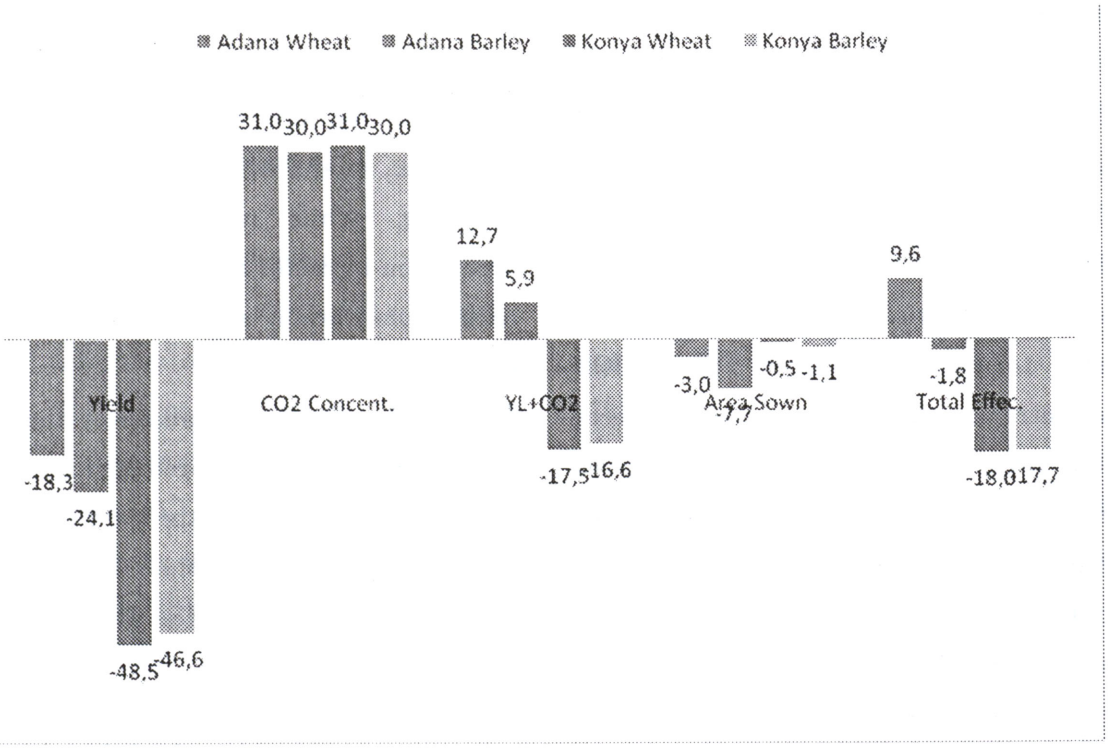
	a+b+c (%)
The Total Impact to Konya wheat production	**- 18,03**

BARLEY KONYA YIELD	Coeff.	Var. Value	Yield 2070's	Estimated Yield 1993-2002	a (%)	c (%)	a+c (%)
CONSTANT	1415,21	1,00	1415,21				
Nominal price change	4,91	78,90	387,48				
CROCT(t-1)JUN(t)	2,13	236,52	503,79				
DDApril(t) %15	-408,93	1,00	-408,93				
DHDApril(t)13,7	-312,07	1,00	-312,07				
DHDMay(t)16,3	-284,87	1,00	-284,87				
			1300,59	**2434,17**	**-46,57**	**30**	**-16,57**

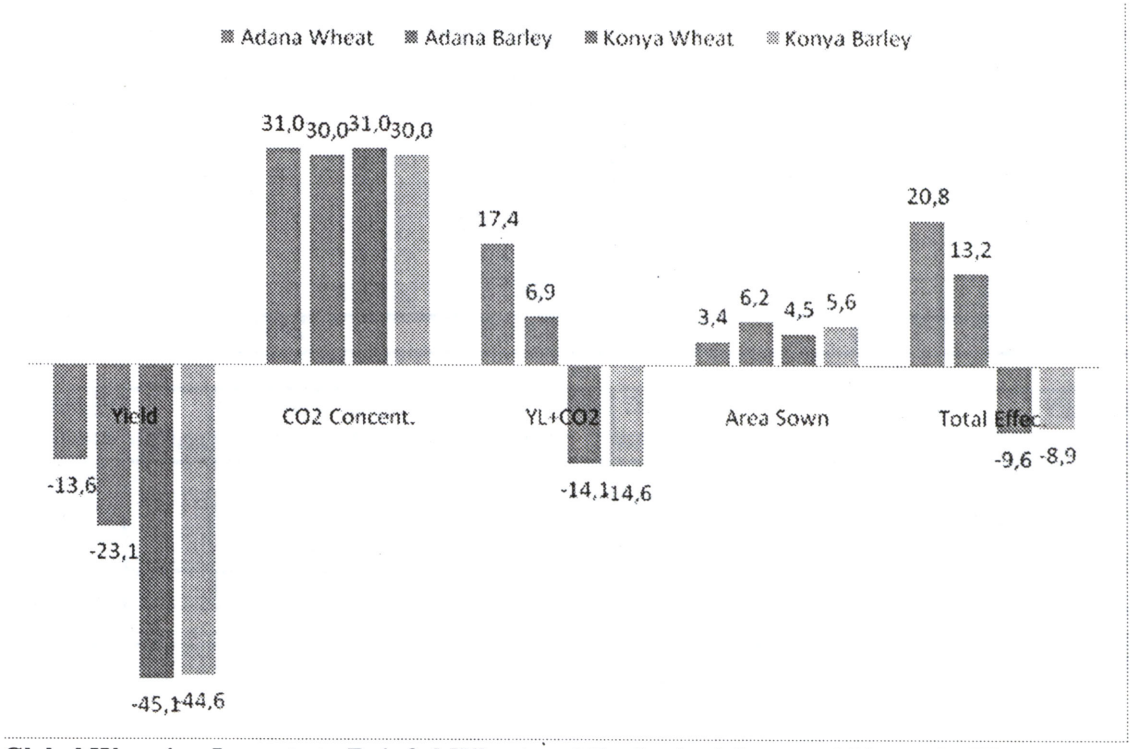
BARLEY KONYA AREA SOWN	Coeff.	Var. Value	Area Sown 2070's	Estimated Area Sown 1993-2002	b (%)
CONSTANT	199257,53	1,00	199257,53		
RelativePriceBW(t-1)	305464,40	0,87	265754,03		
CRJAN(t-1)APR(t-1)	245,75	98,69	24253,46		
			489265,02	494841,18	-1,13

	a+b+c (%)
The Total Impact to Konya barley production	**- 17,70**

For EU accession case, similar global warming effects were calculated, but tables are not shown for saving the space. The summary figures of these effects are shown just below.



Global Warming Impacts to Rainfed Wheat and Barley in Adana and Konya in No EU Accession Case



Global Warming Impacts to Rainfed Wheat and Barley in Adana and Konya in EU Accession Case

3. Conclusion

The economic model predicts both yield effects and area sown effects of global warming in the decade starting in 2070 to wheat and barley in Adana and Konya. The yield effects were predicted by taking into account price effect, drought effect, high temperature effect, and CO2 concentration effect. The area sown effects were predicted by taking into account price effect and soil moisture effect. These predictions were made for two cases, i. e., no EU accession case and EU accession case. In the EU accession case prices used for prediction were assumed to be higher than no EU accession case by the current differences of protection between Turkey and the EU.

The economic model predictions show that wheat and barley production in warmer area, i. e., Adana will benefit from global warming, while wheat and barley production in colder area, i. e., Konya will reduce considerably as shown in Fig 1 and Fig 2.

This result is probably caused by the fact that RCM temperature predicted for 2070 will increase by 21% of the past long-run average in Konya, while the same ratio for Adana is only 14% and the differences of crop varieties between Adana and Konya. So adding the CO2 concentration effect, Adana wheat and barley yields will increase to some extents, while Konya wheat and barley yields will decrease

considerably in both no EU accession and EU accession case under global warming. Area sown effects are all slightly negative in no EU accession case, while the same effects are all slightly positive in EU accession case.

Consequently, the global warming effects to the total production of wheat and barley in Adana are all positive except Adana barley production that is slightly negative in both no EU accession and EU accession cases as shown in Fig 1 and Fig 2. But the global warming effects to wheat and barley production in Konya are all considerably large negative in both no EU accession and EU accession cases. Konya is a large and representative wheat producing province on Anatolian Plateau, and this econometric result suggests fiture severe decline of Turkish wheat food security under global warming.

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