# Chapter 3 The Final Summary of the Socio-economic Sub-group Study of the ICCAP Project

**Hiroshi TSUJII**

**Faculty of Natural Resource Environment, Ishikawa Prefectural University**

**Onur ERKAN**

**Cukurova University**

e-mail: Tsujii@ishikawa-pu.ac.jp

## 1. Introduction

This is the final summary of the research results of the socio-economic sub-group in the ICCAP project regarding the impacts of global warming to cropping pattern, land use and water use in Adana and Konya.

## 2. The Five Components of ICCAP's Socio-economic Study and Their Relationship

There are five components in the ICCAP's Socio-economic Study.

(1) An econometric and agro-climatological study of the impact of global warming and prices to wheat and barley production in Adana and Konya by H. Tsujii, and U. Gultekin.

(2) The new institutional economics analyses of the use of commons such as water and land by farmers, and pastoralists under climatic change and institutional change in both irrigated and rain-fed areas of Turkey by Umetsu and Y. Asami.

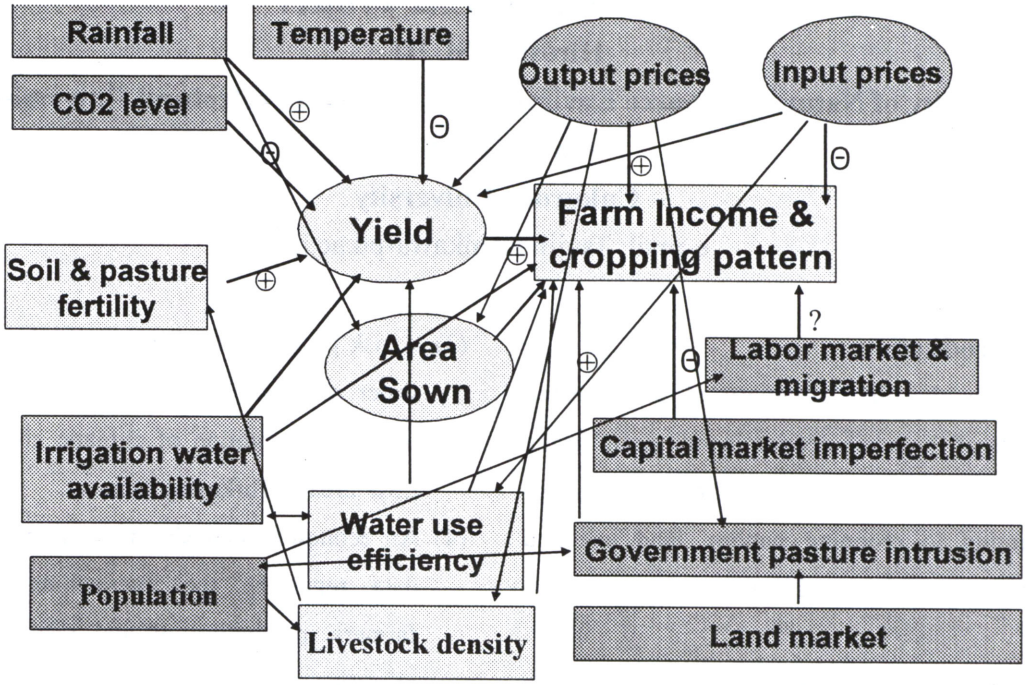
(3) A risk programming analysis of the use of water and crop combination by farmers under the condition of climatic change in LSIP area in Turkey by Umetsu.

(4) An economic analysis of the farm survey data regarding the interactions among farmers' perception of and responses to climatic changes, technological changes, and policy and institutional changes and their impacts to farmers' economy and agricultural sustainability by H. Tsujii, Y. Asami, M. Kusadokoro, T. Maru, O. Erkan, Ufuk Gultekin, C. Oguz, Kenan, Basen, Karayaci, Kan, Avci, Kemaletin Tasdan, Baran, Naciye.

(5) A Country level input-output analysis of interrelations between agricultural sector productivity and climatic change by M. Kagatsume and Sanda.

The variables of these five components are related as shown by the following diagram.

Relationship among the Variables of the Four Components of Socio-economic Sub-group




**3 Main Conclusions of the Socio-economic Research in ICCAP**

Research methodology of the Socio-economic sub-group of ICCAP was described in two methodological and framework papers by H. Tsujii in **The First Interim-report of the Socio-economic Sub-group of ICCAP** published in 2005 (Tsujii, H., 2005a. & Tsujii, H., 2005b.).

In the rain-fed areas in Adana and Konya, an econometric study by Tsujii and Gultekin 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 average temperature, while the same temperature in Adana will increase by only 14%, and that there are large differences in the characteristics of wheat and barley between Adana and Konya. The impacts projection of global warming to yields of wheat and barley include about +30% of yield increase by the increase of CO2 concentration, negative high temperature effects, and drought and soil moisture effects in 2070. The last two effects are found to be very large in Konya.

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 increase by 10%, while the total production of Adana barley will reduce by 2%

under global warming. But, the total wheat and barley production in Konya will decrease by large amounts of 18% and 18% respectively. This may imply a future decline of food security or wheat shortage in Turkey as Konya is a large and representative wheat producing area on the Anatolian Plateau in Turkey.

These reductions of wheat and barley production caused by global warming can be aggravated by the long run soil degradation perceived by most of the farmers surveyed in our farm surveys in Adana and Konya. Our analysis of farmers' perception showed clearly that degrading inherent soil fertility was caused by increasing use of chemical fertilizer and decreasing animal manure input in Adana and Konya. (Tsujii, Kusadokoro, Erkan, and Oguz.. 2005) The short paper on this issue is printed in Chapter 4 in this report. 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 5 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)

From our farm surveys in Adana and Konya and from our risk programming analysis, it was found that global warming with less water availability in the future would be more beneficial to larger and land self-owned farmers in the irrigated area in Turkey as they can diversify the crops they grow to more profitable and less water demanding crops with their higher risk aversion capability comparing with smaller and tenant farmers. Comparing with these farmers, smaller tenant farmers in irrigated area and farmers in rain-fed area will suffer more from global warming as they do not have enough options to adapt their cropping patterns to global warming and enough capability to minimize risk they face during global warming.

In the irrigated area of Adana, Umetsu and others found the following results using their risk programming model. When water availability would decrease under global warming, the farmers in irrigated area would increase land use shares of higher priced commodities, so that they could use scarcer water more efficiently while at the same time minimizing risk of this diversification of their crops. Exactly speaking, the farmers with near real risk aversion behavior standard would

increase the ratio of their land use for watermelon from zero percent in the base case when water is an idle resource to 11% in low water development scenario and 24% in high water development scenario, would decrease cotton land use ratios considerably, and would not change land use ratios of citrus, vegetables, and fruits very much in order for them to obtain desired level of gross revenue and at the same time to restrict risk at an acceptable level when water availability would be reduced by 1 to 5 percent when global warming would take place in 2070.

Erkan and others have recently written a long report summarizing the Turkish side farm survey results concerning farmers' perception about global warming and farmers' responses to global warming in Adana and Konya (Erkan, et al. 2007).

Cennet Oguz and Onur Erkan, Arzu Kan, and Ufuk Gultekin has done logit analysis of their specific farm survey data in order to measure the farmers' responses in their inputs use to weather changes in Konya, Turkey (Onur Erkan, Cennet Oguz, Arzu Kan, and Ufuk Gultekin. 2006.)

We have done farm surveys of about 500 farms in both Adana and Konya during 2002 and 2006 in both irrigated and rain-fed areas. We shall present the results of these farm surveys formally later. But here we like to comment on the results of this risk programming analysis from some results of our farm surveys. We can confirm that Turkish farmers do respond to crop prices and input prices as found in our farm surveys in the case of water melon, maize, cotton, and citrus in the irrigated area of Adana, and in the case of wheat in Adana. Kusadokoro found that farmers do try to averse risk. But they not only averse market risk as it was shown in the above risk response model analysis, but also they try very hard to averse the risk of yield damage caused by continuous planting of a single crop. As we will discuss in detail later, these risk aversion behaviors are closely related to the tenancy situations of the farmers concerned. Thus we think the risk programming model should be modified by taking the tenancy situations into account.

Kagatsume's IO analysis shows that the global warming increases productivity of forestry and fishery sectors greatly, while it increases productivities of grain, fruits, and livestock sectors moderately.

Kusadokoro has predicted the farmers' future cropping patterns under global warming using our farm survey data taking into farmers' tenure status, and analyzed the risk response behavior of farmers using district level time series crop data for Adana. He concludes that in Adana small tenants will be most severely affected by global warming since they have to change their cropping pattern of wheat and maize to vegetables that are very risky. Maze will not be an appropriate crop under global warming. He also found that risk response by farmers was very large.

Maru analyzed the relationship between global warming and feeding types, growth stages of livestock, milk yield, and growth of livestock in Adana.

Asami described the recent fast destruction of government pasture by its illegal conversion by farmers and its overgrazing and analyzed the effectiveness of new Pasture Law for the reduction of illegal government pasture conversion.

## 4. 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 5 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)

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

The Tsujii and Ufuk's, 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.

**4.2 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 descriptions and the estimated yield and area sown functions for Adana and Konya are not shown here because of space problem.

**4.3 An econometric and agro- climatological study of the interactions among production and prices of wheat, barley and other major crops, weather variables, and climatic change in Konya and Adana.**

In this study Tsujii and Gultekin presented a result of their historical econometric analysis of the effects of the negative yield effect of high temperature (heat damage), drought, and output prices to wheat and barley production, and the evaluation of the impacts of heat damage, drought, output prices, and atmospheric CO2 concentration of global warming to these crops in Adana and Konya for 2070 utilizing the estimated yield and area sown functions for wheat and barley in these areas and the RCM climatic projection by Dr. Kimura. In the near future, we shall estimate models for other important crops in Adana and Konya, considering the interdependences between these crops, and analyze the impacts of global warming to the farmers' behavior concerning cropping pattern, land use and water use.

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** |

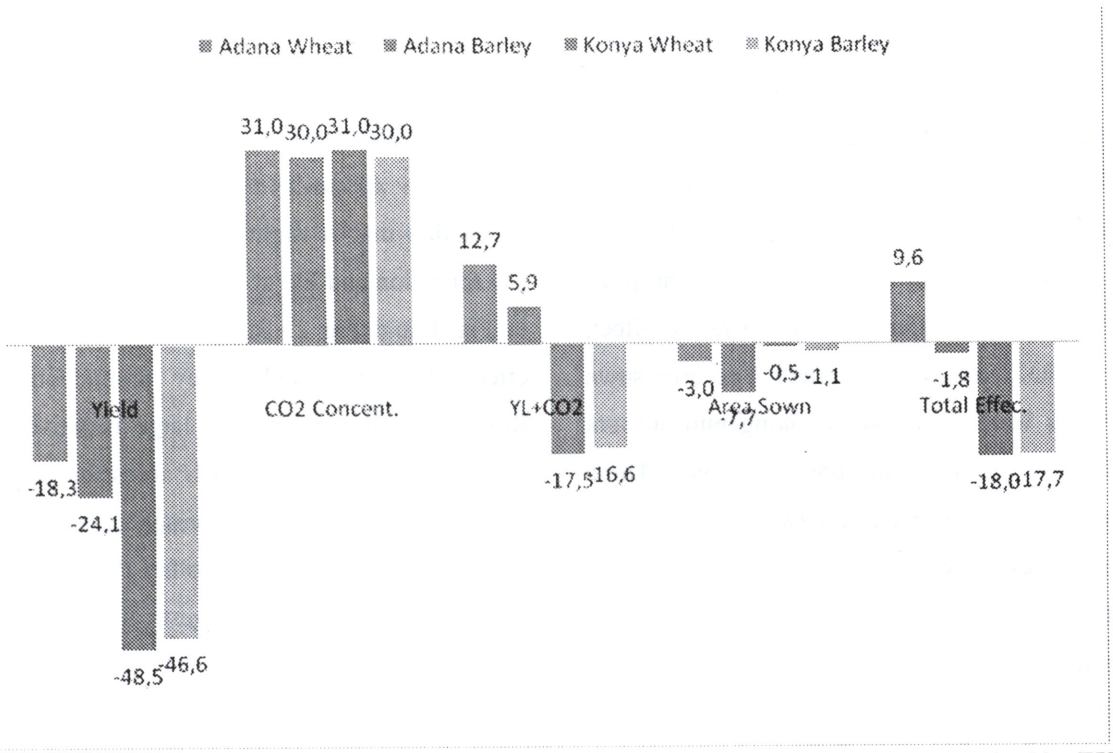
| | a+b+c (%) |
|---|---|
| **The Total Impact to Konya wheat production** | **- 18,03** |

| 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** |

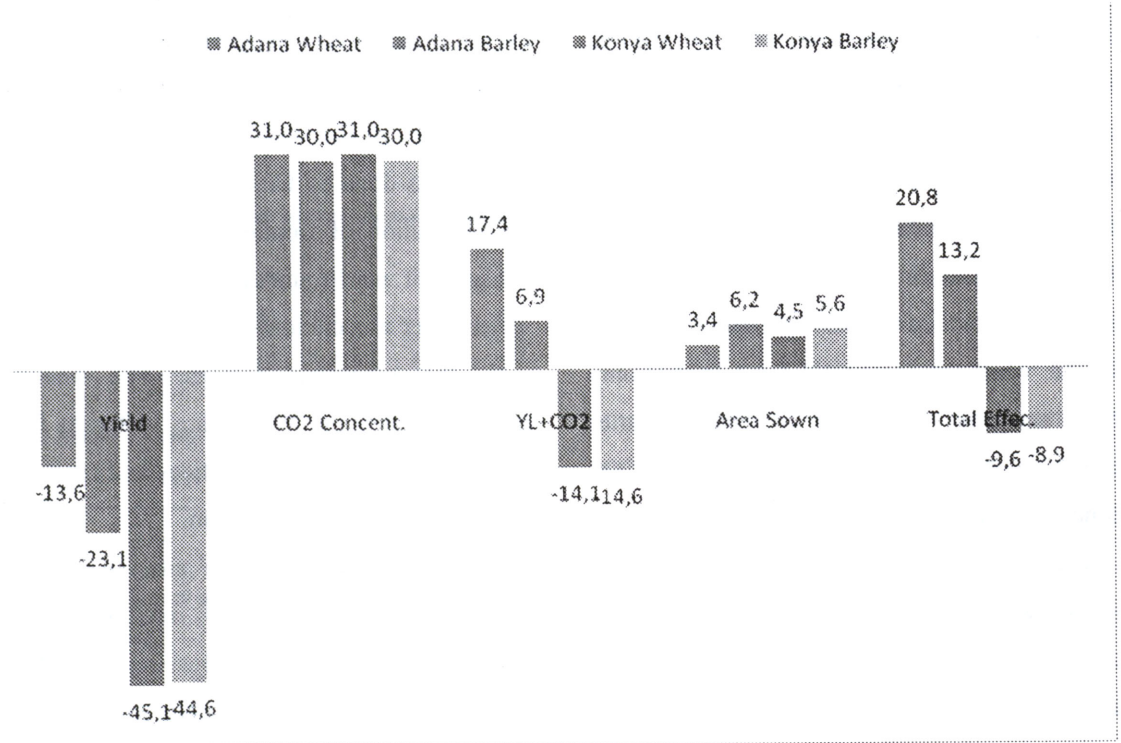
| BARLEY KONYA AREA SOWN | Coeff. | Var. Value | Area Sown 2070's | Estimated Area Sown 1993-2002 | b (%) |
|---|---|---|---|---|---|
| CONSTANT | 199257,53 | 1,00 | 199257,53 | | |
| RelativePriceBW(t-1) | 305464,40 | 0,87 | 265754,03 | | |
| CRJAN(t-1)APR(t-1) | 245,75 | 98,69 | 24253,46 | | |
| |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

### 4.4 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.

## 5 The new institutional economics analyses of the roles of the water users' associations (WUAs) and a risk programming analysis of farmers' choice of cropping patterns.

A survey of the water users' associations in Adana was done by Umetsu in 2003. Based on an application of frontier production function analysis, it was found that the efficiency of water users' associations in LSIP was compared with the emerging options. The analysis revealed that some WUAs are suffering from inefficient management practices and there is a scope for major reorganization.

A numerical optimization analysis of crop combination in Adana by maximizing the expected value of the total gross revenue of the crops grown minus covariance matrix of crops' revenue multiplied by risk aversion parameter of the farmers was done by Umetsu and others in 2005. Table 5-8 shows the simulation results

of four cases. These tables indicate the land allocation to various crops in LSIP with risk aversion parameter (RAP) between 0 and 0.02. When RAP is 0, farmers do not avoid any risk. Higher the RAP, the risk averse attitude of farmers become stronger. Table 5 shows the base case under current water use level (585 mm water availability per annum). When farmers do not care any risk (when RAP=0), the area under citrus and vegetable is 82.3% and 17.7% of the total irrigated land of LSIP with average gross revenue of 1,981 YTL per decare. At the risk aversion level of 1%, area under citrus, cotton, vegetables and fruit is 22.0%, 59.3%, 7.0% and 11.6% respectively. This cropping pattern yielded average gross revenue of 718 YTL per decare at 2005 price. Considering that the actual gross revenue per decare was 707 YTL in 2002 at 2005 price (Table 1), the risk aversion level of farmers in LSIP may be close to 1%. In other words, farmers in LSIP will not likely to accept the gross revenue per decare lower than 2002 level. High risk aversion parameter of 2% yielded low gross revenue per decare because high risk aversion parameter means more reduction of gross revenue from the annual variability between study periods. In the base case under risk aversion level of 1% and 2%, water resources are still under utilized resulting in redundant or idle water resources of 23.5 mm/year and 75 mm/year respectively. This means that in these cases, water is not the constraining factor to allocate land in the model.

Similarly Table 6 shows the simulation results of the climate change case under low water development scenario in the 2070s (580 mm water availability per annum). This case may be considered the pure impact of climate change by giving other social conditions remain

**Table 5. Land allocation in LSIP under base case (585 mm water availability)**

| RAP | 0 | 0.001 | 0.005 | 0.01 | 0.02 |
|---|---|---|---|---|---|
| citrus | 82.27 | 82.27 | 57.45 | 22.00 | 4.12 |
| cotton | | | 17.91 | 59.33 | 70.31 |
| vegetables | 17.73 | 17.73 | 1.97 | 7.04 | 9.41 |
| watermelon | | | 11.72 | | 5.43 |
| fruit | | | 10.95 | 11.63 | 10.74 |
| gross revenue (YTL/da | 1981 | 1770 | 1022 | 718 | 547 |
| shadow price of water | 2.926 | 2.313 | 0.085 | | |
| idle water (mm) | | | | 23.51 | 74.96 |

RAP: Risk Aversion Parameter

**Table 6. Land allocation in LSIP under low water development scenario1 (580 mm water availability)**

| RAP | 0 | 0.001 | 0.005 | 0.01 | 0.02 |
|---|---|---|---|---|---|
| citrus | 60.38 | 60.71 | 56.94 | 21.84 | 4.12 |
| cotton | | | | 49.68 | 70.31 |
| vegetables | 39.62 | 37.14 | 0.32 | 6.63 | 9.41 |
| watermelon | | 2.15 | 35.11 | 11.32 | 5.43 |
| fruit | | | 7.63 | 10.53 | 10.74 |
| gross revenue (YTL/da | 1704 | 1538 | 1014 | 716 | 547 |
| shadow price of water | 2.644 | 2.319 | 0.151 | 0.06 | |
| idle water (mm) | | | | | 23.48 |

RAP: Risk Aversion Parameter

**Table 7. Land allocation in LSIP under high water development scenario2 (535 mm water availability)**

| RAP | 0 | 0.001 | 0.005 | 0.01 | 0.02 |
|---|---|---|---|---|---|
| citrus | 50.98 | 52.34 | 55.71 | 21.86 | 4.13 |
| cotton | | | | 38.57 | 65.00 |
| vegetables | 49.02 | 38.83 | 0.13 | 5.71 | 8.97 |
| watermelon | | 8.84 | 42.60 | 24.32 | 11.64 |
| fruit | | | 1.56 | 9.54 | 10.27 |
| gross revenue (YTL/da | 1585 | 1433 | 1003 | 713 | 547 |
| shadow price of water | 2.644 | 2.382 | 0.333 | 0.083 | 0.022 |
| idle water (mm) | | | | | |

RAP: Risk Aversion Parameter

**Table 8. Land allocation in LSIP under high water development scenario2 with region IV complete (431 mm water availability)**

| RAP | 0 | 0.001 | 0.005 | 0.01 | 0.02 |
|---|---|---|---|---|---|
| citrus | 29.25 | 32.97 | 38.17 | 21.90 | 4.17 |
| cotton | | | | 12.89 | 39.32 |
| vegetables | 70.75 | 42.73 | 3.56 | 3.58 | 6.84 |
| watermelon | | 24.30 | 58.27 | 54.38 | 41.70 |
| fruit | | | | 7.25 | 7.98 |
| gross revenue (YTL/da | 1310 | 1177 | 934 | 701 | 539 |
| shadow price of water | 2.644 | 2.529 | 1.031 | 0.137 | 0.129 |

RAP: Risk Aversion Parameter

the same. The reduction of water availability and the increase of water requirement of crops resulted in lowering citrus production (21.8%) and cotton production (49.7%) which are relatively water intensive, and increasing watermelon production (11.3%) which is relatively high value and high income variability with less water intensity, at 1% risk aversion level. At lower risk aversion level between 0 and 0.05%, vegetable cultivation expanded. Compared to the base case at the same risk aversion level of 1%, the gross revenue per decare decreased from 718 YTL to 716 YTL (both at 2005 price). This may indicate the situation that in face of climate change in the 2070s when farmers want to avoid yielding lower gross revenue per decare, they may have to take a higher risk. The impacts of climate change with other conditions remains the same is not very substantial. At 1% and less risk aversion level, water resources are no more idle resource generating positive shadow prices for water.

Table 7 shows the simulation results of the climate change case under high water development scenario in the 2070s (535 mm water availability per annum). In this case, not only because of the climate change but also the expansion of irrigated area in middle and upper watershed of Seyhan River, the potential water availability for LSIP is further reduced substantially compared to the previous two cases. As a result, at risk aversion level of 1% watermelon further expanded to 24.3% while cotton (38.6%) and vegetable (5.7%) reduced the acreage. When the canal infrastructure in region IV at the downstream is completed in the 2070s, the entire LSIP has to endure with the irrigation water level of 431 mm per annum (see Table 8). In this case, watermelon (54.4%), citrus (21.9%), cotton (12.9%), fruit (7.3%) and vegetables (3.6%) are cultivated. Under the water constraint and variability of gross revenue, farmers are more likely to choose high value added crops relative to water requirement such as watermelon, citrus, cotton, fruit and vegetables. This trend has a similarity with the earlier Delphi forecast by WUA staff members that preferred high value crops such as citrus and vegetables. However this combination of crops will result in 701 YTL per decare, lower than the current level of 718 YTL per decare at 2005 price.

The increasing shadow price of water by decreasing potential water availability in LSIP indicates the increasing scarcity of water resources in the future. At 1% risk aversion level, shadow price of water is 0.06 YTL/mm or 3.48 YTL per decare under low water development case (580mm). The shadow price further increases to 44.4 YTL per decare (535mm) under high water development case and 59 YTL/da (431mm) under high water development case with completed canal networks in region IV. Thisanalysis tried to assess the regional impacts of climate change on agricultural production systems by estimating the potential water availability and crop irrigation water requirement in the 2070s and simulating the possible cropping pattern and the farmer welfare in Lower Seyhan Irrigation Project (LSIP) in Turkey. We used

expected value-variance (E-V) model that is used to analyze risk. The model maximizes total gross revenue of agricultural production in entire LSIP according to the risk aversion coefficient. Under the water constraint and variability of gross revenue, farmers are more likely to choose high value added crops relative to crop water requirement such as watermelon, citrus, cotton, fruit and vegetables. However in the case of climate change case under high water development scenario this combination of crops will result in 701 YTL per decare, lower than the current level of 718 YTL per decare at 2005 price. Also the future increases in variability of rainfall may affect negatively to the farmer welfare by decreasing gross revenue per unit of land.

Several hypothetical risk aversion levels of the farmers, and hypothetical irrigation water deficiency levels related with global warming were assumed, and hypothetical numerical calculation was conducted. Naturally it was found that risk aversion levels affected optimal crop combination. Irrigation water abundance was also found to be an important characteristic of Adana agriculture.

**6 An economic analysis of the farm survey data regarding the interactions among farmers' perception of and responses to climatic changes, technological changes, and policy and institutional changes and the impacts of climatic change to farmers' behavior.**

Farm surveys were conducted in Adana and Konya by Japanese and Turkish graduate students in 2002, 2003, 2004, and 2006. The collected data from earlier farm surveys were input and analyzed. Turkish Socio-economic sub-group in cooperation with Tsujii has done farm survey in Adana and Konya regarding farmers' perception of climatic change and their responses to the perception in 2005. As Japan side has done similar farm survey during last three years, both sides try to analyze the collected data and to integrate the result now. Three master theses using the results of the farm surveys were written by the Japanese students in February 2003, and another master thesis was written in February 2004.

Several 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 sought in the research projects of Hiroshi Tsujii conducted in Nigeria, Tanzania, Indonesia, and Japan using the farm questionnaire similar to the one used in Turkey. English papers by Tsujii and others have been published and were accepted by international journals.

Early this year Kusadokoro, Maru, Erkan, Gultekin, Tsujii and others have conducted farm survey in the following villages in Adana.

Irrigated Villages

- Geçitli (Yüreğir District; 26Households)
- Gerdan (Seyhan District; 25Households)

Rain-fed Villages

- Yeniyayla and Cihadiye (Yüreğir District; 28Households)

- Boztahta (Aladağ District; 27Households)

Tsujii, Cennet, Erkan, Kenan and others conducted farm survey of about 30 farms in Cesimilesevile(rainfed) and Arikoren(irrigated) in Konya, and we conducted farm survey of about 40 more farms in these villages and in Yaglibayat this year soon.

We shall summarize the results of our analysis of farm surveys data, based mainly on past Kusadokoro and Maru's papers. Based on the information collected from this survey, from earlier surveys of ours, and other sources Kusadokoro concluded as follows:

1. The dominance of cotton and wheat in Adana before 1975 had been changed, and wheat has become the dominant crop by the decline of cotton price and increasing shortage of cotton harvesting labor.

2. Thus in the rain-fed area of Adana wheat and cotton rotation had ceased and wheat monoculture was established and the inherent soil fertility has decreased. This decline has been compensated by modern inputs.

3. After 1990 in the rain-fed area of Adana shortage of grazing grass caused mainly by overgrazing and partially by illegal conversion of the government pasture land to crop land by farmers led wheat and barley rotation be adopted by the farmers there in which barley was fed to animals. This has enforced crop and livestock integration and the wheat and barley rotation contributed to soil fertility maintenance.

4. In the irrigated area in Adana, maize and citrus have become important as the factories for sweetening and citrus juice were established, and new maize varieties were introduced after cotton production had disappeared. Single cropping of wheat , maize, and other field crops became popular and was adopted by large owner farmers because they prefer better soil fertility conservation by half year fallow of the single cropping.

5. The double cropping of wheat and maize has become popular among tenant farmers in the irrigated area of Adana. This system is soil fertility depleting, but tenant farmers are not much concerned about this problem, and preferred this system because it has higher land productivity than the single cropping.

6. Citrus is planted widely in Adana. Since it is a perennial crop, tenant farmers cannot plant this crop as tenancy of irrigated land is annually contracted in Adana.

7. Vegetables, especially watermelon is very popular among tenants and small farmers in the irrigated area of Adana, because tenants can evade continuous cropping problem of vegetables by changing the rented land every year, and the vegetables have the highest land productivity among the crops discussed here.

## 7. Impact of climatic change to agricultural and national economy by the IO Analysis

In this research, the following analyses were carried out during 2004 and 2005.

(1). Generation of Agriculture based IO table in 3 time point (1985, 1990, 1996)

(2). Prediction of time series IO coefficients and output shares by RAS method and the Markov Transition Probability Matrix.

(3). Simulation on the effects of weather

change on productivities.

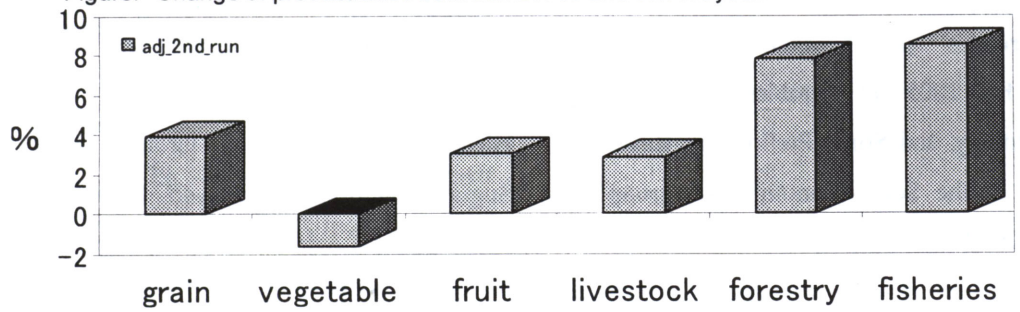
(4). Simulation on the effects of climatic change on productivities.

(5). Simulation on the effects of the EU accession on production amount.

(1) to (3) were done in 2004. More or less good estimation result between the time series IO coefficients and weather variables were obtained.

Then changes in the productivities of major agricultural sectors in Turkey from now to 2070 are calculated using the predicted changes in the May rainfall and temperature in Konya and in May temperature and December rainfall in Adana from now to 2070 in Dr. Kimura's RCM calculatuion. The result of this simulation is shown in the next figure.

Figure. Change of productivities between 2070s and current year.




This figure shows that the productivity of forestry and fishery sectors increases most, while it of grain, fruits, and livestock sectors increases moderately as global warming will occur. This is may be because the products of last three sectors are produced under more protected condition than it in the forestry sector. The predicted increase of grain sector productivity in this study does not necessarily contradict with Tsujii & Gultekin's prediction in the Econ group study of decrease in wheat and barley production, because productivity and production are different concepts. The predicted decrease in the vegetable sector productivity can not be explained at the present time.

Then the effects of Turkey's accession to the EU are estimated for 2073, by estimating and using the Markov transition probability matrix based on 85 and 96 agricultural IO matrices, and adjusting production amount shares according to the EU's help to Turkey during pre-accession period and fishing quota following the ICCAT. Much sharper increases in the product shares for fruit and vegetable sectors, and much sharper decreases in the product shares for gtrain and livestock sectors comparing with the non-accession scenario were estimated for the period from now to 2073.

## ACKNOWLEDGEMENTS

This study was a part of result of an economic research sub-group of the ICCAP (Impact of Climate Change on Agricultural Production System in Arid Area). It is a collaboration research between Japanese and Turkish researchers in many disciplines. This project was supported by the RIHN (Research Institute for Humanity and Nature) in Japan and TUBITAK (The Scientific and Technical Research Council of Turkey) in Turkey.

**6. References**

Tsujii, H., 2005 a.: "Problems, Objectives, Methodology, and Some Preliminary Research Results of the Socio-economic Sub-group of the ICCAP Project," Chapter 1 in Tsuii, H., ed. ***An Economic and Institutional Analysis of the Impacts of Climatic Change on Agriculture and Farm Economy in Eastern Mediterranean and Central Anatolia Regions in Turkey***: The First Interim Report of the Socio-Economic Sub-group of ICCAP. Kyoto: The Research Institute for Humanity and Nature. pp. 5-11.

Tsujii, H., 2005 b.: "A Methodological Framework for Analyzing Farmers' Perception of, and Responses to Climatic Change Using the Farm Survey Data of the Socio-economic Sub-group of the ICCAP Project." Chapter 2 in Tsujii, H., ed. ***An Economic and Institutional Analysis of the Impacts of Climatic Change on Agriculture and Farm Economy in Eastern Mediterranean and Central Anatolia Regions in Turkey***: The First Interim Report of the Socio-Economic Sub-group of ICCAP. Kyoto: The Research Institute for Humanity and Nature. pp. 12-15.

Tsujii, H. ed., 2005: "An Economic and Institutional Analysis of the Impacts of Climatic Change on Agriculture and Farm Economy in Eastern Mediterranean and Central Anatolia Regions in Turkey." ***An Interim Report of the Socio-Economic Sub-group of ICCAP.*** The Research Institute for Humanity and Nature.

Hiroshi Tsujii, Ageng Herianto, and Siti Sugiah Muchfud Mugniesyah, May 2003: "A Multinomial Logit Analysis of Agroforesters' Perception of Plot-wise Soil Fertility and Soil Mining - Fast Expansion of Leaf Banana in a Mountainous Village of West java -," in Y. Hayashi, Syafrida Manuwoto, and Slamat Hartono, eds., ***Sustainable Agriculture in Indonesia***, Gadja Madah Univeisty Press, pp.295-316.

Chianu, Jonas Nwankwo, Hiroshi Tsujii and Joseph Awange. April, 2006. "Environmental Impact of Agricultural Production in the Savannas of Northern Nigeria." ***Journal of Food, Agriculture & Environment***, Vol. 4, No. 2, pp. 255-260.

Hiroshi Tsujii, Motoi Kusadokoro, Onur Erkan, and Cennet Oguz. 2006. "Farmers' Long Run Perception of Inherent Soil Fertility and Their Responses in Fertilizer Application in Adana

and Konya, "To be included in ***The Final Report of the Socio-economic Sub-group of ICCAP*** published in March 2007.

Motoi Kusadokoro. 2004. ***The impacts of credit rationing to farmer's behavior in Adana.*** MS thesis. The Graduate School of Agriculture, Kyoto University.

Takeshi Maru. 2004. ***The development of animal manure market in Konya. MS thesis.*** The Graduate School of Agriculture, Kyoto University.

M. Gulnur. 2003. ***Emancipation of rural female labor.*** MS thesis. The Graduate School of Agriculture, Kyoto University.

Kondoh. 2003. Resource economics of sugar beat in Konya. MS thesis. The Graduate School of Agriculture, Kyoto University.

Onur Erkan, Ufuk Gultekin, and Cennet Oğuz. 2007. ***Impacts of climatic Change to Agricultural Production in Arid Areas: Ecnomic analysis of Climatic Change and Agricultural Production Systems and Identification of Policy Institutional Measures in Cukurova and Central Anatolia Regions.*** p. 95.

Onur Erkan, Cennet Oğuz, Arzu Kan, and Ufuk Gültekin. 2006. ***Measuring the Effect of the Change in Climatic Condition on Input Use on Agriculture in Konya, Turkey.***