

The Progress and Outcomes of the ICCAP Turkish Team

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1. Introduction

The ICCAP Project is a multidisciplinary cooperative research project with Japanese and Turkish scientists on the effect of climatic change in the Mediterranean region. After implementation of the memorandum between Research Institute for Humanity and Nature (RIHN) and Scientific and Technical Research Council of Turkey (TÜBİTAK), ICCAP was launched in July, 2002. TÜBİTAK which supports many scientific works on the environmental problems such as soil, water and atmospheric pollutions, global warming and climatic change cooperated with RIHN to investigate the possible impacts of climatic change and adaptation of agricultural production systems and to extract the historical knowledge of the climatic change in the Seyhan and Ceyhan River basins. In these projects, land and water management and relationship between natural system and social life were considered. Its main objective is to investigate the effects of climate variability and changes on agricultural production system such as farmland development, irrigation and drainage, cropping system, farm management, water balance and water circulation in arid conditions.

The area under consideration is Seyhan river basin placed in the eastern part of the Mediterranean Region of Turkey. The entire basin including upstream-mountains and downstream-delta covers 19,300 km² of catchment area. The Mediterranean climate prevails with wet winters and dry and hot summers, with an annual precipitation of 640 mm. More than 120,000 ha areas is under irrigation in Lower Seyhan Irrigation Project (LSIP) area.

The region can change the interactions of land,-sea and atmosphere due to its topographic character. The complex topography of the region causes large gradients in the land use and the distribution of water and in the interaction of the process at the different scales. The main crops are wheat, maize, citrus, vegetables, cotton, etc. The Seyhan river basin has some agro-systems such as rain-fed agriculture and irrigated agriculture and stock farming/pasture. Additionally, the region is also one of the richest regions in the world in respect to biological diversity.

2. Works and Role of the Turkish Team

TÜBİTAK has established a special network of scientists from different universities and institutions to take part at this project. In addition to scientists from Cukurova (Adana), Mustafa Kemal (Antakya), Selcuk (Konya) and Hacettepe (Ankara) Universities, some researchers from State Hydraulics Works (DSİ), General Directorate of Meteorological Organization (MGM) and General Directorate of Village Affairs (KHGM) are working. Totally, 52 scientists from Turkey and 37 scientists from Japan and 7 researchers from other countries are working in ICCAP. As a part of the agreement with RIHN, more than 25 persons have been invited to Japan to work on parts of the project with their copartners or to attend to the workshops.

Research organization is established by a network of steering committee, advisers, coordinators, and sub-groups. Steering committee in Turkey has been formed by TOGTAG (Agriculture, Forest and Food Technologies Grand Committee) of TÜBİTAK, Turkish coordinator and one member from the-group.

There are six major topics, namely climate, vegetation, hydrology, plant productivity, irrigation, and socio-economics. The sub groups are formed according to major topics of ICCAP project. The plant productivity consists of two minor divisions, on-farm dynamics (C/N Budget) and micrometeorology (SWAP) group.

In order to meet the project objectives measurements and observations are being done throughout the year in points of interest of the basin and its neighboring areas. Some part of the scientific activities are carried out in the irrigated areas of the Seyhan River Basin, while others are in rain-fed areas placed on the upper side of the basin.

3. The Progress and Outcomes of the Turkish Team

a. Crop Productivity Sub-Group

This subgroup has two groups- SWAP and C/N-Budget which have worked independently of each other. Each group's results are presented separately:

Results of SWAP Group

The objective of this study is to determine the effect of soil properties, water regime (precipitation and plant water use) and climate parameters on the plant growth and yield using simulation models. The studies are carried out in Seyhan Plain in existing and global (or local) conditions. Various models were used in comparison to determine wheat and maize evapotranspiration.

Evapotranspiration of wheat and maize plants was determined using water balance method and Bowen Ratio Energy Balance (BREB) Method. Crop growth parameters such as leaf area index (LAI), biomass, plant height, plant root system and harvest index (HI) were all measured or calculated. Additionally, wheat studies were carried out to determine the behavior of wheat under normal (NT: normal temperature, sowing at the current sowing date) and high

temperature regimes (HT: high temperature, sowing at a later date when the main air temperature is increasing in spring). Field experiments were conducted under rain-fed (RF) and irrigated (IR) conditions, to distinguish and to determine the effects of drought and high temperature.

From the results it can be concluded that SWAP model can be used successfully both for wheat and maize in estimating actual evapotranspiration and crop growth parameters.

Wheat studies showed:

- Future grain yield decreases due to increased temperatures are to be expected more drastically under rain-fed conditions.
- Grain yield reductions due to increased temperatures will occur even under irrigated conditions.
- Grain yield reduction due to increased temperatures is related more to the reduced number of grains per ear.
- Adverse effects of higher temperatures on the number of grains per ear were due to both the reduced number of spikelets and to the reduced number of grains per spikelets.
- Grain set seems to be the most sensitive process against higher temperatures.
- Grain weight increases were not sufficient to compensate for the reduced grain number.
- The effect of high temperatures on floret survival is to be focused in future.

Same studies were done to determine photosynthesis and productivity of first and second crop maize.

- Reduced grain yield of the second crop was related to the lower grain weight
- Lower grain weight resulted in reduced photosynthetic activity by short growing period.

Results of C/N Group

The 4-year project results of the C/N group are published in 2 Science Citation

Index articles which summarizes the works done.

- First article in Journal of Environmental Monitoring: Spatial and Temporal Variations in Diurnal CO₂ Fluxes of Different Mediterranean Ecosystems in Turkey by F. Evrendilek, J. Ben-Asher, M. Aydın & I. Celik: Diurnal rates of net CO₂ assimilation (PN) and soil respiration (Rh) in the summer were measured in six Mediterranean ecosystems through an automatic continuous monitoring system (PM-48M). The six sites include a typical evergreen *Pinus pinea* L. forest with two co-occurring sclerophyllous shrubs (*Pistacia terebinthus* L. and *Phillyrea latifolia* L.), citrus (*Citrus limon* L.), corn (*Zea mays* L.), cotton (*Gossypium hirsutum* L.), soybean (*Glycine max* L.) and vineyard (*Vitis vinifera* L.) and measurements were carried out in the Seyhan watershed along south-to-north and east-to-west transects. All six sites exhibited similar behaviors in that low soil water availability and high evaporative demand not only depressed PN and Rh, but also changed the diurnal time course of their peak rates. PN of all the species except for *P. terebinthus* and corn, peaked in the morning (7:30–9:30), and Rh in all the sites were higher during the night than during the day ($p < 0.05$). Mean rates of net ecosystem emission (NEE) of CO₂ to the atmosphere were highest ($-23.9 \mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$) in the corn site and lowest ($-0.6 \mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$) in the vineyard site. On average, all six ecosystems were a net source of CO₂ to the atmosphere, due to Rh effluxes exceeding PN influx. The dependence of diurnal PN and Rh on water vapor pressure deficit and soil water deficit for dry and hot summer days appeared to be major and needs to be re-examined for biogeochemical models of climate change effects on

CO₂ dynamics of Mediterranean ecosystems.

- Second article in Environmental Monitoring and Assessment: Quantifying Carbon Budgets of Conifer Mediterranean Forest Ecosystems, Turkey by F. Evrendilek, S. Berberoğlu, S. Taşkınsu-Meydan & E. Yılmaz: Aboveground biomass, aboveground litter fall, and leaf litter decomposition were measured. Measurements were carried out in an eastern Mediterranean evergreen needleleaf forest, Katran Çukuru-Aladağ. Five indigenous tree stands were pure stands of [1] *Pinus brutia*, [2] *Pinus nigra*, [3] *Cedrus libani*, [4] *Juniperus excelsa*, and a mixed stand of [5] *Abies cilicica*, *P. nigra*, and *C. libani*. Results showed that mean C stock of the conifer forests was estimated as $97.8 \pm 79 \text{ Mg C ha}^{-1}$ consisting of $83.0 \pm 67 \text{ Mg C ha}^{-1}$ in the aboveground and $14.8 \pm 12 \text{ Mg C ha}^{-1}$ in the belowground biomass. The forest stands had mean soil organic carbon (SOC) & nitrogen (SON) stocks of $172.0 \pm 25.7 \text{ Mg C ha}^{-1}$ and $9.2 \pm 1.2 \text{ Mg N ha}^{-1}$, respectively. Mean total monthly litterfall was $376.2 \pm 191.3 \text{ kg C ha}^{-1}$, ranging from $641 \pm 385 \text{ kg C ha}^{-1}$ for *Pinus brutia* to $286 \pm 82 \text{ kg C ha}^{-1}$ for *Cedrus libani*. Decomposition rate constants (k) for pine needles were 0.0016 for *Cedrus libani*, 0.0009 for *Pinus nigra*, 0.0006 for the mixed stand, and 0.0005 day⁻¹ for *Pinus brutia* and *Juniperus excelsa*. Estimation of components of the C budgets revealed that the forest ecosystems were net C sinks, with a mean sequestration rate of $2.0 \pm 1.1 \text{ Mg C ha}^{-1} \text{ yr}^{-1}$ ranging from $3.2 \pm 2 \text{ Mg C ha}^{-1}$ for *Pinus brutia* to $1.6 \pm 0.6 \text{ Mg C ha}^{-1}$ for *Cedrus libani*. Mean net ecosystem productivity (NEP) resulted in sequestration of $98.4 \pm 54.1 \text{ Gg CO}_2 \text{ yr}^{-1}$ from the atmosphere when extrapolated for the entire study area of 134.2 km^2 ($\text{Gg} = 109 \text{ g}$). The quantitative C data from the study revealed the significance of

the conifer Mediterranean forests as C sinks.

- Detection of temporal and spatial changes in land uses & land covers through GIS and Remote Sensing is being done to finalize the project of the C/N group.

b. Hydrology Sub-Group

- The Adana alluvial plain constitutes the major groundwater resources in the Seyhan River Basin.
- The conceptual model was transferred to the mathematical models following the hydrogeological characterization of the Adana alluvial plain. Sea water intrusion was also considered in the conceptual model. In addition to the groundwater flow model, the seawater intrusion was also transferred to a mathematical model and run together with the groundwater flow model. MODFLOW was used to simulate the groundwater flow while the sea water intrusion was simulated by SEAWAT-2000 integrated with MODFLOW.
- Following calibration runs, the models were run to simulate the groundwater flow and solute transport (sea water intrusion) for two climate change scenarios. The vulnerability of the plain aquifer system was then evaluated and interpreted in terms of ground water potential and quality.
- Simulations described above produced results in the form of head and concentration distributions for 80 years.
- The results revealed that changes in hydro-meteorological conditions and water consumption affect the head distribution significantly. Similarly, sea water intrusion will pose a problem. Finally the water budget components are calculated by the model.

c. Irrigation Sub-Group

Predicted climate changes are taken into account in evaluating the observed

changes in the irrigated areas of Lower Seyhan Plain and these changes are being modeled along with the evaluation of the performance of irrigation and drainage systems in Lower Seyhan Plain. Most of the problems are caused by diversifying cropping pattern and increased water demand, excessive water use and high groundwater table partly caused by over irrigation.

Studies showed that:

- Changing to a high water demand crop caused high irrigation water demand in recent years
- An increasing trend, in the gross irrigation depth, in the recent years was determined in the study area. The gross irrigation depth (irrigation intake at the Seyhan Regulator divided by the total irrigated area) of the Lower Seyhan Irrigation Project LSIP- was exceeding 1000 mm and irrigation efficiency was below 50%. Main reasons for this low efficiency are a) the leakage from canals, b) incorrect design of the canals causing the high loss of the tail water, c) diversified crop pattern, d) inexperience of irrigation technicians and e) the over-use of the water in the farm land
- Historical increase of the groundwater level is not significant
- Saline areas have decreased in irrigated areas.
- Some part of 4th stage (area not served by irrigation network) area were affected by severe soil salinity
- The results obtained in the irrigated area, indicated that the groundwater salinity has continuously decreased in the past 20 years in the upper and middle parts of the plain and that the salts were most probably leached out of the system through the drainage. However there still exist some saline areas in the southern part of the plain, close to the end of the irrigation infrastructure.
- Degree of soil salinity depends on its land use
- Salinity problems in the lower delta

- Evaluation of the monthly groundwater fluctuations shows similar patterns in all different elevations and a flow direction from the north to the south. The trends reveal two peaks in a year that groundwater rises from May to September, and it falls in September, October and rises again in November. The main factors affecting this trend are irrigation and rainfall. The fluctuation of the groundwater depth ranges from 1m to 1.5 m from the soil surface in the upper and middle parts of the plain. This is close to 1 m in the lower part of the plain and the depth of the fluctuation range is similar in the selected years.
- Transport losses from the canal were estimated to be 35-45% of irrigation intake

Irrigation subgroup is now in the development stage of GIS for the LSIP which the full integrated information would be available soon. Land use change by satellite image analysis is also carried out by cooperation of other subgroups. Soil scientists are working on monthly monitoring of soil salinity on 50 points along the east-west transect in the project IV area of the LSIP.

d. Socio-Economic Sub-Group

The five components of the ICCAP's Socio-Economic Subgroup are: 1. An economic analysis of farmers' economy, and farmers' perception and responses to climatic changes, technological changes and policy and institutional changes based on farm survey. 2. An input-output analysis on the interrelations among rural industrial structure, agricultural productivities, and climatic change. 3. A mathematical programming analysis of regional relation among cropping systems, water use, agricultural policy, and climatic changes. 4. New institutional economics analyses of the use of commons such as water, grass and soil by farmers, and pastoralists. 5. An econometric agro-

climatological study of the interactions among wheat, barley, and other major field crops production with global warming, crop prices technology and policy.

The purposes of this subproject are to identify the effect of global warming on economic structure and economic results of farms, to determine the impact of global warming on soil fertility, crop yields, cropping patterns, water availability/use/conservation, use of new technology, to understand farmers' perception and behavior concerning natural resources and agricultural production and to identify necessary policies and institutional measures to cope with global warming.

Questionnaires were prepared and submitted to the farmers in Adana and Konya (central Anatolia). Examination of the family size, land tenure and land use by crops of the interviewed farmers as economic structure indicators of the research area showed the following:

- Average family sizes are quite similar in irrigated and rainfed villages of the research area. In rainfed areas family sizes are smaller.
- Land tenure: Size of farm is measured by the size of operated land. Operated land consists of owned land plus/minus rented and share cropped land. We see that use of rented and share-cropped land is quite widespread in both provinces. This situation is very clear in the irrigated villages of Adana province.
- It is clear that wheat is the most important crop in two provinces both in irrigated and rainfed villages. In the irrigated villages of Adana wheat is followed by maize as a first and second crop. Citrus orchards also occupy an important place in the irrigated areas of Adana. Crops such as cotton, sunflower and other crops do not have an important place in the irrigated areas of Adana.

- The most important crop of rainfed villages of Adana is wheat. Farmers also grow some maize on the limited irrigated land of rainfed villages. Corn and soybean are cultivated as a second crop in one year on the irrigated land after harvesting wheat in Adana.
- In the irrigated villages of Konya the major crop is wheat and it is followed by beans and sugar beet. Chickpeas and lentils are also grown by the farmers.
- In rainfed villages of Konya, wheat is the major crop and it is followed by barley. Fallowed land also takes an important place in rainfed villages.
- Average agricultural income on irrigated farms is significantly higher than rainfed farms in Adana and Konya. It is interesting that the average income figures on irrigated farms in Adana and Konya are quite close to each other. The same similarity is also seen on rainfed areas of Adana and Konya.
- Econometric impact analysis of global warming was conducted for wheat, barley, sugar beet, chick pea, dry beans, maize, cotton, soybean, ground nuts for Konya and Adana. This 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 the 12 major crops for Adana and Konya were made. Then at the second stage, the converted pseudo-warming second run N2 data and the socio-economic subgroup basic scenario for prices were inserted into the corresponding variables of the regression equations in order to identify the impacts of pseudo-warming to yield, area sown and production of the 12 major crops in Konya and Adana.
- A new component was integrated into the Socio-Economic subgroup with the title "The Effects of Global Warming on the Livestock Production Systems in the Seyhan Basin". This group's

objective is to study the effect of global warming on the livestock production systems and to determine and compare it with the present situation. With this objective in mind, surveys were carried out in 9 villages. Studies were also done on goats that have been reared on Çukurova University's research and implementation farm since 1970's.

e. Vegetation Subgroup

The study aims at investigating Seyhan watershed in terms of floristic composition and vegetation, analyzing environmental factors and assessing relationships between vegetation and environmental factors. In addition, effects of climate change on natural vegetation are explored with permanent plots established in the field.

In order to examine vegetation and its coverage a field work trip between September 15th April and 25th, 2005 was carried out. Moreover Japanese group took part in the field work and methodologies of two groups were compared. In order to achieve project targets and to use one solid methodology methods of Japanese and Turkish sides were unified. Within this context it was decided to carry out new observations and measures in the coming period on the selected parcels.

Additional observations will be done on the selected transect in 4 localities and in a total of 8 parcels. In each locality two parcels will be chosen which represent the regions in general where the pure solid species are found. The following observations will be made in these parcels:

- Indication of general position and the number of the all trees and bushes in the selected parcels,
- Take aging ring of the numbered trees,
- Measurement of trunk diameter, surrounding and the height of the numbered trees,
- Measurement of young shoots and their height,

- Measurement of tree coverage of each parcel digitally and computing,
- Indication of soil surface and the temperature and the humidity below 5 sm.

It would be possible for the groups to work together and to provide data on the parcels that each group was chosen. Beside this another field work with Japanese side was carried out between November 24 and 28, 2005. As it is stated above, Japanese group took same measurements particularly on the parcels which were characterized mostly by *Juniperus oxycedrus* and *Quercus sp.*

Three-dimensional model of Aladağlar was created by digitizing existing images and maps. Through this procedure easy and fast capture of the situation, height, slopes and sunlight of the parcels became possible.

According to project schedule studies on socio-economic structure were started with the interviews. Interviews were carried out in the winter period when the rural inhabitants have more time. More emphasis was put on the questionnaire for socio-economic structure. To determine the socio-economic structure of the local people face to face interviews were found most suitable.

Before the questionnaire work some steps were followed;

- 1- A map was composed showing villages and research area
- 2- Before starting interviews information were given to the people who carry out the work about the forms and the questionnaire will be conducted at a 25 % exempling rate
- 3- Forestry Management's Forestry Maps and Reports were provided for getting information about the villagers in Aladağlar settlements.

f. Climate Subgroup

- A scenario was analyzed. A decrease in precipitation around the Mediterranean region was significant.

- By analyzing precipitation data of Turkey between 1977 and 2000, the following trends became apparent; i) decrease of precipitation in the western region in January, ii) increase of precipitation for whole Turkey in April with a few exceptions, iii) increase of precipitation in whole Turkey in October except the southern region.

4. Integration of Subgroups

Integration of subgroup works is of utmost importance for this project to be successful. An integration plan as prepared by Dr. Levent Tezcan was discussed and unanimously accepted by all Turkish members. A commission was formed with a single representative member from each subgroup to prepare the final format of the integration strategy.

Dr. Suha Berberoğlu and his group will finish works on C/N Budget firsthand, and afterwards other subgroups will help other subgroups in preparing the infrastructure of their integration policies. Dr. Berberoglu and his group will define the decision variables and dependent variables which could be used in socio-economical analysis of climate change and its impacts. They will report their initial findings to Dr. Tezcan and to the commission.

5. Acknowledgement

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6. References

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