Research Project ICCAP : A Trial of Innovative Integration Toward a New Approach to the Global Environmental Problems

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1. Policy of RIHN and ICAAP

Research Institute for Humanity and Nature (RIHN), Japan, proposes the Research Project on Impact of Climate Change on Agricultural Production System in Arid Area (ICCAP). RIHN was established in 2001, in Kyoto, Japan, with the aim of fundamentally solving global environmental problems, with the following understandings.

With civilization human beings expanded their activities and increased their population size. Such trends, gaining momentum in recent years, accompany increased consumption of resources and energy and the increased demand for food. This means that the human impact on the environment has been incredibly rapid and widespread

The so-called global environmental problems, such as global warming, loss of biodiversity, and depletion of water resources, can be said to be the consequences of humanity-nature interactions being manifested today in various parts of the world. It is fundamentally a problem of human life style or culture in the broadest sense of the word.

One of the difficulties of assessing the global environmental problems is that many of them have appeared in different regions of the earth in a most unpredictable manner. Not a small number of these problems that we see in front of us are caused by factors seemingly far removed from reality both in time and space. Moreover, recent studies show that not only "physical" and "chemical" but also "cultural" factors in the broad sense are exerting strong influences.

It is easy to see that such multi-faceted problems could not be solved by studies with a conventional approach. In fact, the measures taken hitherto were based on the idea of controlling nature and it became clear that such measures would only lead to a vicious circle.

What we have to do now might be to ask first the fundamental question of what is meant by the global environmental problem and to re-examine the concepts developed through the 20th century in this regard.

Secondly, based on such perspectives we need to consider how we can sustain the global environment that has all the future possibilities and what sorts of life style we must adopt in order to achieve it.

To build this foundation it is necessary to develop a new approach academically as well as in other fields.

With this understanding the Research Institute for Humanity and Nature (RIHN) was founded in April 2001 as a cooperative inter-university research organization under the Ministry of Education, Culture, Sports, Science, and Technology of Japan, to carry out integrated research for the innovation of a discipline that will give us the solution to the global environmental problem (RIHN, 2002 http://www.chikyu.ac.jp/).

The ICCAP is a research project for integrated assessment of climate change impacts on agriculture, which is to be launched and carried out based upon the basic policy of RIHN that the above understandings represent. Therefore, the ICCAP is aiming to make clear the circle of interactions between humans and natural systems, and to build a new research field of the global environment, adopting a more integrated, inter-disciplinary overall perspective. It is of still quite challenging. We need to kick-off with a strong will, however, to get a goal.

2. Objectives of ICCAP

Most regional environmental problems have been caused by inappropriate manner of land and water use and management. Agriculture, which is maximizing the use of regional natural resources with vast land and much water, generally gives considerable impact on regional environment. Presently, agriculture in the world's arid and semi-arid areas, is required to improve its productivity due to population growth and increased food demand, while it development is severely restricted by limited water resources availability. Further development of the agriculture in theses areas has been deteriorating farm soil resulting in desertification and causing serious problems on hydrological cycle and environment. The

development of large-scale irrigated agriculture has greatly enhanced agricultural productivity; on the other, hand the crisis on the sustainability of the irrigated agricultural production is creeping under the development projects.

Furthermore, future possible global climate change is likely to affect especially the agriculture in arid and semi-arid zones (for short only "arid areas", below) in the climate and hydrological conditions such as temperature, rainfall and evaporation, and so on. The agricultural production system in arid areas, which depends on unstable conditions even now, may have difficulties to adapt to changes. It would be stressed further facing serious problems which it suffering from. Many researches were executed mainly to predict potential impact of this change on changes in plant growth and yield with the prediction of changes on-farm micro-meteorology and soil condition. However, comprehensive assessment or evaluation of impacts and adaptations is strongly needed which includes prediction of adaptations in production system like changes in choice of varieties or cropping patterns, blight and other plan diseases, and land use management in surrounding areas, which would be the crucial basis for sustainable agricultural production.

The agricultural production system requires effective measures to tackle its land and water management problem both of on-going and of long-term scale. Although water and land management problem in agricultural production system has been taken up in various ways and studies, comprehensive assessment and evaluation, with special references on wide or regional area climate, basin hydrological system, irrigation system, and regional or national agricultural economy, has not been conducted. This research project, firstly, examines and diagnoses the structure of land and water management, secondly, aims to predict and assess the impacts of global warming or climate change and adaptability of the production system. Regarding this prediction and assessment process, in the project, not only the future prediction but also integrated vulnerability assessment of the system should be attempted to identify essential interrelations among various factors and critical values of the factors, which must be clarified just with the prediction process. **Fig. 1** shows the basic framework of the agricultural production system and the project research.

It is obvious that the agricultural production system in arid area could not be examined only from the viewpoint of land and water management. Taking the scale of this project, for example, its term and budget, into account, it is intended to have grasp of the basic structure of the system firstly from the viewpoint of soil and water management, since soil and water are fundamental and dominating elements of agricultural production in arid areas. This project selects two case study areas; Turkey and Egypt, in the arid area on the east coast of the Mediterranean Sea, which is sensitive area in agriculture to the future climate change

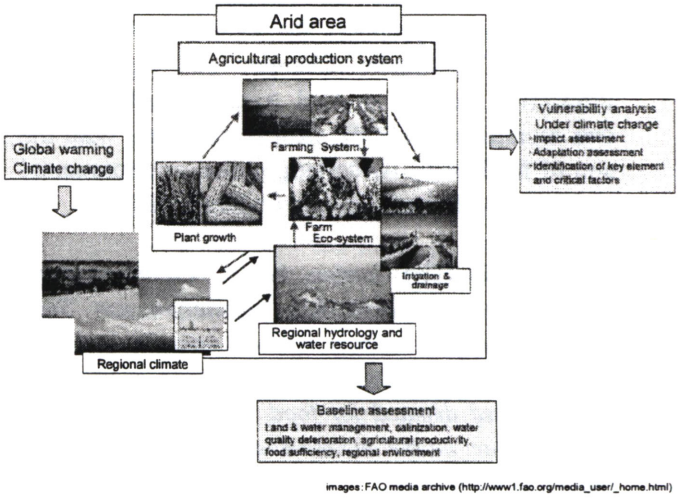

Fig.1 Framework of the research

3. Methodology

Fig. 2 shows the flow of the research. Firstly, the present agricultural production system (APS) is assessed with an emphasis on soil and water management to clarify its baseline vulnerability. The assessments include following elements: a) regional climate and meteorology, b) hydrology and water resources including irrigation and drainage, c) soil-water regime and plant growth, and d) socio-economics with land use management and cropping pattern.

Secondly, regional climate change in accord with the global climate change is estimated through simulations and its impacts and adaptations to it are evaluated. For the time being, precise and quantitative prediction of regional climate change seems difficult to be realized, therefore variance and characteristic of the change will be generated as some scenarios. In this process, the basic structure of APS and interactions among the elements will be made clear and integrated analysis will lead to an overall comprehensive understanding of the relation between natural system fluctuation and human

activity.

In estimation and evaluation of the impact of the climate change and adaptation, it is structurally analyzed to identify dominating factors and critical values, which in turn will be used to clarify direction and extent of the possible change. From these results, important factors for adaptation will be revealed for the specific elements of the studied APS. In this process, socio-economic adaptation of farm household, regional land and water management system, agricultural policies, and international food trade will be included in the analysis to give much concrete materials for considerations.

The research deals with land use and on-farm soil-water regime as core parameters in the whole research combining other elements as shown in **Fig. 3**. These core elements include water and salt balance in fields with certain crops. Its interactions with other elements (i.e. regional climate, regional hydrology, plant and crop production, irrigation and drainage system, agricultural economics, etc.) will be evaluated quantitatively with developing models. Changes of these interactions under the climate change scenarios will also be evaluated. The elements of "livestock farming" and "pest, disease and wildlife" shown in the figure will be out of the research scope of the FY2002, and will be involved gradually in the following years.

The methodology introduced in each module is tentatively planned as follows.

a) Regional climate

The General Circulation Models (GCMs), used to predict global climate changes, are not enough to predict the regional climate change for their rough horizontal resolutions with a few hundred kilometers. In order to predict regional temperature, rainfall, radiation and soil water retention with higher accuracy, this project aims ultimately to develop a "Regional Climatic Model" (RCM) with a 10km horizontal resolution, in collaboration with domestic and foreign climatologists and meteorologists. Because it is a very challenging issue, the outcomes from on-going related research projects in the domain should be incorporated.

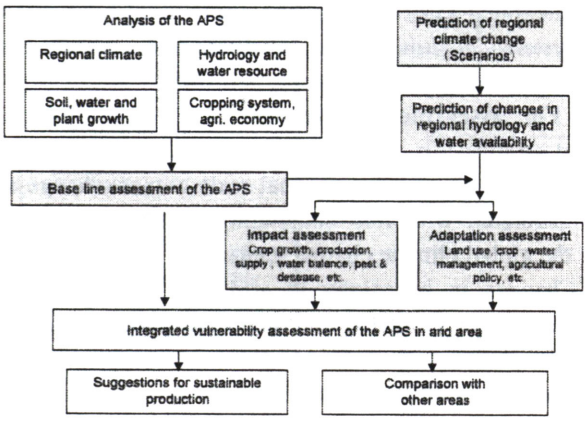

Fig. 2 Flow of the research

It would be very difficult for the GCMs or the RCMs to quantitatively predict the regional rainfalls or evapotranspiration. Therefore modifications of the major GCMs and RCMs will be constantly incorporated and the characteristics of climate system in research area will be identified and introduced into the models. In the RCM, an interim goal will be set to improve the horizontal resolution precision to 20-30km.

Several scenarios will be generated using different combination of models. Methodology for feeding changes in land use, soil water characteristics and evapotranspiration back to the RCM will be developed.

b) Regional hydrology and water resource

Firstly, hydrological characteristics of the study areas will be identified. Then, basin hydrological model will be developed to assess the water resource availability. Historical changes in the hydrological regime due to climate change will be analyzed quantitatively with relationship between land or water use change (especially in agriculture) and regional hydrology. Secondly, precipitation, evapotranspiration, discharge and storage of surface and subsurface water, and other elements of water balance are predicted with regional climate scenarios. Using the prediction results and independent estimate of sea level rise from the GCM, distribution changes in time and space of regional water resources are estimated in terms of quality and quantity. This includes prediction of river flow, groundwater table and water quality (salinity) in the major areas in the region and the estimate of changes incurred by modified operation of major hydraulic structures and water diversion to the cities and industries.

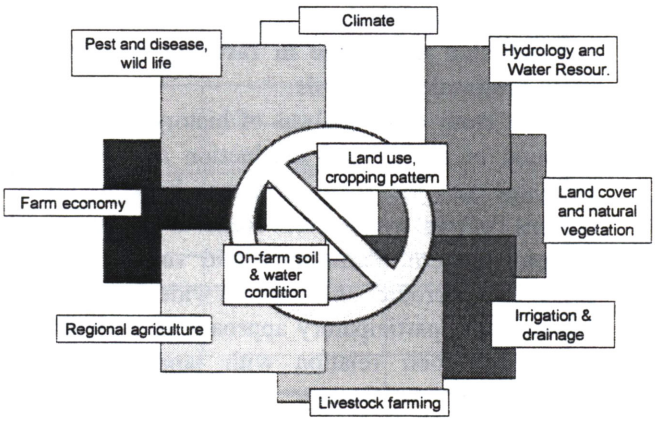

Fig. 3 Research process with special reference on soil and water management and land use as the core elements

c) Plant productivity

An on-farm dynamics model is to be developed at first, which could evaluate quantitatively the relation among micro-meteorology, soil, water and salinity conditions, growth of crops and natural vegetation, modifying the existing crop growth models (i.e. SPAC, SWAP, etc.) with supplemental chamber or glasshouse experiments and field observations.

Secondly, using this model, growth and yield of major crops and natural vegetation is calculated under the condition with higher concentration of CO2 and higher temperature predicted by the RCM, as well as the consequent changes in water consumption. This simulation involves various parameters like crop and variety, cultivation method, water management, soil salinity, groundwater table and irrigation water quality. The model can evaluate the influences of changes in the irrigation management in corresponding to changes in soil salinity and hydrological condition. The model is to be design to output the necessary feedback to the RCM (i.e. NDVI, LAI, albedo, soil water content, CO_2 concentration, roughness of the surface).

d) Irrigation and drainage

Firstly, historical development of the irrigated agriculture in the study area will be summarized, and the basic structure of irrigation and drainage system and water balance in the region will be analyzed, which may combine the on-farm water balance and regional hydrology. A model will be established to evaluate land use, cropping pattern, water demand and supply, water diversion from the source and return into the river and groundwater.

Secondly, futures possibility and stability of water supply and the regional water balance will be predicted, based on prediction of the changes in on-farm water requirement and availability water resources. This will make clear necessary operation of the irrigation facilities and required water management of the related organizations.

f) Prediction of change in farming system and socio-economical analysis

In the study area, analysis of history and present situation of agricultural production and economy will elucidate the socio-economic background or reasons for past and present trend in land use and cropping pattern. Farm-household survey will be useful in this process. Also nation wide deregulation, privatization, participatory approach in agricultural sector and their relation with land and water management, in Turkey and Egypt, will be analyzed.

Then, the impacts of climate change on regional agricultural production system, including land use and cropping pattern, will be analyzed with some scenarios of the responses of farmers and agricultural organizations. Options and alternatives in the cultivation and management are to be examined, such as increase or decrease of fertilizer and pesticide use, choice of crops, expansion or shrinkage of the farmland, irrigated area and grazing area. Existing suitable models are applied to estimate the changes in international and regional food demand-supply and trade, to evaluate the influence on regional farming system.

4. Expected outcomes

The ICCAP expects the following outcomes.

a) For baseline assessment of the basic structure of land and water management in agricultural production system of the arid areas

- Interactions of micro-meteorology, soil and water management, and crop and vegetation growth in arid land is simulated and evaluated by the model developed in this project, in which the effect of salinity is incorporated.
- Characteristics of basin hydrology in arid area are summarized including the influences of agricultural water management as dominant factor for hydrological regime in arid area.
- Water balance structure of irrigated land in arid areas, with inter-relations among land use, cropping pattern, water requirement, water diversion from source river and return flow, and groundwater condition.
- Present land use and cropping pattern in arid area is socio-economically diagnosed, and the effects of the on-going deregulation, privatization and participatory programs upon land and water management will be evaluated.
- Through the processes above, the method for integrated assessment of the agricultural production system in arid areas is developed, where the inter-relation of its elements is involved.

b) For assessment of impact of climate change and adaptation

- The scenarios on the regional scale climate change are generated with less uncertainty in accordance with the global climate change scenarios.
- Changes in hydrology in arid area due to climate change are predicted and quantitative and qualitative distribution of the future water resources is estimated.
- Impact of climate change on crop growth and water

demand will be clarified for various soil condition, cultivation practices and irrigation management.
- On the impact of climate change on agricultural production system, change patterns and future prospect is socio-economically evaluated.
- Important elements and critical points in the structure of agricultural production in the arid region are identified and measures to adapt or mitigate the climate change are suggested.

5. Research plan

The ICCAP has a provisional timetable for five years as shown in **Table 1**, from April 2002 to March 2007; from the Japanese Fiscal Year FY2002 to FY2006, which starts at beginning of April and ends at the end of March.

In the FY2002, the following activities are planned:

a) To hold workshops to discuss the goals and methods of the project with the Japanese collaborators.

b) To have meetings and workshops in Japan and the research areas to discuss the objectives, methodology and field measurements.

c) To collect hydrological and meteorological observation data and related documents and statistics in the research areas.

d) To assist improvement of the GCM and RCMs applicable to the East Mediterranean Region.

e) To develop prototype basin hydrology and groundwater models for the research areas.

f) To survey the present vegetation and analyze its geographic distribution and productivity.

g) To develop a model which combine the on-farm micro-meteorology, soil and water management, water quality and plant productivity.

h) To do experiment to analyze the relations among CO_2 concentration, soil water contents, salinity and plant responses, including evapotranspiration, photosynthesis, and yields, in experimental farm or glasshouses in the case study areas and/or Japan.

i) To investigate the water use facilities and irrigation systems, and analyze the planned and actual water management.

j) To collect the statistics and records about agricultural production and to analyze the transition of farming and cropping systems and agricultural production systems.

Table 1 Research plan : Provisional Timetable for ICCAP

Subject	FY2002	FY2003	FY2004	FY2005	FY2006
General	Data collection, Model developmen	Improving models, Interim review	Interim report	Prediction and assessment, Integrated analysis	Conclusions, Final report
Data collection and Field observations	←	—	→		
Development of RCM and generating climate change scenarios	←	—	—	—	→
Evaluation and model development in various aspects		←	—	→	
Assessment of climate change impacts and adaptations		←	—	—	→
Integrated vulnerability assessment of agricultural production system			←	—	→