H-4 Research on the interaction between regional environmental change driven by the human activities and economic development in the Asia region

Contact Person Hideo Harasawa
Section Head
Social and Environmental Systems Division
National Institute for Environmental Studies
16-2 Onogawa, Tsukuba, Ibaraki, 305 JAPAN
Phone +81-298-50-2507
Fax +81-298-50-2772
E-mail harasawa@nies.go.jp

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1. Introduction

The rapid growth of the population and economic activities in the Asian region have destroyed and deteriorated the environment. To cut off this negative feedback relationship, it is essential to identify the critical factors forming this vicious cycle based on the past research and the field survey, and to integrate them into a human activity - environmental change - economic growth model in a comprehensive manner for future prediction of the environment and the society and for establishment of the better response strategy.

2. Research Objectives

The aim of this research is 1) to identify the critical factors forming this vicious cycle in the Asian region, 2) to predict future conditions regarding water resource, food security, and urban air pollution using an integrated assessment model which was developed to explain this cause-effect relationship and to predict future change assuming several socio-economic scenarios, and finally 3) to propose possible countermeasures for the sustainable development in this region.

3. Research Methods and Results

3.1 Framework of an integrated model for assessing human activities and environmental change in the Asian region.

Framework of an integrated assessment model on interaction between the regional environment change, human activity including socio-economic aspects was developed. The most remarkable problems identified in the Asian developing countries are food security, water resources, and human health. The core modules of the integrated assessment model consists of three sub-models, and an economic model links these sub-models.

3.2 Food security

(1) Food security index
An index is developed to identify the food security of the developing countries. Four factors such as a GNP per capita, calorie intake, population growth rate and children mortality are

taken into consideration. From the calculated index in each country in the Asian region, developing countries in the Indian sub continent are facing very severe food security condition (Figure 1). In addition, the future decline of agricultural product mainly due to global warming in these country will collapse the food demand-supply relationship.

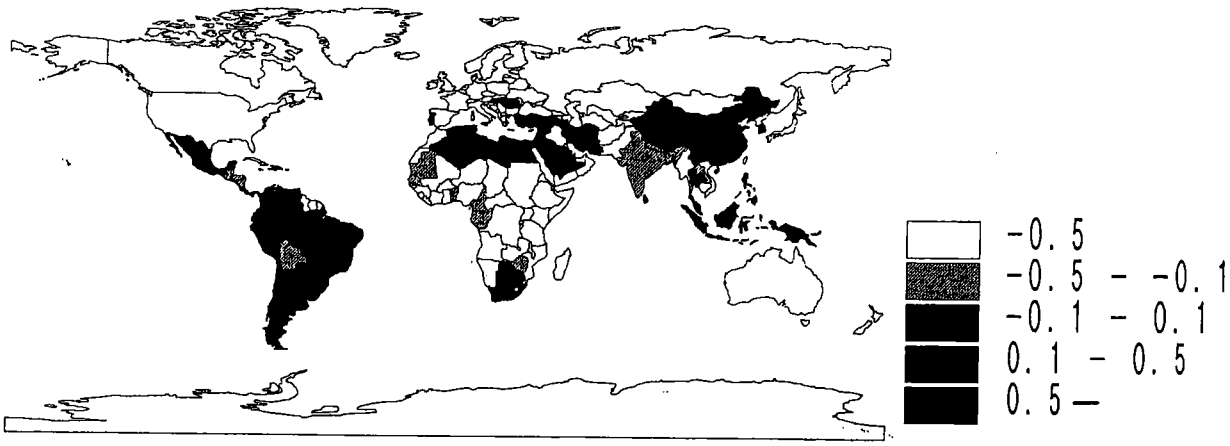

Figure 1 Calculated food security index

(2) Food Security in Asian Region

Impacts of environmental change including climate change on crop production in the Asian region may be one of the most serious problems in the next century. In order to evaluate this problem quantitatively, a modeling framework to estimate an economic impact caused by climate change was developed. The framework comprised two main models, a GIS-based potential crop productivity model and a 30-region international trade model. The former model simulates the physical process of crop growth using the monthly climate data such as temperature and precipitation, as well as the physical and chemical soil data. The latter is the computable general equilibrium model which simulates the domestic supply-demand balance and the international trade.

Without considering the direct impact of atmospheric CO_2 concentration increase, the potential crop productivity of winter wheat decrease by 45% in India and decrease by more than 50% in Bangladesh by the end of the next century, while that of rice and maize will not decrease so seriously in any regions. Taking these regional changes of potential productivity as technical changes in production function of the international trade model, the social welfare in India will decrease considerably, 4.89%, while that in Japan will increase 0.02%. Globally, the social welfare will decrease 0.046%.

The result shows that the economic impact caused by the changed crop productivity is not so severe if it is averaged globally because of the market adjustment through global trade. However, the considerable negative economic impact is estimated in the region where the productivity will decrease and the share of agricultural products in the total private expenditure is high. In the Asian region, impacts of climate change along with other environmental factor degradation directly will affect agricultural production, and then cause

significant negative impacts on regional and international food supply and demand relationship. The research also considers how to deal with such future food shortage problems in consideration with autonomous and social adaptation.

3.2 Water Resources

(1) Water Resources Model

The water resource model consist of a water runoff model and a water demand model. The former model was successfully developed in cooperation with researchers in China and India. The data and information of the environment, and socio-economic condition of water use in these two countries have been collected and stored into GIS database for validation and application of the water resources model. The model will be applied to the Asian region, and the water security will be evaluated at the present and in future condition.

Asian region is predicted to suffer from future change of climate. Especially change in rainfall will affect water supply in the region as well as increasing water demand. We have developed a comprehensive water resource model which is composed of two major sub-models. Those are water supply model (water runoff model) and water demand model. In cooperation with researchers in China and India, water demand related data and information such as water volume used in agricultural, industrial, and urban sectors, and unit water usage in each sector. However data and information were very limited in those countries, so that an estimation method should be developed using relative rich information and data in Japan. Figure 2 shows framework of this water resource model in some detail.

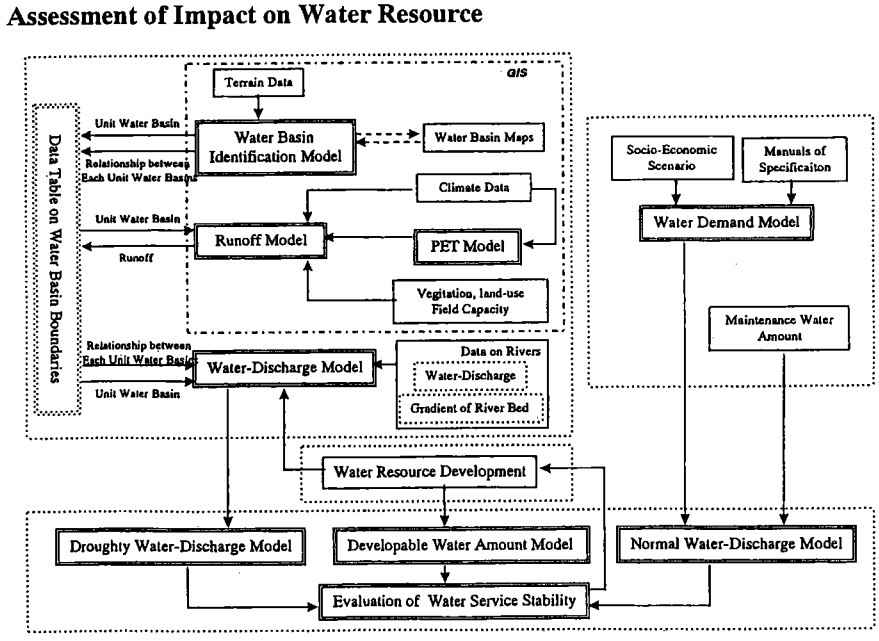

Figure 2 Framework of the water resource model

Figure 3 shows per capita available river flow after global warming. For example in China there observed unequal distribution of per capita available river flow. Many countries in Asian region will suffer from shortage of the water. Growing population and development economic will accelerate this tendency.

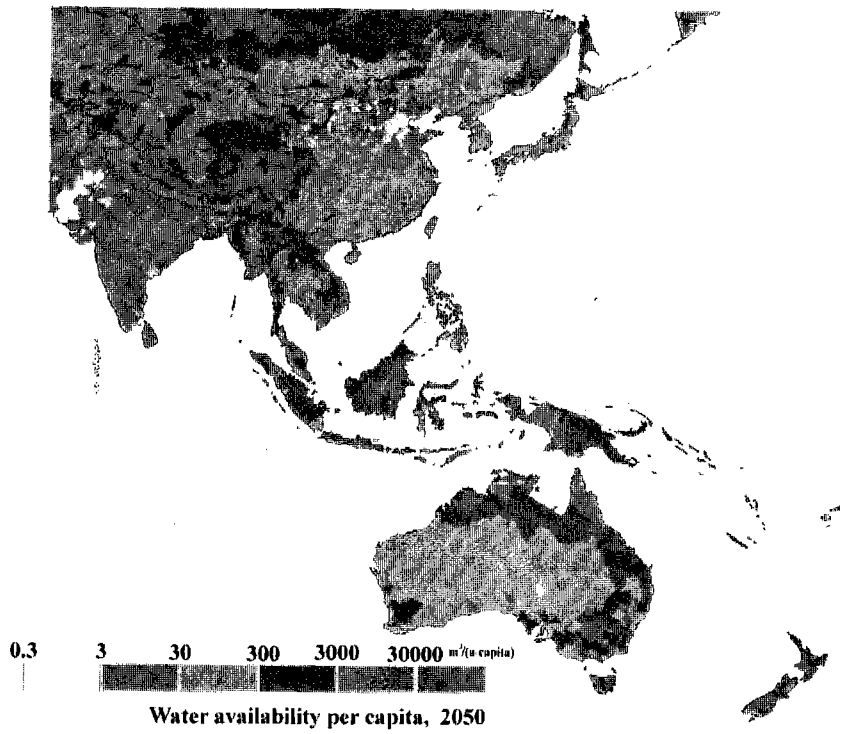

Figure 3 Per capita available river flow calculated (m^3/year/cap)

(2) Model Application to China

In China, water resource scarcity has been one of major concerns for sustainable economic development. To analyze the current situation of water resources problems and to predict future risk of water scarcity in China, a physical factor-based river water runoff model (hydrological model) was developed in cooperation with the National Institute for Environmental Studies, Japan as a part of an integrated assessment model for environmental security.

There are growing concerns that climate change will have significant impacts on the hydrologic cycle and water resources in many regions of the world. Thus the hydrologic cycle is identified as the highest scientific priority for global change research. So far, available water resources has been investigated based on river flow models including possible climate variations. However, it is pointed out that, different formulae of physical processes as well as different conceptualizations of hydrologic components will likely respond differently under climate change scenarios. In development of water resources model, it is essential to consider regional characteristics of hydrologic cycle, especially evapo-transpiration (PET). Several methods of PET calculation were examined for better fits between observed and predicted river water flows.

In addition to the hydrological model, a water supply/demand model has been developed for

agricultural, industrial, and urban water uses. Linking these two models, future risk of water resources scarcity was evaluated. In conclusion, water supply and demand in China will be unbalanced, and risk of water deficit will be increased significantly. To mitigate this predicted water deficit, strict water saving activity should be incorporated into the development plan. Water resources is one of fundamental resources for future sound development of the country, so the research outcomes would be applied to other regions in the Asia.

3.3 Preliminary Analysis of Urban Air Pollution (SPM pollution)

Urban air pollution is glowing concern in Asian mega cities. Especially suspended particle matter (SPM) in urban atmosphere discharged from automobiles and factories is increasing and resulting in health damage of infants and senior people. In this study we intensely reviewed research paper related to air pollution and human health damage, and proposed an integrated framework of assessing air pollution damage of infants.

4. Future research needs

Food security, water shortage and human health in major urban areas in the Asian region are major concerns in considering environment policy. Further elaboration of the model developed in this research and collection and archiving of data and information in GIS format are essential to apply the models in comprehensive manner. In parallel concept of the environmental security should be formulated and modified in consideration of the Asian regional characteristics.