B-15.3 Special Collaborative Studies for Developing the Asian-Pacific Integrated Model (AIM) to Assess Global Warming Abatement Policies with Developing Countries
Development of Food Supply and Demand Model to Assess Global Warming

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Abstract

At the global level, food supply-demand situation is improving. At the beginning of the 1970s, 35% of the population in the developing countries were estimated at or below the starvation level of food intake. This rate has dropped to 20% by the beginning of the 1990s. However, this achievement was not taken place uniformly across the regions. Sub Saharan African countries and South Asian countries remain as the major food deficit areas. The improvement of the food security in these regions must be achieved, but this shall be made with a heavy constraint on their production activities. Because of the global warming, food and agricultural production in these regions are projected to decline. Global warming is estimated to increase their difficulties in improving the food securities in these regions.

With the increasing global temperature, grain yield increases its volatility in major exporting countries such as USA and Australia. The grain stock level sharply reduced in the middle of 1990s because of the expanded import demand in Asian countries associated with high economic growth. Under a market situation where stock levels of grains are keep declining, even a slight increase in yield volatility makes the global grain market more unstable than ever.

In order to evaluate effects of global warming on world food supply and demand situation, a world agricultural model has been developed. The world agricultural model predicted the increased international prices of wheat and corn. By the year 2025, demand for the imported grain and soybeans in developing countries is projected to increase by 58

million tons, mainly due to the supply shortages in Asian and Latin American countries. The increased international prices, caused by the global warming, will seriously threaten the food security of the low income food deficit countries.

1. Introduction

Concerns to the global warming are increasing, with observed increase in greenhouse gases in the atmosphere. Because agricultural activities are critically depend on the atmospheric and soil conditions, it is highly necessary to evaluate the impacts of global warming to the levels of foods and agricultural productions.

Increased temperature, changes in rainfall pattern, and changes in sea-level are projected to cause a change in global food supply situation through changes in grain yields, plant diseases and changes in the distribution of the arable land resources. To improve global food security, it is necessary to identify the needed measures by evaluating the impacts of the global warming.

2. Research Objectives

First, historical analyses of world food markets were conducted and efforts were made in developing a world food supply and demand database and a datahandling system. Based on these previous works, a world agricultural model was developed. The model was applied to simulate the world food market situations to evaluate the global warming effects to identify the regions where most significant effects are prevailed. The necessary measures were proposed based on the simulation findings.

3. Research Results

(1) World Food Situation and Global Warming in the Past

Food situation, at a global level, is apparently improving. At the beginning of 1970s, the undernourished population amounted 35 % of total population in the developing countries. This rate is lowered to 20% at the beginning of the 1990s. For the same period the number of undernourished people lowered from 918 million to 841 million.

However, the achieved improvement in the food security was not made uniformly across the regions. Sub Saharan Africa and South Asian countries are still lagging behind to the global achievement. The food security of poors are still remained at an individual level even a problem was resolved at a country level. An attainment of food security of poors may face a further difficulty as a result of global warming.

During the 1980s, world agricultural market experienced a continuing over-supply situation (see Figure 1, Figure 2). The world economy grew at a relatively slow rate because of the second oil shock impact to the global economy, and because of the slow down of the economies in the former USSR, Eastern Europe and developing countries due to their foreign debt burdens. The tide changed in the 1990s with the increased import demand from the Asian countries.

A clear indication of global climatic change has been observed since 1980s (see Figure 3). It is noticed that with the increased averaged global temperature, volatilities in grain yield increased. These increased yield volatilities are also observed among the production areas of major grain exporting countries such as USA and Australia (see Table 1). With tightening global food markets, the global stock level is showing a clear declining trend. Given lower level of global stock, an increased volatility in grain yields become a major element that causes the world food market situation more unstable than ever.

(2) Development of a Database Covering the World Food Supply and Demand

A database covering the world food supply and demand situations was developed to improve research activities to evaluate the impacts of global warming on world food markets. This database was uniquely developed by collecting data from Food and Agricultural Organization (FAO), United Nations, World Bank, OECD, USDA and others in a common format. Any required historical market data can be retrieved by simply specify region, commodity and time specifications.

Aggregations over regions and commodities are also easily achieved by providing the aggregation specifications. Econometric estimations of the parameters of the world agricultural model is now easily achieved with the development of the database and the data handling system. The outputs from the database is able to be opened by EXCEL. One could easily edit the outputs or process the data by using the EXCEL sub-programs for summation, statistical analysis, chart and graph makings and creation of tables. The number of collected data series now exceeded 1.3 million.

(3) Development of the World Agricultural Model and the Evaluation of the Impacts of Global Warming

A multi-commodities and multi-regional world agricultural model was developed to evaluate the impacts of global warming. In the model, wheat, rice, corn, other coarse grains, soybeans, fresh milk, bovine meat, pig meat, sheep meat, poultry meat, dairy products, oils and fats, oilmeals are covered by disaggregating the world agricultural market into 31 regions.

World Agricultural market situations are projected up to the year 2025 by using the world agricultural model. Population and GDP growth rates were taken from the projected figures by the United Nations and by the World Bank. Growth rates in grain yields were estimated based on the recent 10 years growth rates. For each regions, the impacts of global warming are estimated based on the published recent research by Morita and others. Thepotential changes in production capabilities were estimated as changes in regional impacts to the annual growth rates of yields (see Table 2).

It was projected that international prices of wheat and corn are raised by 5.3 % and 2.7 % by the year 2025 (see Figure 4). The international prices of rice, soybeans, other coarse grains are projected to be unchanged. The estimated relatively small sized impacts

on prices are due to the relatively small estimated impacts of global warming because of the short simulated time period, and because of the market mechanism to adjust supply and demand.

Planted acreages increase when the international commodity prices increase. The increase in harvested acreage were observed in all the regions (see Figure 5). However, because of the reduced yield due to the global warming, grain and soybeans productions are projected to decrease by 5.1 million tons in Asia, 1.4 million tons in Latin America, 2.5 million tons in Africa. The food market situation in the developing countries are projected to be worsened. Grain and soybeans imports are projected to increase by 49.5 million tons for the Asian countries, 12 million tons for Latin American countries, and one million tons in African countries (see Figure 6).

4. Concluding Remarks

(1) Averaged global temperature is showing an increasing trend. At the same time, grain yield increase its volatility. The increased volatilities in grain yields are observed in the production areas of major grain exporting countries. This increased yield volatility evolves as a fundamental cause of unstable global food market situation.

(2) A global food and agricultural market database was developed. Efficient and systematic usage of updated data resources are now available to facilitate the measurement of global warming impacts to the world food and agricultural markets.

(3) An econometric world agricultural model was developed to evaluate the effects of global warming to the world food and agricultural markets.

(4) The model predicted the increase in the international prices of wheat and corn as a result of global warming. These increases in prices are identified as sources of further deteriorating food securities in the regions where food securities are not yet achieved.

Reference

Oga K. and Yanagishima K.(1996) "International Food and Agricultural Policy Simulation Model: User's Guide", JIRCAS Working Report No.1, Japan International Research Center for Agricultural Sciences.

Koyama O.(1996) "Statistical Database System for World Agriculture, Forestry and Fisheries —— JIRCAS STAT —— ", JIRCAS Newsletter No.8.

Koyama O.(1997) "Projections of World Food Supply and Demand for 2020", Farming Japan, Vol.31, No.3.

O'Brien D., Suhler G., Yabe M. and Nakagawa M.(1994) "Climate Variability and its Predictability in Japan", FAPRI Working Paper No.94-1, Food and Agricultural Policy Research Institute, University of Missouri.

Akashi K. and Yabe M.(1994) "A Note on the Optimal Level of Pollution: Integrated Approach to Abatement and Output Reduction", Research Paper No.12, National Research Institute of Agricultural Economics.

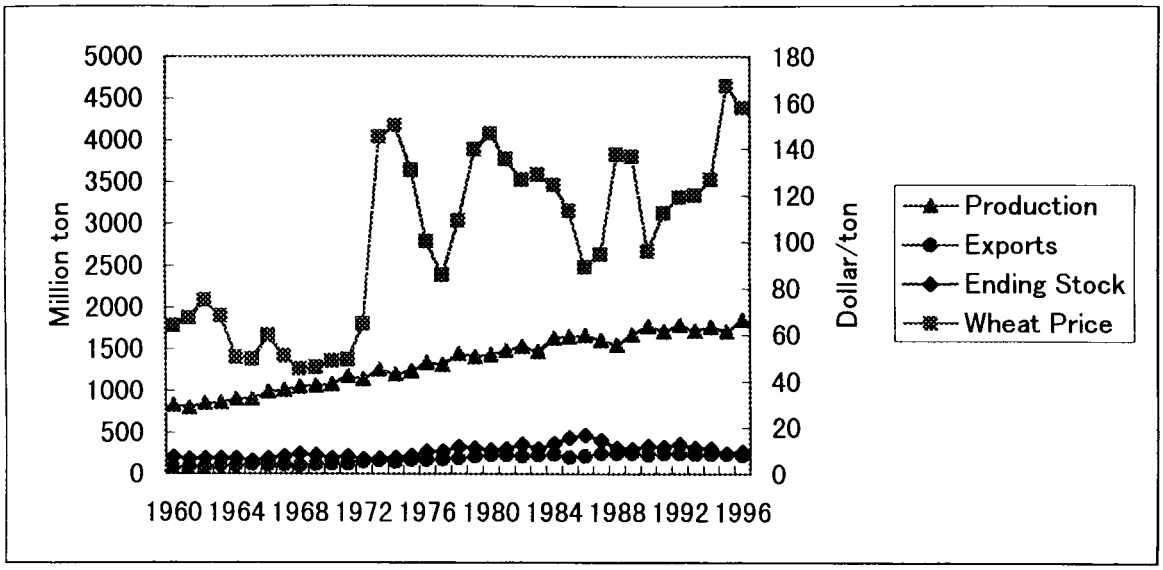
Ito J.(1996) "Trade Liberalization and Agricultural Products and Conservation of the Environment", Research Paper No.15, National Research Institute of Agricultural Economics.

Suzuki N. and Kaiser H.(1994) "Basic Mechanisms of Japanese Dairy Policy and Milk Market Model: A Comparison with US Dairy Policy", Journal of Dairy Science, Vol.77, No.6.

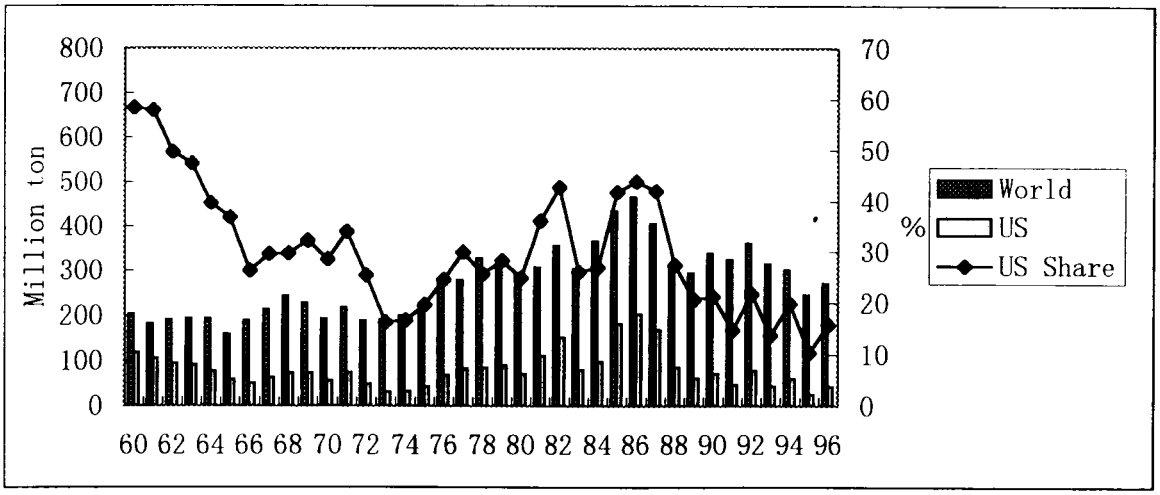
Suzuki N. and Kaizer H.(1996) "A Spatial Equilibrium Model for Imperfectly Competitive Milk Markets", Cornell University ARME Research Bulletin, No.96-12.

Yanagishima K. and Nakagawa M.(1994) "Implications on Rice Trade Liberalization in Japan", Presented Paper at the Annual Meetings of American Agricultural Economics Association.

Koyama O., Oga K., Nakagawa M. and Yanagishima K.(1997) "Global Warming and World Food Supply and Demand", JIRCAS Journal No.6, Japan International Research Center for Agricultural Sciences.

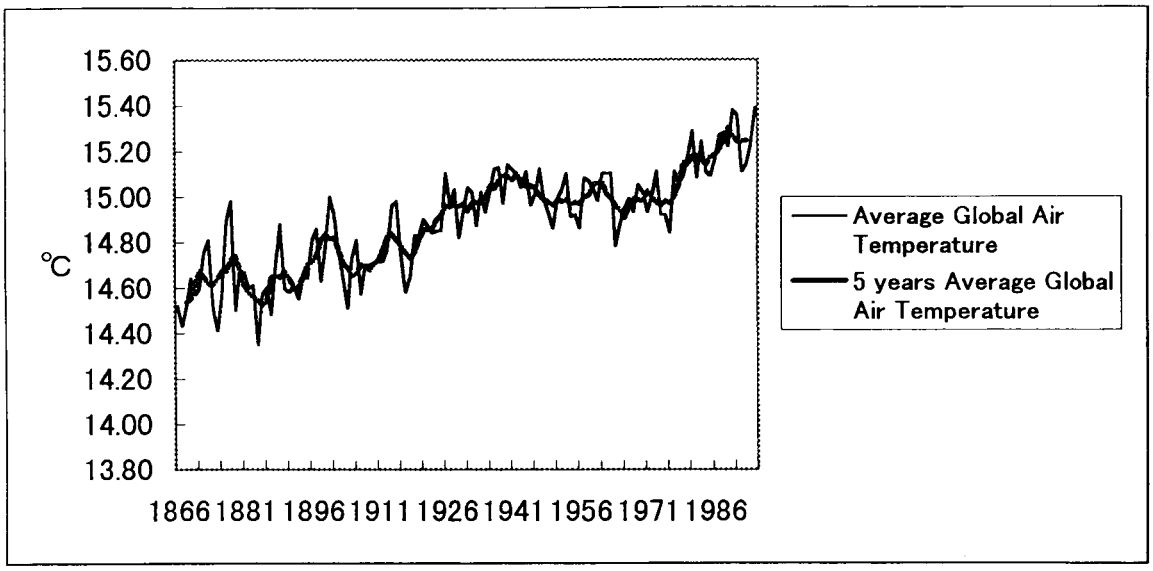


Source : USDA, "PSD View: April 1997", USDA,
"Agricultural Outlook", various issues.
Figure 1 World Grain Production, Export, Ending Stock and US Wheat Price



Source : USDA, "PSD View: April 1997".

Figure 2 Grain Ending Stocks in World and US



Source : Goddard Institute for Space Studies, January 1996.

Figure 3 Long Term Trend of Average Global Air Temperature

Table 1 Variance Coefficients of Grain Yield Indices in Major Grain Exporting countries (%)

	1960-79	1980-96
Canada		
Wheat	15.55	13.11
USA		
Wheat	6.6	7.3
Corn	8.7	12.1
Australia		
Wheat	18.1	20.2

Source : USDA, "PSD Views: April 1997".

Table 2 Changes in Production Potential of Major Crops

	Wheat	Rice	Corn	Other coarse	Soybean
USA	-2.0	4.0	-4.0	-24.1	8.0
EU	-10.5	0.5	11.7	22.7	-2.9
Japan	1.0	3.0	-27.5	0.0	-2.0
Canada	0.0	171.0	113.5	0.0	126.0
East Europe	-8.0	-15.7	2.2	-9.6	-10.9
Former USSR	-2.0	114.0	70.5	27.5	48.0
Mexico	-51.5	-2.0	-32.0	-30.4	-6.0
Brazil	-51.0	-3.0	-36.5	-40.5	-4.0
Argentina	-22.0	-13.0	-36.5	-36.2	-7.0
Nigeria	-19.0	-6.0	-3.0	-2.5	-7.0
India	-60.5	-3.0	-36.0	-19.0	-2.0
Bangladesh	-87.0	3.0	0.0	1.0	-4.0
Indonesia	-61.5	-2.0	-44.5	0.0	-4.0
Thailand	-99.0	-4.0	10.0	9.0	4.0
Korea, Rep.	-8.5	-3.0	-5.0	-5.0	-6.0
China	-18.0	10.0	-19.5	-5.1	2.0

Source : AIM Project Team (May, 1996)
Note: Changes from 1990 towards 2100

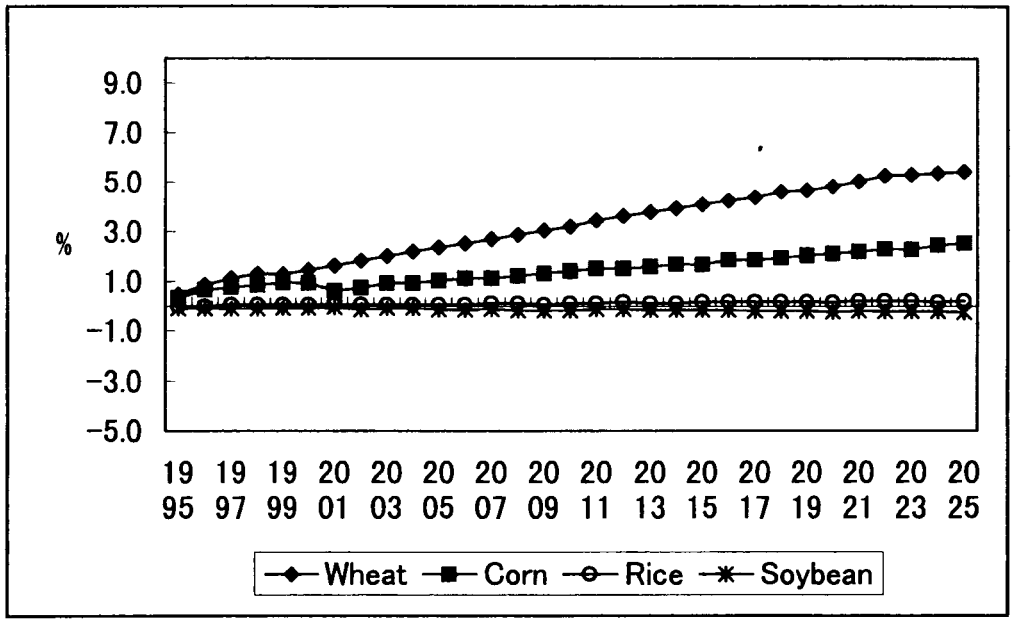


Figure 4 Changes in International Prices of Major Crops in 2025 (Compared to baseline case)

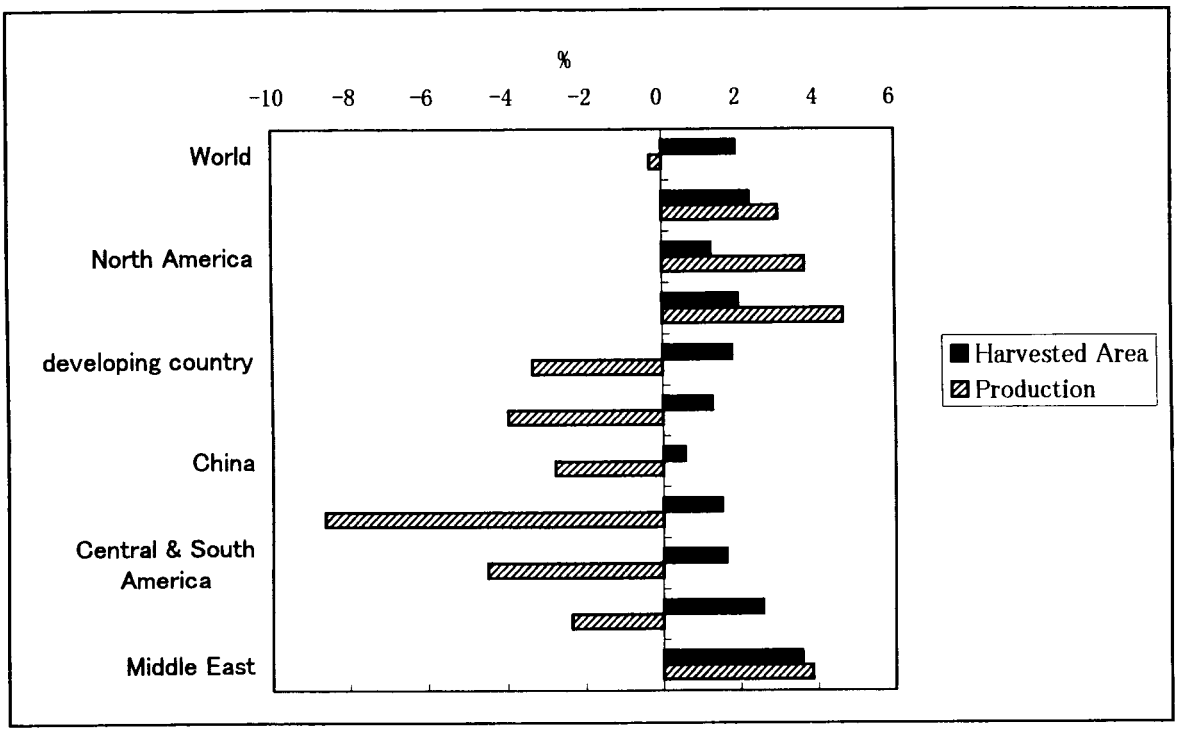


Figure 5 Changes in Harvest area and production of Grain and Soybean in 2025 (Compared to baseline case)

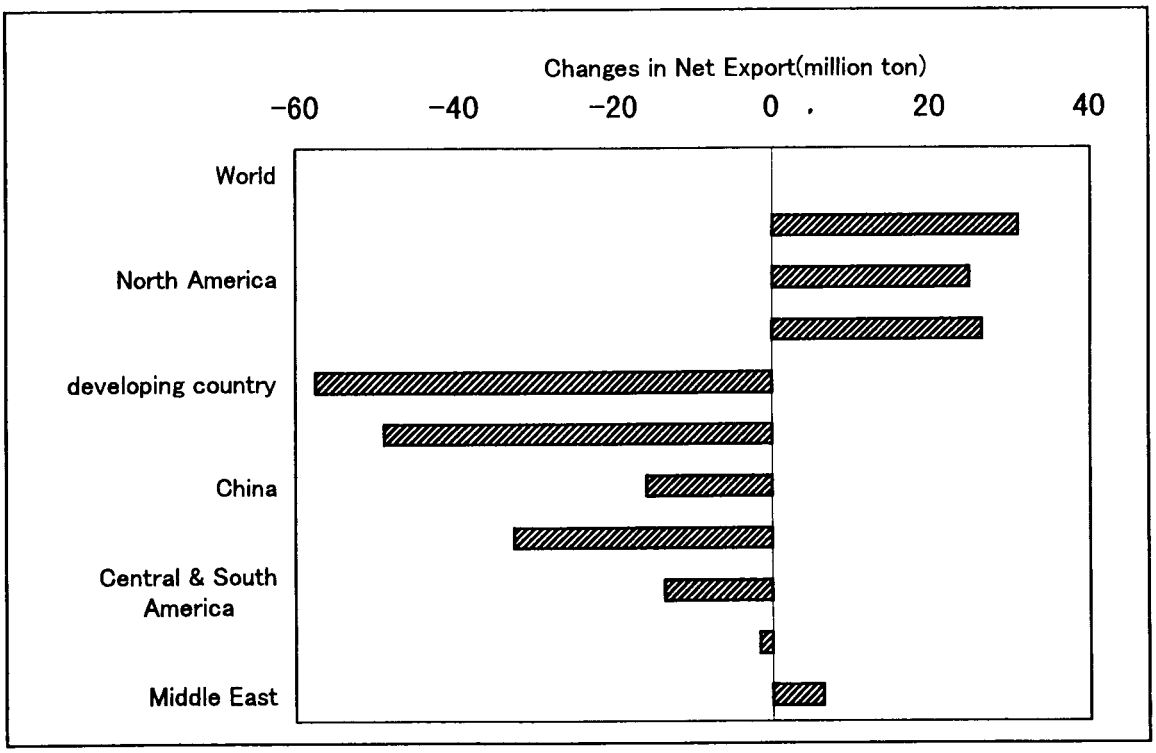


Figure 6 Changes in Net Export of Grains and Soybean in 2025 (Compared to baseline case)