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CLIMATE CHANGE AND AGRICULTURE IN SOUTH EAST ASIA : SYSTEM ANALYSIS TO FORECAST FOOD PRODUCTION IN THE 21ST CENTURY

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ABSTRACT

Global warming will have a little negative influence on countries in South East Asia. However, the South East Asian countries economy is developing well, and it seems that they will be able to adjust to climate change. There are great opportunities for increasing cereal yield in the future because the present yields in this region are relatively low. The probability of countries in South East Asia facing a food crisis in the 21st century is low.

INTRODUCTION

The executive summary of the IPCC report relating to climate change and world food production is as follows:

(1) In mid- to high-latitude regions, moderate warming benefits crop and pasture yield, and even slight warming decreases yield in seasonally dry and low-latitude regions (medium confidence):

(2) Projected changes in the frequency and severity of extreme climatic events have significant consequences for food and forest production as well as food insecurity, in addition to impacts of projected mean climate (high confidence).

The IPCC report only examined the influence of climate change on world food production. However, when the trend over the past 50 years is considered, there is a strong economic influence on food production. The influence of extreme climatic events on food production is small in advanced countries but large in developing countries. In general, the influence of climate on food production is smaller than that of the economy. Therefore, we first consider the trends of the economy in the 21st century and add the influence of climate change to this.

Trends in the past 50 years

Population

The trends in population increase in South East countries are shown in Figure 1. This is the middle variant of the United Nations forecast. The population in 1961 is assumed to be one in this figure. The population hardly increases for the period from 1961 to 2050 in the Japan. It increases in all countries in South East Asia; however, growth slows down after that. The population increase rate especially decreases in Thailand, but does not decrease in Philippines and Malaysia. The population of Thailand in 2050 is predicted to increase to 1.1 times that of the population in 2005. This is 1.7 times in Philippines and 1.5 times in Malaysia.

The population is currently increasing rapidly in Philippines and Malaysia. However, the population in these two countries accounts for about quarter of the total population of this region

(total population of five countries). Therefore, the total population of South East Asia does not expected to increase considerably in the 21st century.

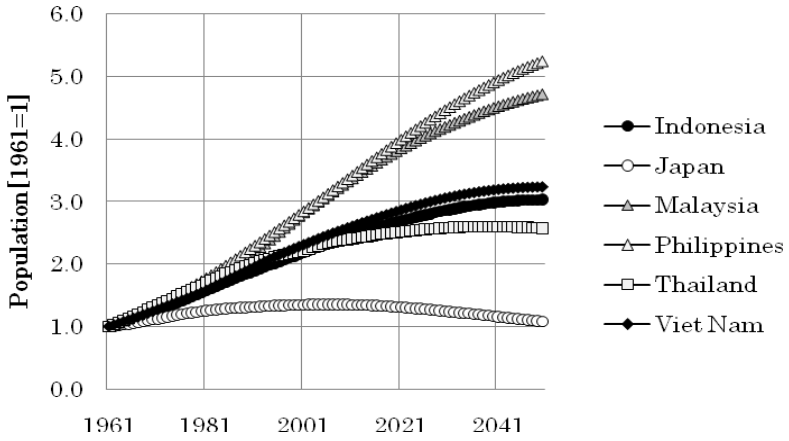

Fig. 1. Population growth, Ratio to 1961

Cereal production

High cereal production is seen in Indonesia and Vietnam. The production in 2009 was 82 million tons in Indonesia, 43 million tons in Vietnam, 32 million tons in Thailand, 23 million tons in Philippines, 11 million tons in Japan and 2.5 million tons in Malaysia (Figure 2a). Cereal production increased almost linearly from 1961 to 2009. Comparison of cereal production in 2009 with that in 1961 shows that, in contrast to Japan where production decreased, production has increased 5.7-, 4.7-, 4.5- , 3.7- and 2.3-fold in Indonesia, Vietnam, Philippines, Thailand and Malaysia, respectively. The increasing production rate in Japan decreased remarkably since the 1980s.

Furthermore, the cereal harvest area of this region has not increased since 1961. Then, why has cereal production increased? The cereal yield in South East Asian countries are almost the same as that in the Japan today, although it was lower than that in Japan in 1961. The yield in South East Asian countries has increased and were almost 4 [t ha^{-1}] in 2009. On the other hand, the yield in Japan has not increased since 1961 (Figure 2b).

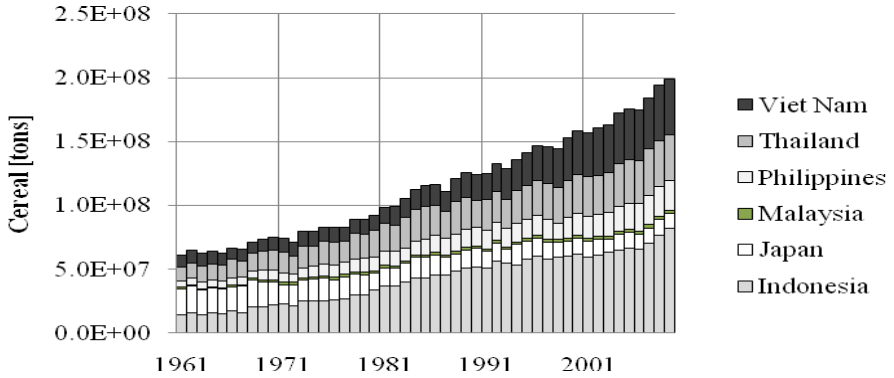

Fig. 2a. Cereal production

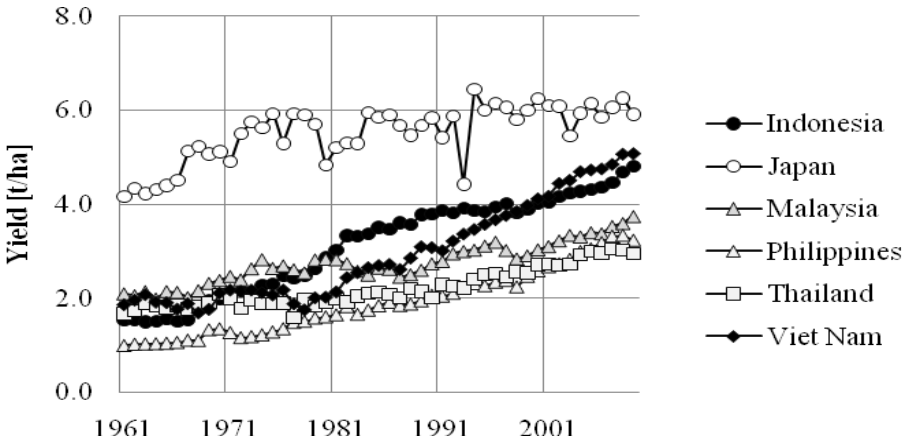

Fig. 2b Cereal yield

Then, why has cereal production of Japan decreased? The cereal harvest area of Japan has decreased. In 2005, it was 0.4 times smaller than that in 1961. Production in Japan has decreased because of this decrease in harvest area.

There is a good relationship between nitrogen fertilizer application and cereal yield (Figure 3). The yield is highest in areas where large amounts of nitrogen fertilizer are applied; it is relatively high in Japan but low in Thailand resulting in low cereal yield. This could increase in South East Asian countries if more nitrogen fertilizer is used, and thus, the region could produce more cereal using the present arable land.

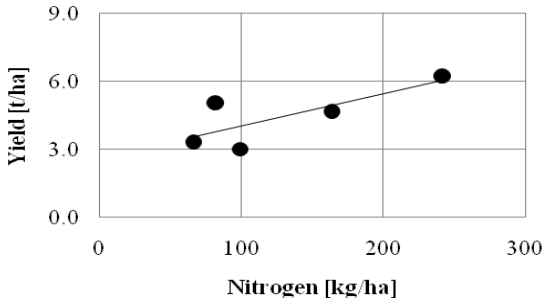

Fig. 3. Relationship between nitrogen fertilizer input and cereal yield

Meat production

Meat production has increased over the past 50 years (Figure 4). It has quadrupled, even though the population of the region has only doubled in 50 years. Therefore, meat production per person has doubled.

Fodder is necessary to produce meat and maize has been used as fodder worldwide. Fodder consumption in the region since 1961 is shown in Figure 5. Japan accounts for more than half of the entire consumption in six countries today. However, consumption in Japan has not increased since the 1980s. On the other hand, consumption has increased in South East Asia. Cereal fodder consumption seems to be almost constant in the 2000s while the production of meat has increased in the 21st century (Figure 4). Meat production and cereal fodder consumption in South East Asian

countries was 3.1 million tons and 4.5 million tons, respectively, in 1981. The ratio of meat to cereal fodder was 1.4. This ratio has increased; it was 1.7 in 2007.

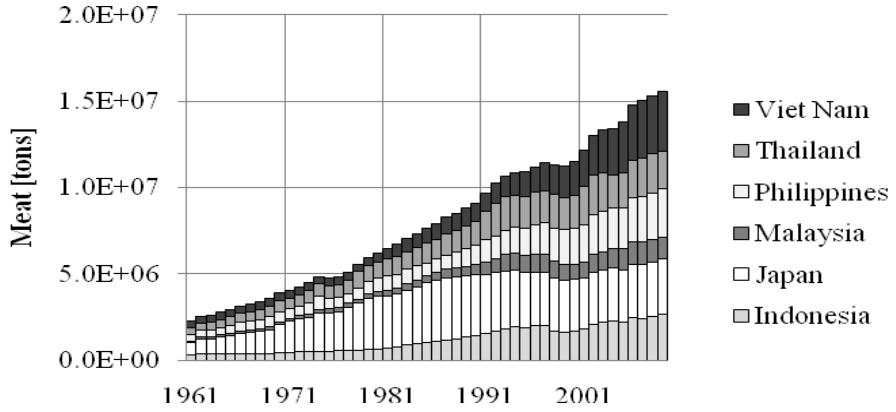

Fig. 4. Meat production

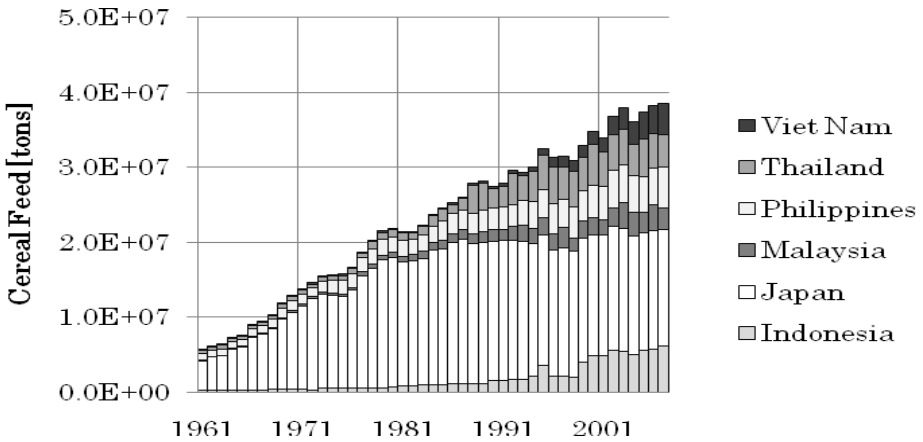

Fig. 5. Cereal feed

Soybeans are produced to make vegetable oil and the solids left after extraction of the oil is called soybean meal, which is high in protein and used as fodder. Cereal fodder consumption has not increased since the introduction of soybean meal. Worldwide soybean production has increased rapidly (Figure 6). Soybeans are mainly produced in the USA, Brazil and Argentina. Production has increased remarkably in South America, while that in the USA has hardly increased.

Trade

Cereal is consumed domestically and traded. World trade is about 300 million ton per year, corresponding to 13% of world production. Cereal is mainly exported from the West to Asian countries. The imported cereal was used as fodder, but has now been replaced by soybean meal. Soybeans are mainly exported to Asia from the USA, Brazil and Argentina. Soybean trade was 58 million tons in 2004, corresponding to 27% of world production. The export ratio of soybean is higher than that of cereals.

The amount of meat trade has increased rapidly, although the increase in cereal trade is not as much. Meat is mainly exported from Thailand. The amount of meat import has increased in Malaysia in recent years. Meat production using imported fodder is decreasing gradually; however, the import of meat has increased in South East Asia. The development of freezing techniques has contributed to meat trade.

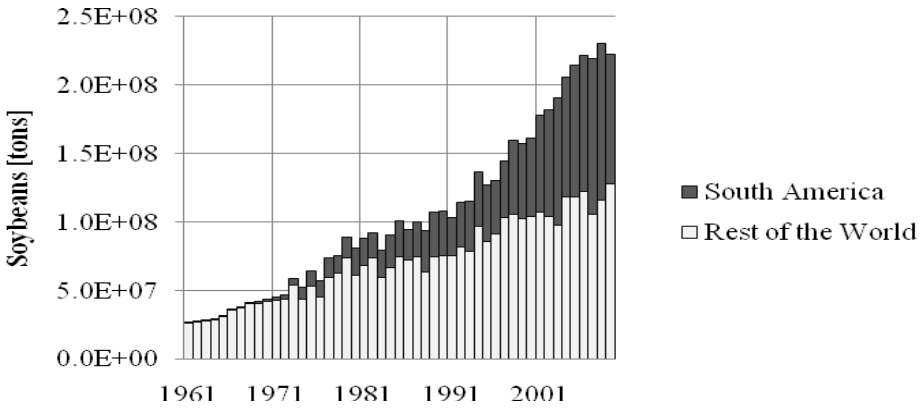

Fig. 6. Soybean production

Amount of food supply per person

Domestic production plus import minus export represents supply. Supply per person is supply divided by the population. The cereal supply per person does not differ (Figure 7a); however, the meat supply per person differs according to the country (Figure 7b). Present trends show that the meat supply in Malaysia and Vietnam has increased sharply. However, the meat supply hardly increased in Indonesia. Because of the different cultures, meat consumption in Indonesia is not predicted to reach the same levels as in the Malaysia and Vietnam. Problems associated with food supply in South East countries have improved in the past 50 years.

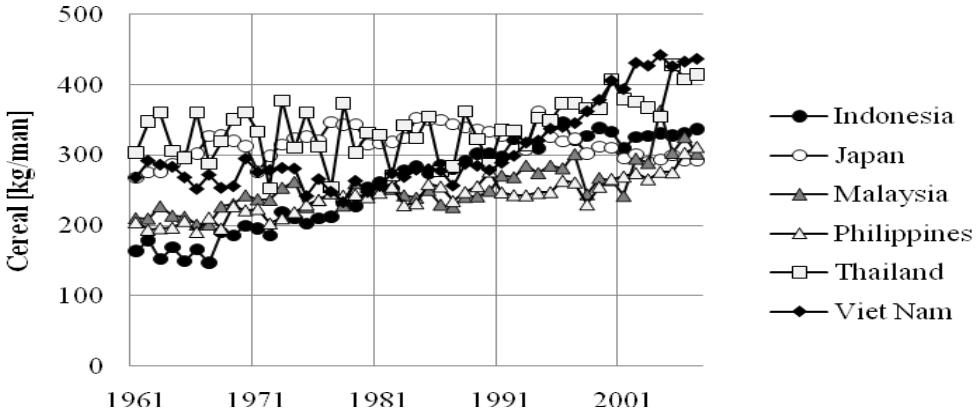

Fig. 7a. Annual cereal supply *per capita*

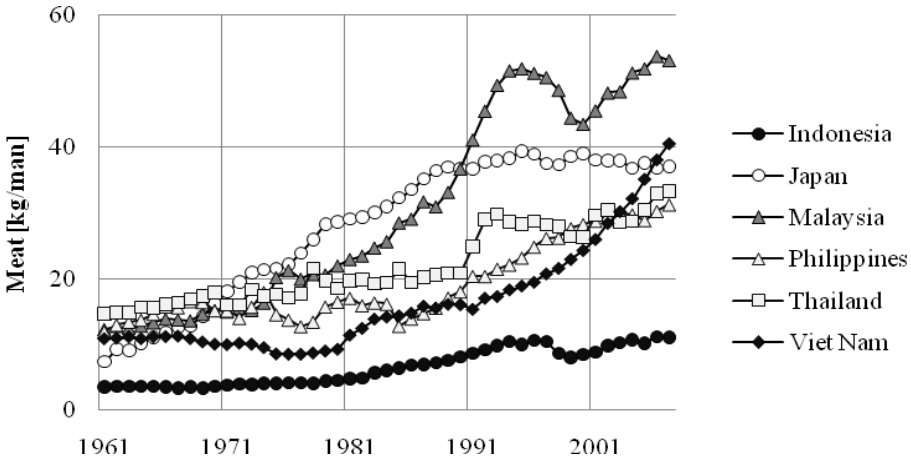

Fig. 7b. Annual meat supply *per capita*

Food production in the future

Earlier, I forecasted the food supply and demand in the 21st century from the population increase and economic trends of the past 50 years. I will now add the influence of climate to it. I refer to the IPCC report to determine the influence of climate change.

Forecast without climate change

I considered patterns for the 21st century in each country based on their past trends.

There is little problem with food supply in Japan because the population increase will decrease in the 21st century. Environmentally friendly pesticides, herbicides and fungicides, effective fertilizer supply systems and many other agriculture-related technologies will be developed in Japan. Ethanol production from biomass will hardly influence the demand and supply of food because the price of biomass is higher than that of crude oil.

Japan currently imports a large amount of cereals from the West. This will continue in the 21st century. However, it seems that the amount of import will not increase in future because the transition to a healthier diet in Japan is almost complete and meat consumption will not change. Japan will keep importing food in the 21st century.

The population increased in the 20th century; however, the rate of increase is now decreasing and South East Asian countries no longer have a rapidly increasing population. South East Asian countries can produce more food. Since Indonesia has large areas of land suitable for agriculture, food production will increase in the 21st century.

Thailand is also a big agricultural country. However, agricultural production here will not expand considerably in the 21st century because most of the land was developed in the 20th century, and there is little unutilized land suitable for agriculture.

Soybean production will increase in Brazil. In the near future, soybean export by Brazil will surpass exports by the USA. Soybean production in South East Asia will hardly increase in the 21st century.

Today, there are many poor peasants in the South East Asian countries. Addressing the problems of poverty is an important task in these countries. Capital investment in agriculture by the government will increase in South East Asian countries, and as a result, this will probably improve the income of poor peasants, especially Indonesia. Although South East Asia has a large population, there seems little possibility that it will face food shortages in the 21st century.

Malaysia and Indonesia are exporting palm oil. Malaysia has trade surplus it is therefore easy to import food. Malaysia is a cereal importing country. The population increases rapidly in this country; it was 8.4 million in 1961. The population today is 28 million and will be 40 million in 2050. Malaysia has a large oil palm planting area and less cereal planting area. Cereal import will continue to increase in the 21st century.

Nitrogen fertilizer usage is currently limited in the Philippine and Thailand. Production in both countries could be increased by using more nitrogen fertilizer. Nitrogen fertilizer usage facilitated the increase in production in both countries; it is necessary for South East Asian agriculture.

Forecast with climate change

The influence of global warming on food production in the West has both positive and negative aspects. In the US, there is a possibility that the mid-West will become drier with global warming. As this area produces the most grain, this will have a big influence on world food supply. The United States currently exports about 100 million tons of cereals. Most cereal fodder used in Japan is produced there. Droughts may occur frequently in Australia as a result of global warming. Because Australia exports a large amount of wheat, this will also influence the world food supply.

Because of global warming, the arable land area in Canada and Russia may increase. The two countries comprise about 20% of the world land area. Land that is frozen now is unsuitable for agriculture. However, there is abundant land in Russia and Canada, even if the frozen soil is excluded. Though capital investment is necessary, farmland area may increase. This will increase worldwide food production.

Drought may occur frequently in South East Asia because of global warming. Climate change will have a negative influence on South East Asia agriculture. However, the South East Asian countries economy is developing well, and it seems that South East Asian countries will be able to adjust to climate change. There are great opportunities for increasing cereal yield in the future because the present yield is relatively low. As a whole, I think the probability of South East Asian countries facing a food crisis in the 21st century is low.

CONCLUSIONS

Global warming will have a positive influence on countries located in northern Eurasia. Most countries of the West are located in this region. The West can adapt their agriculture to climate change because of the rapid development of agricultural technology. This means that a large amount of food will be produced in the West in the 21st century. The prices of food will be kept low in the 21st century. Most countries in South East Asia will not face a food crisis in the 21st century because the population growth rate will decrease rapidly.