Chapter 6. Effects of climate change on world food markets

1. Objectives

Increasing air temperatures are attributable to increased concentrations of greenhouse gases (GHGs) such as carbon dioxide (CO_2). Increased concentrations of CO_2 have some positive effects on plant growth (Poorter and Navas, 2002). Nevertheless, the higher temperatures impede seed growth of crops. Moreover, extreme temperature increases cause sterility.

Decreased crop production caused by climate change is expected to affect not only crop supply but also livestock production because of lower availability of animal feed. Analyses of climate change effects such as the analysis of Fischer et al. (2005) emphasize changes in crop production. Analyses of effects on livestock products are few (Rötter and van de Geijn, 1999).

The objectives of this chapter are to reveal climate change effects not only on crops but also on livestock products using the world food model developed in earlier chapters.

2. Simulation assumptions

Crop yields and per-head of livestock production increase depending on the trend parameter of the linearly estimated functions or the four parameters of the logistic functions. Climate variables follow four RCP scenarios. GDP and population follow five SSP scenarios.

Climate baseline numbers are presented on the assumption that these numbers are fixed in average numbers of three years from the starting year of this simulation: 2010. Furthermore, price differences between those of leader countries and other countries are fixed in the simulation start year.

3. Simulation results

First, climate change effects on crop yields are investigated by comparing results of RCP6.0 and the baseline under SSP2. Figure 6-1 portrays average changes in crop yields for the 2050s. Rice production in North and South American countries and northern African countries are expected to be adversely affected by climate change. Wheat production in low-latitude countries is expected to decrease. Maize and other cereals are used mainly as feed for livestock. Maize production in northern and southern African and South Asian countries are expected to decrease. Other cereal production in low-latitude countries is expected to decrease because of climate change. Soybeans and other oil crop production will not be affected as strongly by climate change as other crops.

Second, changes in yields in four major affected countries are investigated with comparison of the following four scenario combinations: baseline–SSP2, RCP6.0–SSP2, RCP2.6–SSP1, and RCP8.5–SSP3. Figure 6-2 depicts the simulation results, which indicate that rice production in Viet Nam will be 0.2 t ha^{-1} lower and that wheat production in India will be 0.13 t ha^{-1} lower in the 2050s. Higher GDP will engender greater production in India. These results also demonstrate that maize production in Brazil and other cereal production in Nigeria will not be strongly affected by climate change, although changes in GDP are expected to engender larger maize yield differences in Brazil.

Third, changes in food and feed crop supply are investigated by comparing results of RCP6.0 and the baseline under SSP2. Figure 6-3 displays changes in the supply of crops related to climate change worldwide in the 2050s. These maps reveal that the per-capita food supply of rice and wheat, which are unaffected by climate change because production in important rice producing countries in Asia and wheat producing countries in North America and Oceania, are expected to increase because of climate change. These products will be traded to countries in which shortages occur. However, these maps indicate that feed supply in some countries, especially in South America, are expected to be decreased by climate change.

Figure 6-4 portrays changes in the overall feed supply for two crops and two cakes in South American countries. Comparing RCP6.0–SSP2 to baseline–SSP2, feed supply of maize, other cereals, soybean cake, and other seed cakes are expected to decrease respectively by 6.5 million t, 0.5 million t, 3.5 million t, and 0.5 million t in the 2050s.

Finally, climate change effects on livestock product food supply are investigated. Figure 6-5 portrays changes in supply of meats, eggs, and raw milk worldwide. These are results of comparing RCP6.0 and the baseline under the same socioeconomic scenario, SSP2. These maps demonstrate that the effects of climate change on the food supply of beef will not be large. Nevertheless, these results also demonstrate that climate change will adversely affect food supply of other meats, poultry eggs, and raw milk in many countries.

4. Conclusions

Expected climate change effects on food supply and demand were investigated using a world food model: a partial equilibrium model. The core of this model is the crop sector. The yield functions reflect an inversed U shape relation between temperature and yield. Long-run simulation becomes available using crop yield functions.

After feed production and the livestock sector are added to the crop sector, climate change effects on livestock supply are analyzed. Climate change is expected to

decrease crop production severely in some countries. However, crop production will rise in other countries. Regarding feed supply, climate change effects are expected to engender decreased production in some countries, especially in South American countries. Consequently, the supply of livestock products is expected to decrease worldwide.

This expected decrease in livestock supply will engender a tendency of lower consumption of protein and other fundamentally important nutrients, especially in economically developing countries. Decreased nutrition supply resulting from climate change in low-latitude countries such as sub-Saharan African or South Asian countries looms as a potential threat to future generations. To resolve such difficulties, development of high-CO_2-concentration tolerant maize or high-temperature tolerant rice varieties are desired as technologies for climate change adaptation, in addition to facilitation of feed trade.

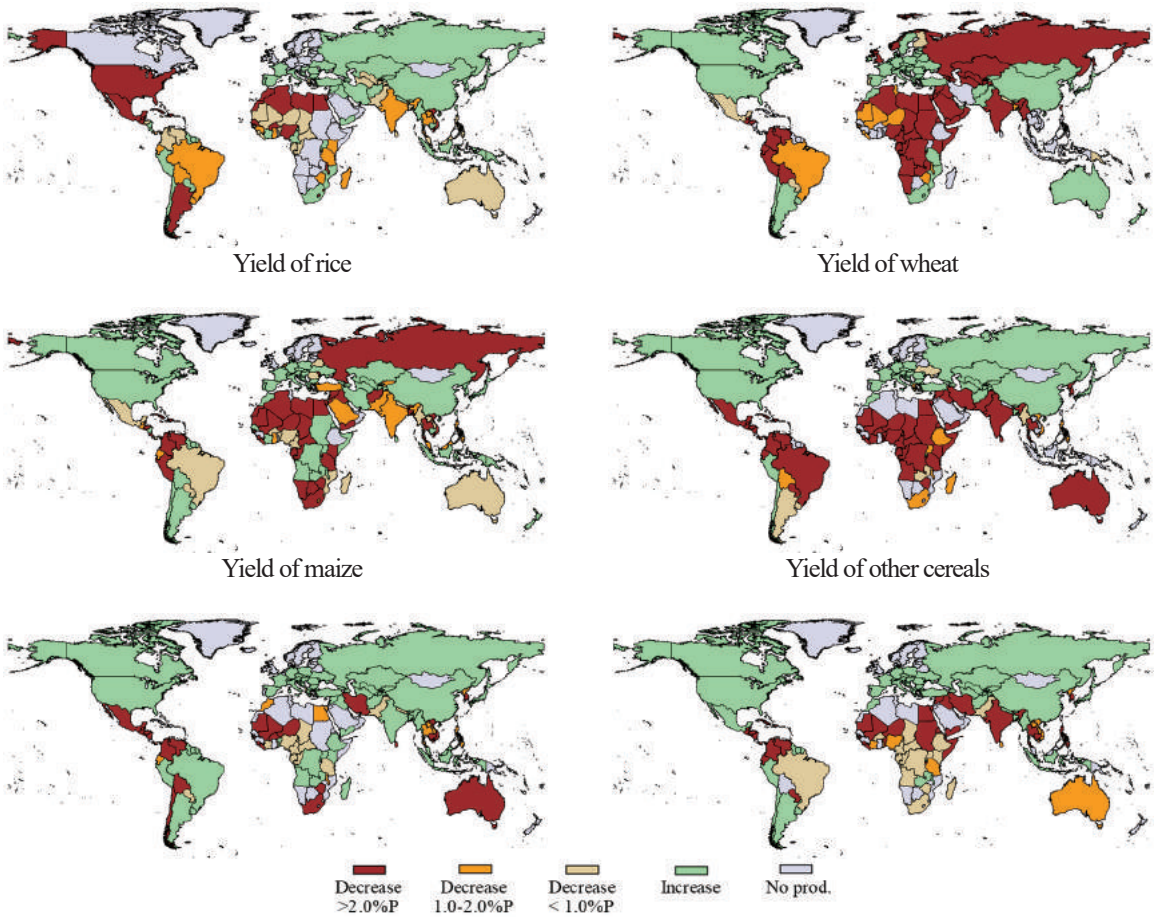
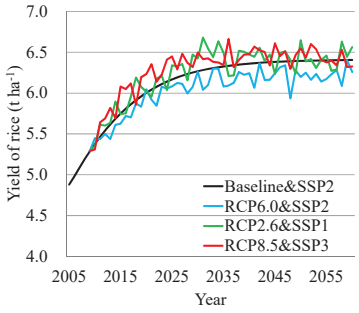
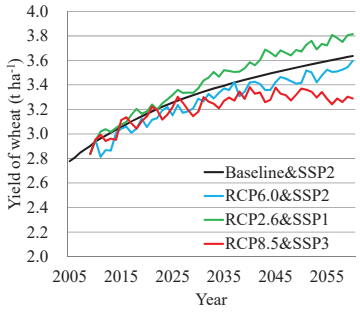


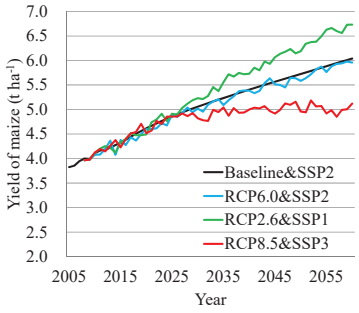
Figure 6-1. Changes in crop yields attributable to climate change in the 2050s.
Note: Comparing results of RCP6.0 and the baseline under SSP2 are portrayed.
The year of launchpad data is 2010.
%P: percent point



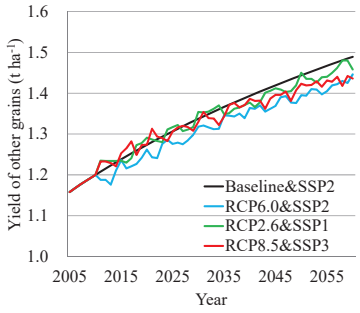
Yield of rice in Viet Nam



Yield of wheat in India

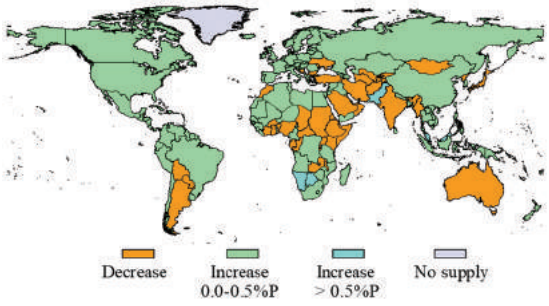


Yield of maize in Brazil

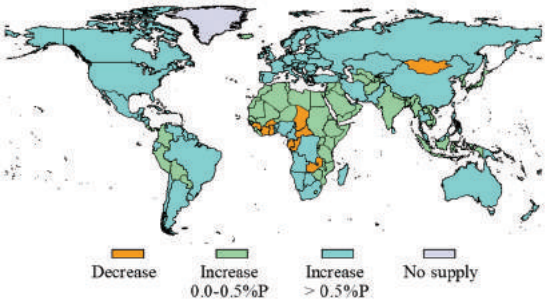


Yield of other grains in Nigeria

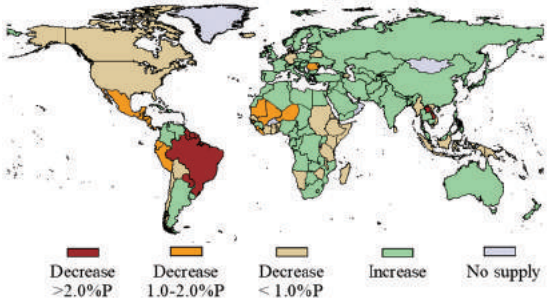
Figure 6-2. Changes in crop yields in major producing countries.



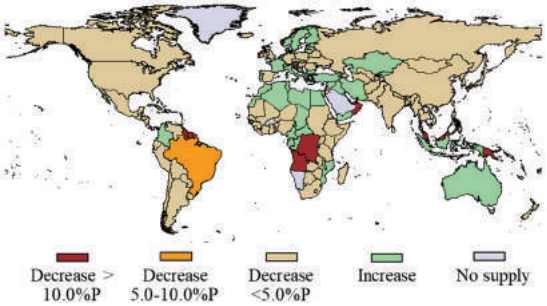
Per capita food supply of rice



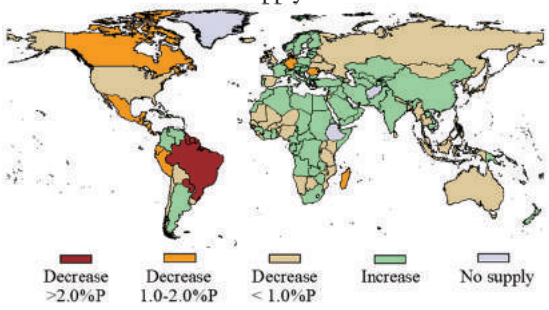
Per capita food supply of wheat



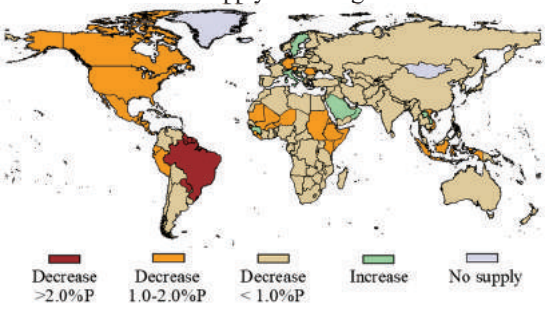
Feed supply of maize



Feed supply of other grains



Feed supply of soybean cake



Feed supply of cake of other oil seeds

Fig. 6-3. Changes in crop supply caused by climate change in the 2050s.
Note: %P: percent point

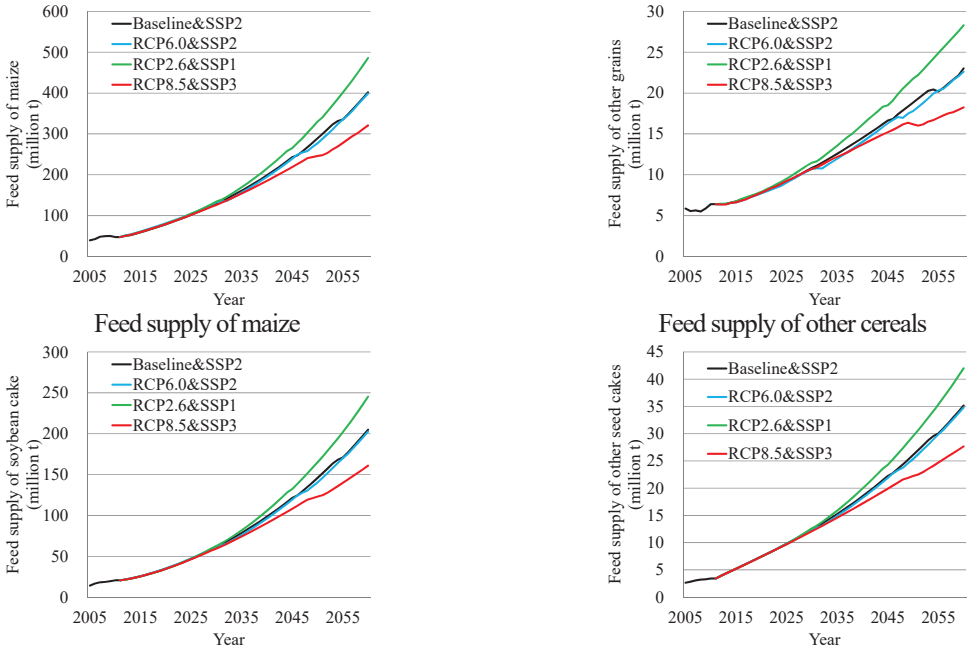


Fig. 6-4. Changes in all feed supply in South American countries.

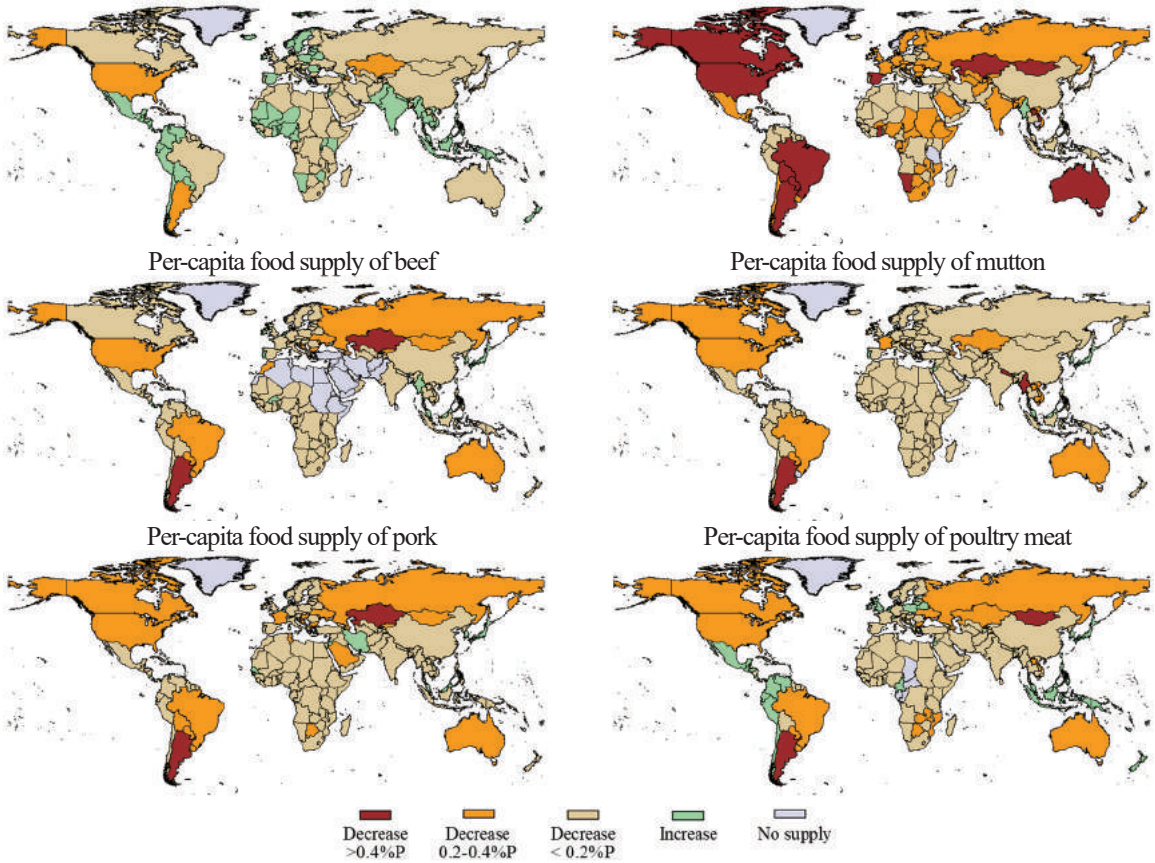


Figure 6-5. Changes in livestock product supply caused by climate change in the 2050s.
Note: %P: percent point