Chapter 1 Introduction

The fourth assessment report (AR4) of the IPCC (2007) described that the global average air temperature increased 0.74°C during the 20^{th} century. The AR5 of the IPCC (2014) reported that the global average air temperature of the worst scenario is expected to increase by around 4°C by the end of this century. Furthermore, the World Meteorological Organization (WMO) (2018) reported that the air temperatures had increased dramatically in the summer in 2018 because of increased seawater temperatures in the western Indian Ocean and higher temperatures affecting agricultural production in southern and eastern Africa. For analyzing the effects of climate change on agricultural production and the supply, a world food model that can produce long run outlooks is necessary because climate change is expected to cause severe damage in the distant future.

Parry et al. (1999) are pioneers of climate change analysis applied to food security. They combined a world trade model and a crop model in analyses that were scientific and well-organized. Many researchers have cited their results. However, the link between the crop model and the economic model is complicated.

Ensuring model transparency, Furuya and Koyama (2005) estimated macro yield functions for crops of which the explanatory variables are climate variables, i.e., air temperature and rainfall. These crop yields are used for the world food model, which is designated as the International Food and Agricultural Policy Simulation Model (IFPSIM) (Oga and Yanagishima, 1996).

Actually, IFPSIM is a world food model developed by JIRCAS and the Policy Research Institute of the Ministry of Agriculture, Fisheries, and Forestry of Japan (PRIMAFF). The purpose of the model is evaluation of policies such as a trade agreement involving agricultural products. This model is a basis of the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) of the International Food Policy Research Institute (IFPRI) (Rosegrant et al., 2008).

Development of IFPSIM started around the late 1970s by the Mitsubishi Research Institute (MRI) consigned by MAFF, Japan. This model was developed by Dr. K. Oga (Ohga) and the research staff of MAFF, although it was completed by Dr. K. Yanagishima and Mr. O. Koyama, who are JIRCAS staff members. This model has been modified and used by PRIMAFF staff members. Furthermore, Furuya and Kobayashi (2009) extended IFPSIM to a stochastic model.

In fact, IFPSIM is a synthetic model for which parameters such as elasticities of supply are introduced from other studies. Unfortunately, what articles include the original elasticities remains unknown today. To change the other world food model, the elasticities of the Agricultural sector linkage-Commodity simulation model (Aglink-Cosimo) Model (OECD, 2015), which was developed by the Organization for Economic Cooperation and Development (OECD) and the Food and Agriculture Organization of the United Nations (FAO), are determined through discussions of the authorities of the constituent countries. Furthermore, the elasticities of the World Agricultural Trade Simulation Model (WATSIM), which was developed by Dr. M. von Lampe of the Bonn University, are introduced from other research papers such as those from IFPSIM.

Some world food models have estimated their parameters of functions independently. Parameters of the Basic Linked System (BLS) (Fischer et al., 1988) of the International Institute for Applied Systems Analysis (IIASA) are obtained by estimating Linear Expenditure System (LES) models, yield functions, and feed cost functions. This model is used for the analyses of effects of climate change such as the study of Parry et al. (1999). On the other hand, the parameters of planted area and demand functions of the models of the Food and Agriculture Policy Research Institute at the University of Missouri (MU-FAPRI) are estimated by using ordinary least squares (OLS) or two-stage least squares (2SLS) method.

Ideally, obtaining elasticities of the model by estimation of the area or demand functions by the model builder is better because the estimation period of the functions is close to the time of development of the world food model and because these estimation methods are identical. However, if the countries or regions of the model are numerous, then it will be difficult for the model builder to estimate the functions.

This study was conducted to develop a world food model to elucidate climate change effects on food supply mainly in economically developing countries such as those several among Sub-Saharan African countries. Therefore, this model must include many countries or regions of the world. To overcome these difficulties, the price elasticities of supply and demand for agricultural products examined in this study are calculated using the cost shares of the respective inputs to the output values, as obtained from data of the Global Trade Analysis Project Data Base Version 9 (GTAP9), which covers 140 countries and regions.

When analyzing climate change effects on agricultural production, if a model does not assume lower crop yields when exceeding optimum temperatures, then the long run analysis results can be regarded as unrealistic. To overcome this difficulty, quadratic or much higher-order yield functions must be estimated. Nevertheless, such estimations are difficult because relevant data are insufficient. Coping with this difficulty of estimating yield functions, the world food model used for this study holds functions for which the relation between temperature and yield is an inverse-U shape (Furuya et al., 2015).

This working report comprises five parts. First, the calculation method of elasticities of supply, input demand, and food demand are explained. Second, the equations and the calculation routine for the supply and demand equilibrium are described. Third, the crop yield function, into which crop model parameters are included, is explained. Fourth, data are used in this model and are presented along with examples of the calculated elasticities. Finally, climate change effects on agricultural production and world markets are described.