Closing yield gaps under climate change in a global computable equilibrium model of the world economy

1. Introduction

Land use and land use change is determined as much by economic and institutional drivers as it depends on the bio-physical conditions. The demand for different uses of biomass is increasing and thus land use change and the expansion of farming areas into natural habitats may threaten ecosystems and their services. Factors influencing this process include climate and demographic change but also an increasing globalisation of agricultural markets paired with an increasing divergence between regional supply and demand of biomass. On the supply side, land productivity considerably increased over the last decades. As an example, global cereal production increased between 1961 and 2013 by 185%, while at the same time harvested area for cereals increased only by 2.4%, arable land by 8.2% and agricultural area by 12.6% (FAOSTAT 2015). However, yield trends of the most important staple crops are not sufficient to double global food production by 2050 (Ray et al. 2013). At the same time agricultural yields as well as production stability are threatened by a changing climate. In addition, agricultural production and agricultural markets highly depend on numerous political interventions, e.g. on the support of biofuels. Socio-economic changes, such as increasing incomes and changes in consumption patterns already lead to increases e.g. in demand for animal feed that outgrows food demand for direct consumption. In the medium to long-run these consumption patterns may also alter the processes of global change. Such future pathways of socio-economic and environmental systems can only be assessed with scenarios which describe possible future paths of development. For this numeric models are one important tool.

Food supply and accessibility depends not only on the ability to produce a sufficient quantity and quality of food, but also on the food price level. Thus, projections of future food supply and prices need to consider various biophysical and socio-economic parameters at the global and local scale. While the increase in global agricultural yields allowed global food production to keep pace with population growth, in many regions of the world agricultural yields are still low and the exploitable gap is therefore high. Changes in agricultural productivity are driven by region-specific factors, but at the same time by economic factors such as the profitability of certain crops in certain areas. In this paper, we aim to study systematically the impact of closing yield gaps under climate change on global agricultural markets.

The impact of climate change on the agricultural sector has been estimated by only a few scientific studies with varying results and high levels of uncertainty (IIASA and FAO 2012; Mueller et al. 2012;

Rosenzweig et al. 2013; van Ittersum et al. 2013). While using different spatial and temporal scales as well as different climate scenarios, they have in common that economic models (partial or general computable equilibrium models) take information on changes in agricultural productivity from biophysical models. Our contribution to this literature is that in contrast to these studies we develop a modelling framework that allows the crop allocation in the bio-physical model to change in the future.

Structure of the paper