Title: From global economic modelling to household level analyses of food security and sustainability: how big is the gap?

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ABSTRACT

Policy and decision makers have to make difficult choices to streamline issues around climate change, food security, energy supply, globalisation of markets, population and economic growth, and declining natural resources. Ex-ante impact assessment using integrated models that systematically link development pathways with biophysical and socioeconomic processes and characteristics offers them a decision support tool to help with these decisions. However, these models need to to integrate relationships across disciplines, levels of organisation and scales (Ewert et al., 2011). This review gives an overview of the state of affairs of this multi-scale modeling of policy interventions, with an emphasis on applications in developing countries. It identifies key gaps in the current approaches to work truely across multiple integration levels, and suggests ways forward to deal with these gaps.

Up to now modelling efforts have focused on specific aspects of policy, market and land systems (e.g. Dalgaard et al., 2003; Volk and Ewert 2011). Current approaches either use top-down global and continental approaches (e.g. macro-economics and large scale land use modeling (e.g. Zhang et al., 2013; Creutzig et al., 2012) or bottom-up approaches, from farm level upwards (farm household modeling, micro-economics, agent based models and landscape level land use modeling) (e.g. Rufino et al., 2011; Parker et al., 2003; Valdivia et al. 2012). Existing models do not sufficiently capture the complexity of human–environment interactions across different scales, and especially the link between landscape and local market levels, and national and sub-national level policies and markets is missing (Ewert et al., 2011; Rounsevell et al., 2012; Creutzig et al., 2012). Existing approaches to assess the consequences of global or regional market models on farm household level, take simplistic approaches to represent farmer's diversity and also ignore the diversity in local markets and their effects on price formation. Bottom-up approaches that take into account crop and livestock productivity and analyse food security of farm households take either a landscape approach (e.g. in many multi-agent models or in land use models) (e.g. Parker et al., 2003) or in a few cases perform a micro-economic analysis including feedbacks between household choices for production of different commodities and price formation at local markets (Valdivia et al., 2012; Laborte et al., 2007; Straatman et al., 2013), but do not go beyond the landscape/local market level.

The paper suggests a step wise approach with increasing data needs to bridge the existing gap from farm to sub-national market and policy level in multi-scale impact assessment models with a focus on smallholder farming in developing countries. Clear improvements need to be made at the description of effects of the distribution of local markets on price formation and the representation of farm diversity within existing large scale maps of farming systems (Dixon et al., 2001; Sere and Seinfeld, 1997). Especially answering the question 'how many are there of which farms, and where are they located' is pertinent. Here remote sensing, farm characterisation questionnaires, and market access and agro-ecological information need to come together. If both environmental and food security related issues are addressed, distributions of farm characteristics need to be linked statistically to both landscape properties (i.e. be given an explicit location in the landscape) and socio-economic factors like distance to markets, thereby increasing substantially the information and model complexity needed to analyse policy interventions (e.g., Verburg et al., 2013). The modellers quest for 'finding homogeneity in heterogeneity' (Messerli et al., 2009) to be able to aggregate fine-scale information for up-scaling purposes has quite some similarities to the one for the holy grail. It is easy to drown in model complexity and unrealistic model data demands, although this danger should also not result in that we only use simplistic representations of the inherent complex socio-agroecological systems (Rounsevell and Arneth, 2011). Detailed micro-market and multi-agent studies are useful in this context if they are used to derive summary functions describing the most important effects of feedbacks between farmers' choices and local markets, thereby possibly simplifying the complexity of the overall model framework needed without losing key interactions. Clearly, these are not approaches that can be easily applied across the globe, but are typically targeted towards multiscale policy analyses in certain regions.

Keywords: multi-scale, integrated assessment, models, macro-economy, food security, sustainability

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