Trade policy and climate change impacts on regional land use and environment

M. Kirchner and E. Schmid[1]

***Abstract* - We analyse the combined effects of trade policies *and* climate change on land use and environment in the case study region Marchfeld, Austria. An integrative modelling framework is conducted in order to account for the heterogeneity in agricultural production and emission as well as the effects of climate change on agronomic measures. Trade liberalization leads to more extensive agricultural land use in the Marchfeld region. This partially mitigates negative effects of climate change such as increasing groundwater withdrawals, but amplifies others such as declining producer surpluses.**

INTRODUCTION

Since the 1990ies – a decade that marks the adoption of the Uruguay Round Agreement on Agriculture – there is an increasing interest in studying the environmental effects of agricultural trade policies. Modelling analyses on trade liberalization project large shifts in agricultural production from Europe and North America to Africa, South-East Asia and South America (see for example Schmitz et al., 2012). On the one hand, Europe may experience a shift to more extensive agricultural land use which could benefit the environment (and associated ecosystem services), but it may threaten rural livelihoods and diminish the multifunctional values of agriculture (especially if land abandonment takes place). On the other hand, tropical regions may experience increases in deforestation due to the expansion of agricultural land. This would negatively affect biodiversity conservation and GHG emissions.

The effects of climate change on agricultural land use are increasingly analysed at regional to global scales (Olesen et al., 2011). For example, higher temperatures and less precipitation may negatively affect crop yields of rainfed agriculture in the Austrian Marchfeld region (Thaler et al., 2012). More irrigation may compensate for less precipitation, but comes at a higher production cost and may increase pressure on limited groundwater resources.

Computer intensive modelling exercises are increasingly considering the socio-economic and climate change effects in impact analyses on land use and environment (e.g. Briner et al., 2012). These studies indicate that considering both effects at the same time yields different results than analysing them separately and may provide some insights on the interactions between these factors.

The effects of trade policies and climate change may differ vastly across regions due to heterogeneity in agricultural production systems and the natural environment. Therefore, we aim to conduct an integrative analysis for the region Marchfeld, Austria. We consider Marchfeld to be vulnerable to trade policy changes because it is one of the most important crop production regions in Austria and water resources are negatively affected both quantitatively and qualitatively by intensive agriculture. Moreover, due to its semi-arid climate it is also vulnerable to climatic changes.

DATA AND METHOD

The biophysical process simulation model EPIC (Environmental Policy Integrated Climate) has been employed to predict crop yields and environmental outcomes (e.g. nitrogen losses) for important crops by natural conditions (i.e. soil types and topography), crop rotations and crop management measures. The crops are – inter alia – winter wheat, winter and spring barley, corn, sugar beets, potatoes, carrots, sunflower, rapeseeds, soybeans and winter rye. Crop rotation shares are derived by the CropRota Model (Schönhart et al., 2011) which takes into account observed crop shares, suitability scores on pairwise crop combinations, and agronomic constraints. Crop management measures comprise of different fertilizer application rates (standard, reduced and low) and irrigation systems (rainfed and sprinkler irrigation).

The gross margins calculations include (i) average crop prices for the years 1998-2010; (ii) premiums for applying reduced or low fertilization rates; (iii) production costs from the standard gross margin catalogue, and (iv) annual capital costs of irrigation systems. In the development of our trade policy scenarios, we make use of applied MFN tariffs for the years 1998-2010 as well as of predicted changes in world prices due to global liberalization scenarios.

Finally, we integrate these environmental and economic datasets into a regional land use optimization model. This model maximizes average annual regional producer surplus (RPS) subjected to regional resource endowments as well as crop rotational constraints.

We use two climate and two trade policy scenarios for the period 2011-2040 and compare these to a reference period (*Past*) 1976-2005 (Table

[1] University of Natural Resources and Life Sciences, Institute for Sustainable Economic Development, Feistmantelstrasse 4, 1180 Vienna, Austria.

M. Kirchner is also PhD candidate at the Doctoral School Sustainable Development (dokNE) (mathias.kirchner@boku.ac.at).

E. Schmid is Professor for Sustainable Land Use and Global Change (erwin.schmid@boku.ac.at).

1). The two climate scenarios are derived from a statistical climate model for Austria (Strauss et al., 2012) and serve as an important input to EPIC. A *partial* trade policy scenario (i.e. the adoption of the Doha Development Agenda) and a *full* trade policy scenario (i.e. full elimination of trade barriers) are further compared to a business-as-usual scenario (*BAU*) where no trade policy changes take place.

Table 1. Reference and Global Change scenarios.

	Past	Scenarios		
Period	1976-2005	2011-2040		
Climate Change		**ClimA**		**ClimB**
Temperature	Observed	*+1.5C°*		*+1.5C°*
Precipitation sums	Observed	No change		*-20%*
Trade Policies		**BAU**	**Partial**	**Full**
Tariff reductions	None	None	*-45%*	*-100%*

Results

Our results (Figure 1) indicate that climate change seems to have negligible effects on fertilizer application rates, while trade liberalization seems to lead to significantly lower fertilizer application rates. Furthermore, irrigation appears to be an efficient response to a warmer and drier climate, but this effect is partially offset by trade liberalization.

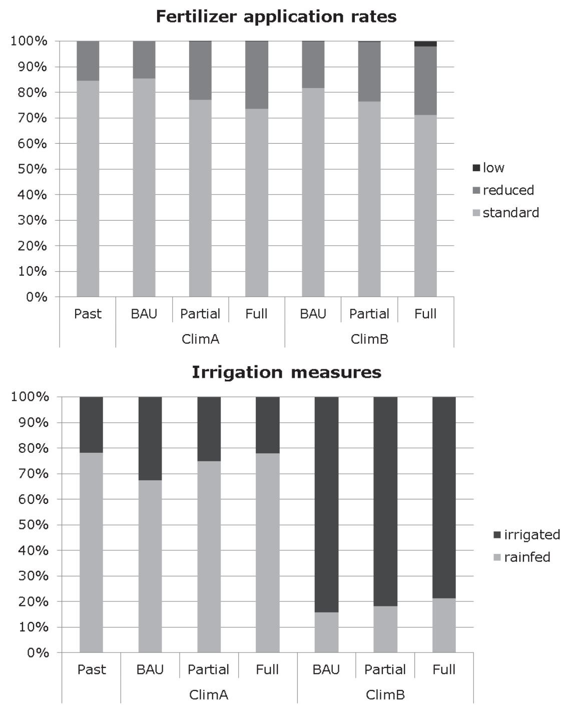

Figure 1. Effects of Global Change scenarios on the composition of crop management measures in % (own results).

It thus seems as if lower prices (due to liberalization) make *extensive agricultural production* more profitable to farmers. Hence, trade liberalization may turn out to provide potential environmental benefits in the Marchfeld region, for example less nitrate pollution. Notably, our model results show only very marginal changes in total nitrate emissions compared to the BAU scenario (no more than -1%). The reduction in water withdrawal (compared to BAU) can be quite considerable (between -2,5% and -28,2%).

Contrarily, the effects on RPS are rather negative, as lower prices decrease revenues. However, the positive effects of climate change on crop yields in scenario ClimA can compensate this effect to some extent.

Conclusion and outlook

Including climate change effects into trade policy analyses may offer new insights into global change phenomena. In the Marchfeld case study region, trade liberalisation may mitigate some negative effects of climate change such as increasing groundwater withdrawals, and amplifies others such as declining producer surpluses. We extent our analysis to include more crop management measures (e.g. soil conservation), and to the national level (Austria). In addition, we apply Monte Carlo simulations to account for uncertainty in some model parameters.

Acknowledgement

This research has been supported by the Doctoral School Sustainable Development (dokNE) of the University of Natural Resources and Life Sciences, Vienna as well as by the project CAFEE (Climate Change in agriculture and forestry: an integrated assessment of mitigation and adaptation measures in Austria), funded by the Austrian Climate and Energy fund within ACRP.

References

Briner, S., Elkin, C., Huber, R. and Grêt-Regamey, A. (2012). Assessing the impacts of economic and climate changes on land-use in mountain regions: A spatial dynamic modeling approach. *Agriculture, Ecosystems & Environment* 149: 50–63.

Olesen, J.E., Trnka, M., Kersebaum, K.C., Skjelvåg, A.O., Seguin, B., Peltonen-Sainio, P., Rossi, F., Kozyra, J. and Micale, F. (2011). Impacts and adaptation of European crop production systems to climate change. *European Journal of Agronomy* 34, 96–112.

Schmitz, C., Biewald, A., Lotze-Campen, H., Popp, A., Dietrich, J.P., Bodirsky, B., Krause, M. and Weindl, I. (2012). Trading more food: Implications for land use, greenhouse gas emissions, and the food system. *Global Environmental Change* 22: 189–209.

Schönhart, M., Schmid, E. and Schneider, U.A. (2011). CropRota – A crop rotation model to support integrated land use assessments. *European Journal of Agronomy* 34: 263–277.

Strauss, F., Formayer, H. and Schmid, E. (2012). High resolution climate data for Austria in the period 2008-2040 from a statistical climate change model. *International Journal of Climatology*: DOI 10.1002/joc.3434

Thaler, S., Eitzinger, J., Trnka, M. and Dubrovsky, M. (2012). Impacts of climate change and alternative adaptation options on winter wheat yield and water productivity in a dry climate in Central Europe. *The Journal of Agricultural Science*: DOI: 10.1017/S0021859612000093