UNIVERSITÄT HOHENHEIM

Impacts of Climate Change on Agriculture and Poverty in Linares Province of Chile

Thesis

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by

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Introduction

"Climate change is one of the greatest challenges facing humanity, and it is the world's most vulnerable populations who are most immediately at risk. The actions of the wealthiest nations, those generating the vast majority of greenhouse gases, have tangible consequences for people in the rest of the world, especially in the poorest nations"

Michael R. Bloomberg, Mayor of New York

Global climate change distress plays a big role in current environmental and development agenda. In last 30 years this topic turned from a field of interest of small research circles and environmental groups to a heavily discussed issue on the highest administrative and media levels, becoming an important subject of political trade. The strong trends in climate change became already evident. Emissions of greenhouse gases caused continuous future warming of the Earth's surface at the rate of approx. $0,1°C$ per decade (IPCC 2007). This fact alone raises demand for impact assessments and development of practical adaptation strategies.

Climate change affects various aspects, which are directly related to human life, such as:

- Fresh water resources availability and quality
- Ecosystems and their properties
- Agricultural and forestry production
- Coastal systems and fishery
- Floods in low-lying geographical areas
- Settlement security
- Food safety and food security
- Health and sanitation

According to World Development Report 2008 (World Bank 2008) agriculture is the core driver of overall development. Agriculture is a very important economic activity, which provides numerous services such as economic, social, cultural and ecological. To meet rising demands for food, driven by the exponential growth of human population agriculture is constantly facing challenges of productivity improvements. Climate

change is seen as an emerging barrier to agricultural progress, adding extra constraints and uncertainties to a risky agricultural business.

It is not the changes itself that matter for agricultural producers, but their lack of adaptation capacity and information, inability to foresee the future climatic conditions in order to be prepared to cope with them. Unfortunately, changes with most impact on agriculture are taking place in the regions with larger shares of rural population - people whose livelihoods are greatly dependent on agriculture (Christensen et al. 2007). Typically governmental budgets of these countries can not provide much support for farmers in dealing with climate change issue. Also, the agriculture in the developing world is smallholder based and due to immaturity of farmers' organizations and a weak political lobby, farmers are not able to attract much attention to their actual and potential problems. This study is designed to show the influence of climate change on poor subsistence farmers in order to create awareness of policymakers and development organizations of impacts that are likely to happen in rural agriculture.

For scenario simulations current study uses MP-MAS software tool, which is a multi-agent modeling framework of household-based economic decision-making. It is coupled with a biophysical model of water supply replication and a crop growth model. One of the main features of using such a tool is that it's able to reproduce the complexity and variability of impacts that different households can face and strategies that they follow. Multi-agent based approach allows identifying different groups of farmers affected by climate change, in order to plan individual future treatments. The specific MP-MAS version constructed by the author is able to conduct simulations also on the level of geographical sectors. With this spatial levels of water security and water deficit can be assessed, water reservoir operations can be simulated.

The modeling software was adapted to local specifics of Linares Province of Central Chile (study area) in the frames of Challenge Program on Water and Food of the Consultative Group on International Agricultural Research, undertaken in 2005-2008. This model application represents around 3600 real farming households of which near 15% are smallholder farms with 5 or less hectares of arable land available, which members in many cases live around poverty line. Therefore, current application can be well used for poverty related analysis.

Agriculture of Linares Province is already facing water scarcity and relatively high prices for irrigation water (Schilling 2007). Moreover, according to Climate Change 2007 report done by Intergovernmental Panel of Climate Change, most of the global meteorological projections conclude, that Central Chile will experience a drop in level of precipitation during this century. Combined with likely annual temperature increases, which would lead to earlier melt of mountain snow and therefore shifts in water supply by rivers towards earlier seasons, which all may have a significant influence on farming practices and farmers' well-being.

The major challenges that one has to overcome, when conducting predictive modeling, associated with proper simulation design and integration of empirical data into the software framework. Researchers have to construct adequate structure of assumptions originated from common theory of multiple scientific disciplines. This thesis also can be seen as a practical example of implementing such procedures.

The first chapter of this work provides a brief introduction and characterizations for basic understanding extracted from major related scientific writings. Climate change and agriculture interrelationships as well as rural poverty definition and descriptions are presented in global, regional and local contexts. Chapter 2 concludes with major results of qualitative analysis of key informant interviews. It portrays the inner problem assessment and visions of possible adaptation strategies by local key informants.

Chapter 3 follows with a brief modeling methodology, discusses mechanisms of interactions that are essential for this research. Analysis of meteorological data, derivation of likely rainfall and temperature trends and its influences on hydrological flows are described in chapter 4. Construction of simulation scenarios, their assumptions, identification of investigated subpopulations are illustrated here. Also, the chapter 4 presents predictions of future market developments used in simulations.

Chapter 5 encloses results of climate change impact analyses derived from different types of model simulations and identifies suitable responses for one of the water reservoirs. The final chapter concludes with the main study outcomes and provides floor for discussions.