Sustainable Agriculture in China: Estimation and Reduction of Nitrogen Impacts

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Abstract In this chapter we present an integrated model for long term and geographically explicit planning of agricultural activities to meet demands under resource constraints and ambient targets. Environmental, resource and production feasibility indicators permit estimating impacts of agricultural practices on environment to guide agricultural policies regarding production allocation, intensification, and fertilizer application while accounting for local constraints. Physical production potentials of land are incorporated in the model, together with demographic and socio-economic variables and behavioral drivers to reflect spatial distribution of demands and production intensification levels. The application of the model is demonstrated with a case study of nitrogen accounting at the level of China counties. We discuss current intensification trends and estimate the ranges of agricultural impacts on China's environment under plausible pollution mitigation scenarios with a particular focus on nitrogen sources and losses.

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1 Introduction

Economic growth, increasing demand for food, feed, fiber and biofuels speed up industrialization of agricultural activities characterized by new technologies, specialization and concentration, higher mechanization, increased chemical and fertilization. Production intensification is primarily guided by profit maximization principles and has a number of comparative advantages. However, there are risks and costs which are often not factored in the production planning process, e.g., loss of food and producers diversity, GHG emissions, environmental and water pollution, problems related to human health and livestock diseases, degradation and decrease of socio-economic conditions in rural areas, poverty, rural-urban migration, loss of cultural heritage, etc.

Adverse implications of production intensification, in particular, environmental impacts and health risks establish the need to identify pathways towards sustainable agriculture planning. Estimation of impacts and mitigation measures to reduce agricultural pollution over large territories is a challenging task. It requires a careful choice of models which is often driven by availability and quality of data on the one hand and on the other, by the reliability and robustness of conclusions. Pollution mitigation measures have to realistically account for location-specific demographic and economic indicators, demand and production, pollution and health risks. They should fulfill various goals and constraints, e.g., environmental norms, ambient targets, required levels of food supply, limits regarding population exposed to environmental risks, etc.

Models for planning agriculture development and assessing impacts are traditionally classified along two main lines. One line involves process-based modeling, which combines resource and production potentials of land with data-intensive biophysical processes and models of agricultural (point and disperse) pollution. The models estimate crop growth, soil carbon dynamics, soil temperature and moisture regimes, nitrogen leaching, and emissions of gases on very fine spatio-temporal resolutions under alternative local agricultural practices (Leonard et al. 1987; Li et al. 1992). Availability of spatio-temporal data, its harmonization and further calibration of the underlying biophysical processes even at local scales is a complex task and the results are essentially subject to underlying uncertainties, data quality and model structure. Cross-comparison of process-based models often shows substantial variability and discrepancies both among the modeled outputs and in comparison to field measurements (Frolking et al. 1998). As pointed out by (Bellocchi et al. 2010), the calibration and validation may require using interdependent multiple criteria, interpolation and statistics for tailoring the validation requirements to the specific objectives of the application.

The second line of models focuses on the socio-economic and behavioral aspects of agricultural producers and consumers, aggregate demand and supply. Models such as IMPACT (Rosegrant et al. 1999) perform on the level of major world regions. Resources like land, water or climatic conditions are described by scenarios in rather aggregate terms. With the focus at global or regional problems, the