Complex Terrain and Ecological Heterogeneity (TERRECO): Developing a basin scale crop yield/production model closely linked with agricultural science

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Background:

While many attempts have been carried out to define best management practices (BMP) with respect to agricultural fertilizer inputs, statistical data suggest that current farming practices in Korea are still greatly removed from the desired ones. Farmers behave differently from optimized behavior not only in terms of social welfare, but also with respect to individual profit. The Soyang Lake watershed is being studied in this context. Intensive dry field farming in high plateau landscapes influence the quality of water derived from the basin due to excessive fertilization and in response to cultivation methods. Water supplies were disrupted due to these causes in 2006 with extreme rain events and erosion – the so-called "Turbid Water Disaster". We can conclude that the behavior of farmers is not compatible (or optimal) with respect to the social welfare of the whole basin. Regulatory agencies subsequently established a number of restrictions on farming practices to aid in solving the observed environmental problems. While the measures have led to improvements, the farmers are uncomfortable with such environmental protection policies and strict regulatory measures. Regulatory policies may not consider the welfare of farmers correctly. Such policies are made to ensure maintenance of specific ecosystem services, but it is difficult to simultaneously comprehend the consequences of policy for farmers' welfare. Conflict between environmental policy and rural development policy is a growing issue. Though agricultural economics is viewed as an analytical tool for dealing with this sort of issue, standard agricultural economic methods requires further elaboration in order to include the complex interactions that are important within social-ecological systems. New modelling approaches are necessary in order to evaluate the impacts of policy and regulatory regimes on agricultural production as well as social response in mountainous terrain of the Soyang Lake watershed.

Research goals:

Our objective is to develop a model that aids in evaluation of the impacts of policy and other influences (e.g., climate change) on the social-ecological system of the Soyang Lake watershed. A first step requires that we develop a crop yield model consistent with natural science observations, i.e., compatible with results from ongoing field experiments but also with published agricultural studies in Korea. In the next step, the yield model must allow us to predict crop production as carried out in real landscapes. Costs and benefit of specific farming practices must be included. In other words, a production model is comprised of the yield model, but modifies predicted outputs in dependence on markets prices for a number of variables. Building a model that can estimate yield and outcome within the context of a given price system is a major goal of this study.

Diagram 1. "Soyang watershed", the study site

a) The watershed extends across the high mountainous area along the Soyang river

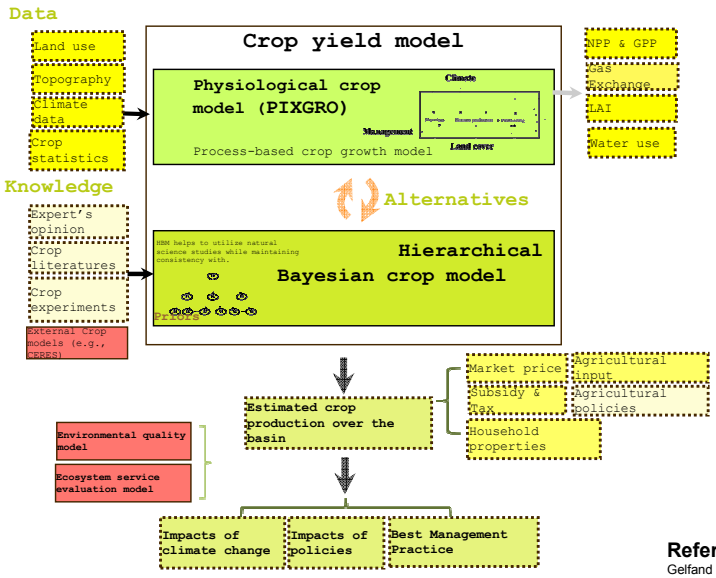
b) Individual catchments in watershed viewed as units upon which the crop yield model will be projected

Research steps:

Developing a crop yield model for focal crops based on crop statistics and agricultural literature is the first step. A Hierarchical Bayesian Model (HBM) is planned that includes concepts and information from physiological crop models projected onto maps developed at Soyang Lake watershed scale. Bayesian concepts simplify the procedures for integration of natural science studies and allow us to maintain consistency in results that are based on information from different sources. In the second step, a production function based on market data and econometrics is required. Algorithms will be applied to optimize or maximize a set of "goal functions" such as aggregated revenue, monetary value of ecosystem services, or even a sustainability index. Deriving BMP, testing of scenarios or predicting impacts of policy instrument can then be attempted.

Diagram 2. Expected outcomes of strict environmental policy applied to control erosion and release of fertilizer residues in the Haean Basin within Soyang Lake watershed

Diagram 3. Schematic diagram of crop production model



Outlook:

The crop production model must be enhanced to provide information from the supply side to the agricultural economics sector model named SAM (Soyang Agricultural Model). The largest challenge relates to methods for dealing with market mechanisms. The simple production model assumes market prices as a given condition, while SAM is intended to deal with markets as dynamic processes. Target values such as economic surplus or social welfare functions may be evaluated in this manner.

Further analysis can be undertaken by maximizing or minimizing a set of goal functions. Deriving Best Management Practice (BMP), tests of scenarios or evaluating impacts of policy instruments are processed in this manner. The influences of impacts on ecosystem services and environmental quality are included from other TERRECO projects.

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