The significance and potentials of integrated farm land use modeling for landscape level analysis

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Abstract **– Landscapes are an important dimension in agri-environmental policies and farm economics but seem underrepresented in integrated land use models (ILM) until now. We present results of a three-year research project. An ILM has been developed that explicitly considers landscapes for cost-effectiveness analyses of agri-environmental measures in spatial contexts. Model results of case study landscape analyses in the Austrian Mostviertel region show that the ILM is capable to (i) find the best cost-effectiveness ratios for selected agri-environmental measures, and (ii) assess the impacts of land use intensity and landscape complexity on biodiversity. The results emphasize the potentials of the ILM and the significance of high resolution landscape data for policy support.**

INTRODUCTION

Quantitative integrated land use models (ILM) are increasingly applied tools for ex-ante and ex-post assessments of agri-environmental policies from local to global scales. Bio-economic farm models are frequently employed as land use decision units in ILM, but appear undersupplied for landscape level analysis (Janssen and van Ittersum, 2007). However, the consideration of landscapes in integrated land use models seems relevant for a number of reasons (Schönhart, 2010):

- The appearance of landscapes determines human well-being, which is also at the center of many debates about the need for maintenance of rural landscapes and mirrored in agri-environmental policies.
- Landscape elements play an important role in biodiversity provision and in landscape processes such as soil erosion and nutrients leaching.
- Landscape elements determine farm production costs as well as market and non-market benefits.
- The representation of landscapes in ILM allows visualizations of policy scenarios, which may be important tools in transdisciplinary research processes and economic valuation studies.

We present selected results from a three-year research project within the Doctoral School Sustainable Development (dokNE) at University of Natural Resources and Applied Life Sciences (BOKU). A spatially explicit ILM has been developed for agri-environmental policy assessments on a landscape level. The article aims at demonstrating the significance of landscape integration and availability of high resolution data for agri-environmental policy analysis.

METHODS AND DATA

The basic structure of the ILM is presented in Figure 1. It consists of three hierarchically linked models, i.e. the bio-physical process model EPIC, the crop rotation model CropRota and the bio-economic farm optimization model FAMOS[space]. FAMOS[space] is based on single fields and optimizes land use decisions by maximizing total farm gross margin subject to farm resource endowments and field arrangements. For a detailed description of the ILM, see Schönhart et al. (2010, 2011b).

Data in the ILM are categorized according to spatial levels in regional, farm, and field data as well as according to the thematic area in socio-economic and natural components (Figure 1). Data on landscape elements – except for fields, which are based on the IACS-GIS (Integrated Administration and Control System) database – have been derived from orthophotos.

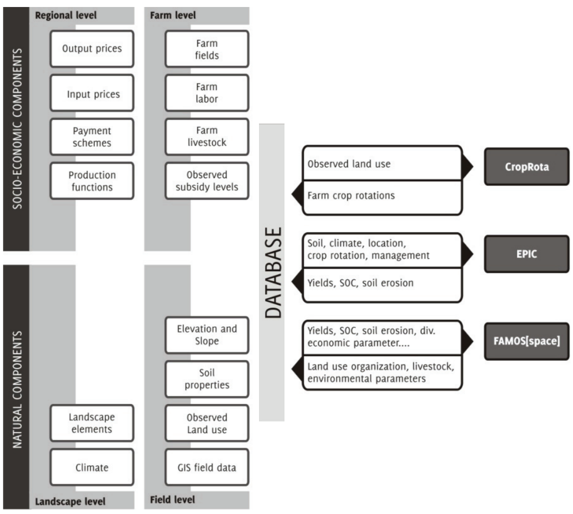

Figure 1. Overview on the integrated farm land use model

The ILM has been applied to different scenarios in the Austrian Mostviertel region. The case study landscape includes 20 farms.

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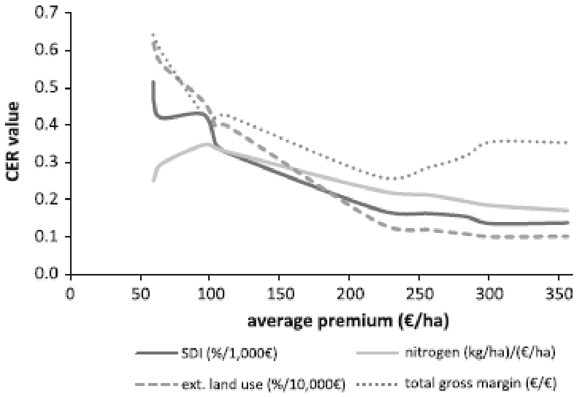
Results

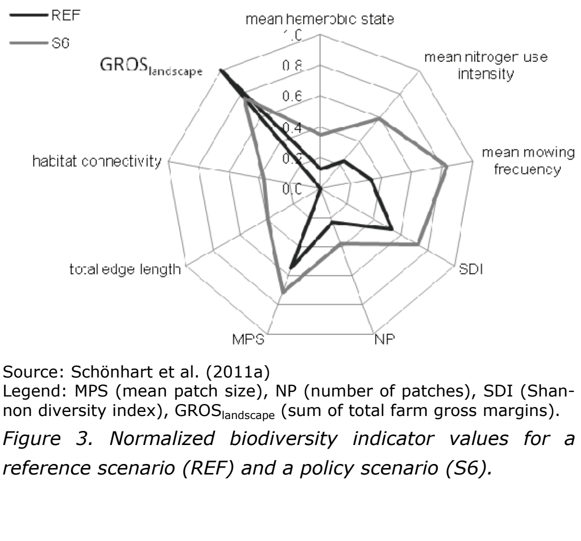
Figure 2 presents results from a model application that aimed at an effectiveness analysis of selected measures of the Austrian agri-environmental program ÖPUL (cf. Schönhart et al., 2010). These measures, i.e. 'Umweltgerechte Bewirtschaftung von Acker- und Grünlandflächen', 'Verzicht auf ertragssteigernde Betriebsmittel auf Ackerflächen' as well as 'Ackerfutter- und Grünlandflächen', and 'Erhaltung von Streuobstbeständen', are supposed to support the main objectives of ÖPUL, namely preservation of water and soil resources, mitigation of climate change, protection of biodiversity, maintenance of cultural landscapes as well as farm income support. The results show both the effectiveness of the measures in reducing average nitrogen application rates, increasing landscape heterogenity, and maintaining cultural landscape elements such as orchard meadows, as well as the importance of targeting for agri-environmental policies.



Source: Schönhart et al. (2010)

Figure 2. Cost-effectiveness ratio (CER) for nitrogen intensity, extensive land use, landscape diversity (SDI), and total farm gross margins at different agri-environmental premium levels.

In a second study, the ILM has been applied to analyze policies for biodiversity protection in agricultural landscapes (cf. Schönhart et al., 2011a). Field and landscape level indicators have been applied to jointly assess possible effects of land use intensity and landscape complexity on biodiversity. Figure 3 presents normalized results for two contrasting scenarios without (REF) and with agri-environmental policy intervention (S6).



Source: Schönhart et al. (2011a)
Legend: MPS (mean patch size), NP (number of patches), SDI (Shannon diversity index), GROS$_{landscape}$ (sum of total farm gross margins).

Figure 3. Normalized biodiversity indicator values for a reference scenario (REF) and a policy scenario (S6).

Discussion

The development of an ILM with spatial contexts has been made possible by the supply of high resolution land use data. The IACS-GIS database provides vector-based field and partially sub-field data. Such data allow to refining estimation procedures of field size and distance dependent mechanization costs, coupling bio-physical data on soils and the geography of fields to management data, and providing more significant output indicators for landscape quality through landscape metrics.

A number of challenges for future research remain such as model validation and handling of trade-offs between spatial, temporal, and systems-based model complexity. However, the ILM together with geo-referenced data offer new research areas to emerge. Particularly, it offers interfaces to integrate other scientific disciplines, e.g. hydrology or landscape ecology as well as to visualize model outputs that foster transdisciplinary research processes (Schönhart, 2010).

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