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Bibliographic information published by Die Deutsche Bibliothek
Die Deutsche Bibliothek lists the publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the internet at: http://dnb.ddb.de.

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http://www.iamo.de
ISSN 1436-221X
ISBN 978-3-938584-42-2

Studies on the Agricultural and Food Sector
in Central and Eastern Europe

Edited by
Leibniz Institute of Agricultural Development
in Central and Eastern Europe
IAMO

Volume 52

In der Schriftenreihe *Studies on the Agricultural and Food Sector in Central and Eastern Europe* werden durch das IAMO Monographien und Tagungsberichte herausgegeben, die sich mit agrarökonomischen Fragestellungen zu Mittel- und Osteuropa beschäftigen. Wissenschaftlern, die in diesem Bereich forschen, steht die Schriftenreihe als Diskussionsforum offen.

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Multi-level Processes of Integration and Disintegration
FRANZISKA SCHAFT, ALFONS BALMANN (eds., 2009)
Studies on the Agricultural and Food Sector in Central and Eastern Europe, Vol. 52, Halle (Saale), IAMO, pp. 3-12.

LANDSCAPE AGROECOLOGY: MANAGING INTERACTIONS BETWEEN AGRICULTURE, NATURE AND SOCIO-ECONOMY

*TOMMY DALGAARD**

ABSTRACT

State of the art GIS and database technologies for landscape scale analysis and the modelling of land use and environmental impacts are presented. These methods have been developed at the University of Aarhus in multidisciplinary collaboration with other research institutions throughout Europe, e.g. during the EU research projects www.mea-scope.org and www.sensor-ip.eu. In the years to come, these landscape-scale research methods will be further developed and integrated with similar frameworks in other EU countries, and used for scenario studies. Scenario studies, visualised in geographical information systems, are useful for evaluating possible future landscape developments, and for identifying potentials for and limitations to combining multiple landscape functions. Here we focus on scenario systems that explore interactions between landscape functions – e.g. the interactions between farm management, economy, nutrient losses, fauna population dynamics, plant community development, etc. Among others, scenarios for drinking water protection via increased set-aside grassland or afforestation are presented; they show that benefits from subsidies targeted to areas with special interests in the protection of drinking waters from nitrogen pollution differ from non-targeted subsidies. Experience has shown that working with scenarios and involving potential users at an early stage of development are important ways of focussing the work effort and ensuring that relevant tools are developed. Developments in data collection and collation at the EU level will allow similar systems to be developed elsewhere.

Keywords: Landscape, agroecology, scenarios, multidisciplinarity, Geographical Information Systems (GIS), multifunctionality.

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1 INTRODUCTION

This paper and the presentation for the Berlin Green week conference on "Multi-level processes of integration and disintegration (HUMBOLDT-UNIVERSITÄT ZU BERLIN, 2009) are synthesized from research carried out in relation to three European landscape research projects; MEA-scope (www.mea-scope.org), SENSOR (www.sensor-ip.eu) and Nitro-Europe (http://www.nitroeurope.eu), as well as a number of Danish research projects (for example, ICROFS, 2009 or DALGAARD et al., 2003a, 2007, 2009).

At the conference, examples from this work were presented together with some additional examples on research carried out within The Department of Agroecology and Environment, Aarhus University, Denmark. This also includes methods for upscaling (DALGAARD et al., 2003b). In this paper, selected examples are described in further detail, with an emphasis on the need for further research developments within the discipline of Landscape Ecology (WOJTKOWSKI, 2004; DALGAARD, 2005).

2 NEW NEEDS FOR LANDSCAPE RESEARCH

Today's demand for sustainability is not limited to agricultural production and profit, but includes other aspects of rural life such as the environment and landscape. Proper utilisation of future landscape requires a holistic approach where consequences of various land uses are assessed and management adjusted. At the same time, regulatory authorities in EU Member States must implement a range of EU directives that target specific policy areas, e.g. the Nitrates Directive, National Emissions Ceilings Directive, Habitat Directive and the Water Framework Directive. If policy initiatives directed towards implementation are developed in isolation, there is a tendency for the resulting regulations to be at odds. For example, as part of the implementation of the Nitrates Directive in Denmark, farmers were obliged to plant more winter cereal crops. This has resulted in an increase in the frequency of pesticide applications, a development that threatens wildlife and conflicts with the objectives of the Habitat Directive.

2.1 The development of interdisciplinary landscape scenario systems

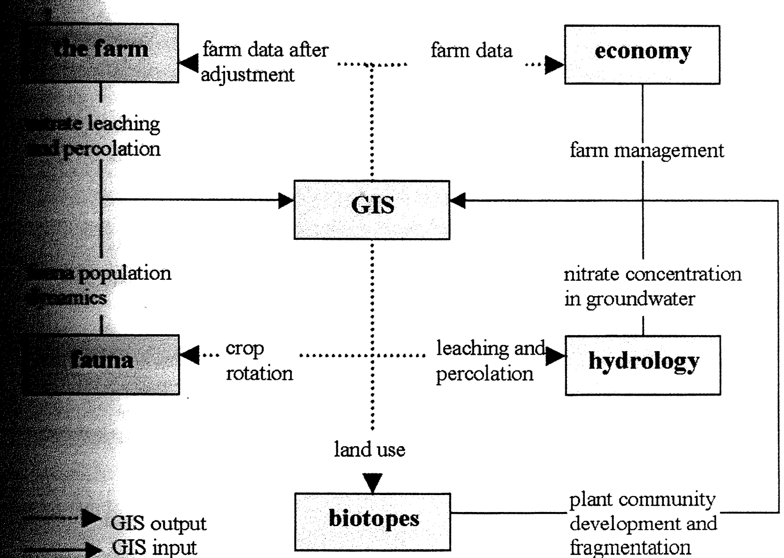
One example of an interdisciplinary landscape scenario system was developed in the project titled "Land use and landscape development, illustrated by scenarios – Interactions between nature, agriculture, environment and land management", which was initiated under the Danish research programme titled "Land use – The farmer as landscape manager" (HANSEN et al., 2002). This multi-disciplinary project involved collaboration between the Danish Institute of Agricultural Sciences, The

National Environmental Research Institute, Geological Survey of Denmark and Greenland, the University of Aarhus, Viborg County, The Danish Agricultural Advisory Centre, and the Danish Institute of Agricultural and Fisheries Economics.

The focus of this scenario study is the farm as an integrated part of the rural landscape. The objective is to develop methods that will enable interactions between policy areas to be identified and quantified. In this way, policy-makers can seek to avoid conflicting policies and promote those that are synergistic.

The policy areas currently targeted by this scenario system are agricultural production, nutrient losses, landscape, and nature conservation. The process involved when investigating a policy initiative is as follows. The policy objective is defined and one or more policy measures are formulated. Often, these policy measures are in the form of regulations or economic incentives to achieve a certain change in land use or land management, e.g. planting woodland or extending livestock farming. These measures are then applied to the target area, either by using an economic model or a decision tree, or a combination of the two, using a Geographical Information System (GIS). The results are spatially explicit changes in land use or land management. The GIS is then used to generate input files for a number of models. The models included concern agricultural production and losses of nitrogen, hydrology and plant and animal wildlife (Figure 1).

Figure 1: An example of an interdisciplinary landscape scenario system

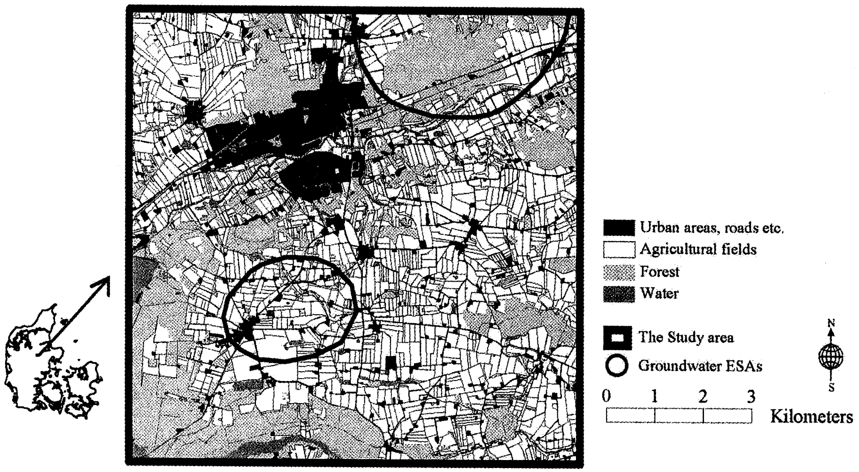


Source: HANSEN et al., 2002.

The main data sources for this scenario system are the national databases for cropping (GLR), livestock holdings (CHR), soil types and climate. The main function of these databases is to support Denmark's compliance with EU support schemes and directives; they are also used for agro-environmental analysis purposes.

The test site for the scenarios is an area of 100 km^2 in Viborg County, Denmark, (see Figure 2). Since the early 1990s, this area has been the focus of an intensive data collection campaign, including a detailed mapping of the soil, geology, biotopes and even of small landscape features such as ditches and field boundaries. The detailed data were collected to enable the importance of the scale of available data on scenario outcomes to be investigated. Data are digitised and stored in a GIS, which is the basis for the subsequent analyses. Presently, this landscape is used for scenario building in relation to the effects of revisions in the EU agricultural and rural development policy (DALGAARD et al., 2009), effects of mitigation options for the reduction of greenhouse gas emissions from agriculture (http://www.nitroeurope.eu), and potentials for bioenergy production and nature conservation (ICROFS, 2009).

Figure 2: Land use in the 10 x 10 km^2 study area, situated around the city of Bjerringbro in the Midwest of Denmark. The ESA's are environmentally sensitive areas with respect to groundwater quality

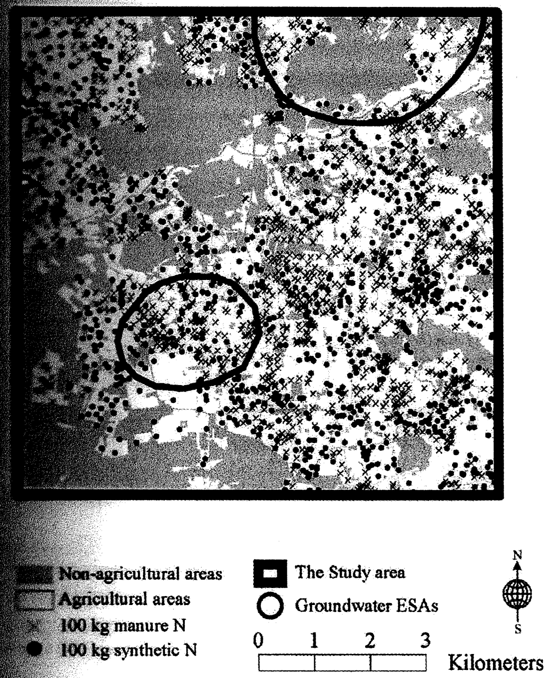


Source: DALGAARD et al., 2001c.

2.2 Example: A scenario for drinking water protection

As an example, Figure 1 illustrates how a scenario system was used to investigate measures for drinking water protection. Investigations have shown that spreading livestock manure is closely related to N-losses (DALGAARD et al., 2002a), and the distribution of livestock manure and fertilisers is the main driving factor for nitrogen (N) leaching to ground and surface waters. A model for the geographical distribution of N between fields within each farm and between farms within the study area was developed (DALGAARD et al., 2001c).

Figure 3: Example of simulated distribution of nitrogen (N) in manure and fertiliser on agricultural land inside and outside ground water protection areas (ESAs) in the project area. Especially manure N is a good indicator for N-losses, and drives the models for N-leaching to ground and surface waters

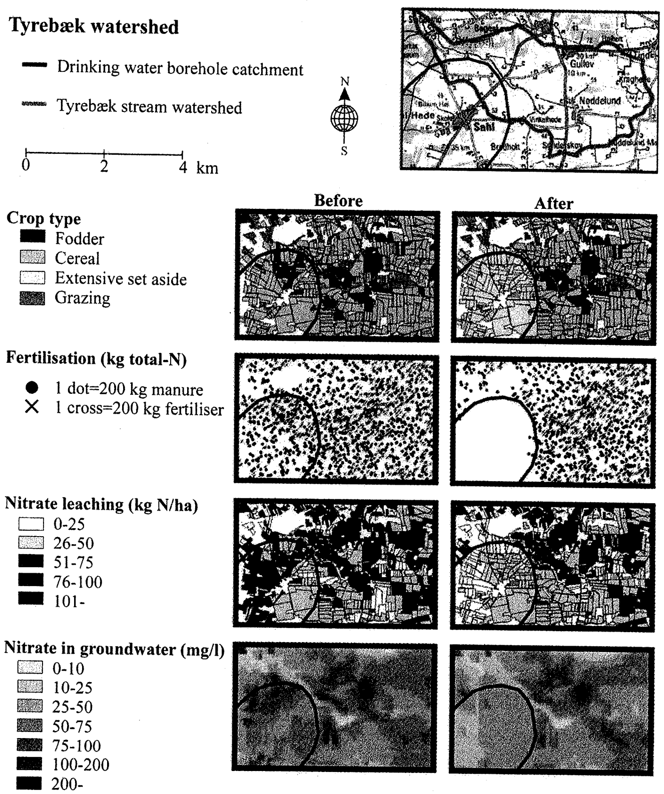


Source: DALGAARD et al., 2001c.

In this model, the N-distribution within and between farms is simulated from number and types of animals on each farm, crop rotation and the choice of cash and roughage crops for feeding livestock, soil types, distances to neighbouring farms and the N-need for fertilising the crops on these farms. Figure 3 shows an example of simulated distribution of N in manure and fertilisers on agricultural land within the study area.

In one scenario, the effect of drinking water protection via extensification in the form of grassland set-aside in the groundwater protection area (ESA) situated in the watershed of the Tyrebækken stream is investigated (Figure 4). This scenario is especially relevant in the context of the EU Nitrate and Water Framework Directives.

Figure 4: Case study site for the groundwater protection scenario, with the Tyrebæk stream watershed in green and the catchment area for the drinking water borehole in blue. The "before" and "after" maps show the results from the crop rotation, manure, farm and hydrogeological models, before and after extensifying the borehole catchment



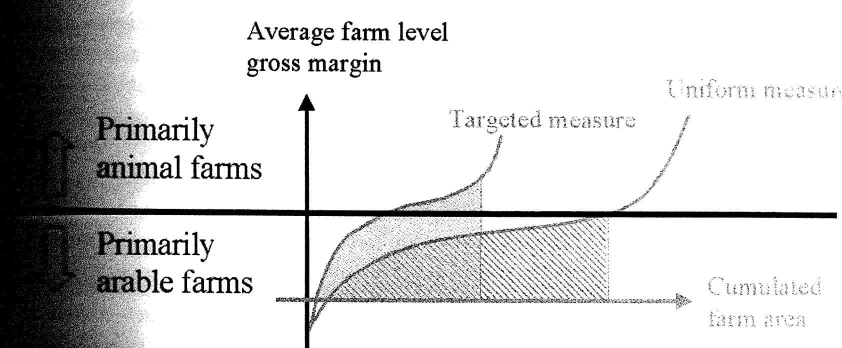
Source: After HUTCHINGS et al., 2004.

According to EU legislation, necessary measures should be implemented in order to protect drinking water quality in designated areas; i.e., the ESA in Figures 2, 3 and 4. When fields in the ESAs are turned into permanent grassland set-aside, the areas are taken out of agricultural production. In the scenario system, each farmer's reaction to these measures, in the form of changed animal and crop production, is decided from a set of rules, and the resulting change in fertilisation practice is decided from the model described above. In this way, the effect on N-leaching is estimated and interactions with other economic and ecological functions in the landscape assessed. As will be described in the following, these interactions are often non-linear and crucial to include when analysing the possibilities for creating multifunctional landscapes.

3 INTERACTIONS BETWEEN MULTIPLE FUNCTIONS

This section provides an example of the interactions between landscape functions that the interdisciplinary scenario systems can help disentangle. The two functions included in the example are the economic benefit from farm production, given by the average farm level gross margin, and the reduction of nitrogen losses resulting from the introduction of afforestation on former agricultural land (see the drinking water protection scenario described above, and RYGNESTAD et. al., 2001, 2002). The policy measures investigated were two different auction-based measures, with an equal, total afforestation subsidy of 2.7 mio. DKK used (Figure 5).

Figure 5: Example of interactions between farm income and drinking water protection via auction-based afforestation



Source: After DALGAARD et al., 2003a.

In the uniform measure all farms are invited to tender and the hatched area is afforested. In the targeted measure only farms within designated areas are invited to tender and a smaller area is afforested. However, the total protection effect of the targeted measure is equal to that of the uniform measure, because the targeted measure affects more of the animal farms that have a higher impact on N-pollution than the mainly arable farms affected by the uniform measure. In the targeted measure, only farms within ground water protection areas (i.e., farms with most of their fields within the ESAs in Figure 2 and Figure 3) are invited to tender. In the uniform measure all farms in the study area are invited to tender, and in both the uniform and the targeted situation, it is assumed that farmers choose afforestation if the aforestation subsidy per ha is higher than the average farm level gross margin per ha.

As illustrated in Figure 5, the uniform measure leads to the largest area afforested (the hatched area). This is because the marginal subsidy needed to make farmers plant woodland increases faster in the targeted than in the uniform measure. However, the farms with low average farm level gross margins which plant woodland as a result of the uniform measure are primarily arable. In contrast, the targeted measure results in more animal farms, which typically have higher gross margins than arable farms, also planting woodland. Because N-losses are closely related to high livestock density, the groundwater protection effect of the targeted measure will be as high as the effect of the uniform measure, even though the area included by the targeted measure is much smaller (DALGAARD, 2001).

4 CONCLUSIONS AND PERSPECTIVES

The interdisciplinary landscape scenario systems illustrated are applicable at a range of scales, from small areas in which each individual farm is considered as a separate entity, to larger scales in which standard farm types are used.

Denmark has been at the forefront of collecting digital farm data in national databases and in the development of methods to combine these data with other data types (DALGAARD et al., 2002b). In recent years, similar data have become available in most EU countries, e.g. from national censuses, the EUROSTAT Farm Accountancy Data Network (FADN), landscape study site inventory campaigns like those initiated in the NitroEurope and the MEA-scope EU research projects, or in less detailed data available from national area support scheme databases (PETIT et al., 2008). Therefore it is interesting to explore the opportunities to develop methods to combine these data in scenarios for landscape development in Europe's various regions.

The ecological, economic, wildlife and visual functions of landscapes within a modern society are determined by processes that operate over a range of scales in space and time. Integrating the knowledge behind these processes into tools that can be used by people who have stewardship over the land, e.g. farmers and regulators, will require an interdisciplinary approach. Such an approach demands significant effort as it must work against the trend of specialisation and fragmentation of knowledge that has occurred over recent centuries. It also requires substantial technical developments relating to data collation from disparate sources, data manipulation, data management and integration of information about multiple landscape functions (VEJRE et al., 2007). Therefore, working with scenarios and involving potential users at an early stage of development are important ways of focusing future research efforts and ensuring that relevant tools are developed.

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