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Rural Landscapes and Agricultural Policies in Europe

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Annette Piorr · Klaus Müller
Editors

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Foreword

These are the final results and reflections of the project MEA-Scope. This project with the full title "Micro-economic instruments for impact assessment of multifunctional agriculture to implement the model of European Agriculture" was a pioneering project. It was among the first which were funded in the new activity Scientific Support to Policies of the 6th Research Framework Programme. Policy decisions – especially at the European level – are never easy. What policy-makers decide will potentially affect the lives of millions of people for many years. This makes reaching informed decisions crucial, and scientific research can help illuminate their policy choices.

MEA-Scope was one of two projects which addressed the research priorities for European Rural areas which were identified in an EC workshop on Multifunctionality in Agriculture in 2001.

Scientific Support to Policies in the Research Framework Programme is facing the challenge to identify in the discussions between policy makers and the research community those topics which can be addressed in a mid-term strategic research programme. When the research topic was published Multifunctionality of Agriculture was among the concepts with many research questions open. It was considered that positivistic approaches into technology aspects of agriculture, forestry and other rural activities based on natural resources and land use are needed, as well as more normative research with regard to trade, food quality and safety, animal welfare, environment, rural development and cultural issues. It was recognised that the need for more knowledge of joint production of goods and services call for many partial studies. It was considered a problem that economic models tend to ignore non-commodity outputs, obviously because they are more difficult to model. Multifunctionality calls for integration. Therefore, integrated approaches like the MEA-Scope project got finally a preference over partial analyses. The inclusion of environmental and social aspects is a big step forward.

Multifunctionality outputs derive from the use of land. Therefore, the characteristics of different farming systems (scale, techniques, employment, food producing capacity) and related spatial characteristics of farming (balance between open space and urbanisation, effects interlinking agro-ecosystems) are important issues.

The MEA-Scope project has addressed these points successfully. This publication provides insight into the concrete project results and its application to model different policy scenarios.

Hans-Jörg Lutzeyer

Scientific officer, European Commission, DG Research

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We dedicate this book to **Prof Dr. Lech Ryszkowski**† whom we remember and miss as a project partner and a personality with a strong sense of mission on his scientific activities and visions, who never became tired of challenging the implications of our approaches and results in a wider interdisciplinary scientific context.

Annette Piorr and Klaus Müller

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Introduction

Rural Landscapes are an essential determinant of the cultural identity all over Europe. Man and society have shaped them over centuries through settlements, agriculture, and forestry. Their variety primarily is attributed to the geomorphologic and climatic diversity within Europe. Most notably, the agricultural land use reflects characteristics of sites and features, as well as cultural particularities which farmers developed in land management. Thus, landscape composition, configuration and land use intensity always affected the economic, social and environmental performance of European regions.

Over the recent years agricultural land use has undergone major changes. With the enlargement of the EU, new challenges towards reducing disparities and improving cohesion came up. New demands with regard to land use emerged (multifunctionality). Societal problems such as migration and ageing are becoming a severe problem in remote rural areas. Consumers' health concerns and societal demands on resource protection result in an urge to introduce environmentally sound management practices.

Even if agricultural production became subject to marginalisation in many regions, especially in those characterised by low soil productivity, the value of agricultural land use for the maintenance of landscape amenities and regional identity is broadly recognized and demanded by society. Farmers' willingness to shift their activities towards combining the production of market goods (commodity outputs) and public goods (non commodity outputs) is a generally observed trend.

The European Common Agricultural Policy (CAP) reflects this line of development. In contrast to the CAP of former decades, when support was predominantly oriented towards maintenance and increase of production, the CAP of today aims at supporting sustainable land use and rural development. In line with this, the Model of European Agriculture (MEA) regards agriculture in a multifunctional role, and aims at helping farmers to adjust their business and land management methods to changing agricultural practices, and society's demands. With the reforms since 1992, the CAP shifted from production oriented direct payments to a decoupling of direct payments from production intensity (first pillar). The New Rural

Development Scheme for the period 2007–2013 strengthened the second pillar with providing more diversity in offers of voluntary measures.

In the course of policy impact assessment duties, the European Commission launched several projects within the EU’s 6th Framework Programme (FP 6) to develop science based quantitative and qualitative policy assessment tools. This book presents the major outcomes of the research project “MEA-Scope”,[1] specifically dealing with the ex-ante assessment of CAP impacts on multifunctionality.

MEA-Scope analyzed how far policies lead to a change in the farm structure of a region, or how far they influence farmers decision making on cropping or husbandry management practices. Focus is the assessment of related economic, environmental and social impacts. The chosen approach was based on the development of a hierarchical linkage of three pre-existing models: AgriPolis, MODAM and Farm-N/ Fasset. By considering the spatial scales of regions and typical single farms in their reactions on existing and possible future policies, the MEA-Scope project provides a highly valuable contribution to concepts, policies, rural development objectives and agricultural land use realities.

For developing the multifunctionality concept into an operational policy instrument, MEA-Scope set five main objectives:

- Further development of the multifunctionality concept for European agriculture
- Answering of policy-relevant questions for the implementation of the multifunctionality concept
- Demonstration of the operability of the integrated assessment framework
- Generation of scientific knowledge on specific questions regarding multifunctionality of agriculture, particularly with respect to spatial scale and regional differences
- Development of a quantitative tool for assessment of the multifunctionality impacts of CAP reform options.

The consortium was built by 11 institutions from the following 9 countries: Denmark, France, Germany, Hungary, Italy, Poland, Slovakia, Switzerland, The Netherlands. After three and a half years of research, the round 40 scientists involved from 11 European research institutions in the project

[1] MEA-Scope: Micro-economic instruments Micro-economic instruments for impact assessment of multifunctional agriculture to implement the Model of European Agriculture. Project (SSPE-CT-2004-501516) funded by DG RTD of European Commission, FP6 “Policy Oriented Research" www.mea-scope.eu

presented the achieved results to the end users, to the scientific community and to the interested public.

The MEA-Scope Final Workshop was held from the 17th to the 20th September 2007 in Florence, Italy. During the workshop 25 oral presentations (3 from invited speakers) were presented and discussed with the audience. This went along with dedicated discussions on the development strategies taken.

The workshop sessions were on the following topics:

- Multifunctionality Concepts, Societal Demand and Impact Assessment
- Modelling of Policy Induced Structural Change and Adaptation of Agricultural Practices
- Linking Scales, Policy Issues and Impacts
- Regional and Local Case Study Stories of a Europe in Change

The book consists of selected papers of the Final MEA-Scope workshop. It is designed to provide an overview on concepts and approaches of multifunctionality impact assessment as well as on societal demand in different parts of Europe. The four parts are organized along the above mentioned workshop topics. All contributions have the character of alone-standing articles. Thus, certain redundancies are inevitable. Even so, the editors decided for a compilation with the subject of each part being explored by various scientists from different points of view and reflecting their respective interpretation of results.

The first part, on *Multifunctionality Concepts, Societal Demand and Impact Assessment,* introduces the MEA-Scope project approach in developing a conceptual and methodological procedure towards multifunctionality impact assessment. In the first paper Piorr and Müller (2009) introduce the overall project structure and outline the MEA-Scope approach of making the conceptual understanding of multifunctionality operable for impact assessment. The analytical framework is based on the determination of non-commodity outputs and indicators, that reflect demand and supply side on one hand, modelling capabilities and data avaibability on the other. Two papers describe in detail the theoretical foundation of the various multifunctionality concepts. Ferrari and Rambonilaza (2009) analyze the existing multifunctionality concepts from the perspective of agricultural activities, rural areas and natual environments as well as deliver an interpretation which crittically draws up the frontiers of the multifunctionality concept. The paper on multifunctionality concepts provided by Casini and Lombardi (2009) focusses on a comparative survey and critically assesses the framework approach taken in the MEA-Scope project. The research results gained from stakeholder participation in evaluating the regional relevance of the production of commodity and non-commodity outputs are presented in the paper by Schader et al. They show how different the societal demand on the provision of multifunctionality proved in a cross regional comparison, and they further discuss reasons for the specific regional priorities from the stakeholders' perception. A completely different approach to the research task of assessing mutifunctionality impacts of CAP policies was developed in TOP-MARD (the partner project of MEA-Scope, launched in parrallel on the same FP6 call). Bryden and Refsgaard (2009) describe the theoretical foundation of their project design, the development of a new model and its application on the example of quality of life assessment in a Norwegion case study.

A central part of the book, *Modelling of Policy Induced Structural Change and Adaptation of Agricultural Practice,* presents research results on the impacts of current agricultural policies and future scenarios that were assessed by micro-economic and environmental modelling procedures (agent based, linear programming, trade-offs). The results provide information on the question how and why farmers in different structural and geophysical framework conditions respond to the new CAP reform and how this matches with regional demands. Zander et al. (2009) introduce the modelling approach developed for a hierarchical linkage of three pre-existing models. For all seven case studies a dynamic simulations of five policy scenarios have been operated a combined modelling approach. Uthes et al. (2009) present a cross country comparison of selected results on farm structural and environmental impacts and discusses the policy incentive structure. One approach applied for the spatial localisation of farms is explained in the paper of Damgaard et al. (2009). The method that recreats spatial location of farms where real farm locations are known is developed and applied within a German and Danish agricultural landscape. This is done using an approach based on indexation of structural heterogeneity. Another approach for farm localisation has been applied in the case study region Mugello (Italy). In their analysis of spatial characteristics of land use patterns, Ungaro et al. (2009) make use of geostatistical methods. They examine how policy scenarios induce landuse changes and assess their effects on abiotic and biotic indicators.

The third part of the book deals with *Linking Scales, Policy Issues and Impacts.* In the paper, Scaling from Farm to Landscape, T. Dalgaard et al. (2009) focus on the modelling of Nitrogen surplus from agriculture as indicator for water pollution. An in depth analysis of different policy options, related adaptational responses of different farm types and the impacts on multifunctionality indicators is provided by Sahrbacher et al. (2009). The paper delivers an integrated analysis of changes in arable and grass land use, shifts related cropping and husbandry management practice, from the perspective of the underlying policy implementation pattern. Following the paper, Implementing the Indicators of the MEA-Scope Multifunctionality Impact Assessment Approach, Waarts et al. (2009) aims at assessing the MEA-Scope ex-ante impact assessment tool. The paper examines whether or not the tool fulfils the needs of the potential end-users. Focus is on the representativeness of indicator results for non-commodity outputs in relation to end user demand.

The final part of the book, *Regional and Local Case Study Stories of a Europe in Change,* particularly refers to the large diversity of changes and adaptation measures, taken by typical farms in case study regions (Denmark, Germany, Hungary, Italy, and Poland). It relates them to the site specific potentials and problems of the regions, or to in-depths analyses that have been carried out on methodological specifications. Each paper describes its specific contribution to the projects objectives, but it also discloses its own scientific value.

Environmental Impacts of Pillar I and II with Specific Respect to Designated Areas, are the central issue dealt with in the paper of Sattler et al. (2009). A fuzzy tool based indicator modelling approach for the assessment of environmental impacts of alternative policy scenarios is presented. This assessment is carried out using results from the MEA-Scope case study Ostprignitz-Ruppin in North-Eastern Germany. The River Gudenå landscape in Denmark served as a validation case study for the agent-based, spatio-temporal model AgriPolis. Damgaard et al. (2009) describe and discuss the procedures applied and results gained in order to prove the modelling outcomes on real farm data available for two time steps. For the case study in Mugello (Tuscany, Italy) Ciancaglini et al. (2009) analyse the impact of three different direct payment options on farm structure, profits,agricultural activities and production pattern. Bienkowski et al. (2009) carried out an analysis, aimed at determing the posibility to develop beef production by considering beef based alternatives available for crop farming. With results from the MEA-Scope case study in Poland, he limits his analysis on natural fodder resources. In the paper Multifunctionality and Survival Strategies in Marginal Farms: the Case of Borsodi Floodplain, B. Balász et al. (2009), using results from the MEA-Scope case study in Hungary, assess the contribution of multifunctionality and the social concerns this has on agriculture.

Part I

Multifunctional Concepts, Societal Demand and Impact Assessment

The Operational Framework of the MEA-Scope Project

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Abstract

This chapter introduces the overall approach of the MEA-Scope project, which forms the common basis of the scientific chapters in this book. It presents the operational structure of the project, based on an integrated framework for multifunctionality impact assessment, bridging from the conceptual understanding of multifunctionality to an operational tool based on microeconomic simulations. The scale of modelling at single farm and regional level required a case study approach. The modelling tasks, forming the core of the project, are embedded into an integrated operational framework for the analysis. A consistent and operable framework has to integrate the different conceptions and policy levels of multifunctionality into an indicator framework applicable for impact assessment. Both, the demand side of multifunctionality, from the regional demand for Non-Commodity Outputs (NCOs), as well as the supply side of multifunctionality, from the agricultural production perspective, are considered. The chapter introduces the elements of the operational approach that were applied in order to develop the final product of the project: The online accessible MEA-Scope tool, that presents the main results of the microeconomic modelling procedures carried out for a number of typical farms in seven European case study regions.

The approach to address the demand side on multifunctional agriculture includes workshops with policy makers to identify their needs and expectations

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concerning impact assessment tools, and regional stakeholder surveys in the seven case study regions.

Keywords: project design; case study; NCOs; multifunctionality indicators; complexity

1 Introduction

The major purpose of the research presented in this book is to generate knowledge on the implementation of the Common Agricultural Policies (CAP) and its contribution to the multifunctionality of agriculture from the regional and farm perspective. In the ongoing process of CAP reforms, policy makers ask for qualitative and quantitative ex-ante assessments of policy impacts. To cope with this challenge, special tools are required that reduce complexity and help focusing on the basic essentials.

Within the Sixth EU Framework Programme for research, technological development and demonstration (FP6) of the European Commission, several projects have been launched aimed to give policy recommendations with regard to multifunctionality of agriculture, being an important strategic objective of the new CAP orientation towards strengthening Rural Development (Helming et al. 2008; Mander et al. 2007).

The FP6 project MEA-Scope responded to a call, which, in contrast to many previous research studies, focused on the microeconomic perspective. Policy makers from the European Commission are interested in the provision of a policy impact assessment tool that simulates and assesses the response of European farms to CAP policies in regards to multifunctionality. Thus this research specifically addresses the scale of regions and of typical farm types. Accordingly, the interest in this project lies in the question how different farms in different geographical and structural settings typically respond to policy instruments, and in how far this affects the multifunctionality of agriculture.

MEA-Scope chose a case study approach for this research. Though originating from social science, case study research has become a relevant application field in policy oriented research (David 2006). Case study is an acknowledged methodology when in-depth investigation is needed for multi-purpose analyses (Feagin et al. 1991). It furthermore is regarded as an appropriate approach to bring out details by using multiple sources of data (Tellis 1997). This latter argument was particularly relevant for the purpose of case study research for multifunctionality impact assessment.

Case study research in MEA-Scope was oriented on the exploitation of multiple sources of data and of qualitative information by actively integrating regional knowledge, from experts, stakeholders, and from literature and data surveys. For each case study a high number of typical farms were identified. For each farm type simulations on farm adaptation behaviour, based on three pre-existing models have been carried out. The models applied required highly specific input data, e.g. on timing and intensity of management practices for different crops at different site qualities within a given case study region. Such information has been compiled from regional secondary data, and where not available, from regional experts. Through linking farm modelling to region modelling with a spatially explicit procedure of localizing typical farms, it was possible to achieve a degree of highly detailed and differentiated analysis at different spatial scales. The physical outcome of the project is an online accessible tool.

The objective of this chapter is to introduce the operational approach of the MEA-Scope project and to give guidance to better understand the linkage between the different chapters and chapters in this book. This chapter provides a first introduction to the elements of the operational framework which will be discussed in detail in the following chapters of this book.

2 From Theory to Impact Assessment

The development of the operational framework of MEA-Scope started with an analysis of existing theoretical concepts of multifunctionality.

Ferrari et al. and Casini et al. (the two first chapters of this book) compare the relevant multifunctionality theories, discuss the relationship between multifunctionality and sustainability, and determine the scope of policies, which affect agricultural land use and the production of Commodity Outputs (COs) and Non-Commodity Outputs (NCOs). Multifunctionality can be defined as the joint production of COs, which are typical market products (e.g. cereals, milk) and NCOs, which are by-products of agricultural production, and which fulfil public or private needs (e.g. biodiversity, fertile soils) (Barkmann et al. 2004; Piorr et al. 2005; Wiggering et al. 2003). Depending on the diversity and intensity of production structures (e.g. mixed farm, crop production farm), on production systems (e.g. conventional, organic) and/or production practices (e.g. soil tillage system, amount of fertilzer) the ratio between COs and NCOs production and the degree of jointness varies (Sattler et al. 2006; Piorr et al. 2007a).

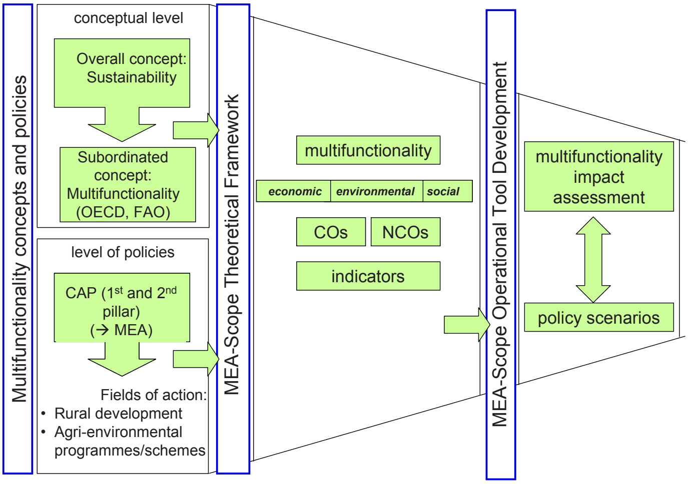

Fig. 1. The MEA-Scope theoretical framework integrating multifunctionality concept, policies and the operational task of tool development

Figure 1 shows how the theoretical framework of MEA-Scope was developed into an operational approach for impact assessment (explained in Piorr et al. 2006).

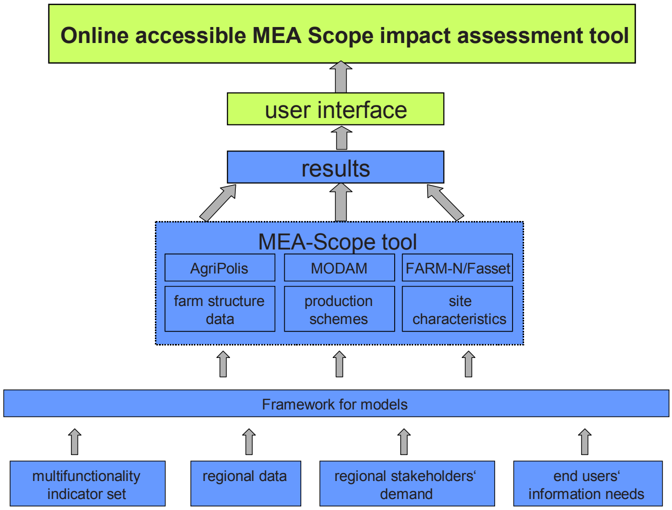

Fig. 2. The MEA-Scope operational approach towards the final product, the MEA-Scope tool (accessible at www.mea-scope.eu)

The operational approach towards the final project product, which is the online accessible MEA-Scope impact assessment tool, includes the generation of different intermediate work results. Figure 2 shows them in a hierarchical order, from the framework for the models, providing the basis, to the final tool, on the top. The operational framework of MEA-Scope project will be explained according to this figure in the following paragraphs.

2.1 Multifunctionality Indicator Set

The basis of the operational approach was the development of an indicator framework that bridges between the two conceptual understandings of multifunctionality by the FAO[1] (2000a, b) and the OECD[2] (2001). In a first step, in analogy to the sustainability concept and to the multifunctionality concept by the FAO, we set up categories for economic, environmental and social functions. In a second step, considering the OECD concept, we selected suitable indicators that hold the characteristics of Non-Commodity Outputs (NCOs).

The selected indicators had to meet following criteria:

- They belong to a relevant indicator framework for sustainability assessment
- They are related or linkable to the Handbook for Impact Assessment used in the European Commission (COM 2002, 2005)
- They match with the capabilities of the three models applied in MEA-Scope

A compilation of indicators from the most relevant indicator frameworks for scientifically oriented policy evaluation and of those used in relevant projects was set up. The list was adapted to the requirements of the project regarding multifunctionality demand (stakeholder surveys) and multifunctionality supply (modelling) (Piorr et al. 2006). Finally the chosen indicators were assigned to the three functional categories (Table 1). Due to the comprehensive compilation, Table 1 only lists the level of NCOs and the related subcategory. For the detailed overview on the indicators and units of measurement we refer to Waarts (2005, 2007).

[1] Food and Agriculture Organization of the United Nations.

[2] Organisation for Economic Co-operation and Development.

Table 1. Categorisation of selected NCO by functions (Waarts 2005)

Functional category	Selected NCOs	NCO subcategory
Economic	Generation of income Employment Rural entrepreneurial Activities	
Environmental	Abiotic resources	• Water quality • Water availability • Soil quality • Air quality • Pesticide use • Energy use
	Biotic resources	⇒ Biodiversity ⇒ Habitats
	Landscape and land use	• Landscape management • Landscape pattern • Landscape amenities • Abandonment of farmland • Farming systems (in protected areas) • Grassland management • Management practices
Social	Cultural heritage	⇒ Maintaining cultural landscape ⇒ Maintaining buildings ⇒ Traditional (farming) practices
	Non-farming activities	• Nature conservation • Educational services • Care activities
	Social infrastructure	⇒ Population characteristics ⇒ Labour use ⇒ Health
	Recreation in rural areas Healthy food/ food safety animal welfare	

The MEA-Scope indicator list is based on the analysis of the following indicator frameworks/ references: The Baltic Environmental Forum (2000); The BIOGUM Project (2004); Bösch P and Söderbäck E (1997); The Commission of the European Communities (2000, 2001); EEA (2001a, b, 2004); The ELISA Project (2000); The ELPEN Project (1999); The ENRISK Project (2004); European Commission and Eurostat (2001); EU (2003); Eurostat (2001); FASSET (2004); The IRENA project (2003); McRae T and Smith CAS (eds) (2000); OECD (2001a, b, 2004a, b); The PAIS Project (2004); Prescott-Allen R, Moiseev A and MacPherson N (2000); Reid WV, McNeely DB, Tunstall JA, Bryant DA and Winograd M (1993); The SAFE Project (2004), UNDP/UNEP/World Bank/WRI (World Resources Institute) (2000); UNEP (United Nations Environmental Programme) (1999, 2001), Wascher D.M. (ed) (2000); WHO (World Health Organization) Europe (2004).

2.2 Regional Data

In parallel, a data collection was performed in the seven MEA-Scope case study areas. The MEA-Scope tool development built on three pre-existing models. It developed procedures and interfaces for their hierarchical linkage (cf. Zander et al. 2009 in the following chapter "The MEA-Scope Modelling Approach"). The hierarchical modelling approach is a top-down modelling approach combining large scale and long-term analysis with the ability to investigate results of an individual farm's daily actions.

Collecting data belongs to the key features of case study research, enabling "understanding" and "explanation" of processes (David 2006). In our approach, particularly the recreation of heterogeneity among farms in the region required a detailed description of typical individual farms (farm data).

Table 2. MEA-Scope database structure related to farm types, production practices, crops, intensities and site qualities

Country	Case study	Typical farms [n]	Total number of farms [n]	Production practices [n]	Crops [n]	Production Intensities [n]	Site types [n]
Denmark	River Gudenå	–	1867	119	20	2	4
Germany	Ostprignitz-Ruppin	26	585	720	40	2	5
Poland	Turew	13	2499	637	14	1	6
Slovakia	Piestany	–	125	15	14	1	2
Hungary	Borsodi Mezoseg	12	864	46	8	2	4
Italy	Mugello	23	1237	204	25	2	12
France	Combrailles	18	570	659	14	1	6

Three broad categories of data were collected for each case study region (Damgaard et al. 2006):

- data describing the structural characteristics of agriculture including total production and farm types
- data on livestock and crop production, and
- regional geophysical and thematic GIS data, e.g. soil quality data.

Representative farms were taken from the Farm Accountancy Data Network (FADN), if such were available from the area. Otherwise the use of expert knowledge or interviews was used as an alternative option.

Table 2 gives an overview of the collected data. To reproduce the total regional farm population, the data for each typical farm were weighted. The procedure of the further data processing is described in the chapters by Zander et al. and in Damgaard et al. (2006) and Dalgaard et al. (2007).

2.3 Regional Stakeholders' Demand

The MEA-Scope operational approach distinguishes a demand side of multifunctionality by society as a whole, represented by regional stakeholders and by policy programmes, and a supply side of multifunctionality represented by the production activities of the farms (Fig. 3).

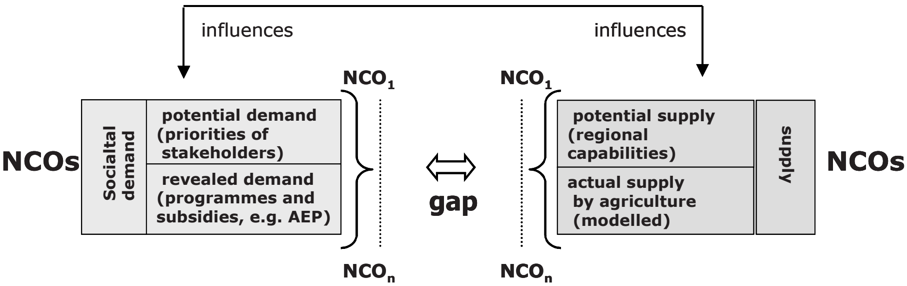

Fig. 3. Conceptual background for NCO demand/ supply identification[3] (Piorr 2006)

The demand by society for multifunctionality becomes an increasing field of interest of Rural Development (Wiggering et al. 2006). Specific regional rural development priorities emerge depending on the given land use structures, the involved sectors, and the development objectives defined by various groups and regional policies. We refer to this issue as "demand by society", e.g. as seen by regional stakeholders.

In four of the seven case study regions the perception of the regional stakeholders about the role of agriculture towards the contribution of multifunctionality has been surveyed. In face-to-face interviews based on a questionnaire, individual assessments of the region specific multifunctionality demands were surveyed by making use of the criteria and indicators

[3] The expression "revealed" demand in Fig. 3 is to be understood in the context of political economics. It means that e.g. agri-environment schemes designed by respective official representatives are already the implementation of the societal demand.

from the MEA-Scope indicator framework. In a second round, participatory workshops were held, in order to determine the region specific priorities. The chapters by Schader et al. and by Waarts in this book address this issue in particular. They discuss in how far the MEA-Scope surveys with regional stakeholders showed that societal expectations on the role of farmers as providers of NCOs often differ from the actual provision of such, and whether the gap identified between demand and supply of NCOs (as charted in Fig. 3), helps to determine the most relevant fields for policy action.

2.4 End-Users Information Needs

MEA-Scope developed the operational approach under a continuous involvement of end-users of the project results. The demand for ex-ante assessment of future policies is a specific interest of policy makers in the European Commission. Policy programmes underlie an evaluation process, in which the ex-ante assessment is a key element. Furthermore the principle of subsidiarity applies to bottom-up driven national, respectively regional implementation, and is for instance given more emphasis with the Rural Development Programme 2007–2013. In parallel this leads to rather complex tasks in comparative policy evaluation at European level. Frameworks for the measurement, processing and analysis of information have to be adapted and further developed. Tools are expected either to directly support decision making or to explain causal relationships on policy implementation and impacts. MEA-Scope was set for the second purpose mainly.

In practical terms the end-user involvement in MEA-Scope was realized through a series of participatory workshops, held due to information needs from both sides. Policy oriented research, as done in MEA-Scope, is meant to deliver short term support to decision making during the CAP reform process. Therefore we regularly informed the officials of the EC on intermediate project results and discussed further dissemination activities. The policy makers substantially contributed to the definition of the MEA-Scope policy scenarios for the modelling simulations, through several guided discussions on policy trends. Finally, the graphical user interface of the final product, the tool, was commonly developed according to the expressed end-users' expectations.

2.5 The MEA-Scope Tool

The supply of NCOs has been modelled taking into account to the general capabilities and yield potentials of each specific region, as well as the currently applied agricultural management practices. The tool is built on three existing micro-economic models, AgriPoliS (Happe et al. 2004), MODAM (Zander and Kächele 1999; Zander 2003) and FASSET/FARM-N (Hutchings and Gordon 2001). AgriPoliS is a multi agent model for the calculation of structural change, working at regional scale, using FADN data and considering interactions between different farm types. MODAM is a bio-economic linear programming model for the calculation of economic-environmental trade-offs for a high variety of management practices at farm level. Trade-offs between farm economics and the achievement of environmental goals are determined in order to assess the degree of jointness of COs and NCOs. FASSET/FARM-N is a dynamic model for matter flow calculations on farm level. The models and the policy scenarios they were applied to, are in detailed presented in the following chapter of this book, by Zander et al.

3 Discussion

During the recent years research on the multifunctionality of agriculture resulted in a number of publications, that deal with the conceptual understanding and that describe in which respect agriculture contributes to the rural wealth not only through the production of commodities, but also by the delivery of non-tradable goods or non-commodities. Van Huylenbroeck et al. (2007) review the literature on the multifunctional role of farming, in which most cases address *this contribution …, both direct through increased values for properties or economic benefits in the tourism sector, but also indirect through conservation of rural heritage or agri-ecological systems.*

The debate on making multifunctional agriculture "to be the new unifying paradigm to bring post-modern agriculture in accordance with the new societal demands" (van Huylenbroeck et al. 2007), is narrowly connected with the CAP reforms. Policy interventions play a multiple role in this respect: They are meant to express the societal demand side, reflecting changed expectations on agriculture. Such refer as well to the landscape aspect (e.g. amenities, diversity, land consumption), as on production practices (e.g. organic farming, extensive pasture farming) and finally the produce (e.g. transparency on product quality and origin, regional brands, traditional varieties).

They are also meant to implement instruments that support the achievement of desired developments. With the still ongoing CAP reforms financial means are shifted from the first to the second pillar. The second pillar of the CAP is intending changes of behaviour of farmers by setting financial incentives. The success of such a policy is therefore particularly dependent on farmers' acceptance of the incentive system. The approach of MEA-Scope, modelling behavioural responses of a high number of different typical farms was therefore applied to different policy scenarios, starting from the agenda 2000 situation to post-2013 options.

To forecast and analyse the success of policies and instruments though appropriate indicators are needed. Though a commonly agreed indicator framework on multifunctionality indicators is missing, few publications define the requirements such indicators should meet: Wiggering et al. (2006) recommend linking socio-economic requirements with landscape and territorial potentials. Van Huylenbroeck et al. (2007) claim the development of indicators measuring the contributions towards desired outcomes, which hence may differ from usual sustainability indicators in the sense that they need to emphasize the positive role of farming in society.

In their literature review on multifunctionality van Huylenbroeck et al. (2007) explain the lack of empirical research in this area with the difficulty to estimate the non-market contributions of agriculture either because of lack of good databases or because wider application of the methodologies is difficult and/or expensive.

The MEA-Scope project received funding from the EC to conduct highly detailed data collection for an in-depth analysis in case study regions. Yet, it has to be clearly mentioned that the purpose was not primarily the improvement of poor data availability. Yin (1994) distinguishes exploratory, explanatory and descriptive types of case study research. Case study research in MEA-Scope clearly focused on explanatory purposes: the identification of causal relationships between policy options, implementation choices of farms, regional characteristics and impacts on the multifunctionality.

The general problem of scale dependency of indicators also applies to the assessment of multifunctionality. The combination of farm and landscape modelling in the MEA-Scope approach offers the opportunity for an integrated analysis of farm level indicators (e.g. nutrient balances, energy use, farmers age, employment) and landscape level indicators (e.g. groundwater supply, corridors between habitats, population density) (Kjeldsen et al. 2006). The operational framework developed in MEA-Scope gives valuable inputs to the discussion of which indicators are valid on farm and on landscape level, respectively whether they have different interpretations at different scales (Kjeldsen et al. 2006). The chapter by Damgaard et al. in this book deliver a deeper discussion of this issue.

Nevertheless, either due to data availability, data quality or specific regional characteristics (e.g. geomorphological heterogeneity) the databases collected proved to be not capable for an identical application of the modelling procedures in all case study regions. In some cases the farm localization approach was applied to real landscape conditions, whether in other cases synthetical framework conditions had to be applied.

The explanatory value quality of results clearly differs from policy impact research at scales of high aggregation. Ungaro et al. finally show that based on spatially high resolution databases, policy impact assessment can profit from the use of methods originating in natural science, like geostatistics, and providing results of high qualitative resolution. Further applications in this field have been carried out by Piorr et al. (2007b, 2009).

The stakeholder involvement in MEA-Scope proved an important element to broaden the knowledge base on the societal demands on multifunctionality of agriculture from the regional perspective. Despite all regional differences (see Schader et al. in this book), a common finding was the prominence of socio-economic issues. Research currently does not seem able to address this issue in equivalence to the priority and urgency of many remote rural areas that have to cope with problems like migration of young people, aging of farmers, lack of successors etc. One reason is the problem of lacking social indicators, which again is connected to monitoring practice for census and other statistical reports. Although data on indicators for rural economy and for rural viability are collected and made available, they don't distinguish between actors from agriculture and other sectors.

For a full implementation of the multifunctionality assessment framework some effort remained unsatisfactory. This is especially due to the insufficient availability of data on the social NCOs and indicators. Thus, currently both research and policy advice have to cope with the lack of social impact assessment criteria, indicators and data. In parallel, the discussion on the definition and assessment of social externalities of multifunctional agriculture is ongoing (Wüstemann et al. 2008). There is definitely a need for monitoring systems that better integrate NCOs in the existing European agricultural databases.

It is expected that the upcoming reforms of the CAP and the strengthening of the Rural Development programs will increasingly have to deal with questions of complexity of policy implementation and policy analysis. The demand for integrative indicator frameworks applicable at different scales will be emerging too. The MEA-Scope project and its underlying approach present an example applied for connecting single farm and landscape level, a scale that so far has received minor attention in the field of multifunctionality research.

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Agricultural Activities, Rural Areas and Natural Environment: Drawing Up the Frontiers of the Multifunctionality Concept

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Abstract

The chapter provides a discussion of some relevant issues concerning the concept of multifunctionality and its application to the field of agriculture. The first section presents the positive approach of multifunctionality, which refers to supply-side aspects of agricultural activities. The second section deals with the normative approach, which supports the Model of European Agriculture. The last section presents some key elements for building an analytical framework bound to evaluate the multifunctional dimension of agricultural public policies.

Keywords: multifunctionality; agricultural policy; sustainability; model of European agriculture

1 Introduction

Multifunctionality has been a successful object of scientific research as the contribution of van Huylenbroeck et al. (2007) recently proves. Initiated in

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the economic sphere of international institutions like the OECD, the FAO or the EU, the thinking over this concept has gradually spread over to other disciplines (sociology, ecology, agronomy …) what has widened its initial scope.

Applied to the field of agriculture, multifunctionality accounts for the fact that the former is an economic activity that produces various non-commodity outputs (NCOs) to society which are associated with a wide range of benefits, such as environmental benefits (recreational amenities and aesthetic values of the rural landscape, non-use values of biodiversity and habitat protection, intrinsic values of ecosystem and watershed functions) and socio-economic benefits (food security, food safety, animal welfare, rural employment and the viability of rural areas, cultural heritage) (Hediger 2004).

More recently, multifunctionality has been a key element in the debate over the definition of agricultural policies at the international level in combination with arguments concerning the introduction of public support programs (Garzon 2005; Glebe and Latacz-Lohmann 2007). One main issue has been to look at a better accommodation of the agricultural policies with the rules of the WTO. In this respect, the search for a shared framework for analysing and implementing domestic policy aimed at non-trade functions of agriculture has been the starting point of an academic research process on the multifunctionality concept. From this viewpoint, the debate on multifunctionality has moved progressively from a trade-related question to an issue connected with rural development concerns.

Those debates have led to two visions of agricultural multifunctionality that have, in turn, given rise to two distinct analytical approaches. According to the first one, supported by the OECD, multifunctionality is a property of the agricultural production process, which attaches a set of social and environmental functions to the farming production. That vision has set the basis for the positive approach of multifunctionality.

At the same time, other international organisations like the FAO or the EU have suggested their own vision of the agricultural multifunctionality. Beyond the multifunctional feature of agricultural activities and land use that are intrinsic, they recognise that multifunctionality can be a target of public policy at national, regional or international levels, which may support the sustainable development of rural areas. This conception has given rise to the normative approach of the multifunctionality and has attracted the attention of other academic fields than economics.[1]

[1] See Le Cotty et al. (2004) for a general survey about the European research referring to multifunctionality.

The positive approach allows analysing the rationality of agricultural policies by addressing their economic efficiency regarding the provision of non-commodity outputs (NCOs). On the other hand, the normative approach favours the analysis of policies which take the agriculture as a central element of the sustainable development of rural areas, while putting aside some of the issues concerning their efficiency (either addressed in terms of provision costs or with respect to trade distortions).

An ex ante assessment of multifunctionality-promoting policies may however probably require to combine those two approaches (Mahé 2001) and to build a specific, analytical framework for a better understanding of the issues at stake.

The chapter is organized into three sections. The first section presents the positive approach of multifunctionality, which refers to the supply side aspects of agricultural activities. The second section deals with the normative approach, which supports the Model of European Agriculture. This model tries to find a new balance between social, spatial and ecological dimensions. In addition, it encompasses the interlinked objectives of farmers and society with respect to the production, territorial, and social aspects of multifunctionality. The last section presents some key elements for building an analytical framework of this concept regarding agriculture. In particular, the questions about the relevant scales (space, time) to retain for implementing public policies or assessing the environmental sustainability of rural areas (through adequate indicators) are discussed. The chapter concludes with some further developments on these topics.

2 A Positive Approach of Multifunctionality

According to OECD (2001, p. 8), which subscribed to this approach, "the key elements of multifunctionality are: (i) the existence of multiple commodity and non-commodity outputs that are jointly produced by agriculture; and (ii) the fact that some of the non-commodity outputs exhibit the characteristics of externalities or public goods, with the result that markets for these goods do not exist or function poorly." More precisely, "Multifunctionality refers to the fact that agriculture, besides satisfying the basic demand of food, fulfils at the same time other functions society requires, such as biodiversity, pollution control, amenity values, cultural heritage, food safety, rural settlement and retention of economic activities in less favoured areas". Accordingly, commodity outputs (COs) refer to the satisfaction of material needs, while non-commodity outputs (NCOs) to the satisfaction of other needs expressed by the society (Belletti et al. 2002). Furthermore, the fact that some of the NCOs exhibit the characteristics of externalities and public goods may require a public intervention to provide the quantity demanded by the society for such goods (Cahill 2001).

2.1 Multifunctionality and Jointness

The first and main aspect of multifunctionality refers to the question of the jointness between COs and NCOs. Originally (Boisvert 2001), joint production refers to a technical link between the productions of two outputs. In the case of agriculture, the multifunctional feature of the production process arises from the biophysical link that supports the production of different outputs. Based on a list of several joint NCOs in agriculture [employment, food security, landscape, biodiversity, environmental quality (soil, air, water), cultural heritage…], empirical investigation about the relationships between COs and NCOs brings some useful insights (Casini et al. 2004).

Firstly, characterising the links between the productions of COs and NCOs (i.e. the degree of jointness) provides clear results only when the NCO are connected to negative externalities. Let us take the example of an agricultural process, which is associated to water pollution and soil erosion. Then, a higher production of the CO would bring about an increase in the level of water pollution and/or soil erosion, whose magnitude would depend on the features of the jointness considered.

Secondly, even if multifunctional effects are generally associated with positive externalities (Glebe 2003), jointness may cover both goods and bads (undesirable outputs). For example, waste and rural amenities may be jointly produced with the commodity output. Yet, when negative and positive externalities are overlapping, characterising the jointness of the agricultural production process may be a difficult task to carry through. In general, the production of the NCOs increases with the production of the CO, except in some cases where the production of the CO has reached a threshold beyond which the production of NCOs may decrease (Vatn 2001).

Moreover, given the mutual influence that the productions of the NCOs may have on each other, some conflicts may occur between social functions (employment and rural viability) and environmental functions of agriculture. For example, (partial) decoupling will in general bring about a fall in employment in the farming sector (directly or indirectly because of the weakening in competitiveness) at least if no measure is decided upon to compensate for the lower production of the COs (von Huylenbroeck 2003).

Finally, the analysis of jointness may be useful if we want to assess to what extent the non agricultural provision of NCOs which are demanded by the society may be implemented, or, in other words, if we want to evaluate a possible decoupling of the production of the NCOs from that of the COs. The answer may not be a technical but an economic one.

If the jointness between the two productions is strong, the agricultural activity will be the only way to provide the NCOs (von Huylenbroeck 2003) and then subsidies for supporting this provision are justified. Otherwise, the NCOs may be provided by other economic activities than agriculture. However, even if the separation of the production of the COs and of the NCOs is technically feasible, there may be potential economies of scope in the joint provision of COs and NCOs (implying that the joint production will be cheaper than a separate production of these outputs (Casini et al. 2004).

To conclude, if both negative and positive externalities have to be considered in accounting for the multifunctional characteristics of agricultural activities, it is only in the case where negative externalities prevail that a significant relationship between NCO and COs can be established (loss of biodiversity, water pollution from nutrients and erosion, threats to animal welfare, irrigation-related problems, greenhouse gas emissions). There is not as much a consensus when positive externalities are considered. It follows that it is important to emphasize the technical linkages between the NCOs and the COs and the relationships between the production factors which give rise to such linkages (Ferrari 2004; Blandford et al. 2005). In addition, as jointness is implemented at a farm level, the quantity of the NCOs depends on specific farm practices, systems or technologies. It ensues that elements, which are exogenous to the production process, contribute to define the conditions in which the jointness takes place.

2.2 Multifunctionality, Externalities and Public Intervention

A second relevant element of multifunctionality within the positive approach is related to the externality and public good characteristics of the NCOs. Externality may be defined as an unintended side effect of the agricultural activity. The reason why we have to discuss externality and public good aspects together is that externalities alone are not necessarily a source of market failure. It can be shown that only externalities with public good characteristics require policy intervention. Indeed, the economic inefficiency, which is associated with these externalities, arises only when there is a gap between the marginal social cost and the marginal private cost.

Market failures associated with externalities occur when there is no market, which can be established to trade the externality between the producers and the consumers. In this context, the market price of the CO serves as an indicator of the provision cost of the NCO. Depending on the level of social demand for this externality, the production of the agricultural good may result in an under provision of the NCO. Public intervention then becomes necessary. However, it is important to analyse public good aspects of externalities in order to define the nature of public intervention, since the latter depends on the kind of the former. Depending on the degree of excludability and rivalry they are associated with different kinds of public goods may be defined. A good is non-exclusive if it is physically or institutionally (e.g. through laws) impossible, or very costly, to exclude individuals from consuming the good. A good is non-rival when one unit of the good can be consumed by one individual without diminishing the consumption opportunities available to others with respect to the same unit. Pure public goods are goods that meet both of the criteria while private goods are defined by the existence of excludability and rivalry properties. Impure public goods lie in-between and are classified according to the degree of excludability and rivalry we may associate with them.

On this basis, public intervention may face different operational constraints that we briefly describe as follows.

Firstly, even if the public authority decides to provide pure public goods, it is often difficult to estimate people's true willingness to pay for those goods (i.e. the marginal values that they will attribute to them). There is therefore a substantial risk of policy failure associated with the over- or underestimation of the willingness of the society to contribute to the provision of a pure public good.

Secondly, for excludable but non-rival goods, private provision may be sustained by user fees. But, in this case, efficiency losses may occur as the private providers will take only the people who can pay the price of the public good (based on the provision cost) into account, and ignore all other users whose willingness to pay is positive but inferior to this price. However, it may be that the impact of market failures would be smaller than the one caused by policy failures associated with public provision. Indeed, private provision could at least force users to reveal their true willingness to pay, what is often difficult to obtain in the case of public provision.

Finally, new institutional practices have recently emerged in connection with the provision of the NCOs by agriculture. Direct transactions between producers and consumers have been observed for COs stemming from environmental-friendly, agricultural processes (OECD 2005).

3 The Normative Approach of Multifunctionality: The Model of European Agriculture

Within the normative approach, agriculture is given the objective of fulfilling certain functions for the society. In this respect, multifunctionality is not merely a feature of the production process but becomes a policy objective in itself. In this context, societal demand refers to various entities: on the one hand there is the agricultural product and its characteristics while, on the other hand, stay the farm, the landscape and the rural areas. Multifunctionality also involves various stakeholders. Within the Earth Summit of Johannesburg in 2002, stakeholders have been defined as people who have an interest in a particular decision, either as individuals or representatives of a group. The definition of multifunctionality, which is implicitly adopted here, does not presuppose any specific definition of the common good or of specific objectives. It is open to the full range of societal needs and demands without passing a value judgment on their desirability. It is only when the content of the related policies will be defined that it will be possible to precise the outlines of what is meant by a multifunctional agriculture.

Connected to this vision, the Model of European agriculture (MEA) was introduced into the terminology of the Common Agricultural Policy (CAP) with the Agenda 2000 reforms at the end of the 1990s. It is based on the suggestion that European farming provides multifunctional side effects which are generally associated with positive attributes and may include food security, food safety, animal welfare, cultural landscape, biodiversity and rural development (Glebe 2003).

The CAP is a widely debated policy, notably with respect to its budget and its instruments. It has evolved from its initial objectives, which were set out in Article 32 of the Treaty of Rome. Those were to increase agricultural productivity, to ensure an equitable income for farmers, to stabilise agricultural markets, to ensure the availability of food and agricultural products and to guarantee reasonable prices for consumers. Forty five years later, the perspective has changed on the objectives that the CAP has to follow: competitiveness rather than productivity is the guideline, the supply of food by agriculture must not only be abundant and affordable but also healthy and safe, markets must still be kept stable but essentially for food security reasons (Gomez and Atance 2004). The rise in the public awareness of the importance of maintaining rural communities has probably been one of the main driving forces in the recent evolution of the CAP in 2003. As a result, agriculture must not only provide an adequate income for farmers but also respond to its social and territorial dimensions. Furthermore, in the course of the past few decades, knowledge of and concern for the environment have also increased substantially in Western Europe that has brought about seeking an adequate management of the relationship between agriculture and environment.

A first key element of the reformed CAP is a single farm payment for EU farmers, which is independent from the production level (decoupling). This payment is made contingent upon the respect of different standards (regarding environment, food safety, animal and plant health and animal welfare) as well as the requirement to keep all the farmland in good environmental conditions (cross-compliance).

In addition, the 2003 reform has given to the rural development policy bigger financial support. This policy referred to in Agenda 2000 as the second pillar of the CAP, includes special environmental measures, known as agri-environment measures. According to the latter, subsidies are granted to the farmers which commit to go beyond good agricultural practices. They constitute an important environmental policy instrument, being compulsory in all rural development programmes and based on a voluntary commitment by farmers to a greener agriculture (European Commission 2005). They also convey the idea that farmers have a tremendous responsibility for the sound management of environmental resources and that this responsibility must be valued.

This rural development policy is also a relevant tool for creating the conditions of a sustainable farming. Sustainable agriculture means ensuring that future generations can enjoy the benefits of Europe’s unique environmental heritage and natural resources, as the current generation does today. Achieving sustainability faces three challenges: an economic challenge which goes through strengthening the viability and competitiveness of the agricultural sector; a social challenge through improving the living conditions and economic opportunities in rural areas; and an ecological challenge through promoting good environmental practices as well as the provision of services linked to the maintenance of habitats, biodiversity and landscape (Casini et al. 2004). For the farmers involved, the concern for sustainability means having to take both the effect that their activities will have on agriculture in the long run and how the technological processes they use shape the environment into account.

To conclude, within the Model of European Agriculture, the multifunctional approach considers a wide range of services going from those related to the agricultural sector and land use to those, which concern the society as a whole. In this context, Gomez and Atance (2004) consider that the CAP requires two kind of corrective actions from the part of the policymaker: first, the optimal identification of public objectives which have to be achieved and, secondly, a suitable choice of policy instruments to be implemented. These aspects are shared by the recommendation lastly suggested by the OECD for policies aiming the multifunctionality of agriculture (OECD 2007).

However, we must recognize that, so far, EU and regional policy makers have lacked tools to assess the impact of multifunctionality-oriented measures. In this perspective, the next research agenda would have to go further on the relationships between agriculture, landscapes and societal demand.

4 An Analytical Framework for Assessing the Impact of Multifunctionality Oriented Policies: The Sustainability Issue

The multifunctional dimension of the EU's Model of European Agriculture contributes to the objective of sustainable rural development, by reducing negative externalities and providing NCOs, which are backed by societal demand. Such a mechanism is built upon a connection of supply and demand side aspects of multifunctionality. In this respect, two main points have to be addressed: first, the linkages between CO and NCOs outputs in agriculture; second, the question of the change in the spatial scale (from a farm to a landscape level).

Up to now, and since the notion of externality refers to the origin of the NCOs but not to the scope of the impact of agricultural activities on NCOs, assessing the impact of public intervention in this domain may be hampered by specific, operational constraints. Indeed, as agricultural externalities are not traded on a market, they do not have any observable monetary value. Therefore they cannot be used as an indicator for NCOs, which are demand-oriented. Usually, according to the positive approach of multifunctionality, the demand is estimated through the willingness to pay. To this aim, economic valuation methods are based on the preferences of economic agents who enjoy the public good.[2]

[2] For more details, see OECD (2001).

But, while the supply of NCOs depends on the farm activity, the different beneficiaries, are not necessarily attached to this spatial level, nor are the values that they attribute to the NCOs. For example, as far as food safety and food security are concerned, the consumers of foodstuffs are the principal beneficiaries of these services that they attach directly to the farm activity and value accordingly. On the contrary, for all landscape functions like the safeguarding of the biodiversity and ecological functions, to which the farm activity also contributes to, the beneficiaries are mainly the residents and/or visitors of the region considered, which attach the corresponding landscape amenity values to a larger spatial area than the farm. It ensues that, as far as the demand evaluation is concerned, we have to distinguish between agricultural multifunctionality when the non-commodity output becomes one attribute of the food product from landscape multifunctionality when the non-commodity output is considered at a larger spatial level than the production level (Casini et al. 2004).

In addition, farmer's activities have to be considered as joint productions of NCOs: it is for instance the case of an agricultural landscape to which a kind of biodiversity may be attached. Up to now, however, conventional economic valuation methods go through drawing up monetary indicators for NCOs taken separately but not for joint NCOs, which may arise from multifunctional activities (like agriculture). Thus, these conventional methods may be not appropriate to correctly evaluate multifunctionality-oriented policies (Bonnieux 1998).

Moreover, existing methods are applicable only to assess the impact of public intervention for well-understood landscape functions (recreation, rural amenity values). In this respect, de Groot (1992) stresses that it is likely that there are many environmental functions that have not been discovered but that may have significant socio-economic importance. While some landscape functions are not yet completely well understood such as biodiversity and habitat, others like regulation functions operating at the level of ecosystems are increasingly relevant in connection with the climate change (floods and droughts notably) (Wiggering et al. 2006). Since landscape functions rely on the states, structures and processes of ecological systems, it would be more relevant to adopt proper, scientific knowledge of landscape functions in order to define the concept of landscape multifunctionality. This raises also the necessity to address the concept of multifunctionality within an interdisciplinary approach of landscape (crossing the pure economic and ecological ones).

Furthermore, a global approach of landscape functions may also contribute to a sustainable development of rural areas. For this purpose, social sciences try to deal with societal needs and expectations by asking users and stakeholders directly. On this basis, a list of the landscape functions expected at the regional level could be drawn. However, in order for such a list to be used for the specific problem of the sustainable development of rural areas, three issues would have to be solved.

Firstly, a relevant selection from the list must be performed that meets the information needs of all stakeholders (local population, non local population, farmers). This is the sectoral and normative/governance dimension.

Secondly, it has to be checked whether the way the landscape functions are specified in the analytical framework fits the problem at hand. This point is related to the spatio-temporal and descriptive-factual dimensions.

Third, it must be sure that no relevant function is missing that may be specific to the local region at stake.

Thereafter, a set of indicators is necessary to link the societal demand and the dynamics of land use.

Finally, depending on the objective assigned to public policy, different measures and outcomes may be emphasised. If the major objective of the policy is the sustainability of the production process, it implies a preference for a reduction of negative NCOs alongside promoting the positive contribution of agriculture for social well-being. But if the objective is to favour the multifunctionality of specific agricultural systems, then public policy will encourage environmental friendly measures through, for example, the preservation of rural landscapes by using organic farming, as it is already the case within the Model of European Agriculture.

Moreover, if the focus has to be pointed on the importance of safeguarding the provision of positive agri-environmental goods, this aspect cannot be sufficient for defining multifunctional policy. Indeed, when the agricultural production process involves negative and positive NCOs (what is generally the case and may be analysed through the positive approach), the multifunctional characteristic of agriculture may not be sustainable because the production process may not guarantee a sustainable use of environmental resources (space, water, energy …) in the long run. It also appears that the time dimension, which is inherently present in the agricultural process, is an essential element to be taken into account for supporting the multifunctionality of agriculture and for giving solid grounds to multifunctionality promoting policies.

5 Conclusions

The link between sustainability and multifunctionality is not univocal: the sustainable dimension may encompass the multifunctional dimension of the agricultural activity considered, but the converse is not true. In addition, the time dimension of the link cannot be ignored.

Yet, the analysis of the multifunctionality is, up to now, mainly implemented in a static framework, which does not call into question how the sustainability of the agricultural production processes can be performed in the long run. For example, the analysis of the production of NCOs does not refer to such temporal aspects. It ensues we cannot establish the very moment at which agricultural producers respond to incentive payments and carry out the necessary measures in this domain. Moreover, the pattern of the adjustments at farm level is not clearly established while changing preferences (on the demand side) may also impinge on the dynamics of joint production.

As long as the dynamics of supply and the dynamics of demand are not independent from each other, the analytical framework of multifunctional policies should take the time dimension associated with the sustainability of the agricultural processes into account. Two main challenges follow from this mere observation.

The first would be to more precisely analyse the "co-evolution" of supply and demand for NCOs so as to think at a more efficient implementtation of multifunctionality-oriented policies in the field of agriculture.

The second would be to bring into the analytical framework of multifunctionality the dynamics of agricultural landscapes in a way, which would integrate all dimensions of sustainability. The analyses performed on agro-ecosystems (Dalgaard et al. 2006) would deliver some useful insights in this perspective.

Trying to face those two challenges would constitute as many as fruitful areas of research for the next future.

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Multifunctionality Concepts: A Critical Assessment of the Framework Approaches

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Abstract

Multifunctionality has been the object of several studies and discussions over the past few years. This has resulted into a significant number of chapters, where the concept of multifunctionality is discussed with different approaches and interpretations according to the contexts in which the debate has been developed. The concept is generally quoted as an assumption for the acknowledgement of the primary sector's complex role for the welfare of the whole society. However, at international level the different concepts originate from a common assumption, although they do not offer an even and comprehensive focus on the issue, but rather provide an interesting overview of the concept's complexity.

The chapter offers a review of some of the main aspects of the approaches adopted by some international organisations in their analysis of the multifunctionality concept. The key issues regarded as relevant in the analysis of the multifunctionality concept are organized into five defining and two application elements. The five defining elements are: (1). the purpose of the definition of multifunctionality, (2). the directly or indirectly involved parties, (3). the time horizon, (4). the space dimension of multifunctionality concept and (5). the elementary objects making up multifunctionality (functions, non commodities outputs, etc.). The two

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application elements are: the instruments for the assessment of the proposed functions and the instruments for the political implementation (constraint systems, targeted payments, tradable permits, auction systems, negotiation agreements, etc.).

The chapter aims at reviewing the concept of multifunctionality, as it results from the different international documents, highlighting shared elements and differences in view of agricultural functions, answering the main questions: How to define different agricultural functions? How to evaluate them?

Keywords: multifunctionality; agricultural policy; environmental economics; non-commodity outputs

1 The FAO Approach: The Multifunctional Character of Agriculture and Land

The past century saw a growing interest towards the issues of food safety, productivity, and the sustainability of economic systems. In the 1990s, this resulted into an approach known as "Sustainable Agriculture and Rural Development" (SARD),[2] aimed at promoting the sustainable development of the agricultural sector. The analytical approach developed within the SARD framework is aimed at promoting the sustainable development in the primary sector that – through its production activities – ensures the preservation of land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable. In this respect, the SARD approach lays the foundations for the acknowledgement of the multifunctional role of the agricultural sector, which is deeply developed by the FAO through another analytical approach – Multifunctional Character of Agriculture and Land (MFCAL, Maastricht, 12–17 September 1999) – aimed at analyzing the complexity of the farming sector that is seen as historically important with reference to the complex interactions it develops with natural resources, society and the economic system.

The MFCAL is generally aimed at pointing out to practical ways to achieve and satisfy sustainability objectives through the multifunctional properties of the agricultural sector. In this respect, the FAO intends to provide an analytical reference model for policy-makers, somehow capable to lead towards the achievement of the objectives contained in the SARD

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[2] Sustainable Agriculture and Rural Development (SARD) and Good Agricultural Practices (GAPs): ftp://ftp.fao.org/unfao/bodies/coag/coag19/j4236e.doc

approach through the management of the multifunctional role of agriculture to a varying scale and under various environmental and socioeconomic conditions: “Our understanding of the factors crucial to achieving greater sustainability in agriculture has increased through building on the potential scope of multiple functions in rural areas.”(FAO 1999). The FAO’s approach is based on the assumption that agriculture and land use have an impact on man’s well-being, which is not exhausted in the production of foodstuffs alone, but can be related to a number of strategic functions for the social, environmental, and economic balance of the whole planet. Agriculture is then seen as an intrinsically multifunctional sector, which has always ensured the achievement of multiple objectives (namely functions) associated with the primary one of producing food, fibres and fuels. The FAO approach considers the whole set of agricultural functions (social, environmental and economic functions) at different territorial levels as positively related to the promotion of sustainable development. The FAO thus recognizes the strong implications linking the concepts of sustainability, multifunctionality and land use, which are considered as a physical demonstration of the synergies between biological and physical conditions and the production activities (of which the different viable functions are key vectors). In this respect, the concept of multifunctionality defined by the FAO recognizes the importance of agriculture to ensure food security and a social, economic and environmental balanced development either for present and future generations. The horizon to define the concept and assess its impacts is, in fact, very wide both in terms of space and time and it allows to consider the impacts of the phenomenon at different scales, including the whole contemporary society and future generations as potential targets of multifunctional agriculture benefits.

The MFCAL is mainly descriptive than methodological or prescriptive. The information at the basis of the concept of multifunctionality conceived by the FAO is strongly affected by the practical experiences gathered from the heterogeneous worldwide agricultural sectors. The different functions of the sector are defined starting from the practical experience reported by the information sources. The same individual functions take different meanings and degrees in relation to the different environmental, economic, and social conditions, thus stressing the relative character of the concept in MFCAL. The importance acknowledged to the environmental role of agriculture is greater in the contexts characterized by a reduced presence of natural resources and a strong pressure on environment. Therefore, the qualitative evaluation of each function occurs according to comparative processes running within any specific local condition. The functions regarding practical experiences are identified directly on the ground and grouped together into the following three main areas:

- *The Environmental Function.* Agriculture and related land use can have beneficial or harmful effects on the environment. The MFCAL approach can help to identify opportunities to optimise the linkages between agriculture and the biological and physical properties of the natural environment.
- *The Economic Function.* Agriculture remains a principal force in sustaining the operations and the growth of the whole economy, even in highly industrialised countries. The evaluation of the various economic functions requires assessment of short, medium and long-term benefits. Important determinants of the economic function include the complexity and maturity of market development and the level of institutional development.
- *The Social Function.* The maintenance and dynamism of rural communities is basic to sustaining agro-ecology and improving the quality of life (and assuring the very survival) of rural residents, particularly of young ones. At another level, the capitalisation of local knowledge and the forging of relationships between local and external sources of expertise, information and advice are fundamental to the future of existing rural communities. Social viability includes maintenance of the cultural heritage. Societies still intensively identify with their historical origins in agrarian communities and rural lifestyles (FAO 1999).

The FAO then acknowledges the variability of multifunctionality in space and time, both in terms of effects and in terms of the different quali-quantitative composition of the pool of the functions that can be delivered.

The spatial implications of multifunctionality lead to a complex reading of the phenomenon and its impacts according to the scale of analysis. Changes in the socioeconomic or political scenarios taking place at a macro-level (national or supranational) can have an impact at a meso- and micro-level with implications on the related environment and land (the phenomenon can also occur the other way around). At the same time, the spatial dimension of multifunctionality as shown by the MFCAL approach also depends on the variable impacts that the same functions can have in different reference contexts.

MFCAL also has a time dimension resulting from the need to identify appropriate reference time horizons for the different functions, allowing on one hand to interpret the effects (either cumulative or cyclic) properly and, on the other, to ensure the identification of a time span large enough to allow a comprehensive evaluation of the effects of each function in the short, medium and long term.

This implies a careful management of the provision of functions, following by their identification and analysis. In this respect, the FAO acknowledges the central role of public decision-makers: "ultimate responsibility for ensuring the viability of agricultural systems and the environment remains in the public arena, and there must be mechanisms for addressing competing interests, immediate needs and conditions for long-term sustainability that take proper account of the general goals of equity and poverty reduction" (FAO 1999a). The FAO acknowledges that the multifunctional role of agriculture can be promoted and facilitated by favourable political, social and environmental conditions (market mechanism, public institution framework, new techniques and technologies).

In particular, strengthening market mechanisms can improve the effects of multifunctionality through: establishing emission rights markets to which all producers could have access; developing mechanisms for public tenders to licence contracts for natural environment maintenance, biodiversity management, water management, ecological infrastructure maintenance, desertification reduction and mineral accounting; developing internalization mechanisms as ecological tourism markets and typical products (FAO 1999).

The institutional framework can, in turn, be improved by: encouraging local agreements between users for the management of renewable natural resources, in order to control erosion and land degradation, and best practices for the use of water, rangelands, forests and wildlife; encouraging local agreements in order to guarantee community economic functions: integrated control, storage of food stocks in the event of food shortages, promoting quality control and labelling; promoting efficient local public authorities with decentralised powers to create infrastructures that can cater for the preferences of local people relating to rural roads, communications and other services.

2 The OECD Analytical Framework of Multifunctionality

The most extensive attempt to provide an agriculture multifunctionality definition was carried out by the OECD, which decided to adopt multifunctionality as a policy principle. This is the result of the 1998 Ministerial Declaration, which expressed shared goals: the recognition of multifunctionality of agriculture and the wish to ensure responsiveness to market signals (OECD 1998).

The result of this baseline context is that “the goal of the OECD report (2001) is to establish principles of good policy practice that permit the achievement of multiple food and non-food objectives in the most cost-effective manner, taking into account the direct and indirect costs of international spill-over effects. On a broader scale, the work on multifunctionality is part of an ongoing effort by the Secretariat to address domestic non-trade concerns, including equity and stability issues, and trade liberalisation in mutually consistent ways” (OECD 2001: 15).

All these questions are closely intertwined and converge on a work programme on multifunctionality based on three main issues: the production relationships underlying the multiple outputs of agriculture; the measurement of the demand for non-commodity outputs; the policy aspects of multifunctionality, including its implications for policy reform and trade liberalisation.

In respect to the first point, the answer that the OECD (2001) report provides results from the analysis of three main economic categories: Jointness, market failure and public goods.

“Jointness: We first need to examine the degree to which a non-commodity output may be jointly produced with a commodity and, if so, whether it can be released from this jointness. If production is non-joint, the non-commodity outputs can be supplied independently. Similarly, if production of a non-commodity output can be separated from the production of a commodity output without any cost, the non-commodity output can be supplied independently. In these cases, there may be no policy link between the goal of agricultural trade liberalisation and the goal of pursuing domestic non-commodity concerns.

Market failure: There may also be non-commodity outputs that cannot be released from jointness with commodity production. Non-commodity outputs that are jointly produced with commodities are by definition externalities, but they do not always cause market failures. In this case, it is necessary to examine whether the non-commodity outputs in question are causing market failures. If not, there is no policy issue, either from a trade or domestic policy perspective.

Public good characteristics: There may be still non-commodity outputs for which both some degree of jointness and market failures have been established. In this situation it is necessary to determine if there are nongovernmental options to minimise market failures” (OECD 2003: 9–13).

Without going deeply into the individual discussions, the results of the first OECD (2001) report agree on a number of general assumptions, and particularly on the following.

Given the widespread existence of agricultural non-commodity outputs (NCOs) and of their variable spatial and technological distribution, the achievement of the desired NCOs production levels cannot be obtained with political economics means, which exclusively operate on commodities. The results of these actions will inevitably be an over- or under-production of some NCOs, with the severe consequence of altering the market of commodities, on which interventions focus on. It is therefore necessary to forecast specific intervention systems for every NCOs one wishes to guarantee.

The analytical framework suggested by the OECD can thus be summarized into the following logical process: “Is there a strong degree of jointness between commodity and non-commodity outputs? If so, is there some market failures associated with the non-commodity outputs? If so, have non-governmental options (such as market creation or voluntary provision) been explored as the most efficient strategy? Finally, and only if the answer to all these questions is “yes”, then the most efficient interventions will be defined by the nature of the jointness that exists on the supply side and by the different public good characteristics of the non-commodity outputs on the demand side” (OECD 2003: 11).

Indeed, the case resulting from the development of this process very often occurs in European hill and mountain agriculture, as well as in other marginal regions where “farming often becomes unprofitable, but the continued provision of some of the non-commodity outputs provided until now by agriculture is considered to be essential” (OECD 2001: 18).

From there on, the economic theory necessarily calls for the development of the two other points described above and, particularly, for a system to evaluate the NCOs and appropriate economic policy instruments.

Actually, without a system of values, even if not necessarily monetary, it is impossible to define an appropriate decision-making process, albeit in the limited rationality context, for public resources allocation to the different production processes. This is thus a crucial point demanding a solution to properly include the non-market social functions in the farmers’ and policy makers’ decision-making processes.

The third point mentioned above is closely related to this issue: the appropriate market instruments to “internalize” non-market functions. The definition of a system of values can, in fact, be either exogenous, thus allowing the allocation of prices (e.g. the so-called shadow prices of the Cost-Benefit Analysis) to externalities and their perception by the farmers within the normal management process, or endogenous originating, for example, from auction mechanisms for the provision of certain social services. Still, the system of values can be other than directly monetary and comply with physical indicators, in turn related to incentive systems. In all these three cases, and particularly in the last two, the information system is obviously crucial for an effective final solution. This opens up the issue of the other class of market failures that are relevant to this framework: information asymmetries, which are widespread in agriculture and pose further problems in the internalization of externalities.

The second OECD (2003) report on multifunctionality – "Multifunctionality: The Policy Implications" – expressly aimed at implementing the proposed analytical framework tackles the problem of integrating these key theoretic themes in such context.

From the economic theory viewpoint, the solution proposed is a neo-classical approach based on the application of the Cost-Benefit Analysis (CBA) methods, especially as far as the evaluation instruments are concerned. The authors themselves highlight the criticalities of this approach, particularly in terms of effective data availability, but conclude that: "the most important message is that the exercise is essential, in order for a sensible policy decision to be made" (OECD 2003: 15).

Starting from these elements the main characters of the above-described taxonomic categories can be inferred.

Once the purpose of the chapter is clarified through the definition of how to establish principles of good policy practice that permit the achievement of multiple food and non-food objectives in the most cost-effective manner (OECD 2001), the involved parties and, thus, the society "judging" multifunctionality can be quite easily identified in the current citizens of the OECD countries, and of the more developed ones in particular, where agriculture's externalities have a greater social value. This highlights clear consequences with respect to the type of values and to the functions that can be attributed to agriculture. The issue of equity is considered, but only in intra-generational terms and not in a comprehensive way: for example, the implications of the evaluations based on the Willingness to Pay and on the equity of the consequent social choices are not considered (i.e. the equity of the present income distribution). In short, the judgement of multifunctionality can be attributed to the current consumers in developed countries, with special focus on higher-income ones. This interpretation is only partly mitigated by some considerations on intra-generational equity: "there are two equity issues in the context of the provision of non commodity outputs as for public good provision in general. One is related to who benefits from the provision of non-commodity outputs while the other relates to who bears the cost" (OECD 2003: 63). But no clear guidelines emerge for an appropriate discussion of the issue that, on the other hand, is not easy to implement it in a CBA context.

The definition of the value objects, i.e. the basic components of multifunctionality, is contained in the first OECD (2001) report by way of examples, but the suggested approach is such that "there is no need to establish a listing of the multiple "non commodity outputs" [NCOs] or negative externalities of agriculture, although examples are often used in this text and in the analytical framework to illustrate the points being made. What is important is that the different steps in the analytical framework are followed by a view, which determines whether a policy intervention is required and, if so, what the nature of that intervention should be. There is therefore no need to establish ex ante what are the effects properly described as negative externalities and what are the non-commodity outputs. All the possible effects of agriculture need to be examined with the analytical framework described below" (OECD 2003: 10). The theoretical consequences of the assumption are that the components of multifunctionality have to be defined at local level (single country, homogeneous set of countries) and based on the current priorities.

The issue of indicators is not tackled and, particularly, no reference is made to the problem of integrating the available indicators, also suggested by the OECD (2001), and the CBA methodologies, which require homogeneous values in monetary terms.

The limits of the neoclassical approach implemented through the CBA can also be inferred from the second OECD (2003) report, which allows the identification of the characteristics of the concept of multifunctionality related to the considered space and time dimensions.

As to the space dimension for the evaluation of multifunctionality, the OECD approach expressly tackles the theme in both micro- and macro-economic terms.

As to the time horizon, the adopted neoclassical instruments imply clear difficulties in discussing inter-generational equity. Hence, there is a substantial lack of consideration for the long-term and future-generation problem, even if some references are made to equity, especially for the negative NCOs: "any risk of irreversible changes in non-commodity provision related to reform-induced changes in commodity production needs to be taken into account although, in practice, this is extremely difficult. In particular, it is not possible to estimate the demand of future generations for NCOs" (OECD 2003: 32).

With reference to the operational side of the proposed multifunctionality concept, the OECD tackles the issue of evaluation and of the economic-policy instruments in a strictly neoclassical perspective. Without repeating concepts that have already been mentioned, the guidelines for the evaluation of the NCOs and for the decision-making models include the CBA, with the described problems. As to the economic-policy instruments, the preferable solutions include the internalization of the NCOs, mainly taking inspiration from Coase's Theorem, even if with a strong focus on the issue of transaction costs, which represent the main limit of this approach.

The creation of market mechanisms aimed at supporting a voluntary based production of NCOs is the preferred solution. Negotiations at local level especially designed to supply one or more NCOs allow the evaluation of the demand for these externalities at best.

The adoption of subsidy forms to farmers is considered a second best solution, which requires special attention instead. In particular, targeted payments represent the applicative practice to privilege from both efficiency and an equity side in this context.

"Targeting in this context is a multi-layered concept that includes geographical or spatial targeting, but also targeting the specific non-commodity output that is desired" (OECD 2003: 76).

Among the limits of this instrument, the report correctly highlights the applicative difficulty of some NCOs – e.g. the landscape – and recommends that the choice of the target to be the closest possible to the NCO, from both a productive and a geographic side. The choice of subsidies per hectare of cultivated land, for instance, can significantly diverge from the quality and quantity of the NCOs one wants to support. If this is the case, "the greater the need is for educational initiatives, strict regulations and monitoring, so as to ensure that the NCO is actually produced in the quantity, quality and location desired" (OECD 2003: 76).

3 The Multifunctionality of Agriculture Within the European Union

The concept of multifunctionality within the "Model of European Agriculture" (MEA) certainly does not present the features of an economic theory like the OECD document,[3] but since the McSharry reform in 1992 this concept has become increasingly widespread and important in the official documents of the European Commission. With the 1996 Cork Conference and then Agenda 2000 the concept of multifunctionality became a linchpin of the CAP.

Starting from guideline documents and implemental regulations, it therefore seems interesting to reconstruct the concept of multifunctionality defined in the EU according to the taxonomic structure presented in the introduction.

[3] The OECD multifunctionality concept shows a clearly theoretical background while the MEA represents the effective, agricultural and rural policy in the EU (Piorr et al. 2005).

The purpose that the EU concept of multifunctionality must fulfil can be defined moving from the political reasons at the basis of its introduction to the CAP. "As a normative concept, multifunctionality fulfils specific functions. It is possible to identify three intertwined functions: it justifies the existence of agricultural policy, the need for change and the necessity to underscore environmental and rural development concerns" (Garzon 2005: 16). In other words, these functions can be summarised into two different requirements: to respond to the needs of the European society to share the objectives of high-level financing for to agriculture; secondly, to make aids to European farmers acceptable in international agreements, especially at WTO tables.

This leads to the conceptual definition of multifunctionality, which presents similar motivations to that of the OECD, but here it is more operative, specifically concerning the definition of a new system of objectives with new agricultural policy tools aiming at minimising the negative effects of farming activity and promote non-market functions.

These objectives are clearly inferable from Agenda 2000 and the preparatory work of the Mid-Term Review.

"The specific role of agriculture as a provider of public goods should be recognised. This is all the more important in order to muster public support to the process of further liberalisation of trade in agriculture. In this context, the multifunctional role of agriculture, which, in both developed and developing countries, includes its contribution to sustainable development, the protection of the environment, the sustained viability of rural areas and poverty alleviation should be recognized" (see Garzon 2005: 15).

More explicitly in the presentation of the Mid-Term Review: "we cannot expect rural zones to be prosperous, the environment to be protected, animals in breed farms to be treated well and our farmers to survive, without spending any money. In future farmers will receive incentives, not to produce in excess but to meet the requirements of citizens who ask them for safe foods, quality produce, well-treated animals and a healthier environment" (European Commission 2002: 12).

Therefore, taking into account especially the guidelines from the OECD report: "targeted payments are likely to be the most desirable option from the point of view of efficiency, equity and international spill-overs" (OECD 2003: 76).

In the application of regulations, however, these objectives seem to be forgotten or at least considered in a very restricted context rather than in terms of full promotion of agricultural multifunctionality. The main concern seems to be promoting agriculture that has no negative effects on the environment, rather than protecting and motivating agriculture which carries out functions – for the landscape, the environment and the society –

that are important in many areas of the country. It seems that the regulations regarding environmental compatibility and lack of resort to direct funding of social functions should be interpreted in this light (which is partly due to general failure to apply art. 69). This approach is probably convincing for many types of intensive and highly competitive agriculture, but not for the hillside and mountain farms that are fulfilling more prestigious environmental and social functions and yet find themselves facing objective limitations in terms of competitiveness.

There are a number of reasons for this divergence between the initial approach and the final regulation concerning the role of multifunctionality in the Mid-Term Review, but they are mainly ascribable to two basic reasons. Firstly, the heterogeneous nature of European agriculture types and the relationship between these and the respective national communities; secondly, the role of WTO negotiations in the definition of the CAP.

Traditionally Great Britain and Germany, like other countries in Central-Northern Europe, interpret agricultural policies in the light of the quest for a growing competitiveness in productive systems, reserving some attention for more marginal agriculture. Mediterranean countries, on the other hand – especially France and Italy and, to a smaller extent, Spain – share a vision that these policies are more directed toward the social role of agriculture. This debate was further complicated by the BSE crisis in 2000. The conclusion of these processes is a regulatory text – Reg. 1782/2003 – in which the concept of multifunctionality, as a guiding element of reform, is replaced with that of sustainability and, consequently, the tools to be applied are linked to monitoring environmental compatibility rather than targeted payments for the production of positive NCOs.

Despite this resizing of the multifunctionality concept, there is still space for member states to define specific targeted payments: in particular, art. 69 1782/2003 “Optional implementation for specific types of farming and quality production” includes the possibility of additional payment granted for specific types of farming, which are important for the protection or enhancement of the environment or for improving the quality and marketing of agricultural products under conditions to be defined by the Commission in accordance with the procedure referred to in art. 144. However, the context in which multifunctionality might find effective implementation tools should be the new regulation for rural development. Agri-environmental measures represent an important tool for the management of multifunctionality in agriculture in a context of targeted payments, but a great deal depends on how these are implemented by individual member states.[4]

Unfortunately the ambiguous and generic nature of many statements in the current regulations prevent complete and definitive analysis of the CAP concept of multifunctionality, but some elements are recognizable and useful also for the implementation of specific assessment and programming tools.

The reference subjects for the concept of multifunctionality are inevitably European citizens, but more precisely it concerns a concept of flexible multifunctionality, which can be adapted to the specific interpretations attributed by each member nation. This solution is coherent with theoretical principles of multifunctionality but raises many management issues and is, in any case, incorporated in the framework of usable tools unique to all member nations.

There is very little to be established on the time and space horizon of European multifunctionality, although stating the concept of sustainability implies in some way a consideration of future generations in the definition of current choices. The spatial dimension for the analysis of multifunctionality is limited to the definition of administrative contexts in which the support tools are applied and coincides with either the member state or its large sub zones (NUTS1-2). Obviously, there is no relation between this spatial definition and the really wide range impact of the NCOs.

Regarding valuable objects to take into consideration, we can define specific social functions of agriculture inferable from other EU documents[5]: economic functions, including security of food supplies and the generation/maintenance of employment in rural areas; functions of public utility ascribable to quality and safety of food and their contribution to the balanced development of the area.

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[4] "Member states are obliged to undertake appropriate environmental measures. In fulfilling their obligations, they have several options at their disposal: agri-environmental measures, environmental legislation, and specific environmental requirements. The latter two options can be enforced by reducing direct payments granted under the first pillar of the CAP in the case of non-compliance" (European Commission 2002: 8).

[5] The results of a study of the OECD countries defines the following "Principal Non-Commodity Outputs and Negative Externalities": Landscape and Open Space Amenities, Cultural Heritage, Rural Economic Viability, Enhanced Food Security, Prevention of Natural Hazards, Groundwater Resource Recharge, Enhancement of Biodiversity, Loss of Biodiversity, Water Pollution from Nutrients and Erosion, Threats to Animal Welfare, Irrigation: Overuse, Salinization, Greenhouse Gas Emissions (Abler 2001).

The cross between these functions and current agro-environmental measures[6] is not wholly satisfactory especially in terms of measures aiming at targeted payments for positive NCOs. Moreover the problem is emphasized by application methods adopted by member countries, which have almost all decided to subsidise the reduction of negative externalities, and very often with approaches that present very low effects.

The new EC regulation no. 1698/2005, 20th September 2005, regarding support for rural development by the European Agricultural Fund for Rural Development (EAFRD), includes an important series of actions potentially connected to promoting multifunctionality. Again, a great deal depends on the choices of member states and especially their willingness to effect targeted payments for the production of positive NCOs, including effective compensation for farmers in disadvantaged areas, which are subject to certain limitations of environmental compatibility.

To conclude our analysis of the concept of multifunctionality inferable from the new CAP we need to asses the operative tools proposed in terms of the evaluation of NCOs and theoretical political implementation tools.

In the first case, the EU has no specific guidelines and the recent report on agro-environmental indicators (EU 2005) gives no specific information regarding application tools for multifunctionality, since its main objective is to analyse the effects of agriculture at a European level rather than identifying individual contributions.

As far as concerns multifunctionality management tools, we have already mentioned the privileged use of restrictive statutory systems, but the new regulation for rural development also leaves room for types of targeted payments; for example (art. 39) regarding agro-environmental payments: “the beneficiaries can be selected through a call for bids, applying criteria of economic and environmental efficiency” (art. 39 REG. n. 1698/2005).

Obviously in this case too, much depends on the application choices of individual member states. The main EU guideline is not to make choices about multifunctionality, but only about sustainability, probably opting for a reduced but politically manageable objective.

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[6] (a) Input reduction, (b) Organic farming, (c) Extensification of livestock, (d) Conversion of arable land to grassland and rotation measures, (e) Undersowing and cover crops, strips (e.g. farmed buffer strips) and preventing erosion and fire, (f) Actions in areas of special biodiversity/nature interest, (g) Genetic diversity, (h) Maintenance of existing sustainable and extensive systems, (i) Farmed landscape, (j) Water use reduction measures, (k) Upkeep of abandoned farm land and woodland, (l) Maintenance of the countryside and landscape features, (m) Public access, (n) Set aside.

4 Conclusions

The analysed documents offer a quite composite interpretation of the multifunctionality concept.

Regarding the definition of the elements used for the comparisons of approaches produced at the international level, the comparative Table 1 shows a synthetic confront between the main solutions adopted by the above cited institutions.

The approach proposed by the FAO with MFCAL makes a strongly descriptive contribution to the international debate surrounding multifunctionality, with the purpose of gathering useful information to trace examples of success in the application of sustainability principles through full assessment of the multifunctional role of agriculture. MFCAL mainly aims at underlining the features of agriculture and illustrating the role of multifunctionality as an objective piece of data toward which the attention of society, researchers and public decision makers should be directed.

The OECD's contribution differs because it derives from a political context that is strongly influenced by the development of international scenarios (new round of agricultural trade negotiations, specific response needed to Article 20 AoA, continuing reform commitments, with still high levels of support) and particularly concerns the assessment of the opportunity to compensate agricultural multifunctionality financially. The OECD document is technically different from that produced by the FAO and offers a purely economical point of view inspired to a neo-classical approach, whose objective is to clarify the phenomenon of multifunctionality and its implications for the market, using economic theory tools. In order to achieve this we must analyse and define the technical aspects, so as to find the way in which the various NCOs are generated within the production process. The document also tackles coherently the aspects of economic policy, indication tools and techniques for the assessment and management of multifunctionality. The concept of multifunctionality proposed by the OECD typically shows the use of neo-classical tools offering a positive rather than a normative approach to it.

Table 1. Comparison of different approaches to multifunctionality

	OECD	FAO	CAP	MEASCOPE
Purpose	To establish principles of good policy practices that permit the achievement of multiple food and non-food objectives in the most cost-effective manner	To developing practical ways to promote sustainability by increasing the awareness of the multiple functions of agriculture and land	To define a new system of objectives able to create new tools for agricultural policy in order to minimize the negative effects of agricultural activity and promote non-market functions	To analyse impact of the CAP options
Subjects	Current citizens of OECD countries	Current and future generations	Current EU citizens, with varying definitions according to member state	Inhabitants of regions studied
NCOs	Components of multifunctionality defined at a local level without any indications on how to determine the specific management approaches	Components of multifunctionality defined at a local level without any indications on how to determine the specific management approaches	Components of multifunctionality defined at member state level	Components of multifunctionality defined at the level of the area under analysis
Temporal dimension	To be dealt with taking into account the effects on future generations, use of Bequest value	Appropriate reading of the cumulative or cyclical effects (negative/positive) expected in the medium and long term.	Dealt with only in terms of development sustainability and therefore mainly concerning negative NCOs	20 years
Spatial dimension	It deals with the theme of minimum survey unit and effects of spill-over	It deals with the theme of geographic localization, relationships with the specific local features and the territorial scale affected	Administrative dimension State, NUTS 1-2	Farm-county
Evaluation system	CBA approach	Comparative evaluation	Only descriptive	Descriptive, quantification of different effects
Management tools	Internalisation of externalities, targeted payments	Coordinated public intervention between different levels: local, regional, national and international	Constraints system, targeted payments	The CAP actual tools

The multifunctionality approach outlined in the EU sector does not directly aim at defining the concept of multifunctionality, but rather to adopt it as an argument to emphasize the importance of the sector in the European nations and societies. The concept of multifunctionality that emerges from the documents underlines the various functions ascribable to the sector, but in the political scheme it tends to standardise the concept of multifunctionality with environmental sustainability.

The approach proposed by the MEA-Scope project is an effective instrument in the EU affairs, as it provides operative tools for the activation of political measures, able to develop the multifunctionality content of agriculture. In this sense the contribution mainly aims at providing tools to assess multifunctionality at farms and territory level. The approach is, therefore, conceptually based on the microeconomic theory and technically wants to interpret the various qualitative and quantitative outcomes, which multifunctionality is intended to create within the various agricultural systems and production techniques.

In conclusion, we believe that some main questions about multifunctionality are still without clear answers: How to evaluate the trade offs among different NCOs or functions? Are the current policy tools the best solution to deal with NCOs production? What are the effects of different policy instruments on agriculture? The right answers to these questions are fundamental not only for the future of the CAP, but also for the whole European agriculture.

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Societal Demand for Commodity and Non-commodity Outputs – A Regional Perspective

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Abstract

Societal demand for the multifunctionality of agriculture was analysed in four case-study regions by studying stakeholders' perceptions of regional priorities. We used the Stakeholder Delphi Approach, which is a qualitative, two-step procedure, based on revealed preferences of a principal consisting of stakeholders and experts from the regions. The results of our case studies imply that demand for functions of agriculture is generally strong. Comparing the priorities among the case studies, we found different demand patterns in each region. Further discussion of the Wielkopolska case study, with a production-focussed demand pattern, and the River Gudenå case study, with a post-productivist pattern, illustrates the regional characteristics that have shaped the distinct demand pattern in these regions.

Keywords: budget exercise; multifunctionality; regional demand; Stakeholder Delphi Approach

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1 Introduction and Aims of the Study

As has been shown in previous chapters in this book, we use the concept of multifunctionality as a normative approach in accordance with the European Model of Agriculture. This approach involves first the recognition of a range of economic, social, cultural and environmental functions of agriculture in Europe (Casini et al. 2004). Second, it is “normative” in that society has to decide which of these functions *ought to be* fulfilled by agriculture.

Decisions about preferred functions of agriculture are shaped by the backgrounds of the decision makers and the contexts in which they are embedded. Throughout Europe, not only do conditions for agricultural production vary; the socio-economic, territorial, environmental and cultural contexts also differ widely. To adequately capture societal demand for the multiple functions of European agriculture we therefore have to take account of these differences, conceiving of society as a number of different “societies” (EC 2007; Lee et al. 2005).

In consequence, an exploration of societal demand for the different functions of agriculture needs to consider the regional contexts in which these societies are embedded (Huber et al. 2007). This is the perspective chosen here, while conceiving of the functions of agriculture as “commodity” and “non-commodity” outputs. “Commodity outputs” (CO) thus refers to the satisfaction of material, and “non-commodity outputs” (NCO) to the satisfaction of other needs expressed by the society (Belletti et al. 2002).

In particular we aim to:

- clarify the role that agriculture plays in the regions investigated,
- identify regional demand for multifunctionality of agriculture,
- explore reasons for the regional demand for multifunctionality of agriculture,
- reveal regional differences in societal demand for the functions of agriculture.

After a brief presentation of the methods applied, we will compare the demand expressed by stakeholders and experts in four countries. The study was implemented in four different case studies: Ostprignitz-Ruppin (OPR) (Germany), River Gudenå (Denmark), Wielkopolska (Poland) and Mugello (Italy). To exemplify the reasons behind the demand, we then discuss the Danish and the Polish case in more detail before finally drawing conclusions from the study.

2 Choice of Methods

There are a number of techniques for valuing non-commodity outputs (NCOs), public goods and cultural amenities consistent with the microeconomic valuation of marketed goods that consider an individual's willingness to pay (WTP). These techniques are based either upon revealed preferences (observed behaviour) or stated preferences (see e.g. Henseleit, 2006). Furthermore, we distinguish between direct and indirect approaches. While direct methods deal straightforwardly with the non-commodity concerned, indirect methods derive values for the non-commodity concerned by investigating related aspects or commodities. In addition to these methods based on individual preferences, approaches have evolved that take into account the fact that preferences are often formed in a discussion process within a collective entity (see Table 1).

Table 1. Classification of approaches to measure Willingness To Pay (WTP)

	Indirect	Direct
Methods based on individual preferences		
Revealed preferences	Household production function approach: – Travel cost method – Averting cost method Hedonic price analysis	Simulated markets Market prices Replacement cost
Stated preferences	Contingent ranking Choice experiments/ Conjoint analysis	Contingent valuation
Methods based on collective preferences		
Revealed preferences	Implicit valuation	
Stated preferences	Citizens' juries Delphi technique Market stall Valuation workshop Expert valuation method Budget game	Multi-Criteria analysis

Source: Navrud (2000), modified

As outlined above, multifunctionality of agriculture is a complex concept including (jointly produced) commodity and non-commodity outputs which are not necessarily traded on a market or accessible to the "ordinary consumer". Hence, ordinary consumers might find it difficult to valorize these types of agricultural functions. We therefore opted for a mixed *panel* *of decision makers, stakeholders, and experts*, instead of polling individuals. In this way, we included persons who are more likely to have an overview of regional contexts, as well as detailed expert knowledge of distinct topics. This collective preference method has the additional advantage of limiting the resources needed.

Since multifunctionality of agriculture is concerned with many different public goods, it can be assumed that non-use values make up a considerable share of the total economic value. It is therefore advisable to opt for a *stated preference technique*, which takes into account non-use values.

Employing an *indirect method* was seen as promising because of the wide range of issues that had to be addressed, including qualitative aspects such as reasons and relationships between the various issues.

Summing up, our approach may be classified as a blend of several indirect/stated preferences approaches found in the literature: a standard Delphi approach (Ziglio 1996), Mann's Expert Valuation Method (EVM) (Mann 2004) and a Budget Game (Budget Exercise) as conducted by von Ziehlberg (1999). This approach will be referred to hereafter as the *Stakeholder Delphi Approach*. Since such a method has not been used before to determine the demand for multifunctionality of agriculture, the study was exploratory in nature. The Stakeholder Delphi Approach is outlined below and explained in more detail in Schader et al. (2007).

3 Stakeholder Delphi Approach

In this study we consulted a stakeholder panel that comprised both representatives and experts. Representatives, on the one hand, are persons from democratically legitimized institutions, such as representatives of regional parliaments, district councils, mayors, representatives of farmers' unions, environmental conservation organizations, tourism organizations, the regional economy, regionally active movements, consumer associations, and health organizations. Experts, on the other hand, are not democratically legitimized, but have close regional ties and are able to provide professional input through their knowledge (e.g. administrative staff from agricultural or environmental institutions, coordinators of LEADER projects, researchers, etc.).

The Stakeholder Delphi Approach consists of two iterative steps: in the first step, face-to-face interviews were conducted with representatives and experts in each case study. In the second step, a structured group discussion was organized with the same persons.

3.1 Step 1: Face-to-Face Interviews

The first step consisted of structured qualitative face-to-face interviews with open and closed-ended questions, which aimed to grasp the whole range of relevant views on the issue.

The questionnaire was subdivided into the following parts: factors not restricted to agriculture that determine living conditions, the role of agriculture for living conditions, the importance of effects of agriculture for the regional population, alternatives to agriculture to achieve these positive effects, and future demand for the functions of agriculture.

A list of 16 positive and 9 negative effects, or functions, was developed in collaboration with the other partners of the project. This list was based on the MEA-Scope NCO[1] list for the indicators (Waarts 2007) and adapted to the demand-oriented context. Stakeholders had the opportunity to add further, region-specific aspects to this list.

3.2 Step 2: Structured Group Discussion with Budget Exercise

The second step consisted of a structured focus-group discussion with the persons interviewed. The aims were to condense the results of the interviews, to reach consensus on an order of magnitude for the various functions and effects of agriculture in the region, and to reveal the reasons behind the expressed demand. After discussing the list of functions and effects of agriculture resulting from the Step 1 interviews, the participants were asked to allocate a budget to prioritize the list of functions and effects of agriculture (von Ziehlberg 1999). The budget allocation of each participant was then presented to the whole group, which had the task of reaching a group consensus through group discussion.

4 Cross-Country Comparison

This section will first of all provide an overview of the roles that agriculture currently fulfils in the different case-study regions, and then discuss

[1] The use of the concept of "non-commodity outputs (NCOs)" within WP6 was considered inappropriate because the list of functions covers a wider range of issues, some having the character of an NCO and some not. Furthermore, "NCO" is a highly technical term that is not necessarily comprehensible to stakeholders in its economic sense. We therefore used the more colloquial terminology "functions and effects of agriculture".

the most important issues and differences regarding prioritization of agriculture's functions (importance of food production, para-agricultural activities, ecological and socio-cultural public goods, as well as reasoning and allocation patterns).

Table 2. Grouping of the generic positive effects of agriculture into economic, ecological and socio-cultural sets according to their predominant nature

Economic	Ecological	Socio-cultural
Regional food processing	Animal welfare	Maintaining social-cultural identity
Regional food supply	Hydro-ecological equilibrium	Preventing migration of young people
Regional tourism	Increased biodiversity	Production of safe (healthy) food
Rural livelihoods	Preserving the rural landscape	Provision of jobs
Stimulation of small businesses	Soil fertility	Recreation in rural areas
		Stimulation of rural cultural activities

4.1 Role of Agriculture for General Living Conditions in the Case-Study Regions

The regional stakeholder groups were composed heterogeneously, with most of the stakeholders taking a societal perspective rather focusing merely on the production function of agriculture. The current multifunctional character of agriculture was affirmed in all four case-study regions. Although most of the stakeholders argued that the way agriculture is practised nowadays has several very important positive effects on ecological, economic, socio-cultural functions, the population of the case-study regions demands a stronger commitment regarding most of the functions. According to the stakeholders, the functions cannot realistically be supplied by an alternative means other than agriculture.

Different portfolios of roles of agriculture were identified for each case-study region. While in the River Gudenå case study, agriculture was characterized by a strong focus on providing public goods rather than agricultural produce, in Ostprignitz-Ruppin the stakeholders emphasized alternative roles of agriculture, or so-called para-agricultural activities (Loibl 1997), such as on-farm tourism and the provision of renewable energies by agriculture. The roles attached to regional agriculture were strongly linked to the overarching societal problem of that region: the high unemployment rate. In Mugello, the interviewed stakeholders thought of agriculture as having two distinct roles (or sets of roles): on the one hand, it is a supplier of high quality, special foods, while on the other it acts as preserver of a sound landscape in the region. In contrast, in Wielkopolska, the stakeholders revealed the continuing predominance of agriculture's role as a provider of food, although broader rural issues, such as establishing a good rural infrastructure, are increasingly important.

4.2 Functions of Agriculture

In addition to the qualitative description of the roles of agriculture in the case studies, as a basis for comparison we aimed to rank the preferences of the regional society in each case study.

Table 3. Overview of budget allocations in the case-study regions, functions sorted by their mean budget share across all case studies

Function/effect	Category	DK (%)	DE (%)	IT (%)	PL (%)	Mean (%)	Max (%)	Min (%)
Provision of jobs	Socio-cultural	5	20	6	7	**10**	20	5
Regional food supply	Economic	4	9	8	7	**7**	9	4
Preserving the cultural landscape	Ecological	5	9	10	4	**7**	10	4
Provision of renewable energy	Economic	11	9	8		**7**	11	8
Quality food production	Socio-cultural		2	10	10	**6**	10	2
Regional tourism	Economic	4	12	5	2	**6**	12	2
Rural livelihood	Economic	5	7	4	6	**5**	7	4
Hydro-ecological equilibrium	Ecological		5	10	6	**5**	10	5
Stimulation of small businesses	Economic	9		6	6	**5**	9	6
Regional food processing	Economic	6	10		5	**5**	10	5
Recreation in rural areas	Socio-cultural	5	2	4	4	**4**	5	2
Animal welfare	Ecological	5	2	3	5	**4**	5	2

Table 3. continued

Function/effect	Category	DK (%)	DE (%)	IT (%)	PL (%)	Mean (%)	Max (%)	Min (%)
Increased biodiversity	Ecological	5		2	7	**4**	7	2
Minimizing nitrate in drinking water	Ecological	7		2	5	**3**	7	2
Production of safe food	Socio-cultural	4	2		8	**3**	8	2
Development / maintenance of infrastructure	Socio-cultural			3	10	**3**	10	3
Stimulation of rural cultural activities	Socio-cultural	4		4	2	**2**	4	2
Minimizing smells from agriculture	Ecological	9		0		**2**	9	0
Preventing migration of young people	Socio-cultural	1	2	5		**2**	5	1
Keeping/ making the landscape accessible	Socio-cultural	8				**2**	8	8
Maintaining traditional socio-cultural identity	Socio-cultural	1	0	5	2	**2**	5	0
Soil fertility	Ecological	1	0	3	3	**2**	3	0
Facilitating social cohesion	Socio-cultural	4				**1**	4	4
Innovative business ideas	Economic		2			**1**	2	2
Cooperation with other sectors	Economic		2			**0**	2	2
Diversification of farms	Economic		2			**0**	2	2
Provision of affordable food	Economic				2	**0**	2	2
Cooperation among farmers	Socio-cultural		2			**0**	2	2
Image of the region	Socio-cultural		2			**0**	2	2
Provision of good working conditions	Socio-cultural				2	**0**	2	2
Minimizing noise from agriculture	Ecological			0		**0**	0	0

Green cells indicate a positive deviation from the mean of > 4; red cells indicate a negative deviation from the mean of >4
Empty cells indicate that the function was not among the 20 most demanded functions in the case study

Table 3 sorts the functions and effects of agriculture according to the hypothetical mean of all the case studies. The top ten functions are mainly economic in nature, while two socio-cultural functions (both with strong economic facets) and two ecological functions (both related to landscape) were also among the most demanded functions. Table 3 also shows the deviations of scores in the different case studies from a hypothetical mean of all the case studies, whereby deviations of more than 4% are highlighted in green (for positive deviations) or red (for negative deviations). The stakeholders identified distinct budget allocations, particularly for the first 5–10 functions, which match the specific situations in the case studies.

4.3 Demand for Food Production Functions

Food production, as the basic function of agriculture, was subdivided into several aspects (regional, safe, quality, and affordable food). This formerly primary function of agriculture had different degrees of importance for the stakeholders consulted in the case studies. In the Polish case-study region, the results indicate that food production still plays a very important role. In the budget allocation, this importance is reflected in the high value assigned to quality foods and the additional function of affordable food production. In River Gudenå and OPR, in contrast, the stakeholders did not allocate significant budget shares to food production-related functions. Taken together, all the functions related to food production (regional food supply, quality food production, production of safe food and regional food processing) received only 13–14% of the budget in both the German and Danish case study, compared with 18 and 30% in Mugello and Wielkopolska respectively.

4.4 Demand for Para-Agricultural Activities

The ten highest-ranking functions and effects included two important para-agricultural activities: provision of renewable energies and regional tourism. In OPR it was pointed out that although production of food is less important nowadays, para-agricultural activities have gained in importance, with the result that the role of the agricultural sector within the rural economy remains equal in weight.

Provision of renewable energies was an important matter for the stakeholders in DK, DE and IT, since it was added to the list of positive functions after the interviews and received a high scoring in the budget exercise. The Danish stakeholders gave this function the highest priority. The Polish stakeholders, on the contrary, did not signal any potential for societal demand for provision of renewable energies through agriculture.

The fact that regional tourism scored a higher budget in OPR than in the other case studies corresponds with its already high current importance in the regional context. It is notable that for this para-agricultural activity, too, there is much less demand in Poland than in the other case studies.

The function of regional food processing may also be considered a para-agricultural activity as far as on-farm activities are concerned as opposed to small and medium-sized enterprises (SMEs). Many agricultural entrepreneurs already have on-farm processing capacities (bakeries, mills, cheese dairies) nowadays, but demand for locally processed food seems to be high, particularly in the OPR case study.

4.5 Demand for Environmental Public Goods

A significant number of ecological public goods were discussed in the course of the fieldwork for this study. It is important to note that most participants acknowledged the importance of agriculture's contribution to nearly all of them. Maintaining the cultural landscape may be regarded as the most important ecological function of agriculture from a cross-country perspective. Stakeholders in all of the case studies attached high importance to this function. Maintaining the cultural landscape was regarded as the most important ecological function in OPR and Mugello.

In the case of some ecological functions, in contrast, there were major regional differences, which may be attributed to the specific ecological and geographical conditions.

While the negative effects of agriculture did not play a role in the German, Italian, or Polish case study, the Danish stakeholders allocated significant shares of the budget towards two of them: minimizing smells and nitrate in drinking water are serious societal matters in the Danish case study, according to the stakeholders interviewed.

Water scarcity received high values in the Polish, Italian and German case study, while the Danish stakeholders did not regard this issue as important. Hence, hydro-ecological equilibrium was interpreted differently in the case studies according to the specific geological and hydrological conditions. In both the OPR and Wielkopolska case studies, hydro-ecological equilibrium was viewed in the context of lack of water for agricultural activities; the disastrous floods affecting the river Elbe in recent years may also have influenced the understanding of this function in OPR. According to the stakeholders' understanding, agriculture influences the hydro-ecological equilibrium by consuming a considerable amount of drinking water on the one hand and as an important factor for minimizing the future risk of floods on the other. In Mugello, meanwhile, hydro-ecological equilibrium was linked to heavy erosion on the slopes. Through management practices, particularly production on terraces, agriculture can prevent erosion in the region. The stakeholders in Denmark, in contrast, did not consider the hydro-ecological equilibrium to be important, because neither droughts nor erosion are a severe problem.

4.6 Demand for Socio-Cultural Functions and Rural Amenities

By far the most important rural amenity provided by agricultural production is the provision of rural jobs. Agriculture is highly important for the provision of jobs in the regions. 20% of the budget allocation of the German case study was allocated to this function, and the stakeholders in the other case studies also ranked this function highly.

Regarding the socio-cultural function quality food production, the results of the budget exercises also reveal considerable differences. While in Mugello and Wielkopolska quality food production is highly demanded, accounting for more than 10% of the budget, this issue was not identified as a major societal demand in the region in either the Danish or the German case study. We assume, however, that there was a difference in understanding of the term quality food production in Wielkopolska and the Mugello case-study region. While the stakeholders in the Polish case study interpreted quality food production more in the sense of meeting quality standards, the stakeholders in Mugello attached a cultural value to products with specific quality characteristics.

Closely linked to the provision of jobs, enabling a rural livelihood and the stimulation of small businesses were valued by the population. In contrast, neither stimulation of cultural activities nor maintaining traditional socio-cultural identity are demanded to any great extent by the population in the case-study regions, according to the stakeholders interviewed. Nevertheless, these issues cannot be viewed as irrelevant; the stakeholders in fact confirmed that these are also part of the multifunctionality of agriculture.

5 Understanding Societal Demand for Multifunctionality: The Cases of River Gudenå and Wielkopolska

The presented differences in societal demand across the surveyed regions illustrate the need for careful consideration of the reasons underlying these demands. In this section we therefore discuss two (fairly contrasting) cases in more detail: the Polish case, where the production function of agriculture plays an important role, and the Danish case, where emphasis is placed on post-productivist aspects of agriculture.

5.1 River Gudenå, Denmark

One of the significant elements of the Danish case is demand for minimization of negative effects of agriculture and low demand for food production-related functions. One obvious reason behind this is the relatively small local economic impact of the agricultural sector within the area, and the relatively low level of unemployment in Denmark (around 4%). Given these facts, the respondents might have reasoned that it is affordable to make high demands in relation to environmental and aesthetic aspects of the intensive, large-scale local agricultural sector. It is also significant that no important role is attributed to agriculture in relation to the functions of maintaining traditional socio-cultural identity, facilitating social cohesion and preventing migration of young people.

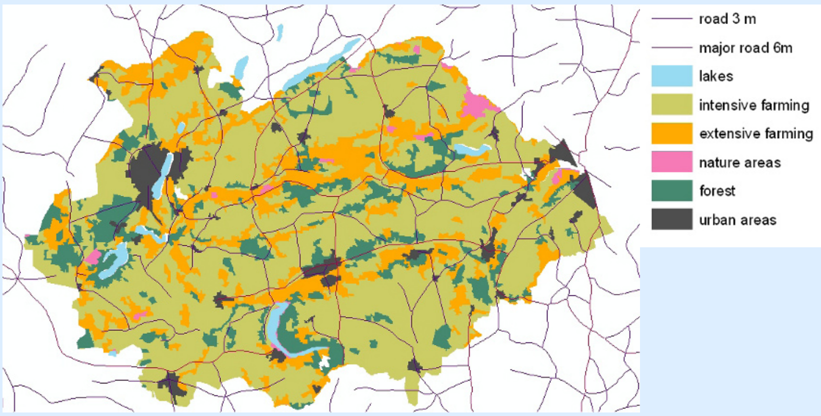
In contrast to the traditional role of agriculture (at least in the pre-modern and early modern epoch of agro-industrialization), the role of bearer of rural culture is not attributed to agriculture in this case study. A low level of cultural importance coupled with demands for better environmental performance suggests that we may designate the Danish stakeholders' perception as being post-productivist.

Another significant issue among the Danish stakeholders was the perceived need to be spatially specific as regards articulating demands for functions. All of the stakeholders found it hard to justify articulating the same demands for the whole of the Danish area. Instead, they proposed alternative demands for areas adjacent to the two rivers. These spatially explicit demands differ considerably from the general demands for the whole area, with unique potential being attributed to the river valleys for co-production of landscape, bioenergy and (rural) tourism. Another aspect is that current agricultural activity within the river valleys consists primarily of extensive grazing systems, which may explain the relatively low demand for minimizing smells and other environmental issues relating to agriculture. The tentative conclusion concerning the demands articulated by the Danish stakeholders is that distinct post-productivist logic can be discerned, along with a distinct emphasis on the importance of being spatially explicit when articulating demands for multifunctionality.

Box 1 The case study area of River Gudenå, Denmark

A recent indexation of degrees of rurality in Denmark (Kristensen et al. 2006) distinguishes between four basic degrees of rurality, respectively urban, semi-urban, rural and remote rural. The Danish case area can be classified as a rural area. The area is well-connected in terms of roads and is dominated by small or medium-sized cities and villages and the river valleys of the rivers Gudenå and Nørreåen. The local agriculture is distinguished by high animal stocking rates and thus also relatively high GDP. The economy of the area is primarily an urban economy, since most workplaces are sited within urban areas. Roughly 15% of all jobs within the area are related to agriculture. The local economy can thus be termed as being "post-productivist", since agriculture plays a minor role. Processes of spatial segregation can be observed on the urban fringe, where alternative patterns of land use such as nature reserves, national parks and golf courts can be observed.

Fig. 1. Land use in the case study River Gudenå



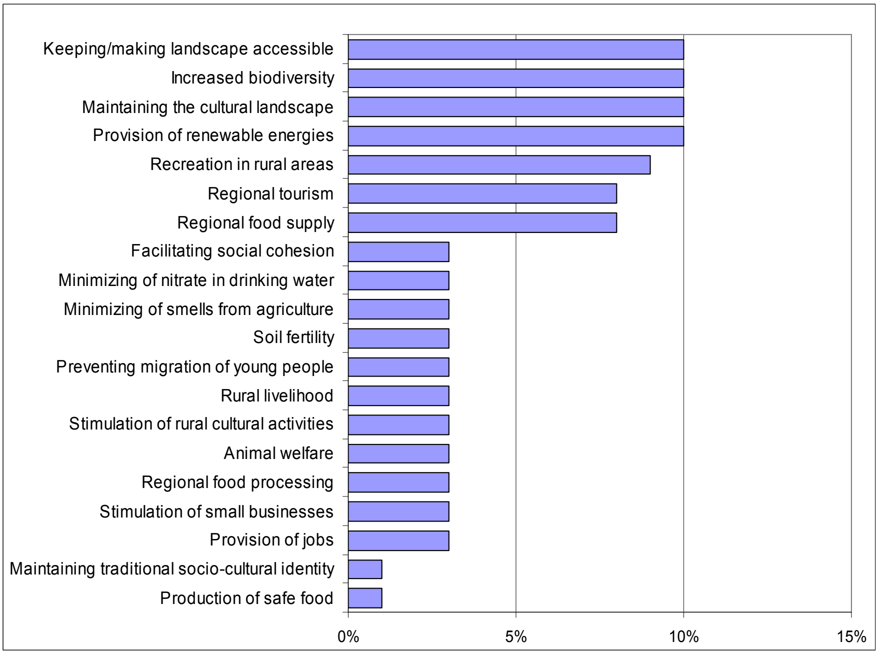


Fig. 2. Alternative demands for functions in the river valleys

5.2 Wielkopolska, Poland

In Wielkopolska, food production-related functions are of primordial importance, especially production of safe, quality food. Provision of such food is expected to increase exports and farmers' revenues, stimulate establishment of small businesses and contribute to the regional economy. Other functions related to developing the region and improving living conditions are also strongly demanded by rural societies (development of infrastructure, provision of jobs and rural livelihoods). Altogether, economy-related functions account for more than 60% of the total stated demand. Demand for ecological services is lower and concentrates primarily on improving biodiversity and the hydro-ecological equilibrium. Typical cultural concerns that can be enhanced by agriculture are marginal in the Wielkopolska case study (Fig. 3).

Box 2. The case study area of Wielkopolska, Poland

Wielkopolska is one of sixteen Voivodships in Poland and in its current shape it has been established after administrative reform in 1999. It is located in western part of country and covers 29826.5 km^2 of land. It encompasses Koscian administrative district among others that is region studied in modelling part of MEA-Scope project.

In general natural conditions (soils, climate, surface features and water conditions) in Wielkopolska are medium-favourable for agriculture (VIEP 2000). Nevertheless Wielkopolska is one of the most important agricultural parts of Poland and very often is called the “food basket” of Poland.

In Wielkopolska agriculture is important branch of industry. Share of agricultural land in this region is 57.7% and is higher than in Poland in average (51%). Also the proportion between arable land and grasslands is higher than in rest of country. In comparison to whole Poland agriculture in this region is more intensive and provides higher yields (Statistical Office 2007). Its contribution to regional and especially rural economy is important. Despite the fact that its contribution to Wielkopolska GDP is low (9%) it is still important source of jobs – 16.8% employers work in agriculture and almost 50% of rural society lives in households holding farms or related with agriculture (Regional Data Bank 2007). Hence agriculture exerts a very important role for living conditions of rural society. It is especially true for Kościan district in which very high share of agricultural land (74%) and high progress in agriculture is observed.

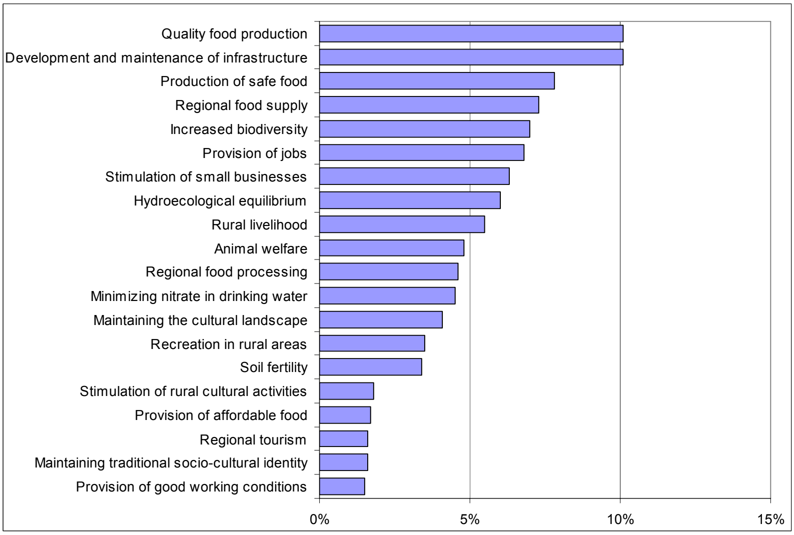


Fig. 3. Budget allocation to agricultural functions in the Wielkopolska (PL) case study

Such expectations of agriculture on the part of the rural society of Wielkopolska result mainly from the region's stage of economical development and pressure to bridge the gap that exists between Poland and Western Europe. For instance, in Poland (including Wielkopolska), gross domestic product is much lower than in the old Member States of the European Union (EU15), and before accession it was only 43% of the EU15 average. The unemployment rate is significantly higher (EUROSTAT 2007). Additionally, a considerable economic gap exists between rural and urban areas in Poland (Central Statistical Office 2007). Demand for intensive economic development is therefore especially high in rural communities.

Demand for ecological functions of agriculture in Wielkopolska is also considerable, especially in relation to its impact on hydro-ecological equilibrium. This is due to the climatic conditions of region, which is one of driest in Poland and Europe due to low precipitation levels and intensive evapotranspiration resulting in low outflow (Kędziora 1995). Enhancing biodiversity is also important, but mainly for cultural reasons and the emotional needs of rural society. It should be pointed out that there is little or no demand for a reduction in the negative effects of agriculture such as nitrate leaching into ground water, degradation of soils, or smells. The main reason why these effects are not disturbing to society relates to the lower level of agricultural intensification, reflected e.g. in consumption of fertilizers and pesticides (in Wielkopolska this was customarily around 15% higher than the average for Poland, but remains much lower than in western Europe (Surawska and Kołodziejczyk 2006)).

To summarize, due to the economic transformation of Poland in the 1990s, the economy in rural areas collapsed. Since agriculture plays an important role in terms of living conditions in Wielkopolska especially, its contribution to regional development is strongly demanded.

6 Conclusions

The Stakeholder Delphi Approach proved to be a valuable tool for clarifying the role agriculture plays in European rural areas, for identifying the different demands for the multiple functions of agriculture at regional level, and for exploring the reasons underlying these demands.

In each case study, the *role of agriculture* in terms of living conditions is shaped by the natural, societal, and political framework. Both positive and negative roles of agriculture were taken into account, although the positive roles were seen as far more relevant, except in the Danish case study. From the societal perspective, the impact on agriculture ranges from economic effects such as production-related functions, through ecological effects such as maintaining the cultural landscape or biodiversity, to different socio-cultural effects.

Our research has confirmed that *societal demand* for functions from agriculture varies across European regions. While the stakeholders of the case-study region OPR gave absolute priority to provision of jobs, the Danish stakeholders attached a high level of demand to eliminating negative effects of agriculture such as bad smells and nitrate in drinking water. In both of these case studies a significant share of the demand was attached to para-agricultural activities such as agri-tourism and provision of renewable energies, whereas functions directly related to food production received a relatively small proportion of the demand. The Polish case study, in contrast, suggests a strong societal demand for food-production related functions such as regional food supply and quality food production, while improvement of rural infrastructure was also given high priority. In the Italian case-study region, the demand structure has two sides: first, functions related to food production received high budget shares, indicating significant societal demand for these; second, landscape-related functions, including the maintenance of hydro-ecological equilibrium, were given equal importance.

Our results in the different case-study regions imply that there are significant *regional differences in societal demand for the functions of multifunctionality*. The most notable of these is the major difference with regard to production-related functions, particularly between the Danish and Polish case study. We found food production-related issues to be very important in the Wielkopolska case-study region, while agriculture is perceived as fairly post-productivist in the other case studies. In the River Gudenå case study, the production function was given least importance, being only a minor issue among many others. The intensive pig farms with their negative environmental effects do not correspond to the demand pattern expressed by the stakeholders in the River Gudenå case study. Correspondingly, para-agricultural activities, e.g. on-farm processing, agritourism, production of alternative energy, and farm shops are important in the case studies OPR and River Gudenå. While in OPR regional tourism is the most demanded para-agricultural activity, the provision of renewable energies predominates in River Gudenå. Maintaining the landscape was found to be the most important ecological function fulfilled by agriculture across all case-study regions, particularly in the OPR and Mugello case-study regions. In the River Gudenå case study, demand for mitigating the negative ecological effects of agriculture is high. This high demand can be attributed to the abundance of specialized pig production farms, which affect the regional ecology. In the other case studies, negative effects of agriculture played a negligible role. There were many differences in the case studies in terms of socio-cultural effects and rural amenities provided by agriculture, the most notable being the strong demand for provision of jobs in OPR.

It is not only demand for agricultural functions that differs in each case study, but also the reasons underlying the demand and hence the interrelations between them. A closer look at *the reasons behind the demand* reveals strong linkages between the functions. By definition, multifunctional agriculture links food production and external effects of food production. This study confirmed the high degree of jointness and interrelatedness between agricultural production, para-agricultural activities and public goods provision. For example, provision of jobs in rural areas through agricultural production is perceived as highly related to earning one's livelihood in the region. Furthermore, it contributes to the survival of other small businesses in rural areas, be they suppliers of agricultural inputs or purchasers of agricultural goods (e.g. mills, supermarkets, traders, food processing plants). Similar linkages exist between rural tourism, landscape design, hydro-ecological equilibrium, the provision of jobs and recreation in rural areas.

In conclusion, variations in societal demand for the multiple functions of agriculture across European regions are related to their socio-economic, cultural and environmental background. The degree of rurality of a region influences the preferences of the local population. Interrelationships between functions are important for the structure of the demand in a region; it is vital that functions are not looked at as isolated issues but in the regional context and in relation to the other functions. How to define a ‘region’ appropriately is thus a crucial issue. While in some cases administrative boundaries may be suitable, in others distinct natural features explain societal demand for the functions of agriculture.

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TOP-MARD Problematique, Structure and Progress – The Case of Norway

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Abstract

This Chapter reports on TOP-MARD, an 11 country research project approved at the same time as MEA-SCOPE and regarded as a "sister" project, taking a different approach to the issues of Multifunctionality and Rural Development. In particular, while MEA-SCOPE focused largely on micro-economic aspects of multifunctionality, TOP-MARD focused on the territorial level. Here we discuss the theoretical and policy background to TOP-MARD, and the development of the core dynamic systems model which was later adapted and applied in the 11 participating countries. We then discuss how this model was adapted and applied for analysis of policy scenarios in Norway, one of the participating countries, and the only one not a member of the EU.

Keywords: systems modelling; territorial development; quality of life; policy scenarios; POMMARD

1 Introduction

The TOP-MARD project is a 3-year, 11 country, project supported by the EU's 6th Framework Programme for Research and Technology Development. The aim of the research project was to build a policy model of multifunctional agriculture and rural development, which would link the multiple functions of agriculture with the development and quality of life of rural regions, and explore the influence of different policies on rural development

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outcomes. In order to deal with both market and non-market outputs, and to explore dynamics over time, a systems modelling approach was adopted.

1.1 Theoretical Background

It is generally recognised that farmers, foresters and other land users perform several functions for the society other than their usual primary market function of producing food and raw materials. According to Euro choices (Cahill 2001) there are a number of different non-commodity outputs that can be covered in a review of the relationships between multifunctionality and rural viability, particularly agricultural employment, landscapes, environmental quality and food security.

In general, these functions may or may not be “tradeable” in the sense of providing the producer with a monetary return. Typically, the combination of tradeable and non-tradeable functions is described as “multifunctionality”. Especially when applied to the sector of agriculture, this term is endowed with both theoretical and practical policy significance. In the TOP-MARD project, we are concerned with the relationships between agricultural multifunctionality (traded and non-traded goods and services produced) and territorial rural development (the development of rural regions, for example NUTS III Regions defined as “predominately rural” or “intermediate” by the OECD 1994 classification, and including small towns etc.). This is because EU “rural policy” as it has emerged in the past 20 years or so has a “double mandate” – first to secure “the European Model” of agriculture as a competitive but environmentally friendly sector; and second to improve living standards and quality of life of people living in rural regions (Bryden and Hart 2004). This last objective has had a mixed history, but it has been brought back into focus by the EU “constitution” which has explicit reference to “territorial cohesion”.

Although most writers take a somewhat “strict” view of “multifunctionality” by confining it to “joint products”, implying that the production of a non-tradable good or service requires the simultaneous production of a tradable, Buckwell (1989) argues that the most common relationship is one of “competition”, while the OECD argues that the available evidence suggests that most significant non-tradable, non-market, externalities in agricultural systems are produced either jointly or in competition with tradable, market goods and services (OECD 2001). The possibility of competition, as a principal relationship, means that an activity involving the production of a tradable will reduce the production of non-tradable and vice-versa. However, if we include such non-tradable as cultural continuity or non-traded value relating to contributions to rural employment and enterprise, both of which are relevant to the wider development of rural regions, it is clear that a broader definition is needed, since no joint production with particular commodities is necessarily implied or even needed, and competition is not necessarily present.

In Norway, several studies argue that in addition to the production of food agriculture contributes to the production of public goods such as national food security, environmental benefits (cultural landscape, land conservation, flood control, biodiversity, and recreation), cultural heritage, and viable rural areas. This is also referred to as agriculture's multifunctional role, in other words, that agriculture produces more than just food and fibres (Prestegard 2004, p.154). These other goods cannot be treated separately as market commodities. A free market could therefore lead to a situation where too little of these goods are produced in relation to the actual demand of the public. However, very few studies in Norway (and internationally) have tried to analyse the linkages between multifunctional agriculture and rural development and quality of life of the residents and how different policies influence on these linkages.

From a theoretical point of view, the issue of non-tradeables in agriculture seems to be a sub-set of general theories of "externalities" in production processes, much discussed for example in relation to regional development (e.g. Marshall 1890; Krugman 1990) and the related clustering of economic activities, as well as in the growth of firms. Thus, non-pecuniary externalities such as ready access to information about markets and competitors' behaviour, as well as access to high value R&D and design services, are held to be important for the development of cities in regional economics (Richardson, 1973). In the same way as Regional and Firm Economics recognises that both pecuniary and non-pecuniary external diseconomies can and do exist, so too the discourse on agricultural multifunctionality recognises that some non-tradables (externalities) have negative impacts (for example, pollution). However, for the purposes of TOP-MARD, the central theoretical idea is that non-tradables or externalities created within agriculture (and elsewhere, in a wider set of natural and man-made amenities) enter into the production function of new economic activities such as tourism and recreation, as well as other new goods and services such as specialised crafts, drink, foods, and cultural artefacts which are increasingly to be found in diversified rural regions.

The idea that there are latent "non-mobile" assets that are important for rural areas can be traced back to a paper for a 1991 EAAE seminar by Cavailhes et al. (1993). Bryden developed this argument in a book on sustainable rural communities (Bryden 1994), and in subsequent work with Shirley Dawe (Bryden and Dawe 1998; Dawe and Bryden 1999) and later within the DORA research project (Bryden and Hart 2004), which examined differential economic performance in 16 rural study areas of 4 countries.The work of the OECD (1999) on amenities in rural development, and that of McGranahan (1999), Deller et al. (2001) and Green et al. (2005) on amenities and rural migration patterns in the USA is also relevant, confirming that non-agricultural "externalities" are also very important for rural development today.

Bryden and Dawe's 1988 paper on economic development in the predominately rural areas commissioned for an OECD conference argued that "important cases exist where … areas have developed effective local strategies to deal with, and indeed capture new opportunities from, globalisation". These strategies revolve around less mobile and less tangible assets at local level.

The idea was later termed the "Bryden theory" by Terluin (2003) who tested it against other rural and regional development theories, using the results of the RUREMPLOI project (Terluin and Post 2000). Terluin concluded that the theory had the best explanatory power of those examined.

The role of tangible and less tangible assets in the differential development of rural regions was more thoroughly examined in the "matched pairs" approach of the Dynamics of Rural Areas Project from 1999 to 2001 (Bryden and Hart2004). Success in this case was largely measured by the ability to hold or increase (through net in-migration) population in rural regions. The authors concluded "Our analysis of the relative importance of the different factors explaining DEP (differential economic performance) between the pairs of study areas in each region led to identification of six key inter-related themes which together explain why some rural areas are doing better than others:

- Culture and society in the shift from state to market
- Peripherality and infrastructure
- Governance, public institutions and investment
- Entrepreneurship
- Economic structures and organization
- Human resources and demography"

In addition, the development of economic activities that transformed natural and cultural assets into commercial activities was a cross cutting theme in stronger economic performance.

It is this growing body of empirically-informed theory that potentially links the production of 'externalities' (positive or negative) on farms with the development of rural territories, and which lies at the heart of the thinking behind the TOP-MARD project.

1.2 Policy Background

From a policy point of view, many non-market goods and services produced by farming and farm households are it seems *desired* both for their own attributes (e.g. species rich meadows) and for their potential impact on rural development. However, the main instruments of EU policy lie within policy payments such as those under the Rural Development Regulation which can be used to persuade and/or compensate farmers for the production of such desired outputs. In addition, the EU seeks to penalise negative externalities through regulation aimed at preventing or reducing undesired non-market outputs such as water or air pollution. Similar kinds of policy exist in non-EU member states in Western Europe, especially Norway and Switzerland. Cross-compliance is a further EU instrument intended to ensure that recipients of single farm payments comply with the standards of environmental regulations. However the EU's rural development policy money is largely spent on agri-environmental and related schemes, and may thus be regarded as being mainly at increasing the "supply" of (or perhaps reducing the decline in) agriculturally-related environmental goods and services, or positive environmental services related to farming. It is much less evidently targeted at territorial development, or the transformation of positive externalities of farming into new economic activities and quality of life of rural residents. Apart from anything else, this is something agricultural ministries and departments[1], steeped as they are in agricultural structures and markets policies the goals of which were supply-orientated, have little or no experience with. One exception exists, and it is the relatively tiny LEADER programme, which some countries and regions have used creatively to create such synergy between agricultural externalities and territorial development.

At the same time, the rhetoric of EU "rural policy" demands that it goes further than the supply of agricultural externalities. Since the Maastricht Treaty (2002), territorial and social cohesion has been an objective of "rural" as much as "regional" or "social" policy. And the rhetoric of the policy documents (including the Rural Development Regulation) stresses the importance of improving the quality of life of rural residents. This is indeed critical if people are expected to stay in, come back to, or migrate to, otherwise declining rural regions. There is little doubt that this will become one of the core issues to be dealt with following the Treaty changes, reinforced by the EU 'health check' on the CAP and the budget review,

[1] Even if they have been re-named as "rural development" Ministries or Departments, since the policy experience of the incumbents remains rooted in the practices of the past.

both precursors to the next reform of the CAP and the Structural Funds in 2013.

2 The Approach of the TOP-MARD Research Project

Building on these theoretical foundations and practical policy considerations, the TOP-MARD project is designed to analyse how the various functions of the agricultural sector affect the sustainable economic development and the quality of life of a given territory, and how different policies affect these relationships. A central hypothesis is that these relationships differ according to a rather wide range of institutional and other factors that vary between regions as well as between policies. The view is that these relationships may be highly dynamic with numerous feedback effects.

Within TOP-MARD we have developed a systems model using the Stella™ software to capture the dynamics and spatial dimensions of these relationships in 11 study areas representing different types of rural areas in different European countries. The study areas, shown on the MAP, are selected to be diverse, and to roughly "represent" the diversity of rural regions in the enlarged EU and adjacent countries (Fig. 1).

The systems modelling approach differs from traditional economic modelling in that it sees economic activity and behaviour as being embodied in the natural (environmental or ecological) and social systems. It also sees these relationships as being fundamentally dynamic. This contrasts with the generally more static and linear thinking of traditional economics where, for example, impacts of economic activities on the ecosystem are handled outside the system not influencing the agricultural productivity directly or the state of the natural environment or where the composition of different economic activities does not influence the social or cultural capital and, through that, the overall well-being of the system.

Fig. 1. Topographic map over Europe indicating the study areas. The study areas are shown within the red boarder lines on the map above

STELLA was chosen as the platform for the TOP-MARD model for several reasons. First, it is a powerful yet relatively user-friendly as well as dynamic modelling system, which is needed if the model is to be useful to policy makers. Second, STELLA is ideal when one of the goals is to encourage systems thinking in research and education. Third, STELLA is designed to help multidisciplinary teams work through complicated problems where a large number of feedback loops, and temporal lags and processes dominate. And finally, it is designed to accommodate systems that include qualitative, and difficult to quantify data. A more detailed account of the development and structure of the model is given in Johnson et al. (2008).

The unique aspect of TOP-MARD concerns the linking of functions of agriculture with the development of the local territory and quality of life in a large range of different rural contexts. In exploring this intellectual and policy domain, conventional tools of economic, social and geographical analyses are not adequate. We have therefore opted for a systems approach, so that the dynamic relationships between agricultural functions (market, non-market, and hybrid) and the success or failure of local economies and societies, and the role that different policies have in these relationships, can be formally explored and tested. In this way we have a model that can examine the impacts on both farm households and local communities of expansion or contraction of policy effort in different areas and different contexts. The model should thus be helpful for policy development and prioritisation at both local and EU levels.

2.1 Methods

A systems model is intended to be discipline-neutral and encourage interdisciplinary working. Thus the language used may confuse some who are rooted in disciplinary language. In Stella, the "systems dynamics" are generated from a set of initial conditions through a series of shocks to stocks and flows which, in turn, reverbate through the system. The shock in our case comes from a policy change (a new policy scenario) or a change in market conditions (built into a scenario, and especially dealing with agricultural commodity prices on the one hand, and energy prices on the other). The model includes a regional social accounting matrix, which is important for tracing the regional economic impacts, and modular elements for resources (land, human resources, capital), migration and demography, agriculture (producing market and non-market "commodities", tourism (the most common "transformation" sector), quality of life, and the rest of the world (everything outside the region). It is populated either by existing data, or new data gathered by special surveys of farmers, enterprises, citizens, and key agents, designed by the team of researchers. The most difficult part was probably the estimation or calibration of important new coefficients, such as the elasticities of migration response to different changes in quality of life elements, a task requiring new survey data and econometric analysis. In addition, teams identified the various market and non-market functions of agriculture relevant in their study areas, while a policy group worked on a set of policy scenarios to be used with the model (Fig. 2).

To model the linkages between regional economic activities, the social system and the ecosystem model we used a capital approach similar to that applied in ecological economics (Costanza et al. 2007; Gowdy and Erickson 2005). In this approach capital is viewed as a stock of productive resources from which flow the goods and services that support human welfare and economic development. Unlike many traditional economic models, this model is supply driven with demand constraints. In our approach, capital is divided into human, built, social, cultural and natural capital. These capitals are combined with labour and raw materials according to alternative production systems and input-output relationships to produce economic goods and services, quality of life and associated social welfare.

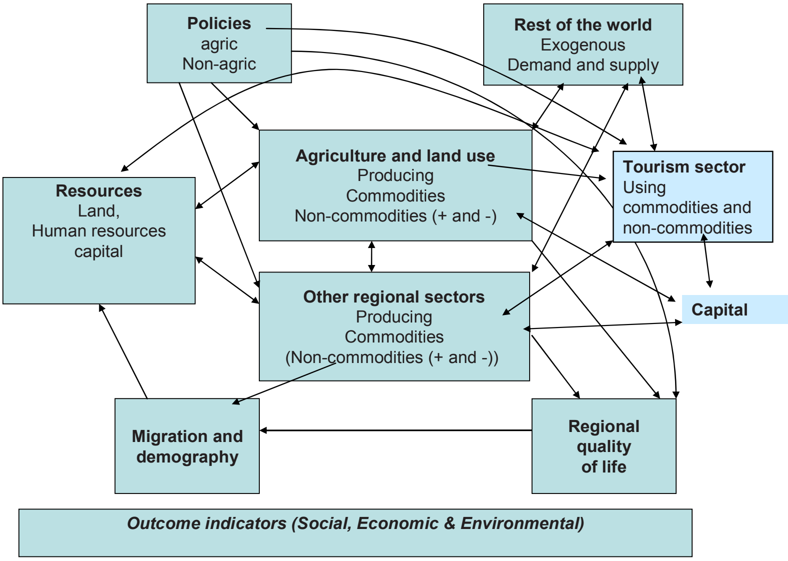

Fig. 2. The structure of the TOP-MARD policy model

We now turn to the application of the model to our Norwegian case study area, Hordaland, located in the West of Norway.

2.2 Description of the Norwegian Case Study Area

Hordaland has a long history of people diversifying their income – farmers working, for example, in construction and fishermen having a small piece of land and some sheep. Since the objective of TOP-MARD involves investigation of the linkages between farms and farming and their rural economies and communities, Hordaland was a very relevant study area because farming seems to be embedded in many parts of rural activity in the region.

The county is about 15,000 km^2 with a landscape of mountains, fjords, glaciers and islands. The population is 450,000 of which 240,000 live in Bergen, and the balance in rural areas and small settlements. Most live in the coastal areas, on the narrow strip of farmland along the fjords and in the bigger valleys. The population of Hordaland is increasing. The reason for this is excess of births over deaths, and immigration from abroad. The domestic net migration is close to zero. However the immigrants mostly live in the Bergen area. In the past 15 years, Bergen and most adjacent municipalities have experienced a two-digit population growth while the population in remote municipalities along the Hardangerfjord decreased by more than 10%. The percentage of the working-age population and of early retirees is somewhat higher in Bergen than in the remainder of the county and the percentage of females is highest in the Bergen area. The rural areas in Hordaland have been going through changes in relation to the technological development within the primary industries, infrastructure and other industry. The magnitude of the impact of these changes on the local communities has been dependent on the distance from urban centres, availability of jobs and the possibility of combining small scale farming with other sources of income.

The industrial sector employs 16%, services 73% and agriculture 3%, the latter consisting of part-time and small-scale farms. Nearly a third of the farms have additional activities like local food, farm tourism, wildlife experiences, green care, hydropower, wood processing, and contracting. Although farming contributes with a small portion to the county's revenue, it is still an important factor in many peoples life also for people not relying on farming as their source of income. The average income was Euro 8,595 in 2006, but the income from agriculture varies considerably, with one third of the farmers having no positive income from farming at all. The numbers indicate that most of the farmers are pluriactive, their main sources of income being salaries, wages, and income from self-employment, which together are three times the income from farming.

Agricultural land in Hordaland accounted for 42,260 ha in 2004 and productive forest 240,260 ha, both being smaller proportions than in the rest of Norway. Farmers in Hordaland are mainly livestock farmers. In some municipalities fruit growing is substantial, but in the county as a whole 97% of total agricultural land is being used for the production of grass. 3,883 farms received support from the governmental production support scheme in 2004. On average, agricultural land including rented land per farm has risen from 7.2 ha in 1990 to 11.4 ha in 2002, of which 38% was rented land being hired from neighbouring farms that have reduced or shut down their farming activities. Most farms are below the average size, which corresponds with the income data.

Farms in Hordaland, as in the rest of Norway, are almost entirely owned by the farmers themselves. Farmers typically live on their land. The settlement pattern in rural areas is the lone standing farms with some villages with a few industrial enterprises and basic services supply. It is fair to say that farming in Hordaland, as elsewhere, has undergone substantial changes. Many of the smaller farms are no longer in operation, and the holdings that continue farming are becoming larger. Marginal land is abandoned and eventually overgrown. At the same time modern machinery has made it possible to drain and level new land. So even if some steep and bumpy farmland is abandoned, the total area of cultivated land has been relatively stable. New cultivation methods change the character and image of the landscape. The valley sides are overgrown by trees and scrub, and pebbly riverbanks and moraines are flattened, covered by soil becoming grassland.

Milk production is the most important production in terms of employment and value creation from commodities. Today, there are about 1,100 dairy farmers in the county, with an average herd size of 12.9 cow years and an annual dairy delivery of 72,800 litres of milk. The production of beef in Norway is mainly a by-product of milk production with dual-purpose breeds. Only few farms keep specialised beef breeds. In recent years there has been an increase of suckler beef production, both in Hordaland and nation-wide. The market is demanding meat qualities that can not be provided by the standard Norwegian breed (Norwegian Red). Traditionally, Hordaland has been a sheep farming region. Access to huge areas of rough grazings is a major asset. Sheep farms are normally small and can be found throughout the entire county. From 1989 to 2004, the production of sheep meat in Hordaland decreased by about 33%, whereas sheep meat production increased nation-wide in the same 15-year period. One important cause of this development in Hordaland is the decline of coastal agriculture. In addition, goat and other livestock are also produced in a few places in Hordaland.

Hordaland is known for its fruit production. The majestic Hardanger Fjord is famous for its steep slopes dotted with small, picturesque fruit farms. Here, fruit has been grown for centuries, mainly apples, but also a fair amount of plums and sweet cherry. Pears used to be a major crop, but the production has declined considerably. Fruit growing in western Norway has been combined with livestock farming, usually sheep. In recent years, though, the trend has been to focus entirely on fruit. There may be several reasons for this: declining profitability in sheep farming, land-use conflicts between forage and fruit production, and contamination of forage crops from pesticide spray drift.

Many farms include some forest land. In 2004, Hordaland produced 83,000 m^3 of timber at a value of Euro 3 million. For Norway as a whole, the corresponding figures were 8,183,000 m^3 and Euro 306.25 million. Nearly half of the harvested wood in Hordaland was used as firewood.

The farms in the area are often diversified. Of the 3,767 farms in Hordaland, about 1,435 had additional activities with some kind of on-farm diversification.[2] The activities for diversified farmers included:

- Renting out land, buildings or machines,
- Machine contracting,
- Added value and local food,
- Marginal area enterprises like extreme sport, renting our hunting and fishing rights etc.,
- Farm tourism activities (e.g. fishing, hunting, hiring out boats),
- Other services like green care,
- Hydroelectric power plant,
- Other biological production like firewood and timber production.

In areas close to cities and other urban centres, alternative use of farm capital may give higher returns on equity than traditional farm operations. An increasing number of applications for re-zoning land indicate that farmland is under considerable pressure in these areas.

2.3 Externalities from Agriculture Enter into New Economic Activities

Top-Mard's working hypothesis is that these agricultural non-commodities and commodities often constitute inputs as external economies for other rural enterprises or add to the quality of life of the general public. In Hordaland, the tourism sector is closely related to the landscape and indirectly therefore to the management of the landscape by agriculture. Other resources – like hunting and fishing rights, rights for hydropower, processing of food or water are other also utilised by businesses and entrepreneurs outside agriculture. The entrepreneurs in Hordaland were specifically engaged in:

- tourism – accommodation, guiding, adventure, etc,
- hunting experiences,
- production of drinking water,
- small scale meat industry,

[2] An additional on-farm activity is an activity that is managed by the owner or the spouse and which utilizes land, buildings and/or machines on the farm unit. The activity is meant to give an income and/or employment for the owner and his/her family.

- small scale food production, and
- supplier of equipment and consultancy for small scale hydroelectric plants.

The companies used the external effects of farming (especially landscape) or the farms resources directly or indirectly in their production, or for marketing purposes.

In addition both non-commodities and commodities produced often constitute inputs or external economies for other rural enterprises or the general public.

3 Modelling Multifunctional Agriculture, Rural Development and Quality of Life Relationships

In the model, for practical reasons, we limited the capital approach described earlier largely to the natural, human, and built capital, dealing with social and cultural capital mainly outside the model, although certain elements of both were considered in the quality of life sector. In Fig. 2 above, the general relationships between the different components of the model were shown. The three types of capital are included in the resources component.

The data in the model are based on Statistics, on surveys about multifunctions among farmers, entrepreneurial activities among entrepreneurs with linkages to agriculture and quality of life for residents in the area.

3.1 Land

Land use has been chosen as the key variable for natural capital because the amount, distribution and use of (rural) land for different purposes are the primary determinants of regional economic, social and environmental activities. The land stocks include annual crops, permanent crops, grass land, forest land and other land. Furthermore, ownership and use of land are closely related to agricultural policy regulations. Land has impacts on both the agricultural and the tourism sector.

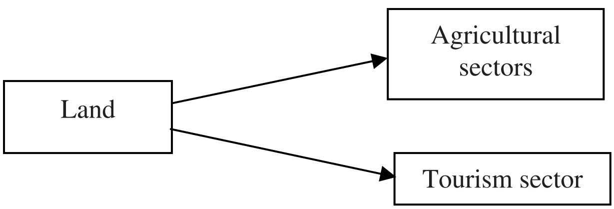

Fig. 3. Relationship of land and the agricultural as well as the tourism sector in the POMMARD Model

3.2 Economic Activities

The economic activities include agriculture being treated as farm production units as these are the major decision units. The tourism sector was also dealt with separately, as this was the most common sector involved in transforming non-commodities into local services in the 11 study areas.

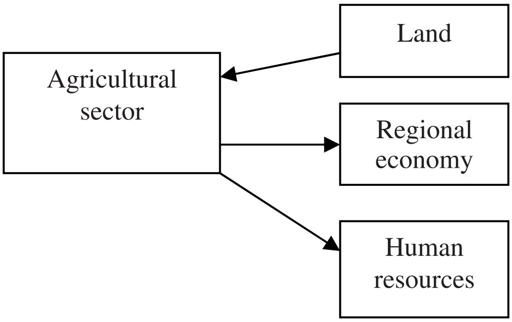

Fig. 4. Relationship between agricultural sector and land, regional economy, as well as human resources in the POMMARD Model

The agricultural sector is impacted by land, and in turn impacts on regional economy and human resources. The agricultural sector consists of different production systems being dairy, sheep, beef, fruit, and other (multifunctional) activities. The sector produces a wide range of different traditional marketed commodities like milk, fruit, meat and timber and less traditional ones like wool, meals, bed-nights, energy and hunting rights. In addition they produce non-marketed commodities (positive or negative) like biodiversity and phosphorus run-off. The sector creates a demand for labour, for land use and other inputs from the regional economy.

3.3 Non-commodities

The non-commodities impact on quality of life and are affected by the agricultural and the tourism sector as well as land. We get information about the value of the benefits and disadvantages through indicators for land cover and change, Shannon index, Mineral fertilizer use, Excess Nitrogen in the system, Biodiversity, Stocking rate, CO^2 etc. There are of course also impacts on the social and cultural aspects to consider, but they are not modeled at this stage. The important point about this sector is that the non-commodities traditionally not are considered in regional economic models. However, they are normally considered in quality of life analyses and so they are also included in the POMMARD model.

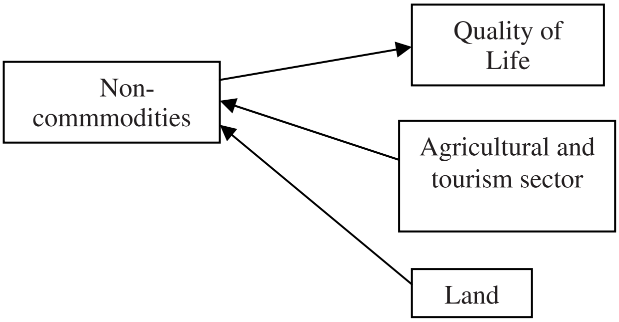

Fig. 5. Relationship between Non-commodities, quality of life, the agricultural and tourism sector, as well as land in the POMMARD Model

3.4 Human Resources

The Human Resources sector consists of the population stock divided by age groups and educational level and the population flow being both natural change and migration. The natural change involves an integrated and straightforward demographic model. The stock of labour supply is given by the population. Labour demand is given by the employers demand in the regional economy including agriculture and tourism, while the supply is decided through the natural population change and net migration driven by quality of life.

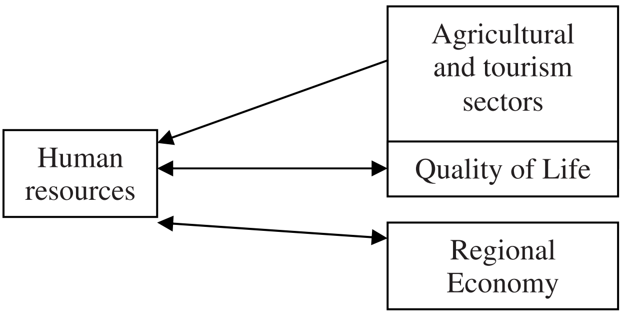

Fig. 6. Relationship between human resources, the agricultural and tourism sector, quality of life, as well as the regional economy in the POMMARD Model

3.5 The Regional Economy

The regional economy sector comprises a regional Social Accounting Matrix (SAM) except for the agricultural and forestry sector which are being modelled outside. The radical inventions here are two-fold. First there is a linkage to quality of life through the demand created by in-migrants being attracted to the area by quality of life factors. Secondly there is a linkage to the quality of life sector where income changes cause variations in the regional quality of life.

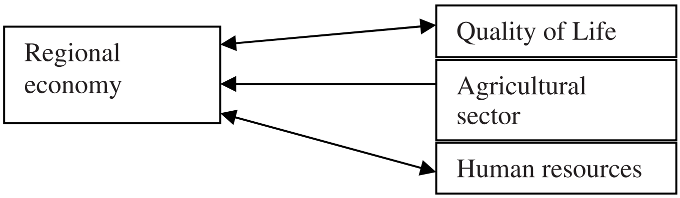

Fig. 7. Relationship between the regional economy and quality of life, the agricultural sector, as well as human resources in the POMMARD Model

3.6 Quality of Life

The Quality of Life sector is the most innovative part of the model. It is impacted both by the agricultural sector and the regional economy and impacts in turn on the human resources sector. The agricultural sector affects the quality of life in the region through the way agriculture and land are being managed and through that the stock of natural capital, while the regional economy impacts on quality of life through the income level in the region. The human resources are impacted through the attractiveness of the region for inward migration. Finally the quality of life gives us indicators for overall quality of life changes in the region.

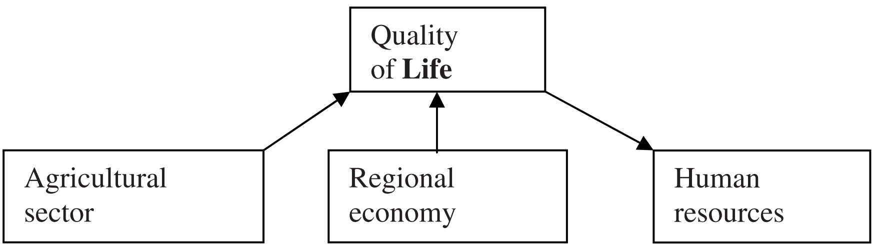

Fig. 8. Relationship between the quality of life and the agricultural sector, the regional economy, as well as human resources in the POMMARD Model

3.7 Policies

The policy box embraces potential policy scenarios and changes in marked conditions as exogenous influences on the regional systems. The model permits the analysis of a range of policies which influence land use and other decisions related to multifunctional agricultural activities. Policy may also directly or indirectly affect local non-agricultural economic activities that make use of those agricultural multi-functions. This is one of the novel advantages of the model.

3.8 Demand

The demand box represents other exogenous influences and constraints on the regional system. While the model is supply driven, based on decisions related to production systems and land allocations, some sectors are influenced by external demand conditions. Prices of exports for example determine the income of the region's residents. External wages may affect immigration rates. These exogenous variables will typically change only to reflect the global and EU-wide consequences of policy changes.

3.9 Output Indicators

The indicators are meant to give a range of information about the performance of the territory, as measured by migration patterns, employment rates and also more complex indicators such as social cohesion, quality of life etc. Some of these indicators can be calculated directly from the model, while others need additional information from surveys of the territory. The regional economy links the activities where there exists a market and thereby also gives values for the economic performance indicators. However the overall performance of each territory is measured through indicators for quality of life.

4 National Policies in Norway

As a non-EU member, Norway has its own agricultural and rural development policies. These policies are aimed for different purposes and different people as well as implemented by different institutions, such as the Ministry of Agriculture and Food, the Ministry of Local Government and Regional Development (KRD), the Ministry of Trade and Industry, the County Governor of Hordaland, Innovation Norway, Hordaland County, the local municipalities in Hordaland, and the Norwegian Public Roads

Administration. In the following, an overview of the relevant policies and instruments is given.

The relevant policies affecting and related to multifunctional activities, to rural development, to the quality of life of the residents and to the migration of different groups are quite broad. There are several policies that in one way or the other impact multifunctional activities in agricultural businesses and related businesses that use agricultural products or services, being it market price support to agricultural products, acreage support, headage support, support for environmental attempts, social welfare schemes, or support for businesses to develop outdoor activities like extreme sport, hiking, horse riding etc. However, there are other policies that have indirect effects on multifunctional agriculture and rural economy/settlement like for example bus services to provide access and existence of schools being of major importance for the family farms.

The aim of the policies for the rural areas in Norway has been to level out the economic conditions for an equal service offer between municipalities and counties to maintain the settlement structure and sustain viable local communities. The government is emphasizing that people should have free choice to settle wherever they want (Ministry of Local Government and Regional Development 2005). They prioritise:

- Real freedom of choice about where to live
- Regional strategy to sustain the current pattern of settlements
- Facilitating economic developments in all parts of the country
- Facilitating fair distribution of growth between cities and rural areas

In Norway, the regional (district) policy is divided into a "narrow" and a "broad" policy (see Prestegard and Hegrenes 2007) and the country is divided into zones for regional policy measures. In addition there is a particular zone for attempts in Nord-Troms and Finnmark which among other benefit from reduced income tax, lower energy taxes and depreciation of student loans.

4.1 The Regional Policy

The "broad" regional policy comprises, for instance, sector policies that have an effect on the possibilities of achieving regional policy goals. Relative high levels of resources are used for infrastructure in the districts (roads etc.), decentralisation of public places of employment and colleges. The measures fall into two broad categories[3] (Ministry of Local Government and Regional Development 2005).

[3] Own translation.

Category A: Measures that have “district” policy aims, or give preferential treatment to regions with weak industrial base, small labour markets or long distance to larger centres.

Category B: Measures implemented in order to compensate some regions for disadvantages, or measures that have effects in some “districts” due to specific circumstances, and also are of particular importance for industrial development, local economies and settlement. The broad policy covers the Distribution and Regional Policy:

- All sectors Income for municipalities
- Health policy for elderly etc.
- Transport and communication
- Fisheries + some agricultural policy outlines (encourage and build up and down)
- Building knowledge (regional Universities, colleges and other institutions.)
- Innovation policy (facilitation)

The narrow regional policy is about the extra effort from the Ministry of Local Government and Regional Development (KRD), which also implements it from a special chapter in the state budget. Important measures are regional development grants to county municipalities, and compensation for regionally differentiated social security contributions, subsidizing of energy demanding industry, and investment grants means under the Municipal and Regional ministry for small and medium sized businesses for business related development attempts and transport support.

- Regional aid/regional differentiated support. The General Purpose Grant Scheme
- The Equivalence Scheme
- Regional support (more to smaller municipalities)
- Northern Norway
- It has three implementation areas
- SIVA network
- Innovation Norway
- The Research Council of Norway

4.2 Agricultural Policy

Agricultural policy is, as mentioned above, part of the “broad” regional (district) policy. Regionally differentiated price support for milk, meat, eggs and vegetables is in Category A. Farms in central regions do not receive such support while farms in Northern Norway receive the highest support. Farms in Hordaland are among those who receive support at "medium" level. The larger part of the agricultural policy measures is in Category B. All farms might receive such support, but usually the rates are highest for farms in remote areas. Farms in Hordaland do get rather high support, but not the highest support rates. Acreage support, headage support, a special support for milk production, and vacation and replacement subsidy are the largest agricultural policy items in Category B. Another, and smaller, measure is the "Rural development grants". The Rural Development Grants (NOK 241 million in 2006) have been allocated to the 19 counties based on criteria such as the number of holdings, utilised agricultural area, and agricultural employment as a percentage of total employment in each county. The administrative responsibility is divided between the Agricultural Departments of the County Governors and Innovation Norway. Innovation Norway is responsible for the farm-business oriented measures, while the Agricultural Departments of the County Governors are responsible for other measures.

Norwegian agricultural and rural policy has mainly had a top-down approach and has been centrally governed. However, there have been some support programmes and measures with a more bottom-up approach, some of these have been connected to rural development initiatives. Recently, some minor parts of the agricultural policy have been delegated from central government bodies to regional authorities (county authorities) and to the municipalities. For example, the administrative responsibility for specific environmental and regional measures, as well as for forest-related funds allocated via the Agricultural Development Fund, was transferred to the municipalities in 2004. Local governments shall draw up a brief long-term strategy with budget proposals for the various objectives, and must submit annual status reports to the County Governor regarding the use of the funds (NOK 130 million in 2006). In 2005, a regional environmental programme amounting to NOK 350 million was established. Each county was assigned the responsibility for establishing instruments and schemes enabling the achievement of the environmental challenges that have received the highest priority in the region. Each of these schemes is to be based on one of the following main areas:

Measures aimed at maintaining the cultural landscape, including promoting the use of mountain dairy farming, and promoting active use of grazing resources; Measures aimed at pollution reduction. All 19 counties have now established regional environmental programmes in agreement with county trade associations.

4.3 The Policy Scenarios in Norway

In TOP-MARD, the following seven different policy scenarios have been developed and analysed, including a baseline or reference scenario.

1. Baseline 2007–2013 policies in EU.
2. 50% cut in annual direct payments P1 reduction in year n, staying the same for the next period. Non reallocation of funds. Teams to decide consequential.
    - Annual farm income changes, and
    - land use changes/production changes
    - NCO changes
3. Rebalance 2007–2013 P2 to give 100% to axis 3, continuing over 7 years.
4. Rebalance 2007–2013 P2 to give 100% to axis 2, continuing over 7 years.
5. 50% increase in annual regional policy spend in the study area (compared with baseline) continuing over 7 years (EU + national). Impacts on I/O via FD, plus on QoL.
6. Energy shortage/100% increase in energy prices over 7 years. Study areas to decide what this does to land use. Needs a bio-energy production system.
7. 100% increase in tourism demand over 7 years. Introduced as a gradual increase. Each study area to decide how to introduce this (seasonality, etc.).

Since Norway is a non-EU member and has its own agricultural and rural policy, we had to “adapt” these policy scenarios to “similar” changes in Norwegian policies as far as possible.

In scenario 2, for example, we have tried to implement a possible outcome of the ongoing WTO agricultural negotiations in Norway as well as simulation of a liberalization of the Norwegian agricultural policy. In Norway, it is difficult to put the different measures into the EU classification of Pillar 1 or Pillar 2 measures. For example, the Norwegian broad-based acreage and cultural landscape schemes fall somewhat in between Pillar 1 and Pillar 2 measures in the EU. Since the Stella model has been under development until recently, the seven scenarios for Norway have yet to be developed in detail.

5 Impacts of Different Policies – Putting It All Together

To assess the dynamic impacts of different policy scenarios on these relationships different scenarios are compared to a baseline reference run of existing policies. One scenario will be implementation of possible outcomes of the ongoing WTO agricultural negotiations in Norway as well as simulation of a liberalization of the Norwegian agricultural policy. Other scenarios will implement increased governmental spending through regional programmes and increased use of measures to maintain agricultural activities or stimulate farmers to invent new businesses. Finally, consequences of increased subsidies to entrepreneurs and local community actors outside the agricultural sector will be analysed.

The model is used to see how the policy scenarios impact at territorial level on rural economic development, on quality of life for the residents using different indicators for these. We want to analyse the policy impacts of:

- Production of farm commodities & non-commodities
- Transformation of commodities & non-commodities into territorial development and quality of life
- The regional economy
- The regional quality of life
- Costs of investment
- Costs of production and marketing
- Governance

For example we can check how different stocks and flows are changing. E.g. how will a change in “Pillar 2” type policies impact on territorial financial flows as well as things like land use and production of commodities and non-commodities, and the transformation of CO and NCO into territorial development and quality of life.

6 Conclusions

The TOP-MARD team has built a core model to explore the relationships between agricultural multifunctionality, territorial rural development and quality of life, and the impacts of different kinds of policies on these relationships. Important innovations have been:

- The linking of the multiple functions of agriculture (including externalities) with the territorial economy;
- The linking of the territorial economy and the externalities from agriculture with the quality of life of citizens in the territory;
- The linking of quality of life with the migration levels and patterns, and hence to demographics and human resources;
- The ability to trace dynamic impacts on a range of economic, social and environmental indicators of different policy scenarios over time.

TOP-MARD remains "work in progress" at the time of writing. The research is currently being finalised, and the core model is being adapted to the 11 participating rural regions. Once this is completed, we will work together to undertake comparative analysis of the results of both the primary surveys undertaken, and the results of the policy and market scenario analysis using the model as it has been adapted to conditions in the 11 participating countries.

Note

Since this chapter was written the TOP-MARD project has been completed, the POMMARD Model built and adapted to the 11 participating countries, and Policy Scenario analysis undertaken. The Final Activity Report, containing results as well as full details of POMMARD, was submitted to the European Commission in July 2008 and approved by them in October 2008 (see Bryden 2008).

Acknowledgements

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Part II

Modelling of Policy Induced Structural Change and Adaptation of Agricultural Practices

The MEA-Scope Modelling Approach

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Abstract

The MEA-Scope project developed, and applied a modelling approach that allows for the ex ante assessment of sustainability impacts of new policies, technologies and market changes. Thereby, the agricultural production at farm level and its effect on social, economic and environmental assets under changing circumstances is examined. The MEA-Scope modelling approach simulates the development of regional agricultural production structures over time. Within the same analysis, the approach considers details of individual farms and soils. During the project duration, three pre-existing models were further completed and interlinked with each other. The modelling approach was applied at two different levels of detail in seven different European regions to examine the effects of five agricultural policy scenarios. The core models involved were AgriPoliS, MODAM and FASSET/Farm-N. In this chapter, the modelling approach, characteristics of the models involved and the policy scenarios are introduced while

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results as well as details on the different modelling applications can be found in subsequent chapters of this book.

Keywords: Land use modelling; policy evaluation; policy impact; regionalisation; AgriPoliS; MODAM; FASSET and Farm-N

1 Introduction

Reasons to develop methodologies to evaluate and forecast land use change are manifold. On the one hand costly policies to foster agriculture have to be justified within WTO negotiations, while sustainable development in the sense of social, ecological and economic terms is meanwhile a mainstream paradigm of policy. Worldwide population and economic growth as well as changing consumption patterns lead to increased demand for food, fibres and energy. The transition processes in Eastern Europe, the former Soviet Union and in developing countries including technological progress have impacts on land use, that may compete with objectives of a sustainable development and that interfere with policy measures.

This chapter presents an overview of the chosen modelling approach of the MEA-Scope project, which focuses on two issues: (1) structural change and (2) environmental impacts of EU-policies and other drivers of land use change at a regional level.

2 Objectives of the Modelling Approach

The specific goals and scope of the MEA-Scope modelling approach were to:

- incorporate different spatial and temporal dimensions in the same investigation,
- simultaneously model and analyse individual farms and regions,
- create a common methodological approach for the included models,
- investigate a multifunctional set of parameters,
- insure that the underlying parameters such as technology are hierarchically integrated in the individual models,
- adapt the tool to seven specific regional settings,
- gain simulation results that meet policy makers' information demands,
- integrate results in an online accessible impact assessment tool.

This chapter gives an introductory overview of the approach. Details of the approach are documented in Damgaard et al. (2006), Osuch et al. (2007), and Uthes et al. (2007).

3 The MEA-Scope Modelling Approach

The modelling approach is build upon three pre-existing core models at farm level: AgriPoliS, MODAM and FASSET (Piorr et al. 2006; Happe et al. 2006a; Happe 2004). In addition, components are developed to allow for an automatic data transfer between the models, a spatial explicit representation of regions, and for the generation of a synthetic, spatial explicit distribution of farms. The farm localisation procedure is explained in detail in the following chapter by Damgaard et al. (2009) chapter "Spatial Characteristics of Land Use Patterns in Mugello (Central Italy) and Policy Impact on Their Environmental Outputs" in this book and by Kjeldsen et al. (2006). The models are loosely coupled in a hierarchical order: On the basis of the synthetic spatial farm allocation, AgriPoliS (agent-based) simulates the development of many individual farms over time, their investment decisions, and their interactions on the land market. MODAM-MP (mathematical programming) simulates the cropping and livestock patterns of the farms, which are the basis for the MODAM-EIA fuzzy-logic-based environmental impact assessment. FASSET and Farm-N, basically simulate the N-matter flows on the farms. Additional tools were developed to store, interchange and visualise the data required by the core models (Damgaard et al. 2006). Each of the models has specific tasks within the approach (Fig. 1).

Each individual model focuses on different aspects relevant in the context of multifunctionality and sustainability impact assessment. Economic, social and environmental indicators as identified in a participatory process (Piorr et al. 2006; Waarts 2005, 2007) are represented in the models (see Waarts 2007 for the choice of indicators). Important issues from stakeholders were employment and the persistence of farms (Schader et al. 2007). AgriPoliS explicitly aims at modelling dynamic aspects of structural change. It therefore can model the policy impact on farm growth, shrinkage and farm exit, labour allocation, and on production and investment decisions. MODAM, a static whole farm linear programming model takes a much more disaggregated approach in simulating the crop and livestock interaction of farms. On the basis of the regionalisation module developed conjointly by the FASSET and AgriPoliS teams, MODAM results are displayed as distinct spatial distribution of environmental achievements. At the end of the model chain, FASSET takes again a dynamic perspective by simulating nutrient flows and pollution on the basis of daily time steps.

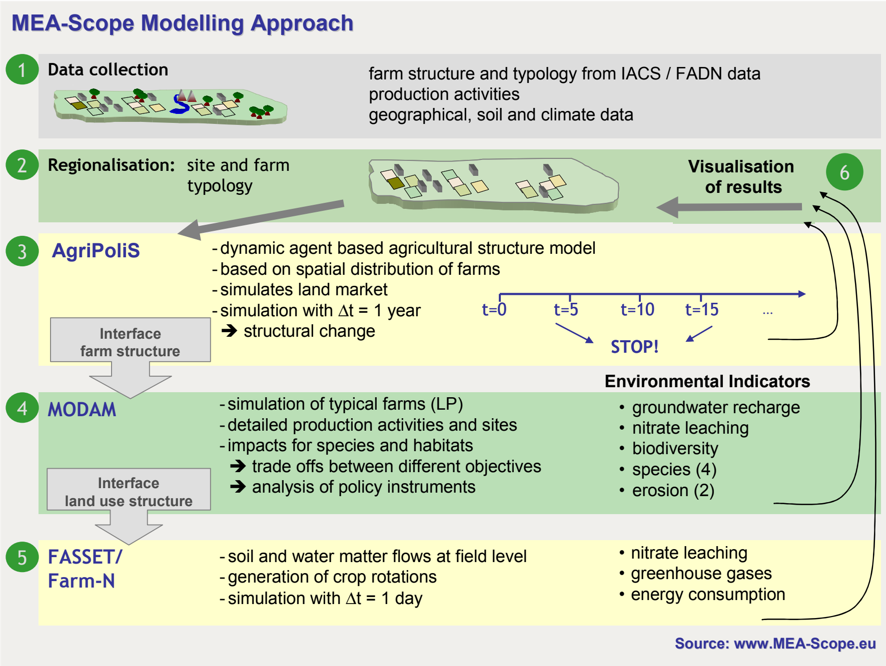

Fig. 1. MEA-Scope modelling approach; Source: www.mea-scope.eu

An important issue in environmental assessment is the specific spatial location in order to capture impacts on environmental indicators in relation to site conditions. Therefore, the farms and their area were spatially located (Damgaard et al. 2009, chapter "Validation of an Agent-Based, Spatio-Temporal Model for Framing in the River Gudenå Landscape" in this book), which allows every farm in AgriPoliS to own or rent particular plots of land with different soil, climate and elevation characteristics specific to each case study region.

The simulations of AgriPoliS run over a user-predefined time period. For case study regions located in the Old Member States, the simulations started in 2002 with the initial policy settings corresponding to those of the Agenda 2000 until the policy change introduced in 2005. For regions of the New Member States, simulations started in 2004 and the policy change was introduced in 2008 (Osuch et al. 2007).

Eventually, two modelling approaches had to be developed – in those regions with good data quality a detailed spatially-explicit approach could be realised in fact for the regions in Germany, Denmark, Italy and Slovakia

(Type I) – while for the regions in France, Poland and Hungary a less detailed approach with fewer attention to detail and fewer data requirements had to be chosen (Type II).

4 Models Used in MEA Scope Approach

4.1 Regionalisation

The regionalization approach of MEA-scope includes the selection of typical farms that represent total regional production and the spatial location of these farms. The resulting synthetic landscapes are the basis for the AgriPoliS model setup. They allow also for the spatial explicit representation of MODAM and FASSET results.

For each case study landscape, around 20 typical farms were selected. The weight of each typical farm was calculated via a least square estimation technique, minimizing the squared deviations for selected, structural data variables, collected for the total landscape and the numbers calculated from an own “artificial” farm structure which is thus defined by assigning weights to typical farms.. The typical farms were selected from Farm Accountancy Data (FADN), if such were available for the area.

The location of the farms selected in the regionalisation process within the landscapes was derived by different procedures depending on the data availability. For the landscapes in Slovakia and Denmark, the exact location of each farm and farm type, from the Land Parcel Information Systems (LPIS), livestock registers, and Integrated Area Control Systems (IACS), obligatory for all EU member states was accessible. In landscapes where the exact farm location was not available a proxy farm type map was derived. The location of farms in such a map was based on the share of grasslands derived from land cover maps. For further detail refer to the following chapter of Dalgaard et al. as well as to Damgaard et al. (2007).

4.2 AgriPoliS

AgriPoliS is a spatial and dynamic agent-based simulation model of structural change in agriculture (Happe et al. 2006b, 2004; Happe 2004). The main purpose of the model is to understand how farm structures change in rural areas, particular in response to different policies. AgriPoliS maps the key components of regional agricultural structures: heterogeneous farm enterprises and households, space, markets for products and production factors (Fig. 2). These are embedded in the technical and political environment.

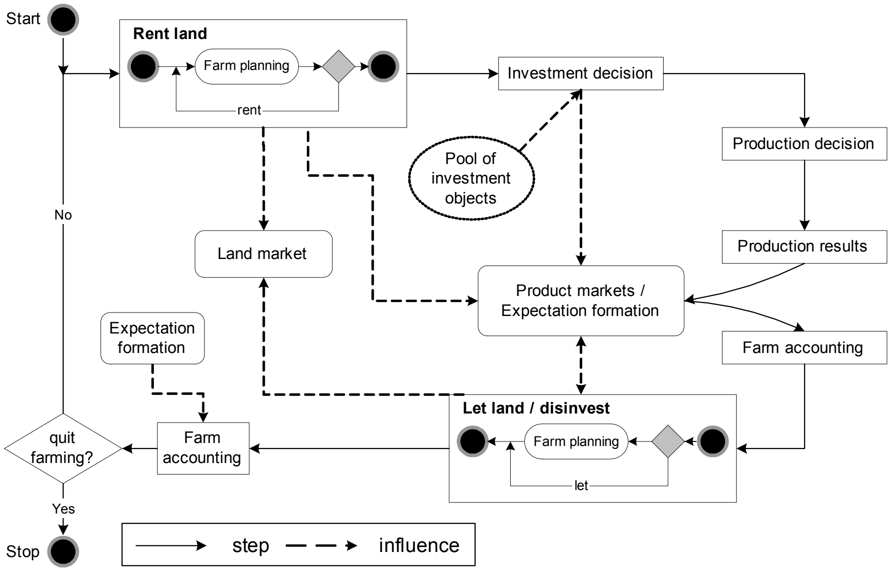

Fig. 2. Flow chart of events for one farm agent in one simulation period Source: Happe (2004)

The model comprises different hierarchical levels: farm agent, plots, regions, farm population, the political environment.

1. *Farm agents* are characterised by state variables such as age, factor endowments (land, capital, labour), ownership structure, location in space, type, managerial ability, full time or part-time farm. Farm agents utilize different production factors of different types and capacities. Farm agents comprise the population of all agents in the region.
2. *Plots* represent physical land units or cells (e.g. 1 ha). Plots take different states: owned/rented, arable and grassland of different qualities distance to farmstead, non-agricultural land. Together, plots/cells form the region.
3. The *political environment* is given by the predominant agricultural policy setting, which affects farm agents, e.g., by way of direct payments, agri-environmental programmes, or limits on stocking density.
4. *Farm agents* interact indirectly via markets for production factors land, labour and capital, and on product markets. Markets for products,

capital and labour are coordinated via a simple price function with an exogenously given price elasticity and a price trend for each product. The land market is implemented as a land rental auction.

5. A *region* is initialised either based on GIS soil maps for the region or based on statistical characteristics of the real landscape.
6. The initial *population of farm* agents is derived from FADN-data in a reference year.

Farm agents are further individualised with respect to production costs, location, age, and the vintage of assets. Technical coefficients and gross margins of production activities are based on standard indicator sets. Upon reading the data into AgriPoliS, farms are further individualised by assigning different vintages to farm assets and giving farms a random age.

4.3 MODAM

MODAM is a bio-economic modelling system that functions as ***M**ulti **O**bjective **D**ecision support tool for **A**gro-ecosystem **M**anagement*. It was developed to evaluate policy effects on the decision behaviour of farmers and on the corresponding environmental effects of the chosen management practices (Zander and Kächele 1999; Zander 2003). The tool allows the calculation of scenarios for different goal attainment levels (goal driven scenarios, GDS) as well as the computation of scenarios of different policy instruments (policy driven scenarios, PDS). MODAM generates results in two kinds of form: trade-off functions between different environmental and economic goals and land use maps. The MODAM farm model simulates farmers' decision behaviour under the assumption of pure economic rationality. The model is a static, mixed integer, linear programming model that is generated from the corresponding data on farm resources and the characteristics and interdependencies of activities relevant for that farm type.

MODAM consists of a set of hierarchically linked modules, which can be divided up into three levels (Fig. 3):

1. At first level, production activities are described in a way that allows economic and environmental analysis of these techniques.
2. The second level performs partial analyses of the production practices for their economic as well as environmental costs and benefits.
3. At the third level, the integrated analysis is conducted, based on multiple goal linear programming (LP) farm models, which are build by a LP-generator.

Crop and animal production activities are key elements of the MODAM bio-economic modelling system. They reflect agricultural practice and represent the pressure of agricultural land use on the environment. Therefore, detailed data were collected for both: crop and animal production activities to allow for the assessment of their costs, economic and environmental benefits – specifically for different soil and weather conditions (see Table 2 in the preceding chapter by Piorr and Müller). Collected data are stored in a database that allows further processing of data in order to perform partial analyses of the environmental impacts of each production practice.

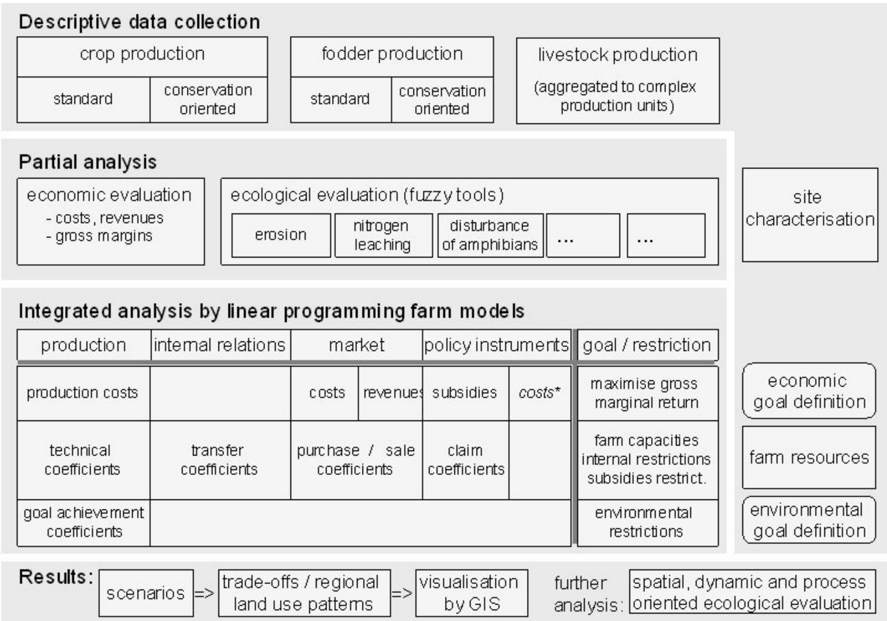

Fig. 3. MODAM model structure. Source: www.mea-scope.eu

4.3.1 MODAM Environmental Impact Assessment (EIA)

The EIA is designed to evaluate agricultural production practices regarding their effects on different abiotic and biotic indicators. The production practices are characterized using distinct parameters (e.g. machinery used or fertilizer rate) to determine their effect on the indicators in question. In order to obtain one index value for each practice a fuzzy tool aggregates all relevant parameters of one production practice and their assessed effects on the indicators (Sattler 2008; Sattler et al. 2006, Fig. 4).

The fuzzy-tool is embedded in the modelling system MODAM. At the start of the MEA-Scope project, each regional partner was asked about which of the environmental MODAM indicators (Table 2) are relevant and of prior interest for their case study regions and should therefore be modelled. Additionally, the regional partners could suggest further environmental indicators for the different case study regions. For these newly suggested indicators assessment modules had to be developed in the course of the project.

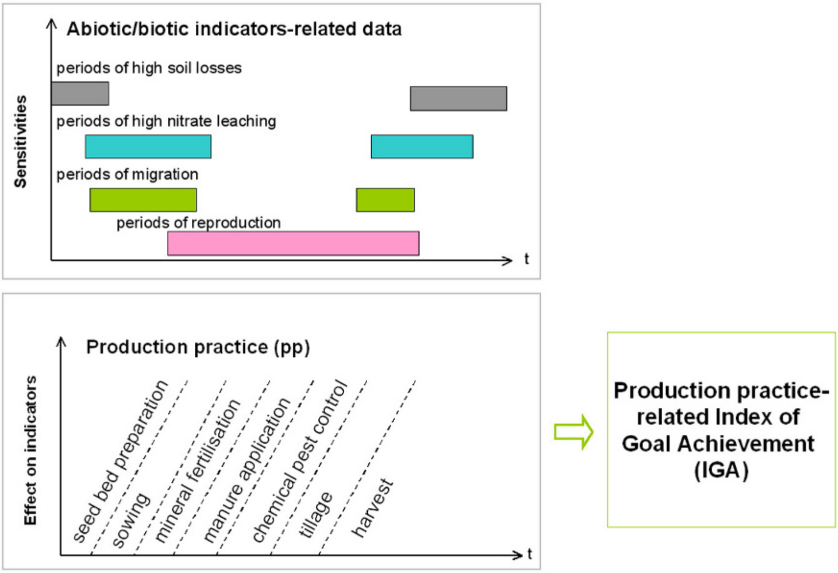

Fig. 4. Abiotic/biotic indicators and production practice
Source: www.mea-scope.eu

The definition of a set of suitable multifunctionality indicators was one of the major challenges within the MEA-Scope project. The final indicator list has to be interpreted as a compromise between an optimal representation of the specific characteristics of the case study regions – and the capabilities of the MEA-Scope modelling approach (Waarts 2005, 2007; Piorr 2006). The impact assessment for the indicators of regional relevance makes use of expert-knowledge that is processed with the help of fuzzy-logic and results in indexes of goal attainment, shortly IGA per ha (for a detailed description see Sattler et al. 2006) an overview of implemented indicators is given by Uthes et al. chapter "A Scenario wise

Analysis of Economic and Environmental Impacts in the MEA-Scope Case Study Regions" in this book.

4.4 Farm Assessment Tool (FASSET)

FASSET is a farm-scale model that simulates production, economics and losses of carbon and nitrogen to the environment (Berntsen et al. 2003). FASSET is a dynamic, deterministic model i.e. uses mathematical descriptions of biological, physical and chemical processes to simulate changes over time. The model uses a daily time step. The main focus of the model is on how farm management and the biophysical environment affect production and losses to the environment (Fig. 5).

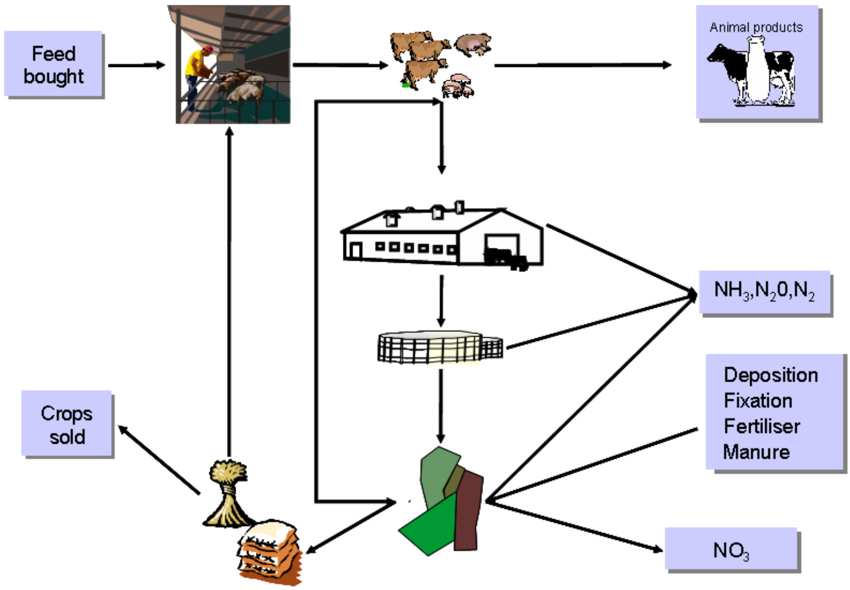

Fig. 5. The FASSET farm model

The input data required include:

1. physical data (e.g. soils, field size, climate, physical structures such as animal housing),
2. biological data (e.g. crop characteristics),
3. management data (e.g. crops grown, how they are managed, animal feeding).

The bulk of the functions within FASSET are dedicated to describing the dynamics of production and of carbon, nitrogen and water on the farm. These include:

1. The production and the uptake and losses of carbon, nitrogen and water by a range of crops are described, based on the availability of these items in the soil and the effect of weather.
2. The corresponding dynamics in the soil describe how these items change form with time (e.g. carbon in organic matter to carbon dioxide) and the vertical movement of these items within the soil.
3. The transformation of carbon and nitrogen in animal feed into animal products and manure, and the subsequent transformations and losses that occur as the manure is managed in animal housing, manure storage and after field application.

The consequences of farm management on farm economics are assessed by tracking the use of energy, labour etc. Outputs of the model are related to

(i)	Production:	(crop yield and quality, milk and meat),
(ii)	Environment:	(nitrate leaching, ammonia emission, emission/absorption of greenhouse gasses, farm carbon, nitrogen and water balances) and
(iii)	Economics:	Farm budget (commodities bought and sold, maintenance and replacement costs, labour).

4.5 Farm-N

Farm-N is a static model, designed to calculate annual N losses related to livestock and arable farming. These losses lead to a large number of environmental problems; for example eutrophication of water bodies, biodiversity reduction in nature areas affected by ammonia deposition, hypoxia in the seas due to nitrate, and emissions of greenhouse gasses (Fig. 6).

The Farm-N model accounts for N-inputs and N-outputs to all farms simulated in the MEA-scope landscapes and scenarios. Subsequently, changes in the N stored in soil are simulated, and the farm gate surplus of nitrogen (N-inputs minus N-outputs plus change in soil N) is distributed on the different types of N-losses using relatively simple submodels, or emission factor calculations. The SIM-DEN model (Vinther and Hansen, 2004), for example, is used to assess the dinitrogen (N_2) and nitrous oxide (N_2O) emissions from fields. The advantage of the Farm-N model over the FASSET model is the much lower demand for input data. However, since the Farm-N submodels are largely regression models from experiments where normal Danish crop management has been applied; the results should be considered indicative rather than absolute, especially when applied to climates and soils that differ markedly from those in Denmark.

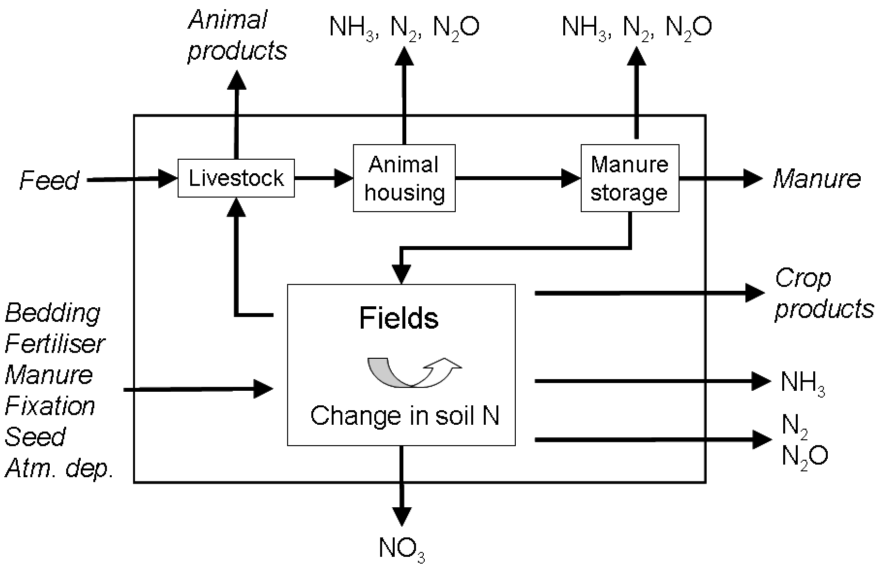

Fig. 6. The Farm-N model
Source: www.mea-scope.eu

The following indicators, resulting from Farm-N, are used in MEA-Scope:

- The farm N-surplus in kg N/ha/yr. Calculated as N-inputs (mineral fertilizer, manure, feed, straw, seed and animals bought + N fixed and N deposited from the atmosphere) minus N-outputs (cash-crops, animal products, milk, manure, and feed and straw sold).
- The farm ammonia (NH_3) loss in kg N/ha/yr. Calculated via emission factors for losses from housing, storage and fields (from grazing, and from spreading of fertilizers and livestock manures).
- The number of Livestock Units, LU ha/yr, where one LU corresponds to 100 kg N in manures ex store.
- The change in the soil N-pool in kg N/ha/yr. Simulated with the *C-TOOL submodel* (Petersen et al. 2002).
- The potential Nitrate (NO_3) leaching in kg N/ha/yr. Assessed as the difference between the N-surplus, the change in soil-N, and the nitrogen lost elsewhere in the system.

5 Policy Scenarios

The MEA-Scope consortium identified a set of policy scenarios which reflect current and likely future developments in policy making in the EU (Piorr et al. 2008; Osuch et al. 2007; Sahrbacher et al. 2009; Uthes et al. 2007, chapter "Analysing Exemplary policy issues using the MEA-Scope Framwork, in this book). The rationale behind the policy scenarios is to reflect the main essence of these developments, but not the policy in its exact detail. The kind of policies chosen focus exclusively on EU-Pillar-I policy measures (market and price policy) and a selection of Pillar-II measures (rural development programmes, Natura 2000). Hence, interactions with many other policy areas (e.g., cohesion policies, specific environmental policies, biofuel policies, social policies) are not dealt with.

Scenarios are a way to elaborate information relevant for decision-making under uncertainty. Uncertainty in this context can refer to unknown future developments, unsatisfactory understood processes or stochastic variables. Different from prognoses, scenarios *cannot* predict the future based on comparatively firmed statistical data to extrapolate current development trends, and different from utopias they still have a plausible reference to the current reality. The development of scenarios involves the identification of main driving forces, the definition of a base or reference year as well as the time horizon and time steps to be analyzed and eventually the centralisation of the scenario results in a storyline (Alcamo 2001).

MEA-Scope applied a participatory approach for the development of future scenarios, involving end-users, regional stakeholders, scientific experts and modellers (Schader et al. 2007). To identify main drivers of the future development of the CAP, stakeholders from the seven MEA-Scope case study regions, the end users of the MEA-Scope tool (namely EC officials), scientific experts and the MEA-Scope computer modellers were involved. In a series of four workshops with an average participation range of 10–15 officials from the EU Commission's Directorate General for Research, Agriculture and Environment, the end-users took part in written brainstorming sessions about the possible developments of a future CAP. The results from the end-user sessions were thematically structured and weighted according to their importance and relevance by the MEA-Scope scientists in a consolidating workshop, eventually resulting in 5 alternative EU policy scenarios (BAS, REF, S1, S2, S3) with varying 1st and 2nd pillar policy settings of the CAP, 2002 as base year and a time horizon of 15 years to be covered. The scenarios aim at an assessment of current and future policy options. These options shape the current discussion about the future of the CAP, such as a further reduction or even abolition of direct payments or ecological impact of agri-environmental programs (Table 1).

The baseline scenario (BAS) imitates the “old” Agenda 2000 CAP settings with coupled crop and livestock payments. This includes mandatory set aside obligations (1st pillar) in combination with agri-environmental payments and Natura 2000 payments for the adoption of extensive, more environmentally friendly farming practices (2nd pillar). This scenario accommodated the model linking in the very beginning of the project since all models were optimally calibrated for these policy settings. It also allowed for a validation of the approach via back-casting.

The reference scenario (REF) is based on an idealized version of the decoupling of payments from production quantities and replacing it by an personalized single farm payment, that reflects the 2003 policy framework in the MEA-Scope regions (idealized personalized decoupled single farm payment). Each farm receives a lump-sum payment based on its historical payment rates independent from its production level (1st pillar). The only condition for eligibility is that, farming has to be maintained. The 2nd pillar settings are identical to the baseline scenario. Both the REF and the BAS scenarios have the closest relation to reality from all five scenarios and were deliberately designed this way to allow for a scenario back casting, based on monitoring data.

In contrast to the two previous direct-payment-driven scenarios, also two “liberalisation” scenarios were identified (S1 and S2). Both scenarios assume a complete abolition of direct payments. Additionally S1 offers the same 2nd pillar schemes as BAS and REF, while in S2 both 1st and 2nd pillar payments are entirely removed. Only of relevance for the EU 15 member states, a fifth scenario is based on the reference scenario, but introduces a ceiling of direct payments above 300,000 € (S3).

In the MEA-Scope modelling approach, AgriPoliS implements the basic setting of pillar one and pillar two into the model by setting region specific payments. Specifications, e.g. the agri-environmental measure “extensive grassland care with the related changes in the model description on management practices and input intensities are passed to MODAM and FASSET/Farm-N. As regards MODAM, Natura 2000 payments are considered explicitly. The indicator results calculated by FARM-N and FASSET for the different scenarios are based on the corresponding scenario results from the microeconomic models of AgriPoliS and MODAM. Results of policy analyses are presented in Sahrbacher et al. (2009) chapter “Analysis Exemplary Policy Issues Using the MEA-Scope Framwork” (this book) and Osuch et al. (2007).

Table 1. Description of MEA-Scope policy scenarios

Scenario name and Summary EU-15 regions (policy change in 2005)		
BAS	**Agenda 2000**	▪ Full implementation-end of 2002 ▪ Agricultural programme on grazing land ▪ No Cross-Compliance
REF	**Reference**	▪ Decoupled Single farm payment ▪ Historical payment (3year. Average) paid to the farm operator ▪ Conditional on running the farm ▪ Agri-environmental programme on grazing land ▪ Cross-Compliance: all farmland to be kept in good condition (at least cutting once a year)
S1	**Liberalisation + Environment**	▪ Removal of direct payments ▪ Agri-environmental programme on grazing land ▪ Cross-compliance: all farmland to be kept in good condition (at least cutting once a year)
S2	**Liberalisation**	▪ Removal of direct payments ▪ Cross-compliance: all farmland to be kept in good condition (at least cutting once a year
S3	**Payment Ceiling**	▪ Like REF but with 300,000 Euros ceiling for direct payment
▪ **Scenario name and Summary EU-10 regions (policy change in 2009)**		
BAS	**Agenda 2000**	▪ Full implementation of policy starting 2004 ▪ Limited stocking density ▪ No Cross-Compliance
REF	**Reference**	▪ Decouple Single farm payment ▪ Historical payment (3year. Average) paid to the farm operator ▪ Conditional on running the farm ▪ Agri-environmental programme on grazing land ▪ Cross-Compliance: all farmland to be kept in good condition (at least cutting once a year)
S1	**Liberalisation + Environment**	▪ Removal of direct payments ▪ Agri-environmental programme on grazing land ▪ Cross-compliance: all farmland to be kept in good condition (at least cutting once a year)
S2	**Liberalisation**	▪ Removal of direct payments ▪ Cross-compliance: all farmland to be kept in good condition (at least cutting once a year

Source: adapted from: www.mea-scope.eu

6 Discussion of Strengths and Weaknesses of the MEA-Scope Modelling Approach

Quantitative modelling has been playing a key role in agricultural economics research, with a focus on policy impact analysis. The goal of agricultural policy analysis is to study the effect of agricultural policies on a range of indicators (e.g. income, efficiency, factor allocation, production, welfare) at different scales (e.g. at the global, national, sector, regional or farm scale). Quantitative models typically used are partial or general equilibrium models, econometric models, and mathematical programming models. A criticism of all these modelling approaches is that they neglect a number of characteristic factors of the agricultural sector, such as immobility of land, heterogeneity of farms, interactions between farms, space, dynamic adjustment processes as well as dynamics of structural change (Happe 2004).

Since the MEA-Scope approach lacks a back-coupling to trade models that predict the changes in commodity prices in the different scenarios, MEA-Scope took price changes as exogenously given. Merely, general price trends for individual products were implemented. Of course, these may not hold out against "external shocks" such as an immediate and complete removal of direct payments from one year to the next as assumed in the scenarios S1 and S2 for instance. Even though real policy usually tries to avoid drastic policy changes and often involves transitional periods between different policies, the results show that under the given assumptions a massive exiting of farms could be reasonable. Moreover, the behavioural foundation of real farm actors is more complex than the maximisation assumed here, for example, because of other objectives or more adjustment options which were not addressed here. Similarly to many modelling approaches, the MEA-Scope modelling system therefore has the tendency to react in a more extreme way than a "real" system would.

The MEA-Scope approach aims to consider spatial relationships such as distances between farms or a spatial clustering of farms in a region. All farms that are modelled with the MEA-Scope modelling approach are spatially located and own or rent particular plots of land (pixels) of different site classes. In agriculture, land use takes a central position. Spatial aspects have a direct effect on farm decision-making and on the economics of the farm. In addition to land value and transport conditions, the suitability of land for agricultural production is determined by non-economic factors such as soil quality, climatic conditions, and inclination. In the MEA-Scope approach decisions on which plot of land is used by which farm for which purpose is determined dynamically and endogenously in the AgriPoliS model. Here, farms interact on a land market such that a farm's total land of a particular type can change over time. Land prices are generated endogenously. Moreover, Spatial-explicitness is of particular relevance from an environmental perspective. Agricultural management differs depending on the characteristics of a particular site type which also influences the environmental impact assessment implemented in the MEA-Scope approach. Both, the MODAM-EIA and the FASSET tool consider site characteristics in their environmental impact assessment as well as the adaptations in agricultural management and use of inputs. Site-specific settings within regions have different and marked impacts on the particular policy adaptation strategies of farms. This results in clearly different landscape patterns. The chapter of Ungaro et al. (2009) chapter "Spatial characteristics of land use patterns in Mugello (Central Italy) and policy impacts on their Environmental outputs. in this book and Piorr et al. (2009) underline the MEA-Scope modelling capability for an integrated assessment of policy targeting considering land use changes and spatial patterns in the context of site characteristics.

Ideally, an environmental impact assessment (EIA) should encompass water pollution impacts, soil contamination impacts, air pollution impacts, ecology impacts including endangered species assessment, geological hazards assessment and human health impacts. In many quantitative modelling approaches, a reliable EIA cannot be incorporated because of the various data that have to be considered and which often cannot be aggregated to the high scales e.g. trade-models act on. The hierarchical modelling approach chosen in MEA-Scope provides access to both an expert-knowledge based EIA (MODAM) and a mechanistic EIA (FASSET) that together cover most important indicators of soil, water, air, habitats and species impacts.

The MEA-Scope project undertook a regional approach, carrying out analyses for specific case study regions only. A full-scale implementation, in the sense of a full coverage of all European regions was never aimed at on the basis of the MEA-Scope approach and would equal a huge number of isolated case studies. Within regions, farms were assumed to be price takers. Hence, no explicit focus was put on implementing price--quantity effects. Theoretically, changes in important commodity prices could also be derived from a stand-alone partial/general equilibrium model. For the AgriPoliS model, this was, for example, considered by Sahrbacher et al. (2007) and Kellermann et al. (2007). However, so far, no endeavours in this direction have been made. Other important developments (long-term changes of farming systems, GMOs, climate change effects) are less easy to incorporate. The already incorporated regions are at most 125,000 ha big, clearly smaller than NUTS-2 level.

The value of the MEA-Scope approach is to derive results on the complex and dynamic interactions between policies, farms, and impacts. The value of the MEA-Scope approach can never lie in an exact representation of reality. Instead, the scenario results have to be interpreted as extremes resulting from the necessary simplification of the real circumstances. The value of these extremes lies in the channelling and highlighting of key interconnections and interdependencies. Eventually, by comparing the impacts of possible alternative policy settings, their advantages and disadvantages, political decision support can be provided.

7 Conclusions

The particular advantage of the approach lies in the simultaneous consideration of dynamic farm level developments and interactions between farms. Linking AgriPoliS with MODAM and FASSET/Farm-N allows to analyse both structural change and agricultural-management-related environmental impacts in a spatially explicit environment. Depending on the focus of the analysis, results of the approach can be looked at from different points of view and at different scales, from a single site type, a single farm, a group of farms to a whole region. The innovative potential of the MEA-Scope approach lies in its bottom–up approach when analysing possible impacts of agricultural policies. In general, the MEA-Scope approach can be interpreted as a complement to those projects that stop at the regional level or neglect the interactions among the farms. The spatial-explicitness is a major plus of the approach, but admittedly was also sometimes a burden as data quality and data accessibility clearly limited the application of the approach in some of our regions. Summarizing, MEA-Scope provides a:

- Dynamic modelling framework simulating the likely policy impact on agricultural structural change using an innovative spatially explicit agent-based approach adapted to each case study region,
- detailed economic optimisation of farm management with respect to production intensities and livestock – grassland – arable production interrelations and
- spatially explicit environmental impacts of agricultural management by
  - dynamic simulation of nitrogen and phosphorus flows in relation to agricultural management and
  - numerous static soil, water and biodiversity related indicators of agricultural management.

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A Scenario-Wise Analysis of Economic and Environmental Impacts in the MEA-Scope Case Study Regions

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Abstract

This chapter summarises economic and environmental impacts of five CAP scenarios in seven European case study regions located in Germany,

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Denmark, Italy, Slovakia, Hungary, Poland and France. The spatially explicit MEA-Scope modelling approach based on three farm-level models – AgriPoliS (agent-based), MODAM (bio-economic), FASSET (bio-physical) – is used to dynamically simulate the behaviour of single farms. At regional level, the change in a range of economic (i.a. number of farms, farm size, farm income) and environmental indicators (related to soil, water and habitat quality) is analysed to compare the scenarios.

The scenario results differ widely reflecting the heterogeneity of the regions. In the EU-15 regions, for example, payment decoupling achieved the best results in conserving the structure of the farming sector, while Agenda 2000 conditions were more effective in maintaining extensive grassland areas. The New-Member-State regions showed the best overall performance in a special accession scenario.

Keywords: MEA-Scope; economic and environmental trade-offs; CAP scenarios; multifunctionality; model linking

1 Introduction

The Common Agricultural Policy (CAP) is a system of European Union agricultural subsidies and programmes. In 2006, the total CAP budget amounted to 51 billion Euros, 16.7% of which were used to finance market intervention measures, 68.1% for direct payments, and 15.2% for rural development measures (COM 2006). Recently, there has been an increasing recognition that there is a need for tools of analysis which enable the impact of CAP measures to be assessed ex post and also to enable the potential impact of new policies to be assessed before implementation (Renda 2006). The core of the EU project MEA-Scope was the development of such a policy impact assessment tool with a special focus on the farm and landscape scale (Piorr et al. 2009).

The possibility of running what-if policy experiments in a controlled "virtual" environment is one of the primary advantages of modelling as it avoids problems in assessing impact that usually occur when assessing policy impacts based on observations, such as separating the effect of the policy from various other influencing factors in the real environment (price fluctuations, institutional changes), establishing an appropriate reference to compare policy effects against (missing control groups), or time lags between policy changes and impact realisation.

This chapter uses the MEA-Scope tool to analyse economic and environmental impacts of five alternative policy scenarios with different settings of the 1st and 2nd pillar of EU's Common Agricultural Policy (CAP) in seven case study regions.

The chapter starts with a brief characterisation of the case study regions. The methodology section introduces the MEA-Scope modelling approach and gives an overview of the policy scenarios and indicators analysed. In the result section, economic and environmental impacts are presented region-wise. Lastly, the results are summarized to derive some more general conclusions.

2 Case Study Regions

The seven case study regions of the MEA-Scope are located in Germany, Denmark, Italy, Slovakia, Hungary, Poland and France. The regions are very heterogeneous with regard to size, geo-physical conditions, existing management systems, and socio-economic characteristics (for a general overview, see Table 1).

The German case study region *Ostprignitz-Ruppin (DE)* covers a utilised agricultural area (UAA) of about 120,000 ha (cf. Table 1) and is situated in north-eastern Germany. Particularly the southern part of the region is rich in grassland. In 2003, the region counted 585 farms with an average farms size of 200 ha and an average livestock density of 0.5 livestock units per ha (LU/ha). Livestock husbandry involves mostly intensive indoor dairy, cattle and pig production, but also extensive suckler cows. In general, agricultural production in this less favourable area is highly subsidised (cf. Fig. 1).

The Danish case study region *River Gudena (DK)* is situated near the city of Viborg in the Western part of Denmark (UAA 75,000 ha). The region is characterised by numerous lakes. River Gudena is an intensive agricultural region dominated by cattle and pig production. In 2002, the region counted 1,871 farms with an average farm size of 42 ha.

The *Mugello (IT)* territory in Tuscany, Italy (UAA 26,000 ha) is characterised by small mixed crop-livestock farms (total number 1,237 farms, average farm size 22 ha). 49% of the farms are smaller than 5 ha, and 92% smaller than 50 ha. The beef sector is of particular importance in this region and mostly composed of traditional farms. Mountain pastures and permanent grassland dominate the land use.

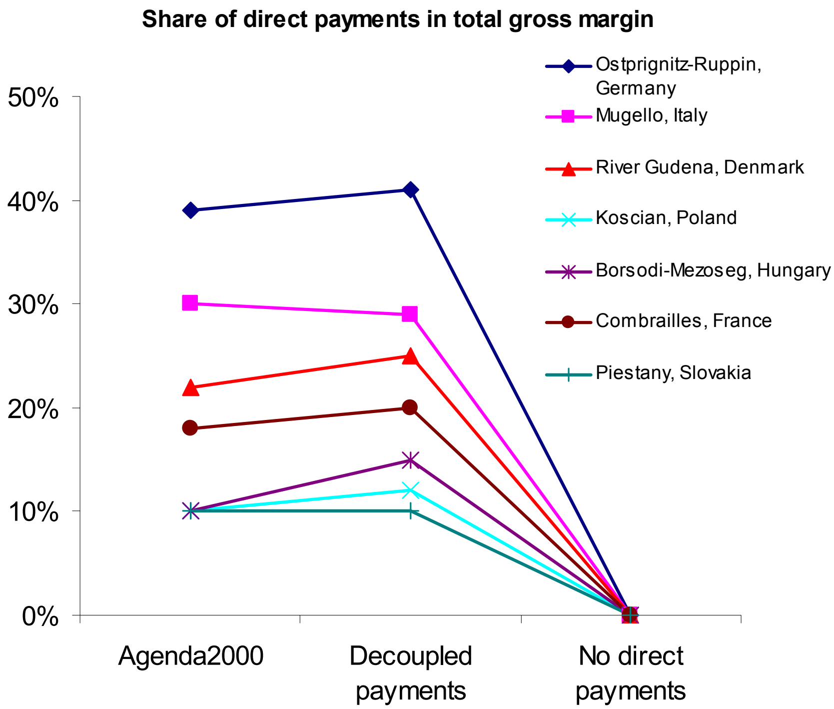

Fig. 1. Importance of CAP direct payments in the MEA-Scope case study regions

The *Piestany (SK)* district is situated in the north-eastern part of Slovakia and includes a UAA of 22,000 ha (94% arable land) used by a total number of 128 farms with an average farm size of 170 ha and an average livestock density of 0.43 LU/ha. Farms are for the most individual farms coexisting with large cooperatives. The most important farm type is arable farms (51%) followed by 41% specialized livestock or mixed farms. The region includes various protected areas with high botanical and zoological value.

The study region *Borsodi Mezoseg (HU)* in Hungary counts 864 farms, among them mostly individual farms that perform their activities on a UAA of 39,656 ha. 76% of the UAA is composed of arable land; arable farms occupy almost 40% of the area. More than 80% of the individual farms are smaller than 10 ha, but these small farms are located on only 11% of the total UAA.

Table 1. Characteristics of the MEA-Scope case study regions (base year)

Region	**Ostprignitz-Ruppin**	**River Gudenå**	**Mugello**	**Piestany**	**Borsodi Mezoseg**	**Turew**	**Combrailles**
Country	Germany	Denmark	Italy	Slovakia	Hungary	Poland	France
Farms [n]	585	1,164	1,237	125	864	2,499	570
Farm size [ha]	206	40.1	15	175	45	12	48.1
Arable land [ha]	88,506	71,934	13,884	19,848	30,478	20,356	10,301
Grassland [ha]	32,451	3,298	12,338	1,487	9,178	10,337	17,127
Land management units [n]	5	4	8	2	4	6	6
Cropping practices [n]	119	720	637	15	46	204	659
Livestock systems [n]	BC, DC, SC, PF, S	BC, DC, SC, PF, S	BC, DC	BC, DC, SC, PF, S	BC, DC, SC	BC, DC, SC, PF, S	DC, SC
Livestock density [LSU/ha]	0.5	1.14	0.31	0.43	0.22	0.91	0.62

BC–Beef Cattle, DC–Dairy Cows, SC–Suckler Cows, PF–Pig fattening, S–Sows.

The *Turew (PL)* area is part of the Wielkopolska region known as the “bread basket” of Poland. The region counts 2,499 farms on a UAA of 30,693 ha, 66% of which is arable land. The agricultural situation is comparable to the Piestany district in Slovakia: small-scale individual farms coexist with large cooperatives. However, the average farm size in this region is only 12 ha.

The *Combrailles (FR)* case study area is located in the Auvergne region in the centre of France. 570 farms occupy 27,428 ha of UAA, 62% of which is grassland. The average farm size in the region is 48 ha. The region has a complex topography (valleys, plateaus, volcanic remains etc.). Most of the farms are located 500 m above sea level: the slope is the main constraint for agricultural land use.

3 Methodology

To analyse the environmental and economic impacts of alternative CAP scenarios, this study makes use of the MEA-Scope modelling approach. The following section briefly describes the modelling approach itself, the characteristics of the five policy scenarios as well as the economic and environmental indicators analysed.

3.1 MEA-Scope Modelling Approach

The MEA-Scope modelling approach is composed of three farm-level models. The models are loosely coupled in a hierarchical order: AgriPoliS (agent-based; simulates the interactions among the farms and their investment decision), MODAM (linear-programming, simulates the cropping and livestock production of the farms; conducts a fuzzy-logic-based environmental impact assessment) and FASSET (bio-physical; simulates the N-matter flows on the farms). The combined tool covers a time period of 10–15 years with 2002 as base year.

Typical farms of the Farm Accountancy Data Network (FADN) and various GIS data sources are used to reproduce the total regional farm population and their likely spatial localisation within the regional landscape (Kjeldsen et al. 2006). The resulting single farms own or rent particular plots of land with different soil, climate and elevation characteristics (grid cell size 1 ha). Farm activities encompass land use and production decisions, rental activities, labour allocation decisions and investments. During the simulation, a farm can change its characteristics such as size, labour endowment, specialisation and production activities.

For a detailed description of the modelling approach, see Zander et al. in this book.

3.2 CAP Scenarios

To develop future CAP scenarios, MEA-Scope applied a participatory approach that involved stakeholders from the case study regions and officials of the European Commission (Schader et al. 2007). The scenarios (BAS, REF, S1, S2, S3) include past and current CAP reforms (e.g. Agenda 2000 vs. payment decoupling) but also recently discussed future options of the CAP (e.g. no direct payment without or in combination with 2nd pillar programs).

With respect to the first pillar of the CAP, the baseline scenario (BAS) imitates the "old" Agenda 2000 CAP conditions with coupled crop and livestock payments and mandatory set aside obligations. Since in the three New-Member-State regions in Slovakia, Poland and Hungary a baseline policy based on the Agenda 2000 reform never existed, special scenario settings were used to imitate the transitional accession period with yearly increasing payment rates. Consequently, the baseline scenario in the New-Member-State regions (SK, HU, PL) is therefore named "ACC" for accession. In the reference scenario (REF), each farm receives a lump-sum payment based on its historical payment rates independent (decoupled) from its production level. The only condition for eligibility is that farming has to be maintained. The S3 scenario is identical to the REF scenario but sets a ceiling of 300,000 Euro of direct payments for each farm. In the Hungarian and the Polish region the S3 scenario has not been simulated because the payment ceiling of 300,000 Euro was too high to be effective.

As regards pillar 2 of the CAP, all direct-payment-scenarios (BAS, ACC, REF, S3) offer payments for the adoption of extensive, more environmentally friendly farming practices (agri-environmental measures, Natura 2000).

In addition, two scenarios without direct payments were simulated (S1 and S2). Both scenarios assume a complete phasing out of crop and livestock payments. The only difference between the two is that S1 still offers 2nd pillar schemes, while in the S2 scenario 1st *and* 2nd pillar payments are phased out.

3.3 Indicators

The development of an ex ante policy impact assessment tool with special consideration of multifunctionality issues also included the task to define a set of suitable multifunctionality indicators (cf. Waarts 2005). The final indicator list was a compromise between the optimal representation of the specific characteristics of the case study regions – and the capabilities of the MEA-Scope models. Table 2 gives an overview of the indicators that have been selected from the final list for this analysis (the regions are listed by country abbreviation).

Following indicators have been analysed to study economic and structural change related impacts: average farm size, number of farms, utilised agricultural area (UAA), utilised grassland area, average farm income per ha and average livestock density (LU/ha).

Table 2. Overview of environmental and economic indicators

	Indicator	Description	DE	DK	IT	SK	HU	PL	FR
Economic	Farm Size	Farm size (ha/farm)	☒	☒	☒	☒	☒	☒	☒
	Farms	Number of farms	☒	☒	☒	☒	☒	☒	☒
	UAA	Utilised agricultural area (ha)	☒	☒	☒	☒	☒	☒	☒
	Grassland	Utilised grassland (ha)	☒	☒	☒	☒	☒	☒	☒
	Farm Income	Farm Income (Euro/ha)	☒	☒	☒	☒	☒	☒	☒
	LU/ha	Livestock units per ha	☒	☒	☒	☒	☒	☒	☒
Environmental (abiotic)	GWR	Potential for groundwater recharge/proliferation	☒				☒	☒	
	NO_3	Reduce risk of nitrate entries into groundwater	☒	☒	☒	☒	☒	☒	☒
	NP	Reduce risk of nutrient (N/P) entries into surface waters	☒			☒			☒
	Pest	Reduce risk of pesticide entries into ground- and surface waters	☒	☒	☒				☒
	WaEro	Reduce risk of water erosion	☒	☒	☒	☒			
Environmental (biotic)	Amph	Habitat potential for red belly toad (amphibians)	☒		☒	☒			
	Bustard	Habitat potential for great bustard (bird)					☒		
	Flora	Habitat potential for wild flora species (winter annuals)	☒	☒	☒	☒	☒		☒
	Hare	Habitat potential for field hares (mammals)	☒	☒	☒				
	Hover	Habitat potential for hover flies (beneficial insects)	☒						
	Sky	Habitat potential for skylarks (field breeding birds)	☒	☒		☒			

To assess the environmental performance on agricultural land, five abiotic and six biotic indicators have been identified in cooperation with regional experts. Not all of the indicators were relevant to all regions depending on the region-specific characteristics (cf. Table 2). So was the abiotic indicator “NO_3” (Risk of nitrate entries into groundwater) important in all regions, while the biotic indicator “Bustard” (Habitat potential for great bustard (bird) was singularly relevant to the Hungarian region (Borsodi-Mezoseg).

The impact assessment for the environmental indicators is based on expert-knowledge and a fuzzy-logic tool. Result of the assessment is an Index of Goal Attainment (IGA/ha) for each environmental indicator. The IGA ranges between 0 and 1 with 0 indicating low and 1 indicating high goal achievement. For a detailed description of the environmental impact assessment, see Sattler and Zander (2004) or Sattler et al. (2006).

4 Results

This section gives a region-wise summary of major developments in the seven MEA-Scope regions. Medium-term effects of each scenario (year 9) are compared to the base year 2002. Table 3 shows the impacts in percentage changes of the different scenarios on the economic indicators (cf. Table 2). Orange marked cells indicate an improve or increase of an indicator, while grey indicates a deterioation or decrease (the darker the worse). For Borsodi Mezoseg (HU) and Turew (PL) no S3 has been simulated, therefore these two regions have no results in the S3 column. Figure 2 shows how the management intensity in the regions is influenced by the different scenarios (example N-leaching index). Only for the base year, Fig. 3 shows the impact of the agri-environmental measure "grassland extensification" on the N-leaching index on grassland. This measure probhibits the application of mineral fertilisers and pesticides and restricts the livestock density (0.3–1.4 LU per hectare). Figure 4 gives mean values (arable land) for the environmental indicators NO_3, FLORA, and WaEro (see Table 2 for the description of the indicators).

In the German region *Ostprignitz-Ruppin*, both economic and environmental indicators faced a strong decrease in the no-direct-payments scenarios (S1 and S2). From the initially 585 farms only 44 farms survived in the worst-case scenario S2 (–75.2 %) while the average farm size more than doubled. The average farm income of the remaining farms was reduced by more than 60% in the S2. At the same time, agricultural intensification on arable land took place, expressed e.g. in the worse performance of the abiotic indicators "NO_3" – risk of nitrate entries into groundwater (–15.23%), "NP" risk of nutrient entries into surface waters (–17.19%) and "Pest" risk of pesticide entries into ground- and surface waters (–26.21%). The reduction in stocking numbers was almost equal to the baseline scenario. However, in S1 and S2 the reduction exclusively concerned extensive livestock types such as suckler cows and extensive beef cattle while intensive dairy and pig production became the prevailing systems after the policy change. Payment decoupling (REF and S3) led to the highest increase in average farm income (followed by the BAS scenario), which is due to that overall payment levels have increased from Agenda 2000 to decoupled payments (cf. Fig. 1). At the same time, payment decoupling caused the greatest reduction in livestock numbers of all scenarios for livestock production received no extra support anymore. In general, fewer farms stopped farming compared to the BAS scenario. The dominant farm type after the policy change became arable (cash crop) farms.

Table 3. Change in economic indicators (year 9 compared to base year)

Region	Indicator	BAS (%)	REF (%)	S1 (%)	S2 (%)	S3 (%)
Ostprignitz-Ruppin (DE)	Farm Size	31.3	–25.3	111.0	111.0	–25.3
	Number of farms	–36.6	–4.6	–75.2	–75.2	–4.6
	UAA	–16.7	–28.7	–47.7	–47.7	–28.7
	Grassland	–58.4	–71.4	–91.3	–91.3	–71.4
	Farm Income	29.1	126.0	–66.3	–66.3	126.0
	Livestock units	–60.9	–71.1	–64.3	–64.3	–71.1
River Gudenå (DK)	Farm Size	73.8	45.3	67.6	66.6	44.0
	Number of farms	–43.6	–38.0	–63.4	–63.4	–40.4
	UAA	–2.0	–9.9	–38.7	–39.1	–14.1
	Grassland	–2.1	–4.9	–20.9	–25.3	–5.1
	Farm Income	20.0	20.0	19.1	19.7	26.9
	Livestock units	–52.0	–61.3	–48.7	–48.6	–59.4
Mugello (IT)	Farm Size	10.7	12.4	22.7	17.1	12.4
	Number of farms	–33.8	–31.1	–40.8	–41.1	–31.1
	UAA	–26.7	–22.6	–27.4	–31.1	–22.6
	Grassland	–57.1	–48.3	–58.4	–66.3	–48.3
	Farm Income	90.9	93.8	40.1	44.8	93.8
	Livestock units	64.1	20.5	21.1	25.1	20.5
Piestany (SK)	Farm Size	21.4	21.4	64.2	68.8	21.4
	Number of farms	–17.6	–17.6	–39.2	–41.6	–17.6
	UAA	0.0	0.0	–0.2	–1.4	0.0
	Grassland	0.0	0.0	–2.3	–20.6	0.0
	Farm Income	–23.6	–26.6	–75.5	–75.6	–26.6
	Livestock units	8.1	–9.4	–11.4	–13.0	–9.4
Borsodi Mezoseg (HU)	Farm Size	164.2	248.1	1278.9	1108.0	
	Number of farms	–62.2	–73.7	–94.0	–92.4	
	UAA	0.0	–8.5	–17.0	–7.7	
	Grassland	0.0	–36.9	–66.5	–25.1	
	Farm Income	–36.4	–55.8	–96.9	–99.1	
	Livestock units	–73.9	–87.6	–99.9	–99.9	
Turew (PL)	Farm Size	34.9	37.2	45.7	45.2	
	Number of farms	–25.9	–29.8	–34.4	–35.1	
	UAA	0.0	–3.7	–4.4	–5.7	
	Grassland	0.0	–8.6	–10.8	–15.4	
	Farm Income	–0.4	–5.4	–21.1	–21.4	
	Livestock units	–20.7	–21.4	–31.5	–36.0	
Combrailles (FR)	Farm Size	43.4	22.1	74.7	80.1	22.1
	Number of farms	–31.1	–28.9	–44.7	–50.4	–28.9
	UAA	–1.1	–13.3	–3.5	–10.6	–13.3
	Grassland	–1.8	–21.3	–5.5	–16.9	–21.3
	Farm Income	–10.5	26.5	–37.8	–37.2	26.5
	Livestock units	8.2	14.6	3.1	10.2	14.6

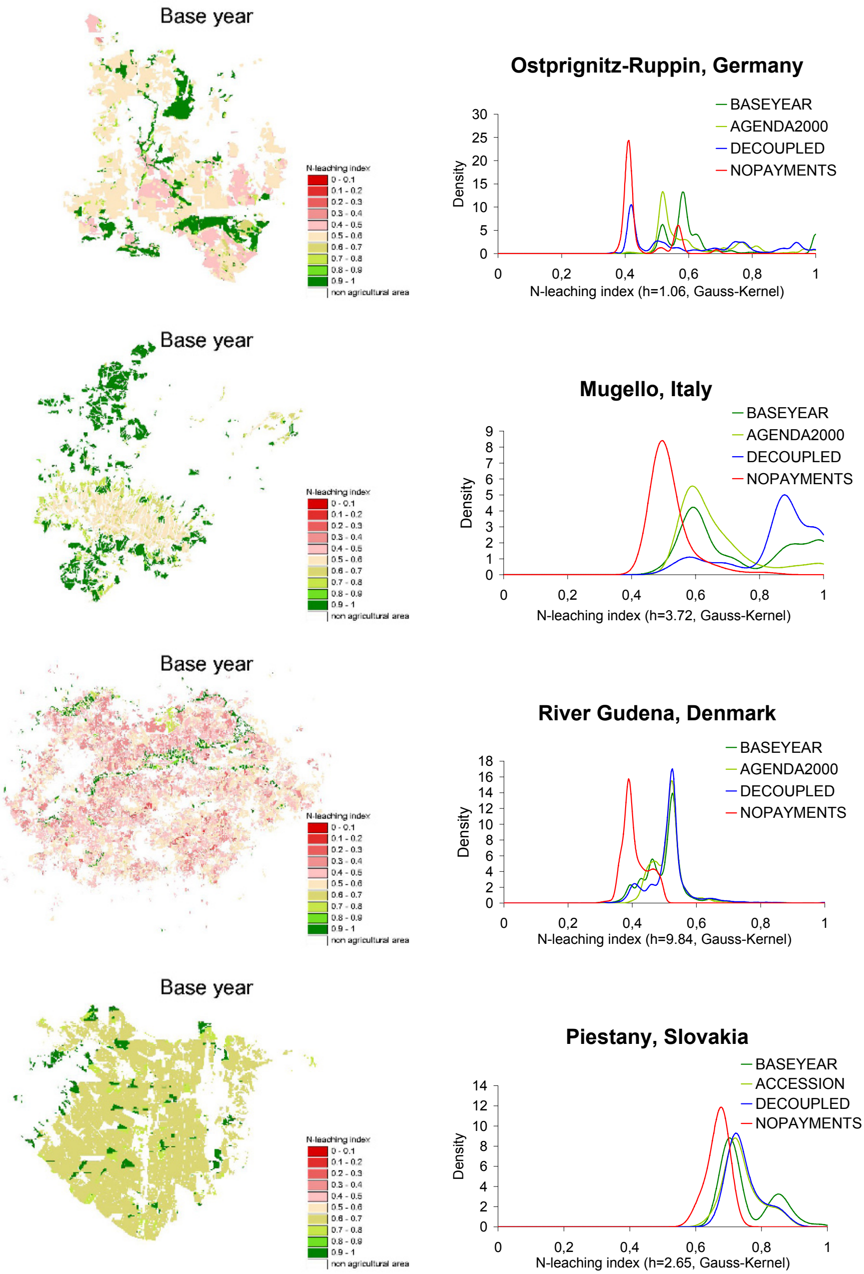

Fig. 2. Regional impacts of changes in the direct payment scheme on the N-leaching risk index [0 – high risk; 1 – low risk]; map (base year) and kernel density estimation (policy scenarios)

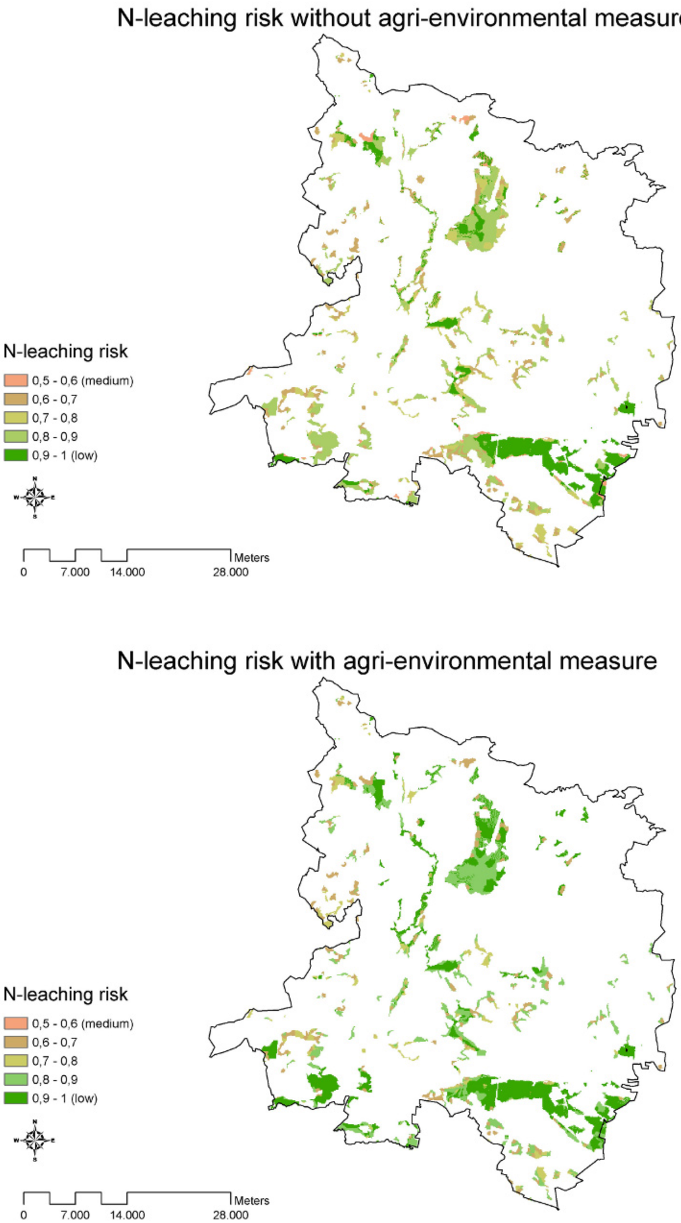

Fig. 3. Impact of the agri-environmental measure "grassland extensification" on the N-leaching risk index in Ostprignitz-Ruppin, Germany (grassland area); counterfactual comparison (base year)

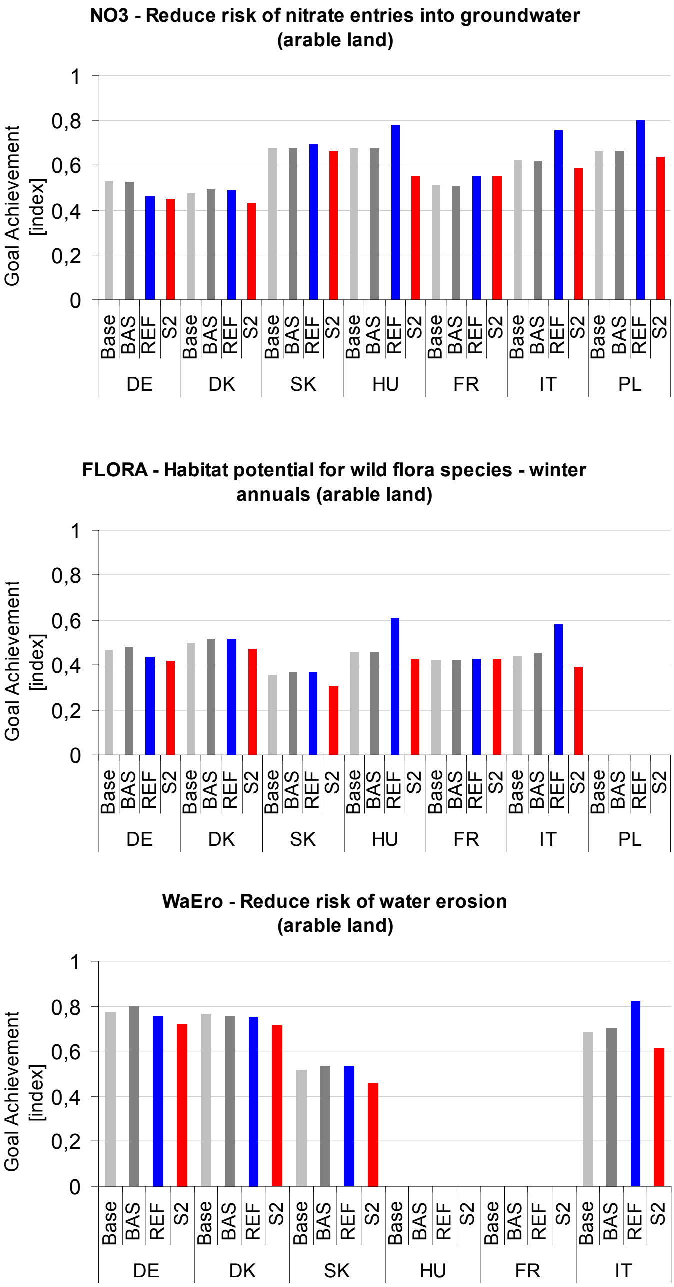

Fig. 4. Environmental indicators [means] (no values = indicator was not relevant in this region, see Table 2)

None of the scenarios stopped the loss of extensively managed grassland (cf. Fig. 5), which is characteristic for this region, whereas in the no-direct-payments scenarios the loss was almost twice as much as under Agenda 2000 conditions (BAS). The grassland abandonment in REF/S3 was only slightly lower than in S1/S2. Since the remaining grassland in REF/S3 had to be managed after cross-compliance standards, the performance of a part of the environmental indicators improved, even in comparison to the BAS scenario ("NO_3": +10.88%, "Amph"-habitat potential for red belly toad: +10.93% and "Hare"-habitat potential for field hares: +10.79%).

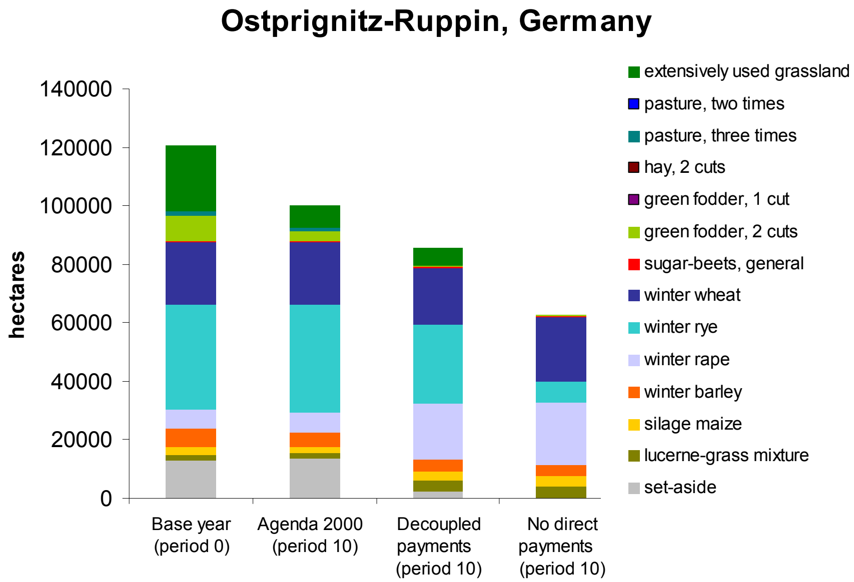

Fig. 5. Changes in cropping pattern caused by the different scenarios

The Danish region *River Gudena* reacted less sensitively to the policy scenarios. Instead, the behaviour of the region was characterised by a strong scenario independent structural change (in all scenarios the number of farms was reduced by around –40 to –50 %). The baseline scenario led to the greatest increase in average farm size, even more than the no-direct-payments scenarios. The farm income increased by around 20% in all scenarios. The environmental performance was also less sensitive to the scenarios. Respective indicators stayed on the level of the base year in both the BAS and the REF scenario (with a slight improvement of the indicators

"NO_3" and "Hare" on grassland). BAS, REF and S3 were effective in maintaining grassland while S1 and S2 caused a remarkable loss (S1: –20.9%; S2: –25.3%). In the worst scenario (S2) the environmental indicators "NO_3", "Hare" and "Sky" (habitat potential for skylarks) faced deterioration on both arable and grassland, while the offered agri-environmental measures in the S1 scenario helped at least to stabilize the environmental performance on grassland.

Also in the Italian region *Mugello*, the number of farms decreased in all scenarios (BAS: –33.8%; REF: –31.1%; S1: –40.8%; S2: –41.1%; S3: –31.1%), accompanied by an increase in average farm size, whereby the deviation in farm size between the two extremes Agenda 2000 (BAS) and S2 was only 6.4%. All scenarios led to a considerable loss of mountainous grassland areas of around –55 to –66%. In the REF/S3 scenarios, the loss was only slightly lower (-48.3%). Livestock numbers were only moderately reduced causing an increase of livestock units per ha in all scenarios, particularly in the BAS scenario where livestock payments made beef production even more attractive. In environmental terms, REF and S3 caused improvement on arable land, reflected in the IGAs of all chosen indicators (+9 to +33%), while the situation on grassland remained on the constant (good) level of the base year. No changes occurred in the baseline scenario itself, while the absence of all payments led to a worse performance of the indicators "WaEro" (risk of water erosion), "Flora" (habitat potential for wild flora species) and 'Hare' (only on arable land). Centralised, the scenario results for Mugello build three groups: the scenarios REF and S3 caused an extensification of the farming systems (relevant decrease of cultivated areas, increase of typical crops, such as alfalfa and spelt that replace cereals). S1 and S2 led to an intensification of the farming systems (abandonment of set aside, increase of cultivated cereals, particularly on the valley sites). The baseline scenario (BAS) resulted in moderate extensification on the hilly sites and slight extensification on the valley sites. All scenarios showed an evolutionary trend characterized by the loss or even disappearance of open areas.

In the *Piestany District* (Slovakia), all scenarios were characterised by a decreasing number of farms (ACC: –33.8%; REF: –31.1%; S1: –40.8%; S2: –41.1%; S3: –31.1%) accompanied by an increase in average farm size, whereby the increase in the scenario S2 was three times as high as in the accession scenario (ACC: +21.4%; S2: +64.2%). The utilised agricultural area and the use of grassland remained almost constant in all scenarios, except for S2 (decrease). The agri-environmental measures in the S1 scenario helped to avoid a potential loss of grassland compared to the S2 scenario (ACC: 0.0%; S1: –2.3%; S2: –20.6%). All scenarios led to a decrease in average farm income, particularly the no-direct-payments scenarios (accompanied by reduced stocking numbers). The environmental performance in the region remained on a high level in both absolute and relative terms in all scenarios. The highest IGAs were associated with the indicators "NO_3", "NP" and "Pest" and the lowest IGAs with the indicators "Flora" and "GWR" (potential for groundwater recharge).

The *Borsodi Mezoseg* region (Hungary) was the least stable from all regions. The economic situation was already severe in the initial situation, and even got worse in all scenarios. In the scenarios S1 and S2, the farm income per ha totally collapsed. From the initially 864 farms only 7.64% survived in the S2 scenario but even without phasing out direct payments two thirds of the farms dropped out of production (BAS scenario). The initial average farm size of 45 ha tripled in the direct-payment-scenarios and increased by more than 10 times in the no-direct-payments scenarios (only large arable farms in the region survived). Livestock production was unprofitable to a large extent and therefore drastically reduced in the direct-payment-scenarios (ACC, REF), and almost entirely dropped in the no-direct-payments scenarios. Livestock production and grassland use were directly coupled. In the no-direct-payments scenarios, large parts of the grassland area were taken out of production. As regards the environmental indicators, the REF scenario improved the IGAs of "Bustard" (habitat potential for great bustard), "Flora" and "NO_3" while "GWR" faced deterioration (on arable land). The scenarios S1 and S2 led to a change for the worse with respect to the indicators "NO_3" and "Bustard". Here, the already less varied cropping pattern in the initial period was even further limited to only two crops (winter rape and winter wheat). In general, small dairy farms (<50 ha UAA) showed the best and arable farms the worst environmental performance of all farms.

In the *Turew* region (Poland), the number of farms decreased significantly in all scenarios (–35.05% at most) while the utilised agricultural area (UAA) remained almost constant (at most –5% in the S2 scenario). The two direct-payment-scenarios ACC and REF (S3 was not simulated for this region) led to a relatively stable situation, as both farm income and farm size remained almost constant. In contrast, the scenarios S1 and S2 caused a decline in farm income of at most –22% compared to the base year. The stocking density (initially 0.91 LU/ha) in the region was subject to an overall structural-change-driven trend that caused a significant decline in all scenarios. The loss of direct payments in the no-direct-payments scenarios intensified the trend. The stocking density in the accession scenario changed by –20.74% (0.71 LU/ha), compared to –36.0% in the S2 scenario (0.58 LU/ha). The two IGAs ("GWR" - potential for groundwater recharge/proliferation; "NO_3"-risk of nitrate entries into groundwater) for this region are characterised by an antagonistic behaviour. The agricultural intensification in the scenarios S1 and S2 caused a worse performance of the indicator "NO_3". At the same time, the indicator "GWR" improved (less areas with permanent soil coverage, therefore higher infiltration possible).

In *Combrailles* (France), the baseline scenario led to a slight decrease in average farm income, while REF and S3 caused an increase of at most 27%. In the no-direct-payments scenarios, the farm income went down to a level of 62% of the initial value. In all scenarios, the number of farms was drastically reduced, particularly in the no-direct-payments scenarios (–50% at most). The average farm size (48 ha) increased by around 50% in BAS, REF and S3 and nearly doubled in the scenarios S1 and S2. The livestock density remained almost constant on its rather low initial level of 0.6 LU per ha (BAS, S1) or increased slightly (REF, S2). The land use in total was also only slightly reduced compared to other regions (–14% at most). The share of extensive area was the highest in the BAS and S1 scenario. In the S1 scenario, agri-environmental programs became of higher importance for the farms (direct payments phased out), so that the share of extensive grassland area (condition for participation in the program) went up. In the two decoupling scenarios REF and S3, a grassland abandonment of around 20% took place as a result of a stronger market orientation of the farms.

5 Summary of Economic and Environmental Results

In *economic terms,* we observed that all seven regions experienced a considerable structural change in the scenarios expressed in a decreasing number of farms over time and an increase in average farm size. Both effects were more pronounced in the no-direct-payments scenarios (S1 and S2) compared to the three scenarios with coupled or decoupled direct payment support (BAS, REF, S3). Also the farm composition changed; particularly beef-producing farms were very sensitive to the phasing out of livestock payments. Although all scenarios bore the risk of land abandonment in marginal areas, e.g. less fertile arable areas or extensively used grassland areas, most of the marginal areas were abandoned in the no-direct-payments scenarios, while the decoupling scenarios (REF and S3) showed less drastic effects. Agenda 2000 conditions (BAS) were the most effective in avoiding grassland abandonment except for Mugello (IT) and Combrailles (FR). Livestock densities were reduced in almost all regions and scenarios, except for Mugello (IT). In Ostprignitz-Ruppin (DE) the most drastic livestock reduction occurred in REF/S3, while in River

Gudena (DK) all scenarios showed a similar reduction supporting the assumption of a general policy independent trend. The baseline scenario led to an increase in average farm income in Ostprignitz-Ruppin (DE), River Gudena (DK) and Mugello (IT), while Combrailles (FR), Piestany (SK), Borsodi Mezoseg (HU) faced significant losses and Turew (PL) remained on a low but stable level. The no-direct-payments scenarios caused an income loss in DE, SK, HU, PL, FR, while the farm income (of the remaining farms) in DK and IT increased, though in IT less than in the direct-payment-scenarios. At the same time, participation and share of income from 2nd pillar programs increased. In the EU-15 regions (DE, DK, IT, FR), payment decoupling (REF, S3) led to an increase in average farm income, while the New-Member-State regions faced income losses compared to the base year.

From the *environmental perspective*, it could be observed that in all scenarios the chosen biotic indicators were more sensitive than the abiotic indicators proportional to the use of grassland. Fell grassland out of production or was used more intensively, which happened for example in the S2 scenario, the situation for the biotic indicators got worse in all regions (no biotic indicators available for Turew, PL). A comparison of the S2 and the S1 scenario shows that 2nd pillar programs (agri-environmental measures, Natura 2000) could act as a corrective to some extent (e.g. in Piestany and Combrailles). The REF scenario, designed as an implementation of the current policy framework in the MEA-Scope regions, led to intensification on arable land as a result of a stronger market-orientation of the farms, but also to extensification on grassland as a result of the reduced stocking numbers and cross compliance obligations (Happe et al. 2006). Particularly in the German region Ostprignitz-Ruppin, the REF scenario caused a worse performance of the environmental indicators on arable land due to an increase in oilseeds (cf. Fig. 5) while on grassland the decoupling of payments in combination with grassland-related-cross-compliance conditions caused relief compared to the baseline (cf. Uthes et al. 2008).

6 Best-Performance Scenarios

In general, impact assessment not only involves the presentation of results but also their interpretation and judgement. Whether an increase in average farm size, for example, is a positive or negative impact depends on the political objectives pursued with the CAP. In order to provide a comprehensive picture of the modelling results across the different indicators, the indicator performances in each scenario have been assigned to common goals of EU agricultural policy.

Typical (sometimes contradictory) objectives of the CAP are e.g. to develop a competitive farming sector (suggested indicators: farm income), while at the same time conserve typical farm structures (suggested indicators: farm size, number of farms); to maintain farming in general (suggested indicators: UAA); to maintain valuable grassland areas e.g. in flood endangered areas, or in mountainous areas to avoid landslides (suggested indicator: grassland use); and to keep labour in agriculture. Keeping labour in agriculture is often associated with maintaining livestock producing farms since livestock production is usually more labour-intensive than cash-crop production (suggested indicators: number of farms, LU/ha). Other political objectives might not only relate to the maintenance of target areas, but rather to their environmental quality (suggested indicators: environmental indicators – IGAs).

With the help of a performance matrix with a the given set of political goals and contributing indicators, the most beneficial (or least deteriorating) policy scenario for each region can be determined, the results of which are shown in Table 4.

Table 4. Best-performance scenarios with respect to typical objectives of the CAP

Goals/ Regions	**DE**	**DK**	**IT**	**SK**	**HU**	**PL**	**FR**
Competitiveness	REF	S3	REF	ACC	ACC	ACC	REF
Conserve farm structure	REF	REF	REF	ACC	ACC	ACC	REF
Maintain farming	BAS	BAS	REF	ACC	ACC	ACC	BAS
Maintain grassland	BAS	BAS	REF	ACC	ACC	ACC	BAS
Keep labour in agriculture	S3	BAS	BAS	ACC	ACC	ACC	REF
Environment	BAS	BAS	REF	S3	REF	S2	REF
All goals	REF	REF	REF	ACC	ACC	ACC	REF

In the EU-15 regions, the best scenario over all goals was payment decoupling (REF). Payment decoupling in these regions led to the smallest reduction in farm numbers while still generating a tolerable farm income. However, in maintaining extensive grassland as well as farming in general and with respect to the goal “environment”, the baseline scenario showed a better performance than the REF scenario (DE, DK).

In the Italian region, the good performance of the baseline scenario in keeping labour in agriculture was mainly related to the higher stocking numbers and the structure conserving impacts of this scenario. In total, the REF scenario was the first best option underlining the trade-offs between the different goals. In the New-Member-State regions the accession scenario (“ACC”) was the best scenario with respect to almost all goals as it conserved the farm structure best, generated the highest farm income and led to the smallest abandonment of grassland areas.

In all regions, the two no-direct-payments scenarios in total performed worse than the direct-payment-scenarios, though in the Polish region S2 had the best performance with respect to the environment goal as a result of the antagonistic behaviour of the only two environmental indicators in this region.

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Recreating Context in Spatial Modelling of Agricultural Landscapes

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Abstract

This study uses spatial location of farms as a case of recreating context in spatial modelling of agricultural landscapes. When working with generally available agricultural structural data such as FADN data, spatial reference on farm location is not available. This means that methods to reliable recreations of spatial context must be developed. This study recreates spatial location of farms within a German and a Danish agricultural landscape where real farm locations are known, using an approach based on indexation of structural heterogeneity. The approach can be used generally since it is based on the utilisation of generally available data across the EU countries. Based on the Danish case, it is concluded that the method leads to a close to random location of farms. An additional case study carried out in Italy concludes that initial spatial location of farms is important in an area with great spatial heterogeneity like Italy, but might mean less in spatial homogenous areas like Denmark and Germany.

Keywords: spatial context; modelling; farm location; sensitivity; reliability

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1 Introduction

To recreate a reliable representation of the complex reality is one of the fundamental challenges in creating empirically founded models. Numerous models are based on abstract representations of the underlying system and do not need the empirical foundation for investigating the characteristics of the object of study. However once the findings from the models are used for policy recommendations, realistic and empirical founded models are preferred. This is also the case when the task at hand is locating farms within a landscape. Obtaining sufficiently empirical data for models through field studies is seldom possible. Most models are instead relying on available data from databases or other collectively gathered information. The accuracy of these data differs a lot. Many of the most adequate economic data are indirectly collected by the local authorities through the assessment of taxes or similar administrative issues, with the International Association of Classification Societies (IACS) as a prominent example. This means however, that the most reliable data are at times restricted to insure personal privacy. The European Farm Accountancy Data Network (FADN) is one of these large but restricted data collections. Every year a large sample of farm accounts is collected in each of the member states in the European Union. From this base sample a number of so-called "representative" farms are found. Each with an extrapolation factor constructed in such a way that the farms provide a representative sample for the commercial farms in a given region. The extrapolation factor incorporates the regional characteristics, the economic size and type of farming found in the whole collection. The term "representative" as well as the accuracy of the methodology is up to debate within the scientific community (Beers et al. 2001; Meier 2004, 2005).

The sensitive nature of the micro-economic data within the FADN sample means, that the data comes with no other specific geographical reference than which region/country the collective sample represents. However the spatial nature of agricultural production means that both the farms' production potential as well as its impact on the surrounding environment makes it vital for a potential modelling application based on FADN-data to recreate the plausible spatial locations of the farms in the sample.

A few attempts based on indirect statistics have previously been published (Fais and Nino 2004; Fais et al. 2005). One of the most ambitious attempts is undoubtedly the work done by the SEAMLESS project (Elbersen et al. 2006). The methodology developed here is also making use of statistics and remotely sensed data. However the restricted nature of the

FADN data sample makes it difficult to validate the findings. The analyses in the MEA-Scope project have thus taken a novel approach.

The basic challenge for using farm data gathered from FADN is to connect them to locations in the landscape. The context for spatialising farm data in each of the case study areas which MEA-Scope was based on ranged from having extensive spatial knowledge on the actual location of farms and on to having very limited knowledge (Fig. 1).

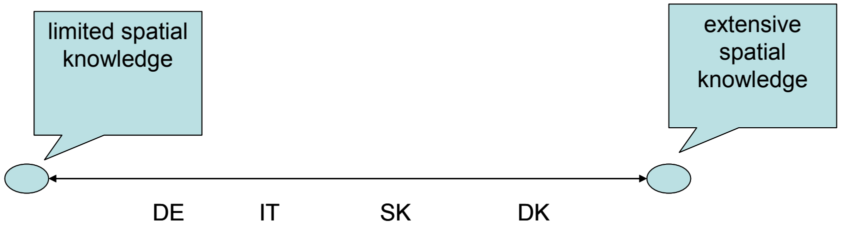

Fig. 1. Types of spatial knowledge on location of farms

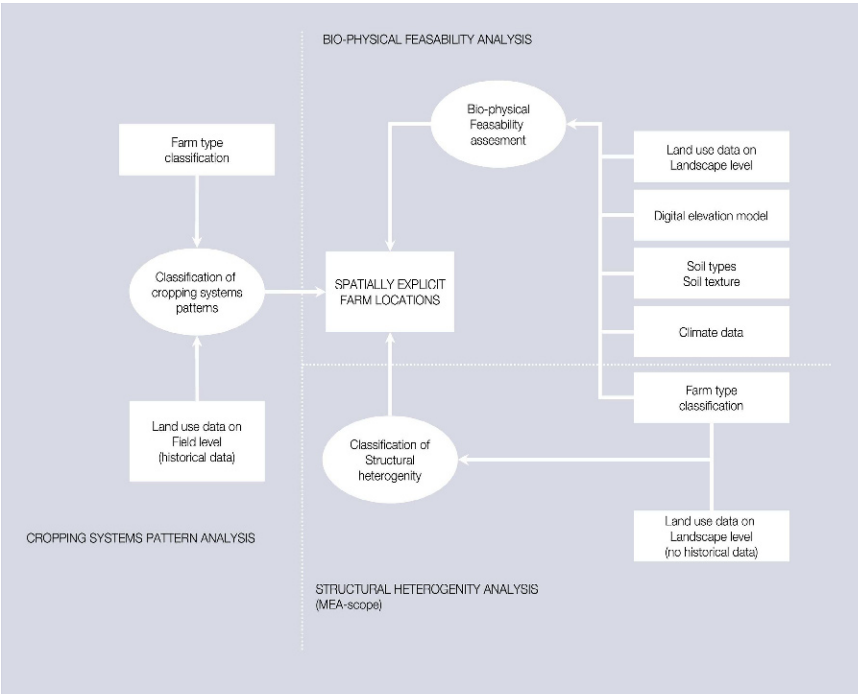

Fig. 2. Pathways to specialising tabular farm data (Kjeldsen et al. 2005)

There are several parallel pathways to try to “spatialize” tabular farm data, depending on the level of spatial knowledge available. In the MEA-scope project, at least three pathways have been used, (Fig. 2).

Two of these approaches are relatively common approaches and are dependent upon a high level of spatial knowledge. The first approach is to determine the spatial location of farms via an assessment of the biophysical feasibility of a given set of sites for a given type of agricultural production. The other approach is an analysis of historical cropping patterns on a given territory in order to determine what types of farms are present. The latter approach is distinguished by a higher degree of dependence on highly detailed spatial and temporal data. The third approach is what has been termed a structural heterogeneity approach (Kjeldsen et al. 2005). The basic idea behind this approach is to utilise data on the most general level which is available for all EU countries, namely land use data from Coordinated Information on the European Environment (CORINE land cover) and FADN farm data. Based on the information there, an indexation of structural heterogeneity can be carried out and used to locate farms in the landscape. The approach can thus be used as a general approach across all of the MEA-Scope case areas.

Approaches similar to the two first types have found extensive use in a wide range of scenario studies and studies related to land cover/land use change (WRR 1992; van Ittersum et al. 1998; van Latesteijn 1999; Irwin and Geoghegan 2001). Even though, a possible application of these approaches in the present context faces some problems. One of them is the lack of historical data on land use in the case areas, as well as the lack of data on field level. Yet another problem is the overall validity of using a bio-physical assessment approach, since this approach presupposes that it is possible to deduct from the bio-physical context for farming and on to spatial location, without including socio-economic factors in the actual location pattern of farming systems. At least for regions with less spatial heterogeneity it will be hard to leave out the socio-economic dimension. All this left the MEA-Scope project with the third approach, which should aim at demonstrating how farms can be located in the landscape, using generally available data (CORINE land cover and FADN samples).

This study is using a sample of 1871 farms located in the Danish watershed to river Gudenå. Both the exact location as well as production data for all the 1871 individual farms are known with similar categories as offered in the FADN sample, with the exception of the economic data present in the FADN sample. Modelling with the agent-based simulation model AgriPoliS in an agricultural catchment in the Danish river Gudenå watershed is used as the basis of evaluating the approach. As mentioned above, the approach is based on indexation of structural heterogeneity of land use patterns, which again is used to locate farms from an FADN sample. As it will be concluded regarding this approach, it leads to more or less random spatial location of farms. The initial conclusion is that there is no substitute for collecting actual farm data to insure the ability to reproduce a reliable map of a given region. But this does not tell us much about what the significance of these findings are, in the meaning that this does not tell how sensitive our model is to random farm location. In order to evaluate that, we have also tested the spatial sensitivity of the model AgriPoliS. A preliminary investigation of this issue has been carried out in the Italian case area.

2 The Structural Heterogeneity Approach to Recreating Context

What we positively know about the spatial characteristics of the farms in the case areas is the distribution between arable and grassland on the individual farms, as this is listed in the FADN sample. Our assumption is here, that farms with a given structural composition, calculated as the index value of the ratio between grassland and total farm area, must be located within parts of the landscape which exhibits similar structural characteristics. The calculation is expressed by this equation:

$$I_{100} = GA_{1\dots n} / TA_{1\dots n} * 100$$

Where I_{100} is the grassland index value, $GA_{1\dots n}$ is the area with grassland for farm 1 to n and $TA_{1\dots n}$ is the total area of farm 1 to n. When this indexation is applied on the land use maps for the case areas, calculation is done in a neighborhood. The structure of how the calculation is carried out, using a raster environment in the GIS software package ArcGIS, is illustrated in Fig. 3.

Neighborhood size thus defines how much of the surrounding pixels which should be included in the analysis. The land use classes in the CORINE land cover were prior to the calculation reclassified, with grassland pixels set to 1 and all other land use types set to 0. The value calculated then expresses the share of grassland in the neighborhood. The calculation yields a map, which gives a fuzzy measure for the structural characteristics of the case areas. The advantage of using a fuzzy measure is that an exact fit is not needed for aligning farm index values, which otherwise would prove very difficult to obtain in the actual map of the landscape. The mean index values per grid cell were then grouped in 10 intervals between 0 and 100, which adds to the fuzzy character of the measure.

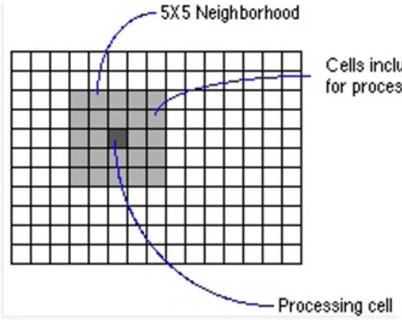

Fig. 3. Structure of the FOCALSUM function in ArcGIS spatial analyst

The same reindexation into 10 intervals between 0 and 100 was also applied to the FADN farm data for the German case area, and joined to the index map. This procedure produces a virtual farm map, which depicts areas within which selected farm types are likely to be present in (see Fig. 4).

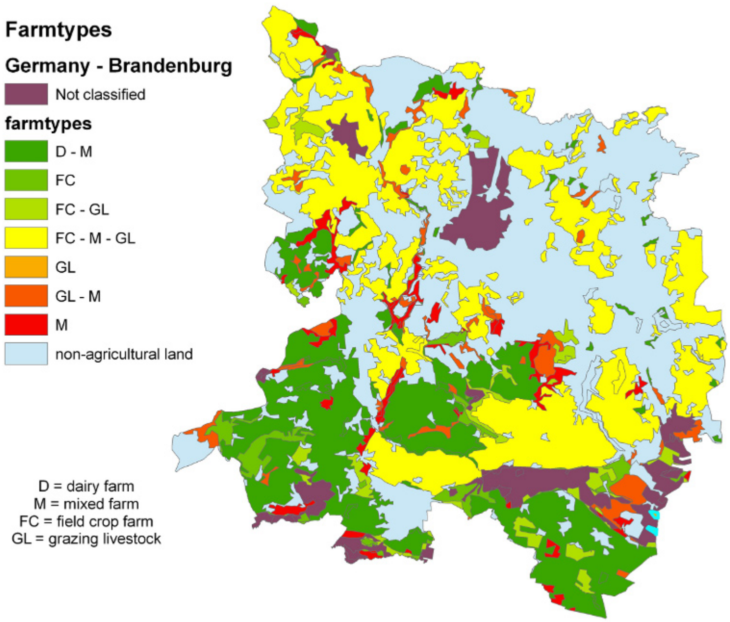

Fig. 4. Virtual farm map for the German case area

One major problem with the calculation, as it is demonstrated for the German case area, is that it can not be validated, as there is no reference map available. In the Danish case area the situation was quite different, since a reference was available.

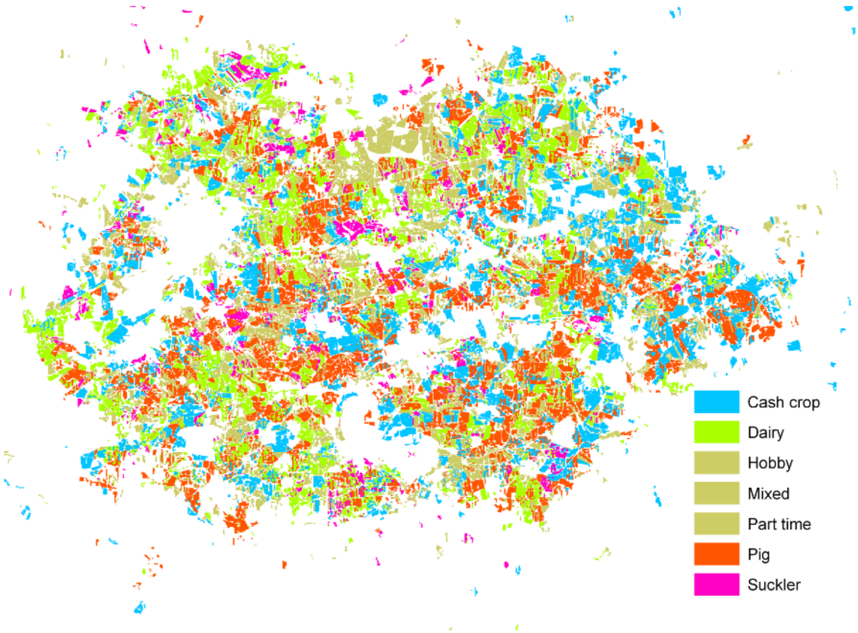

Fig. 5. Farm type distribution on field level in the Danish case area

The same calculations as in the German case area was then applied for the Danish area, thus leading to at series of maps of grassland/arable index values with varying neighborhood sizes (see Figs. 5 and 6). Calculations were carried out for neighborhood sizes 25, 100, 400, 900, 1,600 and 2,500 ha. Increasing neighborhood size leads to a significant reduction in frequency distribution of index values. But when used for spatialising the farms in the FADN sample, all of the neighborhood sizes exhibit only minor variations in terms of frequency distributions of deviation to the reference map. The measure of deviation between real and virtual farms is the Euclidian distance between them.

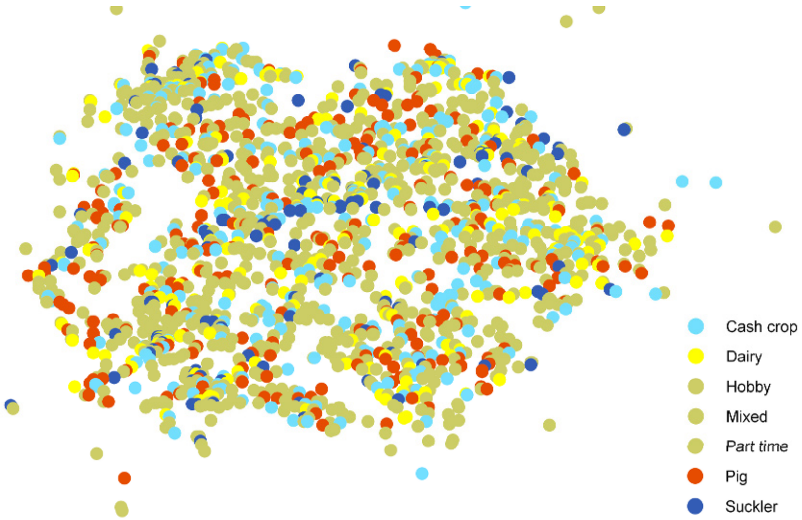

Fig. 6. Virtual farm map for Danish case area based on indexation neighborhood size of 25 ha

The frequency distribution between the calculations differs only to a minor degree. For all of the calculations for the 5 different neighborhood sizes, the mean values of deviation in relation to the reference farms are roughly around 19 kilometers. Given that the size of the Danish area is around 55*40 km, distribution of the proxy farms is more or less random. This leads to the conclusion, that the proxy farms for the German area are supposed to exhibit the same degree of randomness and that there does not seem to be any obvious substitute for mining "ground truth" from this area, meaning information on the real location of the farms.

3 Evaluating Results Using a Sensitivity Analysis Approach

To investigate how the initial spatial location of the farmsteads and their fields influence modelling results, ten maps of the Italian region of Mugello have been constructed. On each of these ten maps the farms have the same amount of arable and grassland even though farmsteads and fields are located differently. All other factors are kept unchanged between the ten different simulations. Also the spatial sensitivity of the distribution of the different landscape characteristics is investigated. The Italian region has been chosen as the spatial sensitivity in a mountainous region must be particular large. Hereby is the most extreme deflection due to the spatial sensitivity investigated?

For this analysis 30 soil maps were constructed where sub-types within the group of arable land and within the grassland types where shifted locations. This means that the maps were constructed without any resemblance to the real landscape other than that the areas with arable and grassland maintain the same. Table 1 provides an overview of the combinations of the site types used in the analysis.

Table 1. Combinations of site types in Mugello

Soil type	Number
Arable_Land_High_Hills	0
Arable_Land_Low_Hills	1
Arable_Land_Low_Mountain	2
Arable_Land_Plain	3
Arable_Land_Terraces	4
Grassland_High_Hills	5
Grassland_Low_Hills	6
Grassland_Low_Mountain	7

In Table 2 the grey marked numbers in the second column (the location of the soil) show the real sub-soil type by which another sub-soil type has swapped place. That means that soil type 1 occupies the location of soil type 0 while type 0 occupies the location of type 4 and so on.

Table 2. Configurations of site types in 30 maps with shifting landscape characteristics

The location of the soil	The number of the soil map																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
0	0	1	2	3	4	0	0	0	0	0	0	3	0	0	1	1	1	2	2	0	0	0	0	0	0	0	0	4	4	4
1	1	2	3	4	0	2	3	4	1	1	1	1	2	2	0	3	4	0	3	2	3	3	3	3	3	4	4	0	2	2
2	4	3	4	0	1	1	1	1	3	4	3	4	3	4	2	4	0	1	1	1	2	1	4	2	4	3	3	3	3	1
3	2	4	0	1	2	3	2	2	4	3	2	2	4	3	3	0	2	3	4	4	4	4	1	1	2	1	2	2	0	0
4	3	0	1	2	3	4	4	3	2	2	4	0	1	1	4	2	3	4	0	3	1	2	2	4	1	2	1	1	1	3
5	5	6	7	5	6	7	5	6	7	5	6	7	5	6	7	5	6	7	5	6	7	5	6	7	5	6	7	5	6	7
6	7	7	6	7	5	5	6	7	6	7	5	5	6	7	6	7	5	5	6	7	6	7	5	5	6	7	6	7	5	5
7	6	5	5	6	7	6	7	5	5	6	7	6	7	5	5	6	7	6	7	5	5	6	7	6	7	5	5	6	7	6

Modifying the maps by such a dramatic procedure will of course produce considerable variations in the simulated results. By shifting the location of the sub-soil type is the farms sensitivity towards they initial possession of different sub-soil types investigated. The region share of different quality soils will at the same time differ. So in some of the artificial created landscapes are larger areas covered with better soils as in the reality. In other simulations is the opposite the case.

In this investigation, the benchmark that both the 10 different farm location and the 30 different allocations of landscape characteristics has to be measured against, is the region simulated with the presumed right farm location on the regional landscape characteristics subject to a continuation of a Agenda 2000 like support scheme. This means that the farms not subject to any abrupt changes in their wider environment and the region is thus subject to a stable development.

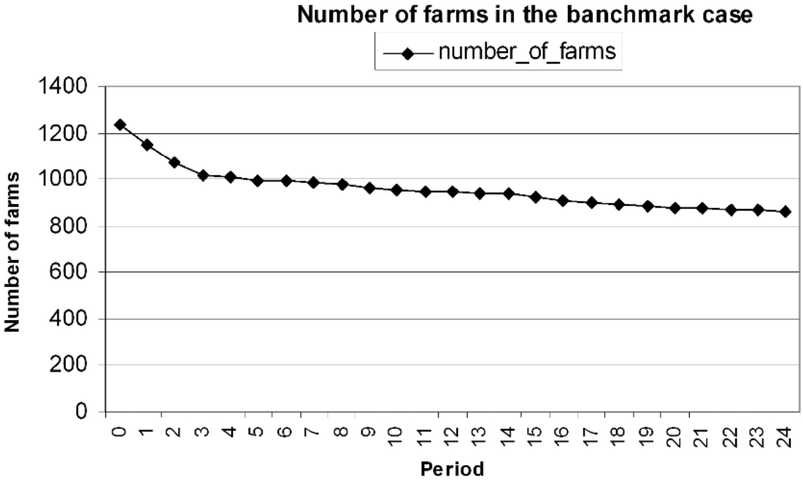

Fig. 7. Number of farms in the benchmark case

Eventhough the region does not experience large abrupt changes from the political level; the region will still undergo structural development. The competition between the farms will force some of the farms out of the sector while other will flourish and grow. The region initially has 1,237 farms in period 0 and in period 24 only 864 are left (as can be seen in Fig. 7). These numbers cover variations between different farm types. It is this structural development within the region that the 10 different farm locations and the 30 different allocations of landscape characteristics will be benchmarked against.

In the case of the 30 different allocations of landscape characteristics the locations of the farms are maintained as in the benchmark case, only the soils below the farm and its fields are changed. There are of course large variations in the number of farms surviving all 24 periods of simulation between the 30 different simulations. In general a considerably lower number of farms are enduring the full 24 simulation periods. In Table 3 the average, mean, maximum and minimum number of farms for period 0, 5, 10, 15, 20 and 24 of simulation is shown.

Table 3. Average, median, maximum and minimum values for structural development in simulations with shifting landscape characteristics

Period	0	5	10	15	20	24
Average	1,237	911.23	799.56	690	609.8	563.96
Median	1,237	881.5	807	712.5	638	574
Maximum	1,237	1,000	956	879	827	797
Minimum	1,237	853	664	518	400	339

In Table 4 is the average, median, maximum and minimum values relative to the benchmark –1 shown in percent. The lower number of farms within the 30 different allocations of landscape characteristics simulation is particular evident when the number of farms in the benchmark case is compared to the maximum number of farms in anyone of the 30 simulations. The number of farms in the benchmark is higher in period 15, 20 and 24. This strong decline in the number of farms in the landscape characteristics simulations is clearly an expression of the misfit between the farms and the landscape characteristics of their fields. Even though allocation of farms and fields in the benchmark version also is an artificial construct, the matching between the landscape characteristics and individual farm location is optimised with respect to the real landscape. Thus the artificial landscapes must be hindering more farms to survive. This documents that the model is sensitive towards changes in landscape characteristics. At the same time the large however not too extreme variation among the 30 different simulations shows that the model reacts to the different initial conditions without running into the pitfall of some obvious extremes such as the termination of all regional farming enterprises.

Table 4. Overall number of farms in simulations with shifting landscape characteristics

Period	0	5	10	15	20	24
(Average /Benchmark)–1 (%)	0	–8.6	–16.01	–25.4	–30.62	–34.72
(Median / Benchmark)–1 (%)	0	–11.58	–15.23	–22.97	–27.41	–33.56
(Maximum / Benchmark)–1 (%)	0	0.3	0.42	–4.97	–5.91	–7.75
(Minimum / Benchmark)–1 (%)	0	–14.44	–30.25	–44	–54.49	–60.76

The overall number of farms as either average, median, maximum or minimum hides again differences between the ability of different farm types to cope with variations in landscape characteristics.

In the case where the landscape characteristics maintain the real ones and the location of the farms within this landscape changes, the results looks different. In Table 5 is the average, mean, maximum and minimum number of farms for period 0, 5, 10, 15, 20 and 24 of the 10 simulations shown.

Table 5. Average, mean, maximum and minimum number of farms in simulations with shifting farm locations

Period	0	5	10	15	20	24
Average	1,237	983.5	929.5	869.7	823.6	796.7
Median	1,237	985	920.5	855.5	810	783
Maximum	1,237	997	961	931	900	875
Minimum	1,237	972	905	846	795	764

In Table 6 is the average, median, maximum and minimum values relative to the benchmark –1 shown in percent of the 10 different farm location simulations.

Table 6. Values relative to benchmark in simulations with shifting farm locations

Period	0	5	10	15	20	24
(Average / Benchmark)–1 (%)	0	–1.35	–2.36	–5.98	–6.3	–7.79
(Median / Benchmark)–1 (%)	0	–1.2	–3.3	–7.51	–7.85	–9.38
(Maximum / Benchmark)–1 (%)	0	0	0.95	0.65	2.39	1.27
(Minimum / Benchmark)–1 (%)	0	–2.5	–4.94	–8.54	–9.56	–11.57

The sensitivity of the different farm locations is – as expected – clearly much lower compared to the location of the landscape characteristics. Though the variations between the 10 simulations or relative to the benchmark is considerable smaller there however still are measurable differences. Regarding the large effects of the allocation of landscape characteristics on the farms' performance, a considerable part of these variations can be caused by the unavoidable small displacements of landscape characteristics between some of the farms. The relatively small variations demonstrate however that the displacements must be mirror. Another likely component for the variation between the 10 different farm location simulations is of course the changes in the individual farms local competition for land. The effect of the competition is however only witnessed indirectly.

The structure of the development is broadly in line with the benchmark simulation. There are of course variations between the values for the individual farm types as also reflected in the number of farms, but none of the farm types witnesses dramatic changes due to the different farm locations. So though the model is affected by the spatial location of the individual farms and this is reflected in the variation of the exact number of farms surviving at a given time period, the structure of the regional development is not changing in any notable way. It is the case when the model is subject a stable political development that the spatial location of the individual farms exhibits these minor disturbances.

4 Conclusions

This study first concludes that the approach chosen for locating farms in Denmark leads to a close to random spatial distribution. This might also be the case in the German case, but reference data, which might confirm this, is not available. Further development of models to allocate farms in space might improve reliability, which must be carried out in future studies. Even though spatial location of farms might be close to random, it is not given that this affects modelling results. In our study, a sensitivity analysis of modelling with the model AgriPoliS in a spatially heterogeneous area of northern Italy points towards that the model is fundamentally stable in its results at the same time as it reacts to changes in the initial conditions. The initial spatial constellation of the farmsteads and their fields seems to play an increasing role once the model is simulating sudden dramatic changes in the structural development. This underlines the importance of recreating a reliable allocation of the farms in space and supports the argument of incorporating the spatial dimension into the model. Since this is the case in an extreme case as the mountainous regions of Northern Italy, this might not necessarily be the case in the spatially homogenous areas of North-Western Europe, like in this case Denmark and Germany. Further studies of spatial sensitivity in spatially homogenous settings will be necessary in order to address this issue. Given the fact that in most cases, reference data on farm location is not available, there is every reason to put much effort into securing reliable recreations of spatial context for modelling of agricultural landscapes.

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Spatial Characteristics of Land Use Patterns in Mugello (Central Italy) and Policy Impacts on Their Environmental Outputs

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Abstract

Scenarios induced land use changes and their effects on abiotic and biotic indicators are analysed for a heterogeneous territory in Northern Tuscany. Results show that under a specific policy scenario the responses are highly variable within a given region depending of the landscape component considered and that scenarios induced changes result in significant modifications of land use patterns. The changes in crop spatial pattern are clearly differentiated in three groups of responses depending upon the scenario settings. The spatially explicit approach adopted proved to be necessary to properly evaluate the impacts of policy scenarios on the environmental services provided by agriculture.

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1 Introduction

The modelling tool set up within the MEA-Scope project (Piorr et al. 2007) allows identifying the supply of NCOs with focusing on environmental services. In order to do so two spatial scales of reference are considered within the tool: the farm scale and the landscape scale (Dalgaard et al. 2007). The link between farm typology and site topology must then be consistent with the physical and the ecological characteristics of the landscape and with the potential values of its components on one side, and with the economic activities that take place on these components on the other.

Data collection and inputs structuring for the application of the MEA-Scope tool to the Italian study area have paid particular attention to the spatial aspects of landscape functions so to explicitly account for their spatial heterogeneity. Within this approach it is possible to analyze models' outputs following the same spatial hierarchical structure adopted to structure the input data required by the MEA-Scope modelling tool.

2 The Study Area

The Mugello area (1,126.71 km^2, elevation 1601,241 a.s.l.) in Northern-Central Tuscany (Fig. 1) is dominated by the large valley bottom of River Sieve, formed on a paleo-lacustrine environment, and surrounded by two main ranges, which are part of the principal North Apennine chain.

The valley has a NW-SE orientation, roughly parallel to the Apennines chain. The area has a temperate climate with dry summer (annual average temperature 13.5°C, average annual precipitation 9,501.200 mm yr^{-1}). Land cover is mainly broad-leaf woodland forest (65%), followed by permanent non-irrigated arable land (4%) and permanent pastures (3%). In terms of UAA (32,111 ha), this represents only 28.5% of the total area (National Institute of Statistics, ISTAT 2002), with a reduction of 6.9% with respect to the previous general census (1991).

The Mugello counts about 57,600 inhabitants (National Institute of Statistics, ISTAT 2002) with the lowest population density of the province (51 km^{-2}) but with a 6% increase with respect to previous general census; 5% of the working population is employed in agriculture (average age 65 years) with 1,774 farms (2,540 in 1991) of an average size of 18.1 ha

(ISTAT 2002). Notwithstanding the decrease in the number of farms and in both total and utilized agricultural areas, agriculture still represents a strategic sector of local development, with a relevant share of organic farming with 132 biological farms (7.4% of total farms and 19.9% of UAA). The distribution of livestock resources contributes, especially through cattle and ovine farms, to the definition and maintenance of typical landscape features in certain areas (marginal lands of high hills and mountains). Concerning cattle, Mugello counts 9,822 heads (ISTAT 2002), more than 70% of the entire province of Florence, with 835 specialized farms (beef and dairy). Such relevance is confirmed in terms of density, with 13 heads of cattle every 100 ha of agricultural land. The value exceeds the Florence province average of 7 heads of cattle per 100 ha. More than 20% of cattle farms in Mugello (256 or 55% of the province) are organic farms, with 40% of heads. Permanent grasslands and pastures represent more than 40% of UAA. Natura 2000 areas cover about 499 km^2 (23%).

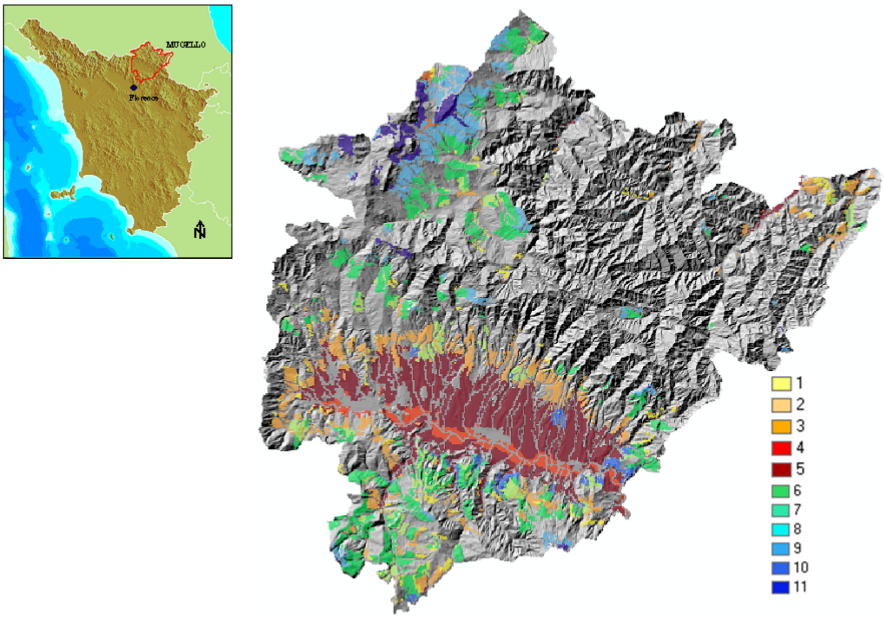

Fig. 1. Study area and field type map (1: Arable high hills; 2: Arable low hills; 3: Arable low mountain; 4: Arable valley plain; 5: Arable valley terraces; 6: Grassland high hills; 7: Grassland low hills; 8: Grassland low mountains; 9: Grassland valley terraces; 10: Grassland high mountain; 11: Grassland valley plain)

3 Field Type Definition and Mapping: Linking Farm Typology and Site Topology

In order to use the MEA-Scope modelling tool in a spatially explicit context, farm production techniques must be allocated in the landscape, coherently with climate, soil and terrain constraints. In the absence of digital IACS/LPIS (Integrated Administration and Control System/Land Parcel Identification System) for the study area, an automatic allocation is not possible, which means that the assignment of farm typology to different site topology must relay on different and combined data sources. A map-classification model (Fig. 1), based on a number of specific “field types”, was developed for identifying the suitability of the territory on the basis of empirical and theoretical evidence, based on a multi-criterion approach in a GIS-environment. The following layers were used to derive the field types map: Digital Elevation Model (DEM 10 m resolution), soil map (1:50,000), map of Land Capability Classes (LCC, 1:50,000) derived from the soil map, revised CORINE Land Cover (CLC 1:50,000).

Table 1. Field types classification

Plant production system			Site		Soil LCC		
Use	Altitude	Intensity	Field type (share %)	Morphology	1st	2nd	3rd
Arable	Valley < 300 m	High	VL (7.7%)	Plain (slope <5%)	3	3/4	
			VH (54.4%)	Terraces (slope >5%)	2	3	
	Hills 300-700 m	Medium	HL (28.9%)	Low (< 500 m)	3/4	4	4/6
			HH (8.4%)	High (>500 m)	4	6	
	Mountain >700 m	Low	ML (0.6%)	Low (< 900 m)	6	4	
Grass-land	Valley < 300 m	Low	VL-G (0.14%)	Plain (slope <5%)	3	3/4	
			VH-G (50.7%)	Terraces (slope >5%)	2	3	
	Hills 300-700 m	Low	HL-G (21.2%)	Low (< 500 m)	3/4	4	
			HH-G (50.7%)	High (>500 m)	4	6	4/6
	Mountain >700 m	Low	ML-G (21.2%)	Low (< 900 m)	6	4	
			MH-G (8.7%)	High (< 900 m)	6	4/6	

Each field type (Table 1) results then from a combination of soil type, terrain morphology, elevation class and climatic conditions characterized by different intensity of land use. In each field type, given a specific set of environmental constraints (soil depth, available water capacity, slope, rockiness, stoniness, elevation, drainage, chemical fertility etc.), the typical crop rotations and associated production techniques were allocated. Crop allocation (Table 2) resulted from direct surveys and interviews, statistical data from the agricultural census (ISTAT 2002) and revised CLC.

Table 2. Crop allocation in the different field types.

Field Type	CROP 1	CROP 2	CROP 3	CROP 4	CROP 5	CROP 6
VL	Triticum durum	Hordeum vulgare	Zea mays	Medicago sativa	Vicia faba var. minor	Others
VH	Hordeum vulgare	Zea mays	Triticum durum	Vicia faba var. minor	Medicago sativa	Others
HL	Vicia faba var. minor	Hordeum vulgare	Triticum durum	Triticum spelta	Medicago sativa	Helianthus annus
HH	Vicia faba var. minor	Triticum spelta	Hor-deum vulgare	Medicago sativa	Helianthus annus	Others
VH-G	Leafy permanent fallow (3-10 years, minum care)					
HL-G HH-G	Leafy permanent fallow (3-10 years, minum care)					
ML-G MH-G	Leafy permanent fallow (3-10 years, minum care)					

Typical crop rotations in the Mugello (year): VH, VL: Maize (1–2) Barley (3) Maize (4–5) Alfalfa (6–10); Barley/Wheat (1) Maize/Sorghum/Sunflower (2) Alfalfa (3–6). HL, HH: Maize (1–2) Barley/Wheat (3) Fava bean (4) Barley/Wheat (5) Alfalfa (6–10); Barley/ Wheat (1) Silage maize (2) Alfalfa (3–6). HH: oat (1) potato (2) spelt (3) grassland (4–8).

4 MEA-Scope Policy Scenarios: Land Use Changes

Since land use is one of the primary determinants of ecosystem vulnerability, the assessment of changes in land use pattern for the different scenarios (Table 3) is crucial to understand how environmental services provided by agriculture are affected by the different policy scenarios. The general cropping pattern at the initial reference state (BAS00) is highly differentiated in terms of occurrence of the different crops in the different field types (Table 4).

Table 3. The MEA-Scope policy scenarios. Results are always considered at year 0 (BAS00 = initial state) and at year 5 (short term) and 9 (medium term)

Scenario	1st Pillar	2nd Pillar
BAS	Agenda 2000	AEP, Natura 2000
REF	Decoupled single farm Payment	AEP, Natura 2000
S01	No subsidies	AEP, Natura 2000
S02	No subsidies	No AEP, no Natura 2000
S03	Decoupled single farm payment + ceiling	AEP, Natura 2000

Grassland in Mugello is exclusively run under extensive grassland use, which are grassland areas (3–10 years) that receive a minimum grassland care of one cut per year. Under all scenarios there is an increase in arable land and a decrease in grassland that disappears completely under the S02 scenario in all field types. Under all scenarios there is a dramatic abandonment of the mountain grassland field types (MH-G and ML-G): –62% at BAS09, –51% at REF09 and –91% at S0109.

Table 4. Crop share in the arable field types for the main crops of the area: relative differences (%) with respect to initial state; in italics crops whose share drops down to 0%

Scenario	Field type	Fava bean	Alfalfa	Set aside	Barley	Spelt	Maize
Initial	HH	26.3	14.9	9.0	26.3	0.0	16.5
BAS09	HH	–15.6	12.5	2.1	2.5	0.0	2.6
REF09	HH	*–26.3*	5.3	–0.1	27.5	0.0	–0.5
S0109	HH	*–26.3*	14.0	13.4	–18.9	0.0	24.8
S0209	HH	*–26.3*	10.5	12.0	*–26.3*	0.0	37.2
Initial	HL	17.4	15.9	8.2	26.8	14.0	13.3
BAS09	HL	–7.3	9.9	2.4	–2.6	–5.1	4.3
REF09	HL	*–17.4*	2.9	0.7	29.5	*–14.0*	1.9
S0109	HL	*–17.4*	10.1	13.6	–18.5	*–14.0*	30.7
S0209	HL	*–17.4*	11.9	14.2	*–26.8*	*–14.0*	36.5
Initial	VH	10.7	27.6	9.0	10.9	17.0	0.0
BAS09	VH	–0.7	3.0	0.6	–3.9	–0.1	0.0
REF09	VH	*–10.7*	0.7	–0.3	23.2	*–17.0*	0.0
S0109	VH	*–10.7*	0.3	0.8	*–10.9*	*–17.0*	0.0
S0209	VH	*–10.7*	–3.2	0.5	*–10.9*	*–17.0*	0.0
Initial	VL	9.2	25.9	10.2	2.8	27.0	0.0
BAS09	VL	–1.9	–0.9	0.8	2.6	–1.5	0.0
REF09	VL	*–9.2*	1.2	–1.5	32.2	*–27.0*	0.0
S0109	VL	*–9.2*	9.7	–0.4	–2.8	*–27.0*	0.0
S0209	VL	*–9.2*	6.7	–0.4	–2.8	*–27.0*	0.0

The change in the share of set-aside land provides a clear picture of the structural changes under decoupled subsidies (REF and S03), that result in a relevant increase of uncultivated land, and under absence of subsidies (S01 and S02) where, on the contrary, there is a (nearly) complete disappearance of set-aside land and an increase of cultivated areas. The structural changes under decoupled subsidies (REF and S03) lead to an increase of arable lands in hilly field types and at the same time result in a relevant decrease of cultivated areas and in an increase of typical crops such as alfalfa and spelt that replace cereals. The structural changes under no subsidies (S01 and S02) result in an increase of arable lands in the valley field types (VH and VL) and at the same time lead to the abandonment of set aside practices with a relevant increase of cultivated areas under cereals (mostly maize and barley).

5 MEA-Scope Policy Scenarios: Environmental Services' Indicators

The environmental responses expressed in terms of a dimensionless Index of Goal Attainment (IGA) ranging from zero to one (Sattler et al. 2006) for a number of selected indicators are shown in Fig. 2, which illustrates the relative % change in IGA at year 9 with respect to the initial state for the whole area.

At year 9 under the BAS scenarios, all the selected indicators show a slight gradual decrease over time (from –2 to –5%), with the exception of the indicator for wild flora (fall germinating), which exhibits a positive trend with a final increase of 10% with respect to the IGA value at initial state. A marked decrease in IGA values is observed for all indicators under the two liberalization scenarios, with a relative decrease between 5 and 40% under S01 and between 7 and 44% under S02. In both cases, the less marked increase is observed for the indicator wild flora and the more relevant one for the indicator field hare. An opposite trend is observed under the decoupling scenario: in this case all indicators exhibit a positive trend, with a final relative increase with respect to the initial situation ranging from a +5.6% for the pesticide indicator to the +42.6% for the wild flora indicator.

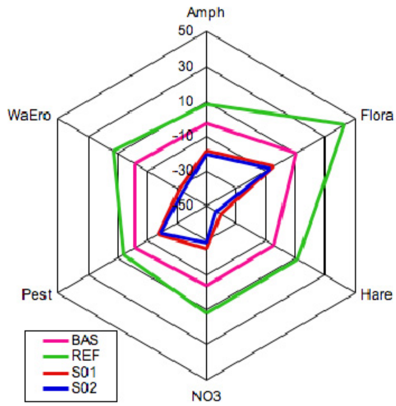

Fig. 2. Relative % change in index of goal attainment (IGA) at year 9 with respect to BAS00 for the selected indicators. *Amph:* impact on the habitat potential for amphibians (*Bombina variegata*); *Flora:* impact on the habitat potential for wild flora (fall germinating); *Hare:* impact on the habitat potential for field hares (*Lepus europaeus*); *NO3:* risk of nitrate leaching to groundwater; *Pest:* risk of pesticide entries into groundwater and surface waters; *WaEro:* risk of water erosion

Figure 3a–d shows the relative % change in IGA at year 9 with respect to the initial state for the different field types under arable lands. In the case of high hills field type (Fig. 3a) the trend is always positive under all the policy scenarios and for all the selected indicators, with the most marked increase in IGA under the decoupling scenario for the wild flora (+48%) and the water erosion risk (+31%) indicators. In the low hills field type (Fig. 3b), the changes in land use result in a positive trend of all the IGAs under the REF and the BAS scenarios, while in the case of the liberalization scenarios the trends are negative for field hare under both scenarios (–6 and –10% respectively for S01 and S02 at year 9) and for nitrate leaching risk under SO2 (–3% at year 5 and –1% at year 9). This is due to the marked increase in spelt share (37%) under the liberalization scenarios coupled with an increase in barley share (12%). The share of cereal crops in the low hills field type increases also under the BAS scenario, but in this case the increase is lower, resulting in higher IGAs. In the valley field types the effects of land use changes on agriculture's environmental services are generally negative but the response is again site dependent. In the valley terraces (Fig. 3c) the only scenario that results in an overall positive trend for all indicators is REF, while for all the other scenarios the trend is always negative for all indicators, with stronger decreases under the liberalization scenarios. The same holds for the lower valley field type (Fig. 3d), but in this case the decrease in IGAs is less pronounced for the liberalization scenarios and under BAS there is a positive trend, with increases between 3 (pesticide risk) and 10% (wild flora). In these cases too, explanations are to be sought in the changes in crops shares under the different scenarios: under S01 and S02 grain maize increases its share by 25–30% in the valley terraces and by 17–20% in the lower valley, while decreases by 11% in both field types under the decoupling scenarios and remains substantially unchanged under Agenda 2000. An average increase by 8% is observed for winter barley under the liberalization scenarios only in the lower valley field type, while set aside increases by 23 and 32% respectively in the valley terraces and in the lower valley field type only under the decoupling scenario, while decreases under the liberalization scenarios but less markedly than in the hilly field types.

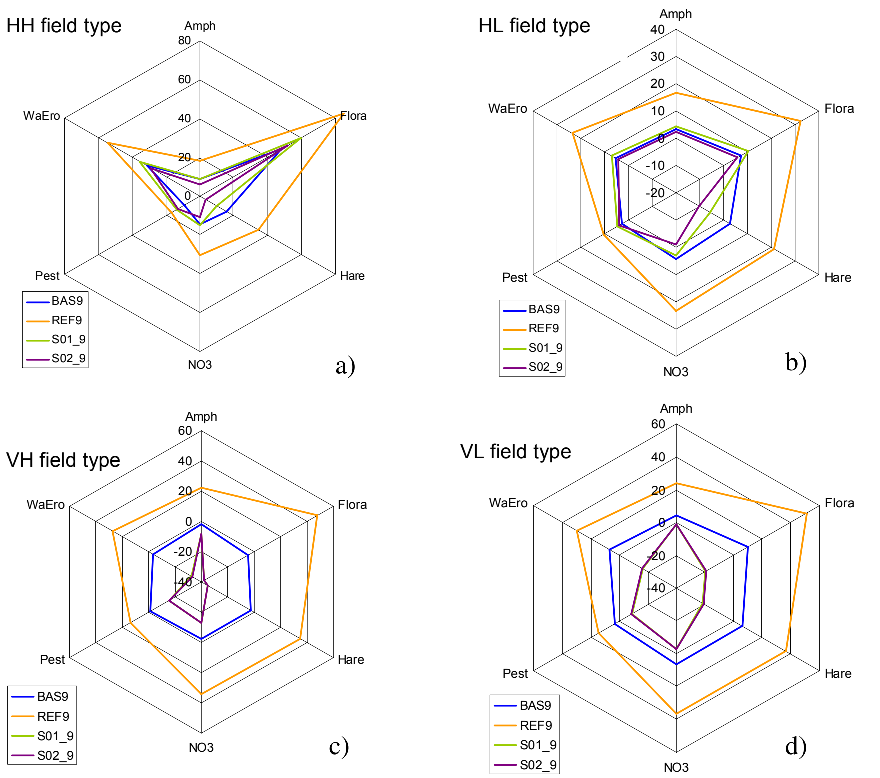

Fig. 3. Relative % change in index of goal attainment (IGA) at year 9 with respect to BAS0 for the selected indicators in the different arable field types

The effects of the changes in land use intensity on the environmental indicators can be better appreciated considering an indicator directly related to crop management practices such as nitrate leaching. This indicator depends upon four factors: (1) the total N-fertilization, (2) the frequency of fertilization, (3) the amount of N provided in autumn, and (4) the N balance at harvest. The average N input at the initial state for the whole area is 46 kg ha^{-1} yr^{-1}; this figure increases under all scenarios: 66.6 kg ha^{-1} yr^{-1} at BAS09, 49.9 kg ha^{-1} yr^{-1} at REF09, 114.1 kg ha^{-1} yr^{-1} at S0109 and 123.6 kg ha^{-1} yr^{-1} at S0209.

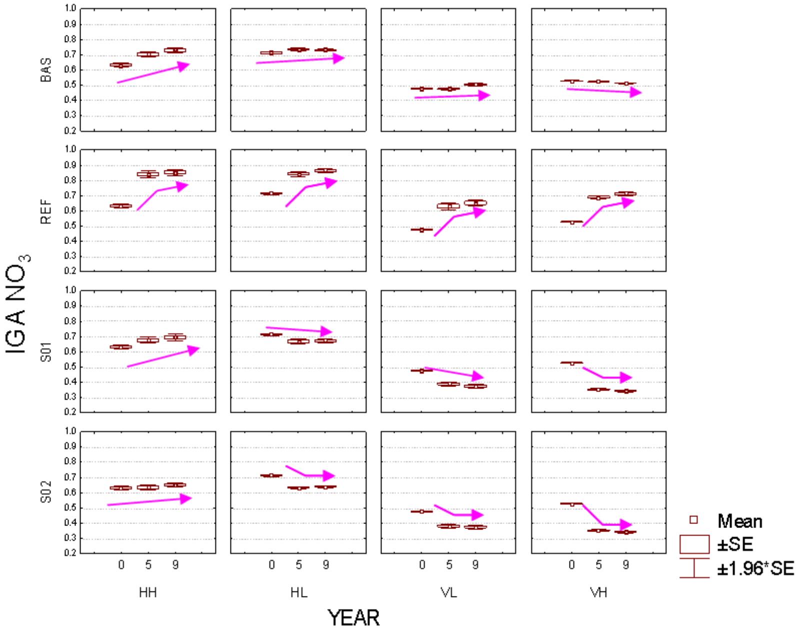

Fig. 4. Index of goal attainment for risk of nitrate leaching to groundwater (IGA NO_3): temporal trends in the different arable field types and four policy scenarios

The box and whiskers plots in Fig. 4 illustrate the different trends of the indicator in the different field types as resulting from increasing or decreasing land use intensity under the different scenarios. The trends observed are consistent with the level of N-input in the different field types at the different time steps as shown in Fig. 5.

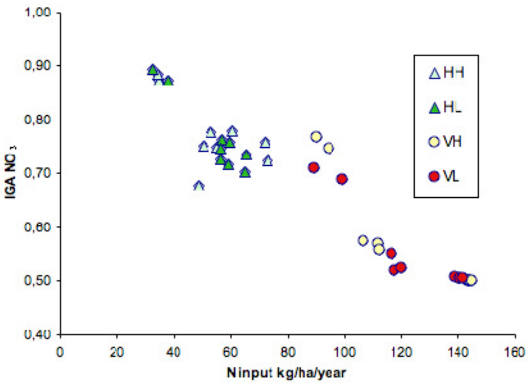

Fig. 5. IGA-NO_3 vs. average N input in the different field types

6 MEA-Scope Policy Scenarios: Quantifying Spatial Patterns

The raster maps in Fig. 6 (pixel size 1 ha) show the spatial distribution of the IGA for risk of nitrate leaching to groundwater at the initial state and at year 9 under the different policy scenarios.

Prior to analyze the differences in the spatial patterns of the indicator as clearly shown in Fig. 6, it is relevant to point out that the modelling system MODAM (Zander and Kächele 1999) does not simulate single crops, rather crop rotations within a given production system, allocating more than one crop to a 1 ha plot. For this reason it is not possible to localize a single crop in each plot at the different time steps, but rather its share in any specific plot. Each production system is on the other side characterized by a certain level of inputs (for example NO_3), which determine land use intensity at a given site, providing the basis for the environmental impact assessment (EIA) within MODAM (Sattler et al. 2006). Hence EIA results for a given area reflect the underlying production system(s) and the specific crop rotations associated with it. Then the spatial pattern of the indicator (for example IGA for NO_3) reflects the patterns of the different crop combinations in terms of input intensity, and its variations over time under the different scenarios are due to correspondent variations in cropping patterns.

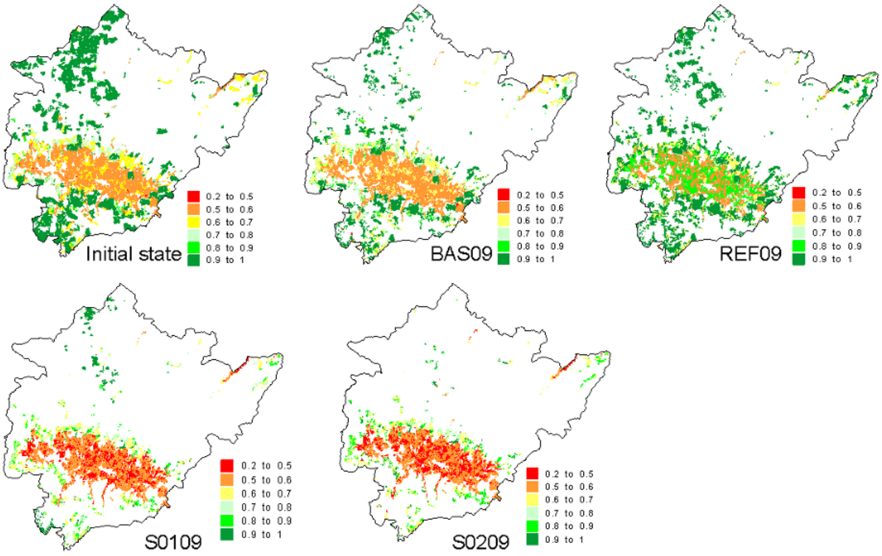

Fig. 6. IGA NO_3: spatial distribution at initial state and at year 9 under the different policy scenarios

The differences in the spatial patterns of the indicator shown in Fig. 6 result from: (1) reduction or disappearance of grasslands in parts of the area; (2) change in set aside land under the different scenarios; and (3) change in land use intensities related to different crop patterns.

In order to quantify and compare analytically the spatial structure of the land use intensity resulting from the different cropping patterns at landscape level under the MEA-Scope policy scenarios, the experimental standardized semivariograms (Fig. 7) of the IGA for NO_3 have been calculated and interpolated with authorized models (Goovaerts 1997).

Variograms are being used increasingly to investigate spatial patterns of raster data providing information about the spatial variability structure of the variable of interest, including land use (Dendoncker et al. 2007). In this case the structural changes of the variograms for IGA NO3 under the different policy scenarios result from substantial changes in land use patterns, with clear modifications with respect to the initial state. These differences are less relevant, although significant under Agenda 2000, more evident under the decoupling scenario, but quite dramatic for the liberalization scenarios.

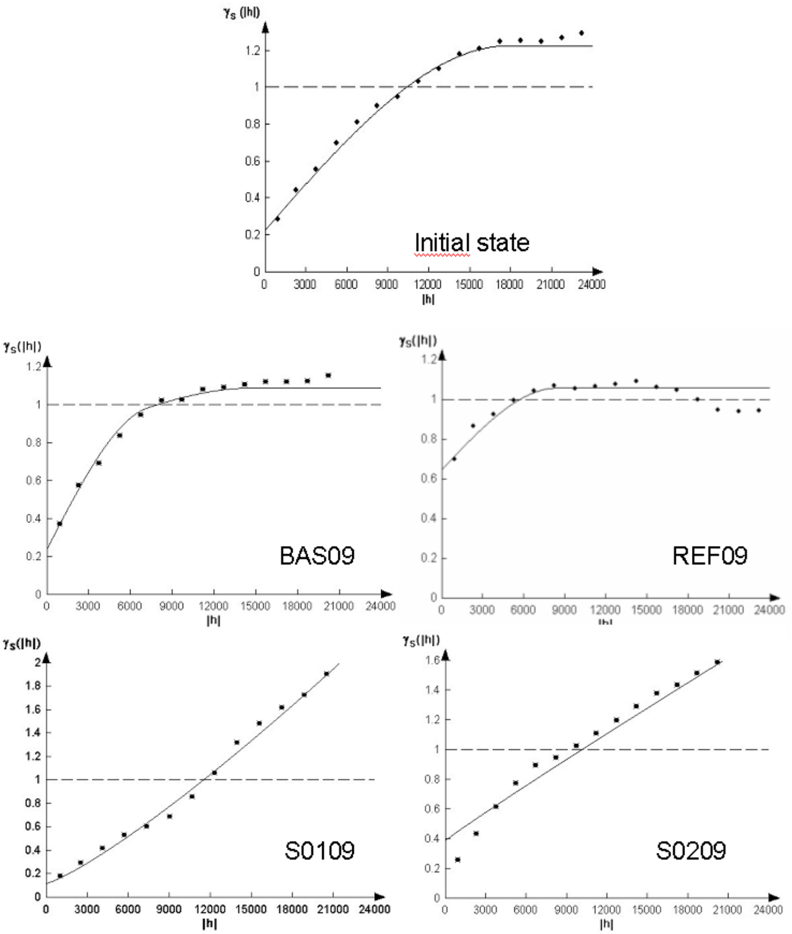

Fig. 7. Semivariogram models for IGA NO3 at initial state and at year 9 under the different policy scenarios. *Black dots*: experimental semivariogram; *continuous line*: semivariogram model

In terms of variogram model parameters, it is possible to identify a clear trend from the initial state to BAS09 and REF09, characterized by an increase of the nugget effect (spatially uncorrelated variance) and a decrease of the range of the variograms (i.e. the distance at which the observations are no longer spatially correlated), which are described by a spherical model with a nugget component in the three cases. The first evidence suggests an increase of the spatial randomness, i.e. a decrease of the spatially structured variability, and a higher degree of fragmentation; the second indicates a decrease in the size of patches with similar land use intensity, which under REF09 are more likely to be surrounded by smaller patches of contrasting land use intensity with respect to BS09 and to the initial state.

In the case of the liberalization scenarios, the spatial structure of the indicator is described with non-transition models (unbounded models without sill), for which the corresponding random function is only intrinsic and have neither covariance nor finite a priori variance (non-stationarity). In this two cases a power semivariogram model indicates the prevalence of large continuous and contiguous areas of different land use intensity, with a spatial pattern characterized by large patches of the same level of intensity and polarization of contrasting land use intensity in two main field type groups the HH-HL and the VH-VL field types, both characterized by a great degree of homogeneity within themselves.

7 Conclusions

The outcomes of scenario driven simulations can be of three kind (Ausdley et al. 2006): (1) similar for all scenarios: this implies that the outputs investigated are not as uncertain as the difference in the scenarios would suggest and, more important, policy makers cannot control it; (2) similar for groups of scenarios: this implies that a certain aspect of these scenarios has a large influence; this is then an indicator for policy makers concerned with outcomes; (3) different for all scenarios: this is the least informative although it may be possible to identify an observable trend in some of the output of the scenarios. This aspect is then an indicator for policy makers concerned with outcomes.

In terms of land use controlled environmental services, scenarios' outcomes for Mugello can be clearly distinguished in three groups: REF and S03 result in an extensification of the region farming system (increase of arable lands in hilly field types, relevant decrease of cultivated areas, increase of typical crops, such as alfalfa and spelt, replacing cereals); S01 and S02 result in an intensification of the region farming system (increase of arable lands in valley field types, abandonment of set aside practices, increase of cultivated cereal areas, mostly with maize and barley); BAS results in a moderate extensification in the hilly field sites and in a weak extensification in the valley field type. All scenarios showed an evolutionary trend characterized by the disappearance, complete under the liberalization scenarios, of open areas, coherent with the historical data for the mountain areas of the central Apennine (–18.6% between 1990 and 2000).

Responses in terms of environmental services at landscape scale appeared to be clearly and significantly site-specific with the different "field types" characterized by different degrees of vulnerability to policy induced changes on NCOs production.

Multifunctionality assessment in varied and complex landscapes such as Mugello cannot then ignore site specific conditions and constraints as ecosystem functions stemming for land use are strongly if not completely determined by changes in cropping patterns at farm scale driven by the different policy scenarios.

A spatially explicit approach is then required in order to properly evaluate the impacts of the different scenarios on the environmental services provided by agriculture and to provide sound indications to policy makers and stakeholders.

The changes in land use intensity highlighted by the different spatial autocorrelation functions observed for the different scenarios indicate that the scenarios induced land use changes at medium term are likely to result in radical changes of landscape patterns (i.e. homogenization with trend under the liberalization scenarios; a more complex and fragmented mosaic under decoupling and a strongly spatially structured pattern under Agenda 2000) and its ecological functions.

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Part III

Linking Scales, Policy Issues and Impacts

Scaling from Farm to Landscape

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Abstract

This chapter presents upscaling methodologies, implemented in the MEA-Scope strategic research project. MEA-scope is based on a bottom-up approach, where farm information are collected for landscapes in Germany, Slovakia, Poland, France, Hungary, Italy and Denmark. This chapter is about the upscaling from farm to landscape level, and focuses on the modelling of Nitrogen surplus from agriculture as an indicator for water pollution. It is demonstrated in detail how farm information from the Danish landscape is upscaled for such landscape level analyses, using the EU Integrated Area Control System (IACS) and GIS. Subsequently, farm N-surpluses, upscaled for each of the other the landscapes, are also presented, and different upscaling pathways are reviewed. Based on the results, advantages in the bottom-up approaches applied are emphasized. It is concluded, that bottom-up methods for upscaling are needed to convey information from research to decision-makers, and that it is important to specifically address the scale issue within the cycle of strategic research, where an iterative interaction

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between researchers and decision-makers is carried out. MEA-Scope is an example of a project where such interactions have been practised.

Keywords: farm; landscape; scaling; bottom-up modelling; Integrated Area and Control System (IACS); Geographic Information System (GIS)

1 Introduction

Strategic research is characterized by an iterative interaction between researchers and decision-makers (Bierkens et al. 2000); denoted "The Cycle of Strategic Research" (Fig. 1). The MEA-Scope strategic research project (SSPE-CT-2004-501516), from which results are presented in this publication, is a good example of such interaction. Within this context, the present chapter focuses on one of the major challenges within the cycle of strategic research, namely the problem of scaling research results to the scale, where information is needed by decision makers (Dalgaard et al. 2003).

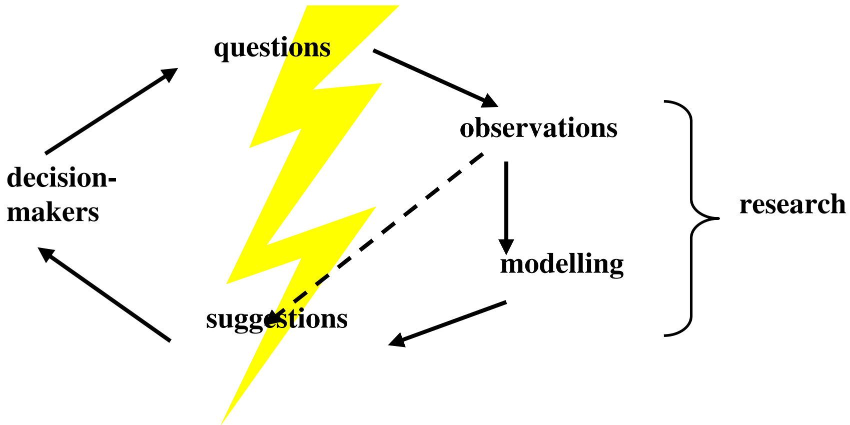

Fig. 1. The cycle of strategic research (Bierkens et al. 2000). The lightening symbolizes the gap between the scale where decision makers operate, and the scale where observations and modelling typically are carried out by researchers

In MEA-Scope, the initial question was formulated by The European Commission, requesting *an integrated framework for the assessment of the multifunctionality impacts of the EU common agricultural and rural development policy reform* (Müller and Piorr 2008). The consortium of research institutions behind MEA-Scope responded to this question with a project formulation, focusing on an impact assessment of the agricultural production and its multiple functions in seven landscapes selected. During end-user workshops in Brussels, the research progress was presented. Based on feedbacks from these meetings and from internal project workshops, data collection (observations) and modelling approaches were designed (Figs. 1 and 2).

Fig. 2. Examples on steps within the cycle of strategic research (Fig. 1) carried out within the MEA-Scope strategic research project (Müller and Piorr 2008). The left photo is from the second end-user workshop in Brussels. The photo in the middle is from a visit to one of the Polish farmers who delivered farm data to the project, and the right photo is from one of the MEA-Scope researcher workshops where modelling and data collection were discussed

As mentioned, the present chapter addresses the gap between the scale where decision-makers need advice, and the scale at which most research and empirical observations are carried out (illustrated with the lightening in Fig. 1). In MEA-Scope, the decision-makers (in this case the end-users) need a tool for landscape level impact assessments. However in the research project, models are developed based on empirical data collected from single farms within the landscapes (Fig. 2). To overcome this problem, the present chapter demonstrates methods to scale information from the farm to the landscape level, and thereby overcoming the scaling problem. Furthermore, examples on results from the application of these methods in MEA-Scope are presented. The results presented will illustrate the importance of specifically addressing the scale issue in MEA-Scope, leading to a general discussion, and to conclusions and recommendations for addressing the scale issue in future strategic research.

2 Materials and Methods

There are two main approaches to derive landscape level farm information for the use in decision-making (Fig. 3). The first approach is a top-down approach where information from national or regional farm statistics are disaggregated (downscaled) to the landscape level. Recent examples of such approaches are outlined in Leip et al. (2007). In MEA-Scope, we use the second approach, where landscape level farm information is derived bottom-up. This means that the landscape level information is aggregated (upscaled) from farm information required locally within the actual landscape (for example from local farm surveys and detailed GIS land use maps in combination with maps over the placements of specific farms within a landscape, see below).

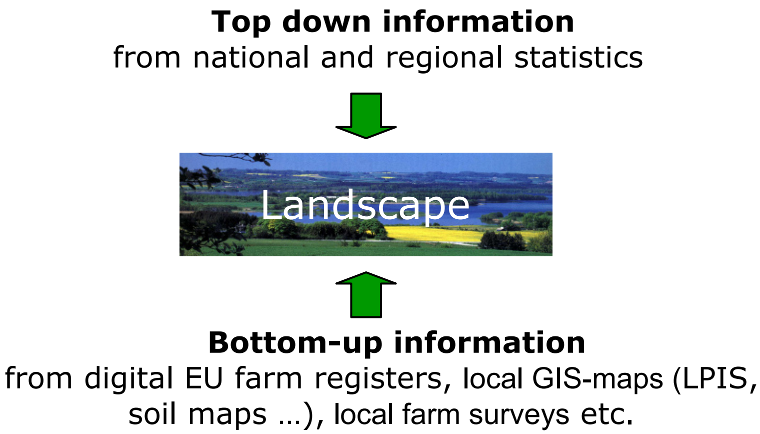

Fig. 3. Sources for top-down versus bottom-up derivation of farm information for landscape level studies

In MEA-Scope we apply two different levels of bottom-up landscape farm mapping.

- The first level includes "real farm maps" required from the mandatory EU digital farm registers, while
- The second level relies on "proxy farm maps", derived from local farm surveys and GIS-information.

While Ungaro et al. (2009, chapter "Spatial Characteristics of Land Use Patterns in Mugello (Central Italy) and Policy Impacts on Their Environmental Outputs of this volume) and Damgaard et al. (2009, chapters "Recreating Context in Spatial Modelling of Agricultural Landscapes" and "Validation of an Agent-Based, Spatio-Temporal Model for Farming in the

River Gudenå Landscape" of this volume) focus on the second level of farm mapping, the present chapter uses the first level "real farm maps" to exemplify points regarding scaling. The "real farm maps" are derived from the mandatory EU digital farm registers. According to The European Commission (1992) all EU member states are required to set-up an Integrated Area and Control System (IACS), where subsidy payments are digitally registered. Moreover, a GIS-based Land Parcel Information System (LPIS), to which the subsidy payments can be geographically related, must be established (Fig. 4).

In MEA-Scope, IACS and LPIS data have been available for the study landscapes in Denmark and Slovakia. From this information maps showing the areas belonging to each farm within each land parcel can be constructed. Figure 5 shows an example of such map, where each of the 1.871 farms in the Danish study landscape in year 2002 has been classified into four main types, according to the European Farm Accountancy Data Network, FADN and EUROSTAT methods (McClintock 1989; Dalgaard et al. 2002b).

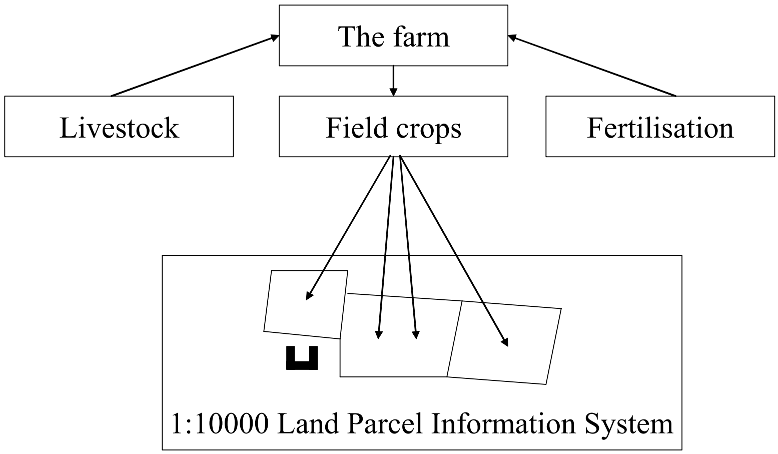

Fig. 4. Illustration of the types of digital farm data registered in EU member states for the control of farm subsidies paid. Via the obligatory Land Parcel Information System (LPIS) these data can be geo-referenced and mapped in GIS. It is mandatory to include livestock and field crop registrations, while fertilisation practices are only registered in some member states

There are two different pathways for the upscaling of bottom-up farm level information for landscape level modelling (Marshall et al. 1998; Kjeldsen et al. 2006). In the first pathway, modelling is initially carried out on the single farm data, before aggregating the model results to the landscape level, while in the second pathway the farm information is averaged before modelling (Fig. 7).

In the present chapter it is demonstrated how these two pathways can lead to significantly different results. This is demonstrated using the Farm-N model (www.Farm-N.dk; www.Farm-N.dk/farmNtool) to simulate farm nitrogen (N) surpluses for the Danish study landscape in 2002. With this model, the farm N-surplus is calculated in kg N/ha/yr as N-inputs (mineral fertilizer, manure, feed, straw, seeds and animals bought + N fixed and N deposited from the atmosphere) minus N-outputs (cash-crops, animal products, milk, manure, and feed and straw sold). For more details see Dalgaard et al. (2007b).

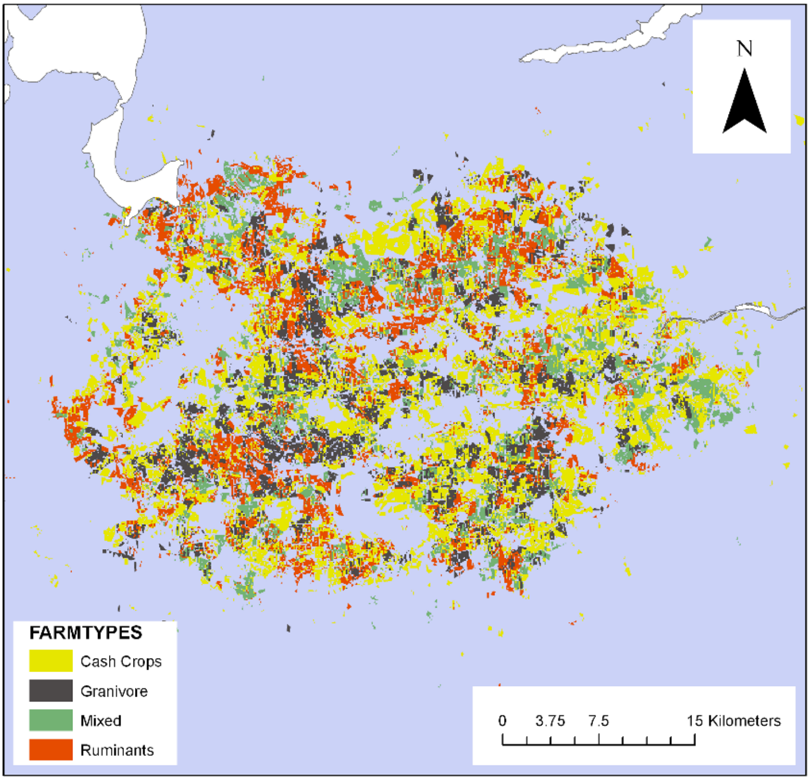

Fig. 5. "Real farm map" for the Danish study landscape in year 2002. Each of the in total 1.871 farms has been classified into four main types, according to the EUROSTAT/FADN methods (McClintock 1989, Dalgaard et al. 2002b)

In total, the MEA-Scope model framework is applied to seven European landscapes (Fig. 6). Additional key figures for agriculture and land use in these landscapes can be found in Dalgaard et al. (2007a) and at http://mea-scope.eu/.

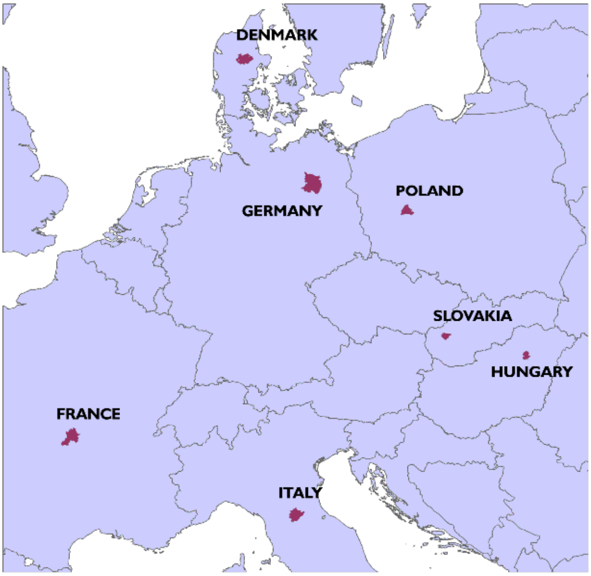

Fig. 6. The geographical location of the seven MEA-Scope study landscapes

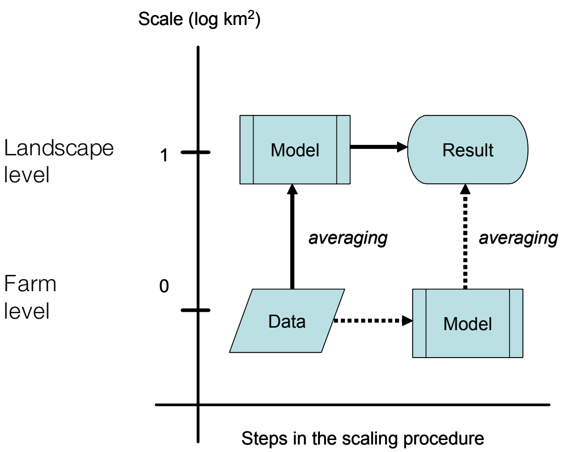

Fig. 7. Two pathways for the upscaling of farm information and model results from farm to landscape level (based on Kjeldsen et al. 2006). In pathway 1 farm data is modelled before averaging and in pathway 2 vice versa

3 Results

Based on the bottom-up farm information available, the nitrogen surpluses are modelled for all the 1.871 farms in the Danish study area, and plotted against the livestock density (Fig. 8).

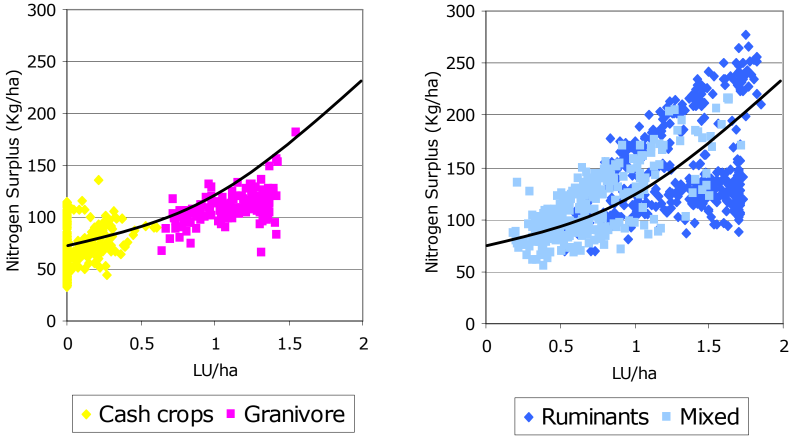

Fig. 8. Nitrogen surplus estimated with the Farm-N model for each of the 1.871 farms within the Danish study landscape in year 2002, and plotted against the livestock density in livestock units (LU) per ha. The farms are divided into the four main farm types of Fig. 5, and the regression line ($y = 77\ e^{[0.56x]}$) from an empirical study of 41 farms within the study area (Dalgaard et al. 2002a) is added

The model results show a non-linear relationship between nitrogen surplus and livestock density, corresponding to the relationship derived empirically by Dalgaard et al. (2002a) (Fig. 8). This non-linear relationship indicates that the bottom-up information approach applied in the present study results in another N-surplus result than if a top-down approach was applied. If a top-down approach had been applied, the farm N-surpluses would namely not have been modelled for each farm separately (pathway 1 in Fig. 7), but for averaged groups of farms (pathway 2 in Fig. 7). For example according to the non-linear relationship in Fig. 7, farms with 0.5, 1.0 and 1.5 LU/ha would typically yield around 100, 135 and 180 kg N-surplus per ha per year, respectively; according to the regression line ($y = 77\ e^{[0.56x]}$) derived from an empirical study of 41 farms within the study area (Dalgaard et al. 2002a). However, the average of (180+100)/2 = 140 is not equal to 135, and a top-down approach following the pathway 2 scaling procedure would in this case typically overestimate the total N-surplus from a group of farms.

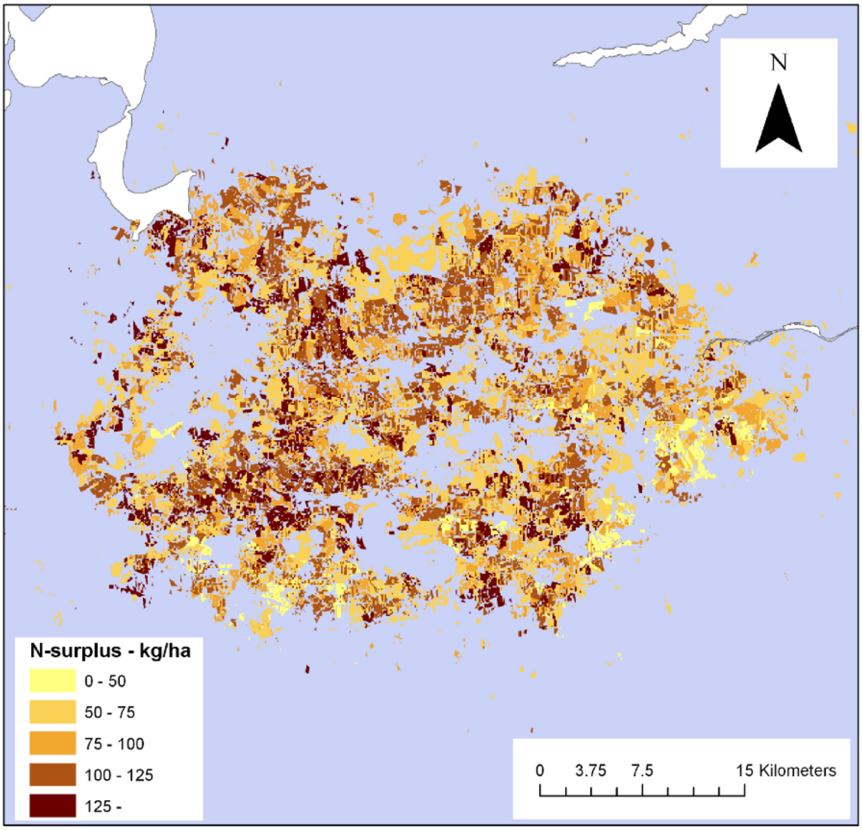

Fig. 9. Farm Nitrogen surplus map over the 1.871 farms in the Danish study landscape in year 2002. The mapped N-surplus values are equal to those presented in the scatter plot of Fig. 8

Another important advantage in using a bottom-up approach based on single farm data is the possibility for detailed mapping and geographical analysis. Figure 9 shows an example of such mapping based on the farm N-surpluses of Fig. 8 and the "real farm map" of Fig. 5. With such map it is possible to identify nitrogen surplus hot-spots in the landscape, and to make overlay analysis with maps over Natura 2000 sites, groundwater protection areas etc. Finally, explicit mapping of the farming structure enables advanced analyses of the relations between farm structural development and environmental effects of agriculture in the form of nitrogen pollution. However, this is out of the scope with the present chapter, and must be left for future studies.

Based on the bottom-up farm information acquired in the seven MEA-Scope study landscapes of Fig. 6, the N surpluses for all farms in each of the landscapes are modelled with the farm-N model, and the results are upscaled to the landscape level using the pathway 1 approach of Fig. 7. Figure 10 shows the summarised nitrogen surplus results from the seven MEA-Scope landscapes in year 2002, distributed on the four EUROSTAT main farm types of Fig. 5: ruminants (mainly cattle), granivores (mainly pigs), mixed farms and cash crop farms.

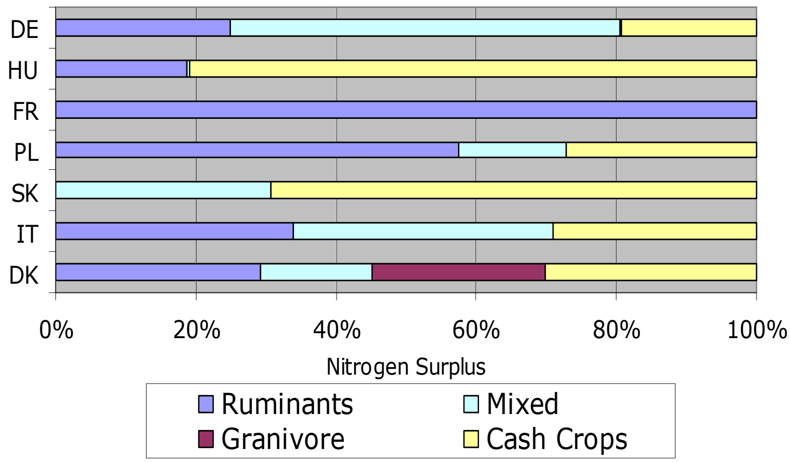

Fig. 10. Upscaled farm nitrogen surpluses from the seven MEA-Scope study landscapes in Germany (DE), Hungary (HU), France (FR), Poland (PL), Slovakia (SK), Italy (IT) and Denmark (DK). The N surpluses for all farms in each of the landscapes are modelled with the farm-N model, and the results are upscaled to the landscape level using the pathway 1 approach of Fig. 7. Finally, the results are summarised in the four main EUROSTAT farm type classes of Fig. 5

4 Discussion and Perspectives

Since landscapes can be conceived as a conglomerate of different homogenous units (Forman and Godron 1986), of which farming is a very important part, it is vital from the perspective of multifunctionality to represent landscapes in a manner which reflects their multifunctional nature (Brandt and Vejre 2004; Vejre et al. 2007).

The upscaling procedure can be said to aim at establishing a representation of landscape functions, building on the farm level simulations, which aims to serve two purposes: adaptation of the knowledge generated in the project to the needs of the potential end users, in addition to pinpointing areas in need of further research. It can be expressed as in the Fig. 11, which depicts scaling as a procedure which aims at balancing both research and policy needs.

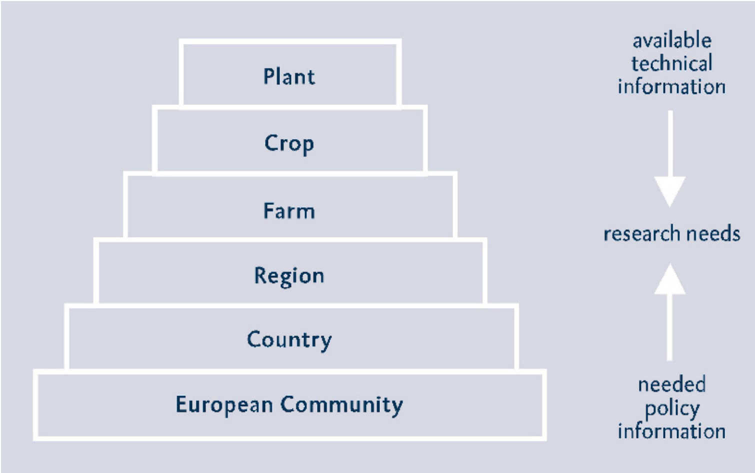

Fig. 11. Levels of scale and research needs (van Latesteijn 1999)

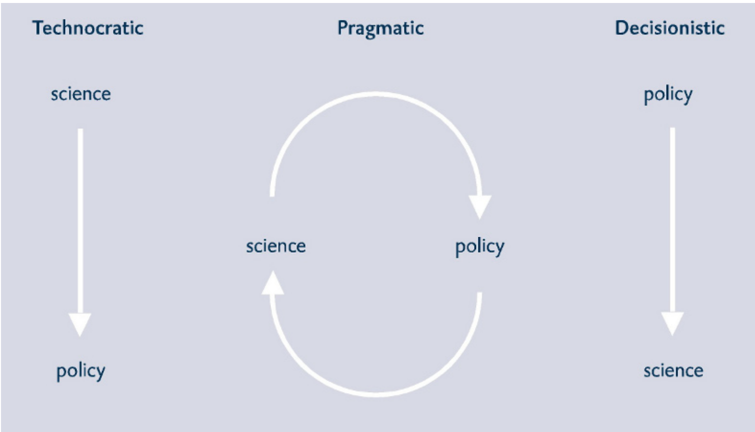

Fig. 12. Three different views on the relation between science and policy according to Habermas (van Latesteijn 1998, 1999)

Regarding the relation between science and policy in the MEA-Scope project, as it appears in the context of upscaling, it can be termed a pragmatic approach, because there is a continuous interaction between science and policy (van Latesteijn 1999). This approach can be termed pragmatic, relative to two other possible models for science-policy interaction, which can be derived from Habermas' work on the relation between science and policy in his analysis *Technik und Wissenschaft als "Ideologie"* from 1968. As illustrated below, the two other approaches can be described as a one-way movement from science to policy or the other way round.

Dalgaard et al. (2003) has dealt with the interactive process of setting the appropriate scale relative to the needs of decision-makers. The framework derived from this work is summarised in Table 1.

Table 1. General upscaling framework to support and evaluate the conveyance of information between science and decision-makers (Dalgaard et al. 2003). See the text for further explanation

Criteria 1. Define the decision-maker and the problem and the scale at which the decision-maker needs information.
Criteria 2. Determine on which scales information regarding this problem is available and collect the relevant information.
Criteria 3. Create a hypothesis of how existing information, identified in criteria 2, can be transformed to the scale needed for decision-making, identified in criteria 1. First try with simple linear scaling procedures, and after having tested them in criteria 4, try more complicated, non-linear or hierarchical scaling procedures.
Criteria 4. Test the hypothesis of criteria 3 with independently sampled decision-maker scale information. If the hypothesis is rejected, try with a new hypothesis or seek new information, which can be transformed to the decision-maker scale.

In the MEA-Scope context, application of this upscaling framework could be expressed with the following four criteria analyses:

1. Identify the most relevant landscape functions, required by decision-makers for the specific landscape: for example the present chapter focus on nitrogen surplus and the related provision of clean drinking water and non-eutrophicated surface waters. This is especially an important function in the Danish landscape (Schader et al. 2009, chapter "Societal Demand for Commodity and Non-Commodity Outputs – A Region Perspective" of this volume).
2. Review and collect relevant farm and landscape level data.
3. Scaling from farm to landscape: Mapping indicators via GIS-data, farm-data geo-coding, farm type modelling and regionalisation
4. Test the upscaled results

As the above framework incorporates insights from systems theory (Spedding 1979; Altieri 1995; Gliessman 1998; Checkland 1999), a distinction is made between different types of upscaling: linear, non-linear and hierarchical (Dalgaard et al. 2003). Linear upscaling refers to a case where upscaling is simply a matter of aggregation of lower level data, whereas non-linear and hierarchical upscaling takes emergent factors into account. A practical example, which is used in the article quoted above, is the influence of increasing field size on farm level fuel use. Another example is the results presented in the present chapter, and the non-linear relationship between nitrogen surplus and livestock density (Fig. 8). Non-linear upscaling addresses issues within relative fixed boundaries of the system in question, whereas hierarchical scaling can be considered an extended case of non-linear scaling, since it deals with the consequences of extending system boundaries. One practical example is when scale is increased from farm to landscape level. The consequence is that scaling must be approached in a reflective and iterative way, taking into consideration many different levels of organisation and the different temporal and spatial scales that might be of importance for the long-term sustainability of the system as a whole (Dalgaard et al. 2006; Fresco and Kroonenberg 1992).

5 Conclusions

The results presented in this chapter illustrate clear advantages in using the bottom-up approach applied in MEA-Scope, compared to the more usual top-down approaches. Moreover, advantages in upscaling of model results from farm to landscape level, using the first pathway of Fig. 7 are illustrated, and dangers of the second pathway are emphasized.

In reality geo-referenced bottom-up farm information is often not readily available at the landscape level all over Europe. This makes the creation of detailed maps like Figs. 5 and 9 difficult, and a combination of the first and the second upscaling pathway of Fig. 7 must be applied. Actually, such aggregation is also applied in MEA-Scope, where bottom-up farm information for “real farm mapping” has only been available for Slovakia and Denmark, and where farm group information has been applied in some part of the modelling instead of farm specific information. It is important to be aware of the potential problems of applying such compromises. It is our hope that the present chapter can draw attention to some of key problems in scaling from farm to landscape, and help to enlighten some of the errors that might appear when doing the needed compromises in the scaling procedures.

To finally conclude on the nature of upscaling, it can be defined as an iterative process, where the actual outcome cannot be seen in isolation from the policy needs formulated by the end users. Thus, the MEA-Scope end user workshops and the scaling of information within the Fig. 1 cycle of strategic research produce a very important input to this process.

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Analysing Exemplary Policy Issues Using the MEA-Scope Framework

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Abstract

This contribution links the activity of farming in rural areas in response to policy changes to the achievement of economic, social, and environmental policy objectives. The focus here is on a model-based evaluation of policy impacts on the supply of multifunctional activities using an indicator framework. We apply the MEA-Scope modelling approach.

Keywords: MEA-Scope modelling approach; structural change; simulation; policy analysis

1 Introduction

According to a recent statement by EU Commissioner Mariann Fischer Boel, *The European Union's agricultural model reflects both the needs of farmers and the expectations of a society which pays special attention to food safety, animal health and welfare, environmental standards and the conservation of the rural environment. The Common Agricultural Policy (CAP) is designed to meet all these aspirations across diverse farm types*

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and climatic zones. It comprises a wide variety of measures, but also delivers many public goods to EU citizens. (EU Commission 2006, p 3). This specific view of agriculture has developed over several decades and has been the driving force of the most recent CAP reforms. Since the early 1990s, the further developments of the CAP have laid out the path towards considering farming as an integral part of rural areas. Policy measures are designed to consider the various functions of farming in rural areas.

Agriculture has different roles within the European Model of Agriculture. It contributes in different ways to the achievement of policy objectives. Practical policy implementations such as the most recent CAP reform measures (EU Commission 2003) may, however, not guarantee the full achievement of these goals in all cases. The reason is that rural areas in Europe are highly diverse, e.g. with respect to actors, natural conditions or prevailing institutions. Moreover, actions by farmers exert influence on natural environment, the extent of which again depends on site-specific characteristics. All in all, rural areas make up a highly complex system. Given the complexity and non-linear interactions within the system, the specific impact of policy measures designed to achieve a certain goal, may not be that clear after all.

The objective of this contribution is to link the activity of farming in rural areas in response to policy changes to the achievement of economic, social and environmental policy objectives. Here the focus is on a model-based evaluation of policy impacts on the supply of multifunctional activities. For this we apply the MEA-Scope modelling approach (Damgaard et al. 2006; Happe et al. 2006; Zander et al. 2009, chapter “The MEA-Scope Modelling Approach” of this volume), which explicitly considers the dynamics of farm structures and interactions between farms and the environment. Each model focuses on different aspects of multifunctionality represented by a set of indicators identified as representing the provision of non-commodity outputs (Waarts 2005). Overall, the approach followed in MEA-Scope reflects the different requirements set out by the MEA-Scope analytical framework (Casini et al. 2004), the MEA-Scope multifunctionality concept (Piorr et al. 2005), regional specificities and model possibilities.

To demonstrate the operability of the framework, we analyse the impact of two policies. The policy implemented under the 2003 CAP reform is compared to the previous Agenda 2000 policies. The case study region used is the county Ostprignitz-Ruppin (OPR) in Brandenburg, Germany.[1] Results are placed in a simple analysis framework.

[1] Analyses for other policy settings and case study areas as well as detailed descriptions of regions and data can be found in Osuch et al. (2007) and on www.mea-scope.eu

2 Materials and Methods

The MEA-Scope modelling approach developed in the project is based on three agronomic and economic simulation models. In the past, each model has been focussing on specific aspects of the agricultural system (Fig. 1).

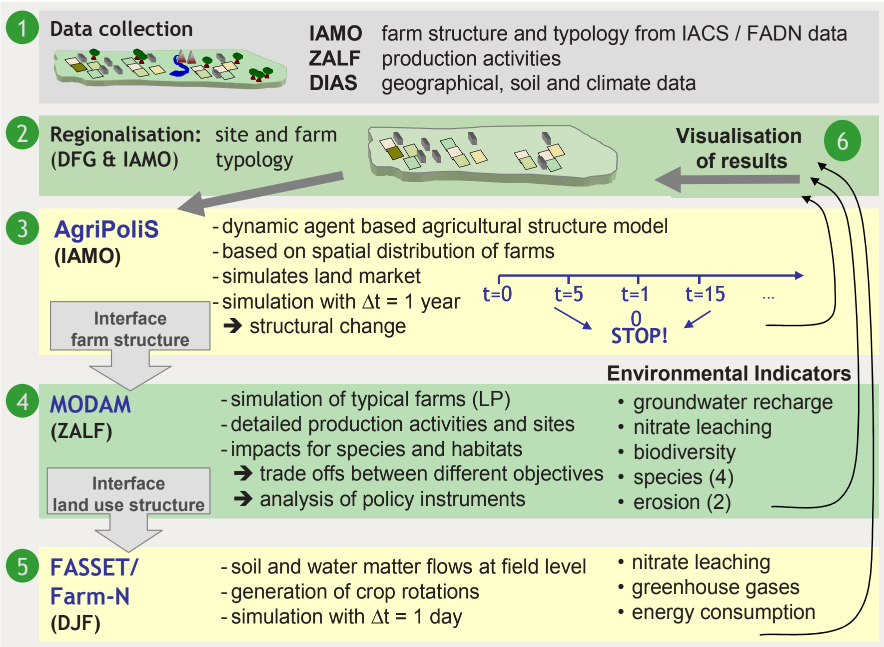

Fig. 1. MEA-Scope modelling approach (www.mea-scope.eu)

Depending on the individual models' scope, linking the three models allows to extend the capabilities to model multifunctional aspects of agricultural systems in two directions by:

- combining individual strengths of each model and thus obtaining a more complete model with regard to spatial, analytical and temporal aspects;
- covering a wide range of multifunctionality indicators which are simulated in the respective models and analysing results with regard to these.

The list of indicators takes into account the models' capabilities as well as the relevance of indicators and their applicability in the case study regions (Waarts 2005). Following the common differentiation into economic, ecological and social functions, the indicators have been assigned to these three categories (Fig. 2).

Economic indicators

Average farm size	[ha]
Number of farms	[number]
Profit	[€/ha]
Rental prices arable	[€/ha]
Rental prices grassland	[€/ha]

Social indicators

Farm exit	[number]
Labour input	[AWU]
Income from off-farm activities	[%]

Environmental indicators

Animal husbandry	[LU]
Land abandonment	[ha]
AEP Land	[ha]
Minimal care	[ha]
Set-aside	[ha]
Nitrogen balance	[kg N/ha]
Ammonia emission	[kg N/ha]
Amphibians	IGA
Wild flora species	IGA
Population of farmland birds	IGA

Fig. 2. Categorisation of selected NCO by functions and units (Waarts 2005, 2007). Notes: IGA = index of goal achievement (Sattler and Zander 2004; Sattler et al. 2006)

Figure 3 lists and describes the policy scenarios simulated using the modelling framework. Here we present results for two policy scenarios only. Results for the remaining scenarios are documented in Osuch et al. (2007). As the MEA-Scope modelling tool was calibrated to the end of the year 2001 the baseline scenario (BAS) assumes a continuation of the policy framework into the future. In the OPR region, this is Agenda 2000. To observe differences generated by different ways of decoupling direct payments, the second scenario considers the actual implementation of the CAP reform 2003 in the respective EU-15 regions (scenario Actual). In the OPR region the actual implementation corresponds to a hybrid dynamic decoupling scheme (BMVEL 2005). With the "Actual" policy scenario, the decoupled payment is introduced by way of payment entitlements per hectare which farmers can activate for eligible land. Initially, payment entitlements consist of a farm-specific part and a regional-specific part. With the "Actual Policy", the farm-specific part is reduced over time and reshuffled to the regional-specific part. At the end, in 2013, the payment is fully regionalised. In the two scenarios modelled, from 2001 until the end of the simulations, the second pillar agri-environmental measure (AEM) "extensive grassland" is introduced as an incentive for farmers to use parts of their grassland extensively (MLUR 2002). Farms have to use at least 30% of their total Utilised Agricultural Area (UAA) as extensive grassland in order to receive the Agri-Environmental Payment (AEP) of 130 Euros per hectare. Each hectare of this activity requires labour, machinery and capital, but it also provides extensive pasture land for ruminants. The stocking density of ruminants should not exceed 1.4 livestock units (LU) per hectare on this type of land.

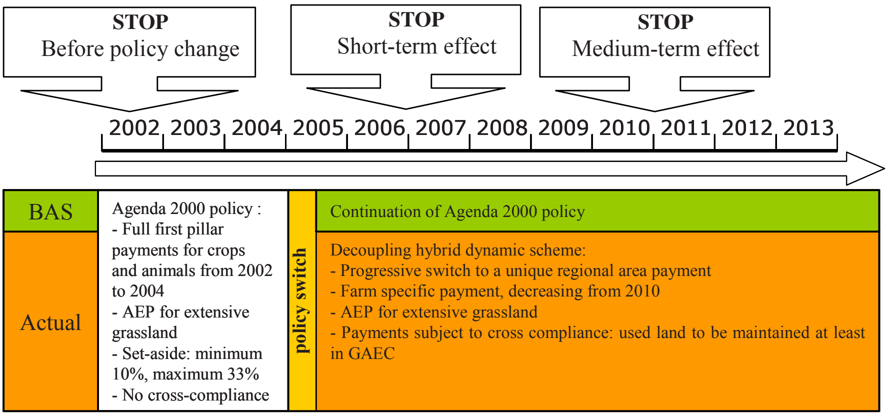

Fig. 3. Summary of simulation experiments for the OPR region

Simulations start in 2001, a policy change sets in after 2004. The date of the policy switch has been chosen in accordance to the real date the reform actually took place in Germany. Afterwards, new policy settings are simply introduced as new parameters. Farms are perfectly informed between two periods how high direct payments will be for each production activity in the next period to come. Farm planning is possible with only one year sight for each agent. It means that at the end of a period p, agents know exactly which will be the political settings at period t+1, but not for ulterior periods of the simulation. Whereas AgriPoliS simulates the farm structure evolution over the entire period between 2001 and 2013, MODAM and FASSET/FARM-N provide results on environmental indicators.

Policy scenarios are compared through the light of their impacts on the selected indicators. To summarise the impact and to give a quick visual overview, for each indicator scenarios are classified on a relative scale on the basis of the value they reach on a range from "low" to "high", from the lowest value to the highest one for the corresponding indicator.

We adjusted the modelling framework to the regional farm structure of the region Ostprignitz-Ruppin located in Brandenburg, Germany. The models are initialised reproducing some of the region's structural characteristics in 2001: very large farms are to be found in OPR nearby smaller family farms. Three arable land soil qualities (low, medium-low and medium-high) defined as regards potential agricultural yields, and two grassland soil qualities (low and medium quality) have been introduced, based on the real soil quality distribution in OPR. The grassland share is 26.7% out of a total of 120,957 hectares of Utilised Agricultural Area (UAA).

3 Results

Simulations started with 585 farms in the OPR region. Figure 4 summarises results for the economic and social indicators in 2010. On average, the introduction of the Actual policy leads to a larger average farm size. At the same time more farms remain in the sector as compared to the BAS scenario. Despite of higher rental prices, average profits are also higher than in the BAS scenario. At first sight, these results may be counterintuitive. But they suggest that the structure of farming has changed between the two scenarios. To find out about this change and the reasons behind it will be the subject of the remainder of this contribution.

Indicators		High						Low
Average farm size	[ha]		>>	Actual	>	BAS	>	
Number of farms	[number]		>>	Actual	>	BAS	>>	
Profit	[€/ha]		>>	Actual	>	BAS	>	
Rental prices arable	[€/ha]	Actual	>	BAS	>>		=	
Rental prices grassland	[€/ha]	Actual	>>>	BAS	>		>>	
Farm exit	[number]		>>	BAS	>	Actual	>>	
Labour input	[AWU]	BAS	=	Actual	=		>	
Income from off-farm activities	[%]		>>	BAS	=		=	Actual

Fig. 4. Comparison of economic and social indicators in 2010 between BAS and Actual scenarios. Legend: ">": greater than; ">>" much greater than; "=": comparable values

Figure 5 compares the distribution of farm size classes by scenarios. The Actual policy sees a slower structural change in terms of the number of farms than what is observed in the BAS scenario. However, the structure of farms remaining in the sector in 2010 differs between the scenarios.

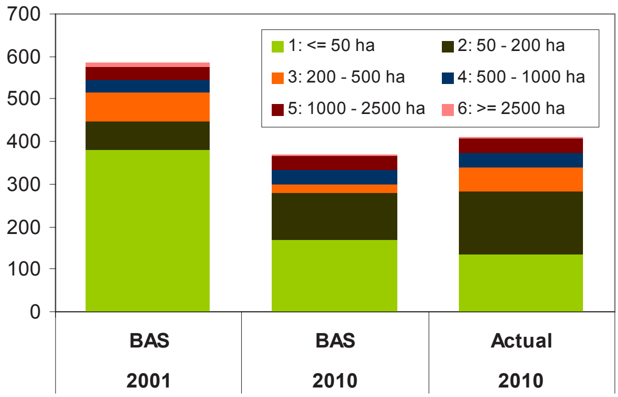

Fig. 5. Number of farms in size classes

The proportion of farms larger 200 ha slightly increases compared to the beginning of the simulation in the BAS scenario. In the Actual scenario, the proportion of farms bigger than 200 ha is almost 10% higher than at the beginning. In this latter case significantly more farms operate with a larger farm size than in the BAS scenario. The move towards larger farm size classes becomes possible, because land abandoned in the BAS scenario is taken into management (Table 1).

Table 1. Land use by soil types in 2001 and 2010

Policy	Year	Arable land in use [ha]			Grassland in use [ha]		Abandoned land [ha]	Total [ha]
		Soil quality						
		Low	Medium	High	Extensive	Intensive		
BAS	2001	3,073	83,773	1,660	9,472	22,979	0	120,957
	2010	3,073	83,773	1,660	3,446	8,757	20,248	120,957
Actual	2001	3,073	83,773	1,660	9,472	22,979	0	120,957
	2010	3,073	83,773	1,660	8,382	19,703	4,366	120,957

Also the type of farming changes over time and in response to the policy change. AgriPoliS classifies farms in four distinct categories: grazing livestock, field crop, specialised granivores and mixed farms, inspired from the FADN classification[2] (EU Commission 1985). A farm is classified in one of these categories if most of its revenue is provided either by grazing livestock (including dairying), field crop farming, specialised granivore breeding and/or fattening or a mix between these technical orientations.

[2] For more information, please look at Happe (2004).

Farms exiting from agriculture are classified in the category "Exit". Figures 6 and 7 show how farms initially qualifying as grazing livestock farms and mixed farms change their type over time. Field crop farms are not shown as their type and numbers remain stable throughout the simulation.

As for grazing livestock farms, out of the 110 farms initialised in 2001 (19% of all farms in OPR), 75% of them remain in grazing livestock farming in scenario BAS right after the policy switch in 2006. This percentage is only 42% in the Actual policy scenario, where 34% of grazing livestock farms in 2001 has converted to mixed farming in 2006 as well as to field crop farming (24%). In the medium-term (2010), among the farms which have survived 54% are still in grazing livestock farming in the scenario BAS (only 30% in the Actual policy scenario). But, while in the scenario BAS almost 33% of grazing livestock farms present at the beginning have closed, a bit more than 95% of them stayed in agriculture in the Actual policy scenario. They have switched to more field cropping oriented productions: the majority of them is performing field crop farming (57%), furthermore 30% of survivors have kept grazing livestock orientation and the rest is classified into mixed farming.

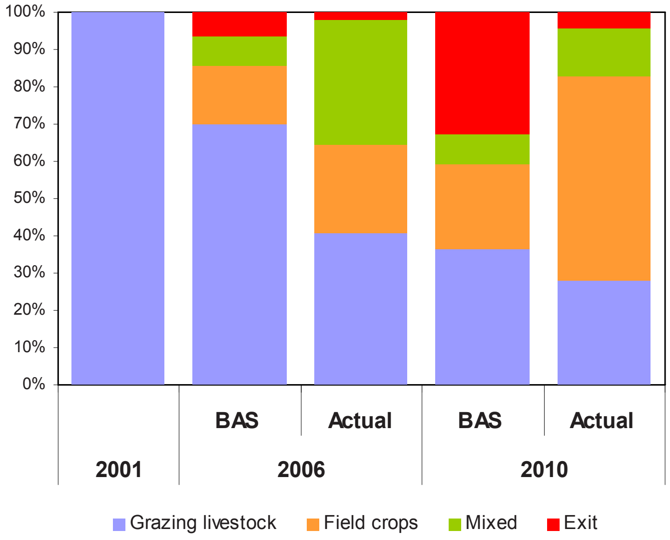

Fig. 6. Change of farm types initially classified as grazing livestock farms

As for mixed farms, in the short-run, a massive conversion into field crops farming is then observed by remaining farms under the Actual policy (85% of surviving farms) than in the reference scenario BAS, where mixed farms from 2001 turn into field crop farming or stay in the mixed farm type in the same proportions. It is in 2010 that things evolve differently compared to grazing livestock farms. While about the same share percentage of farms close down in the BAS scenario in 2010, 48% of the farms originally classifying as mixed farms have closed down in the Actual scenario by 2010. Out of the farms still operating, the same proportion between field crop farms and mixed farms is been observed in the two years 2006 and 2010 (80 and 20%). In the case of BAS, the relative balance between field crop farms and mixed farms observed in 2006 has been changed in favour to the former one, which is the technical orientation chosen by more than 80% of remaining farms.

Why does field crop farming seem to be the dominant farm type in the case of the Actual policy scenario? Why do mixed farms "resist" better to structural change in the framework of the BAS scenario than in the Actual one? What saves small farms and what makes lots of farms close down following different dynamics depending on the policy designs?

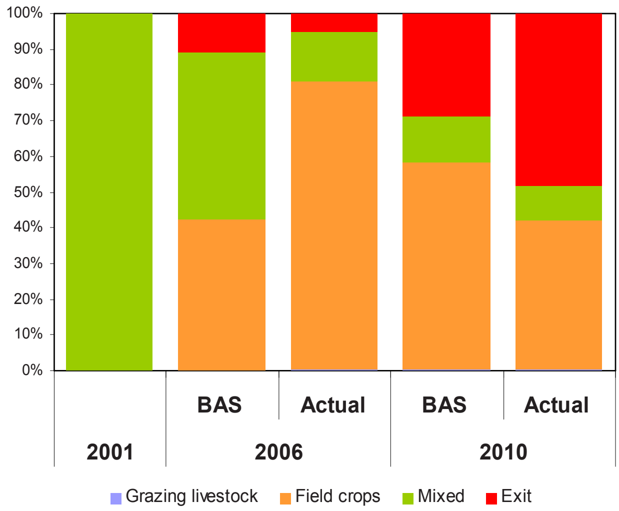

Fig. 7. Change of farm types initially classified as mixed farms

Answers to these questions can be found in analysing the linkages between policy, land use options and animal husbandry. Here the focus is put on a selection of indicators linked to land use patterns in OPR in 2010. They reflect main issues coming from the modalities of implementation of policy changes introduced in BAS and Actual scenarios (Fig. 8). The main point here is that the continual redistribution towards a regional area payment leads to some significant adjustments in the animal husbandry and related land use options.

Rental prices arable	[€/ha]	Actual	>	BAS	>>		=	
Rental prices grassland	[€/ha]	Actual	>>>	BAS	>		>>	
Animal husbandry	[LU]	BAS	>	Actual	>		>	
Land abandonment	[ha]		>>		>	BAS	>>	Actual
AEP Land	[ha]	BAS						
Minimal care	[ha]	Actual	>>		>>			
Set-aside	[ha]	BAS	>		=		=	Actual

Fig. 8. Selected land-use related indicators in 2010

As regards animal husbandry, in 2001 there were five types of livestock production systems in OPR which were initialised in the model: pigs for fattening, breeding sows, dairy cows, beef cattle and suckler cows (Fig. 9). Whereas the feeding regime for the former two is based on bought concentrates, the production of the latter three is coupled to the provision of grassland and arable fodder. Feeding requirements differ between dairy cows, beef cattle and suckler cows.

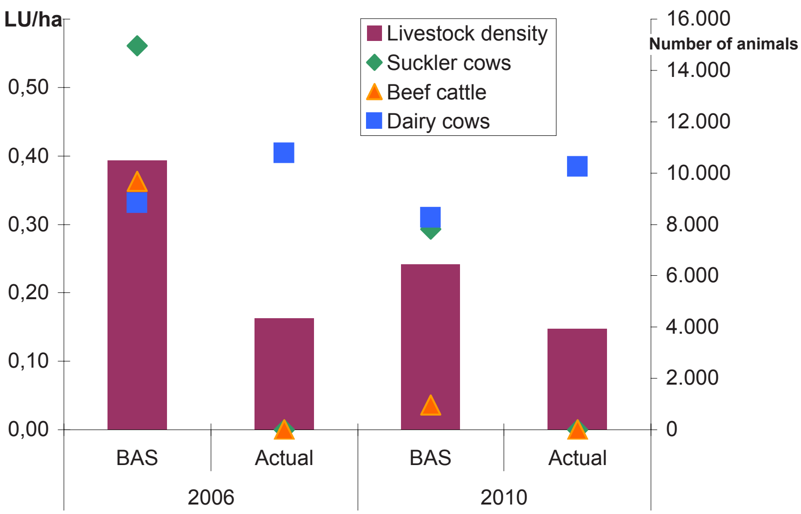

Fig. 9. Animal husbandry in OPR in 2006 and 2010

What limits the extent of livestock production is thus the link between livestock and land on the one hand. On the other hand, there is a maximum stocking density of 2 livestock units (LU) for all land (1.4 LU/ha for extensive grassland under the agri-environmental programme). These conditions are the same for both policy scenarios. Yet, a distinctive feature of the Actual scenario is that the headage payments granted in the BAS scenario are removed in 2005. They are partially transferred together with the premiums linked to arable land production to a regional premium per hectare of land and to a farm payment decreasing from 2010 on. The effect on livestock production is that in the case of the BAS scenario, suckler cows and beef cattle productions are only progressively given away by farmers while in Actual, when the policy changes occur in 2005 these productions are completely abandoned (Fig. 9). On the contrary, in Actual, dairying still takes place in the region and the levels of production in the short and medium-term are a higher than in BAS.

Animal direct payments in the BAS scenario, coupled to the possibility to feed ruminants on extensive grassland granted by an AEP, is an incentive high enough for farmers to keep their stalling and to continue producing suckler cows and dairy cows. This is of particular importance for one group of farms identified in the section before. Actually, mixed farms and grazing livestock farms, rather small-scaled, which have herbivores at the beginning of the simulation and enough pastures to feed them go on farming and keeping animals in this scenario. Producing suckler cows and beef cattle on AEP extensive grassland ceases once the Actual scenario is introduced (Fig. 10).

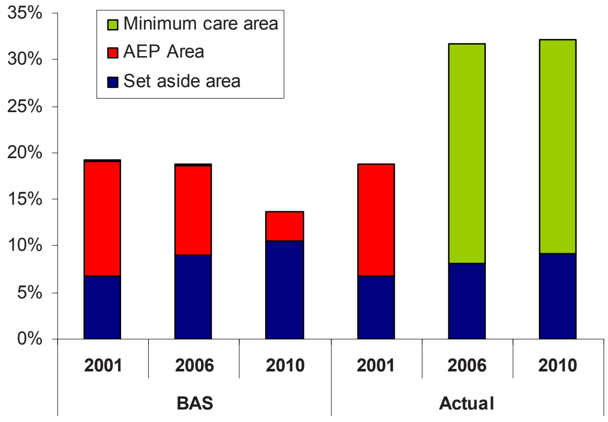

Fig. 10. Extensive land use in 2001, 2006 and 2010 as share of total land

In the Actual scenario, the use of grassland is diverted from AEP grassland tied to specific restrictions of minimum care area (Fig. 10). For Actual, all land (arable land and grassland), is granted by a regional payment per hectare from 2005 in addition to a specific farm payment.

With headage payments being abolished shadow prices for grassland increase (Fig. 11).

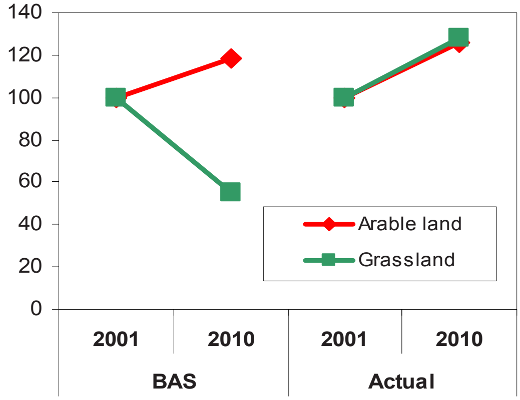

Fig. 11. Change in rental prices for arable land and grassland between 2001 and 2010 (2001 = 100)

No premium linked to beef cattle or suckler cows anymore also implies that farms which go on farming tend to abandon herbivore production, use their best arable lands in production by growing crops on it and keep the rest (very often most of their area of grasslands) in GAEC ("Good Agricultural and Environmental Conditions") – called "Minimum care area" in Fig. 10. This is also reflected in the fact that many farms convert into field crop farms, especially those in the scenario Actual which were initially classified as grazing livestock farms as was seen before. As a matter of fact, farms progressively abandoning herbivore productions but keeping their land in GAEC turn out to see their technical orientation changed into field crops farming. Note that as regards land abandonment, 83.2% of total UAA in BAS in 2001 is still used in agriculture in 2010, the rest being abandoned. In the Actual scenario, this percentage reaches 96.4%: it is the highest among the four scenarios. The incentive to keep ruminant livestock is not very strong anymore in the case of the Actual scenario. But even though animal production is given away, farms which were strongly dependent on animal production at initialisation do not close down under the Actual scenario.

Besides of land use and land abandonment, what are the environmental consequences of the change in the production and farm structure? For this, we take a look at results generated from the MODAM and FASSET/FARM-N models for the years 2010 and 2006, respectively (Fig. 12).

Indicator	Unit	High					Low
Nitrogen balance	[kg N/ha]		>>	BAS	>	Actual	>>
Ammonia emission	[kg N/ha]	BAS	>		>	Actual	>
Amphibians	IGA	Actual	>	BAS	>		
Wild flora species	IGA	Actual	>	BAS	=		
Population of farmland birds	IGA	Actual	>	BAS	>		

Fig. 12. Overview of environmental indicators for BAS and Actual in 2010

The interpretation of the nitrogen balance indicator comes along with both animal husbandry and land abandonment indicators, indicators which determine its value. As in the BAS scenario, more livestock was kept in general and more land was abandoned than in the Actual scenario, the N-balance is higher in BAS than for Actual. Ammonia emissions depend on both the number of livestock and the scale at which livestock farms are operating. Actually, it was assumed that larger stalling operations generally emit less nitrogen per Livestock Unit (LU). Here, less livestock is kept in BAS (i.e. less manure and slurry is applied to the land), and the manure losses have to be compensated by an increased use of mineral fertilisers. This leads to a lower total ammonia emission. However, as in BAS much more land has been abandoned during the simulation than in Actual, the emissions per hectare are consequently higher. This explains why ammonia emissions, especially due to the maintenance of animal productions in BAS, are the highest in this scenario.

As regards the impact on biodiversity indicators (amphibians, wild flora species, farmland birds), the index of goal achievement is related to the intensity of land use. Comparing the share of extensively managed land in terms of set aside arable land or grassland either involved in AEP or minimum care (cp. Fig. 10), the situation in the Actual scenario provides a more beneficial condition. In the Actual scenario more than one third of the land is managed extensively in comparison to less than 20% (2006) or less than 15% (2010) in the BAS scenario. On set aside land and grassland kept under minimum care (GAEC), only one cutting takes place per year and no pesticides and fertilisers are applied. Hence, these land use options are assessed to be very beneficial for the indicators in question, as for instance mineral fertiliser application (particularly ammonium nitrate) during migration periods can be highly toxic for amphibians (cp. Oldham et al. 1997) and cutting operations during breeding periods are very crucial for skylarks because clutches get destroyed (cp. Wilson et al. 1997), while for wild flora species herbicide treatments are most relevant (cp. van Elsen 2000).

4 Conclusions

In this article we demonstrated how the MEA-Scope modelling framework could be applied to the analysis of policy impacts on multifunctional farming. We showed how a set of indicators for multifunctionality reacted to a policy change using the MEA-Scope modelling approach. The novelty of this approach is that adjustment reactions are farm-specific and result of dynamic actions and interactions between a set of different farms. In general, the modelling approach provides a kind of "regional simulation laboratory" representing some components of the actual system. Results show that transferring production linked direct payments (BAS) into farm specific decoupled payments (Actual) – as it was the case with the 2003 CAP reform – changes patterns of production and consequently landscapes. In other words, the experiments demonstrated that "simple" changes in the distribution of first pillar payments have immediate consequences on the decision making of all farmers concerned. Here environmental, economical and social impacts of policy change have been investigated simultaneously. Such integrated tools like the one used in these experiments can therefore help to grasp consequences of policy changes on a wider analytical scale.

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Implementing the Indicators of the MEA-Scope Multifunctionality Impact Assessment Approach: A Gap Between Supply and Demand of NCOs?

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Abstract

In this chapter we present an analysis of whether the MEA-Scope ex-ante impact assessment Tool fulfils the need of the potential end-users with regard to the representativeness of indicator results for non-commodity outputs (NCOs) in relation to end-user demand.

The end-user demand for NCO indicators is explained, and compared with the NCO indicators simulated in the MEA-Scope Tool. A similar exercise is conducted for the regional stakeholder demand for NCOs from four MEA-Scope case study regions.

The conclusion that is drawn from the analysis is that the MEA-Scope NCO indicators mostly satisfy end-user demand for NCO indicator outputs relevant within the MEA-Scope framework. Furthermore, the relevant NCOs demanded by the regional stakeholders are also often simulated in the MEA-Scope Tool. This, and the fact that the MEA-Scope Tool

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functions well as an ex-ante impact assessment tool, shows that the MEA-Scope Tool presents meaningful results for various policy scenarios and for regions with varying characteristics.

It is not the intention of this work to provide an exhaustive review of the relevant literature as it is by nature an evaluation based on empirical knowledge. Where appropriate, relevant literature is cited.

Keywords: multifunctionality indicators; impact assessment; non-commodity outputs; gap analysis

1 Introduction

In the MEA-Scope project,[1] an ex-ante multifunctionality impact assessment tool based on a micro-economic farm approach was developed. Through this MEA-Scope Tool, three future Common Agricultural Policy (CAP) reform scenarios are modelled to assess the impacts of possible future conditions of CAP reforms on multifunctional agriculture.

Impacts on *multifunctionality outputs* of agriculture are assessed because not only is the production of commodity outputs (COs) like yields or revenues of products important for society, but also the provision of non -commodity outputs (NCOs), which *"encompass the full range of positive effects that are listed as pertaining to the multifunctionality of agriculture and includes those that are weakly (or not at all) jointly produced, positive externalities of agriculture and positive externalities of agriculture that have been internalised"* (OECD 2003: 10).

In the evaluation stage of the project, it is interesting to assess whether the MEA-Scope Tool fulfils the need of the potential end-users and regional stakeholders with regard to their demand for NCO indicator outputs. In the MEA-Scope project these "end-users" consist of European Commission officials who are active in the fields of agriculture, rural development, regional policy, research and environment. Another target group of the MEA-Scope results are representatives from the seven MEA-Scope case-study regions based in Brussels.[2] Regional stakeholders are defined as "persons or organisations with a legitimate interest in the multifunctionality of agriculture and rural development" (Moschitz 2007)

[1] MEA-Scope is the acronym for "Micro-economic instruments for impact assessment of multifunctional agriculture to implement the Model of European Agriculture", a Policy Oriented Research Project of the Sixth Framework Programme launched by the European Commission in 2004. See http://www.mea-scope.eu/

[2] From Denmark, France, Germany, Hungary, Italy, Poland and Slovakia

and are representatives from democratically legitimised institutions and organisations and experts with close regional ties like administration, agriculture, environment, tourism coordinators or regional projects for regional development and researchers.

This chapter therefore presents a gap analysis in comparing the demand for and supply of NCO indicator outputs.

2 Understanding End-User Demand for Non-commodity Outputs

Policy programmes need ex-ante, mid-term and ex-post evaluations of their impacts, and the Rural Development Programme is no exception in this regard. In Council Regulation 1698/2005, the need for such evaluations is described as to “improve the quality, efficiency and effectiveness of the implementation of rural development programmes” (EU 2005). Furthermore, these evaluations need to take into account “sustainable development requirements and environmental impact, meeting the requirements of relevant Community legislation” (EU 2005).

Impact assessments can be targeted to optimise the effectiveness and efficiency of CAP reform options towards multifunctionality implementations. To facilitate such impact assessments, monitoring and evaluation frameworks and various indicator lists have been developed by the European Commission. The most relevant framework and indicator lists for rural development issues, and therefore for the MEA-Scope project, are the Common Monitoring and Evaluation Framework (CMEF) and its Baseline indicators related to objectives and Common Impact Indicators (EC 2006). The Baseline indicators related to objectives are specifically developed to assess the compatibility of regional rural development policies with their objectives.

Another policy indicator list which is of interest for the MEA-Scope simulations is that containing Sustainable Development Indicators (Eurostat 2006). These indicators are linked to the priority areas of the EU Sustainable Development Strategy, which was adopted by the European Council in Gothenburg in June 2001 and renewed in June 2006. The indicators have been developed to monitor the progress towards the goals of this Strategy.

End-user demand for NCOs has been derived not only from the policy NCO indicator lists, but also from information stemming from two MEA-Scope end-user workshops. Important issues arising from the end-user workshops concern the Lisbon Agenda (rural development and employment issues) as well as landscape conservation, environmental protection, diversification and off-farm income issues.

When analysing the policy indicator lists and the information from the end-user workshops, it is concluded that most of these demanded indicators can be seen in a broad sense as NCO indicators, as agriculture can make them available in connection with the production of commodity outputs. The end-user demand for NCO indicator outputs is therefore derived from the development of these policy indicator lists and statements in the MEA-Scope end-user workshops.

In Table 1, the relevant NCO indicators from the three policy indicator lists and the NCO indicators mentioned in the MEA-Scope end-user workshops are consolidated into one table, as many of these indicators overlap. For the table with all demanded NCO indicators per source, see Waarts (2007). It must be noted that only the NCO indicators that are relevant for MEA-Scope have been listed here, as there are many NCO indicators in the policy indicator lists, which are not relevant for the scope of the MEA-Scope project.

Table 1. End-user demand for NCO indicators

Demanded NCO indicators by end-users	
Economic development	Soil: Organic farming
Employment rate	Production of renewable energy from agriculture and forestry
Unemployment rate	UAA devoted to renewable energy
Labour productivity	Gas emissions from agriculture
Population (index) of farmland birds	Diversification
High Nature Value farmland and forestry	Farmers with other gainful activity
Area under agri-environmental support	The number of farms/households
Abandonment of farming	Livestock density index
Gross Nutrient Balances	Household size
Water: pollution by nitrates and pesticides	Weighted emissions of acidifying substances, by sector
Groundwater abstraction	Weighted emissions of ozone precursors, by sector
Soil: Areas at risk of soil erosion	

NCO indicators which are demanded by the end-users but which are not relevant for the scope of the MEA-Scope project can be found in EC (2006) and Eurostat (2006). Examples of such indicators are: tourism infrastructure, internet take-up in rural areas, the development of the services sector, tree species composition, net migration, food security and lifelong learning in rural areas. Also, indicators related to inflation, investment, health, age, waste, transport, import, energy consumption, education, turnover, non-economic factors influencing farmers' decisions and social cohesion are outside the scope of the MEA-Scope project and are therefore not taken up in the end-user NCO indicator demand overview.

3 Regional Stakeholder Demand for Non-commodity Outputs

Regional stakeholders have a demand for the economic, ecological and social NCOs,[3] which are delivered by agriculture, although "there are significant regional differences in the societal demand for the functions of multifunctionality" (Schader et al. 2007).

The results of the research on regional stakeholder demand, described in Schader, Stolze and Moschitz (2007), are used in this section to compare regional stakeholder demand for NCOs with the supply of the MEA-Scope NCO indicator outputs.

Regional stakeholder demand on functions of multifunctional agriculture was assessed within the MEA-Scope project in four MEA-Scope regions in Germany, Denmark, Italy and Poland.[4] The objectives of this assessment were to "clarify the role that agriculture plays in the regions, identify the regional demand for the multifunctionality of agriculture, explore reasons for the regional demand for multifunctionality of agriculture and to reveal the regional differences in the societal demand for the functions of agriculture" (Schader et al. 2007).

The NCOs demanded by the regional stakeholders that fall within the scope of the MEA-Scope project simulations are presented in Table 2. Many of the NCOs that are demanded by the regional stakeholders fall outside the focus of the MEA-Scope project simulation focus. They are related to tourism and recreation, regional business development, cultural heritage and safe and quality food production. The complete list with demanded NCOs/functions can be found in Schader et al. (2007).

[3] With regard to regional stakeholder demand, the notion of function is normally used instead of the term NCOs because technically many of the aspects MEA-Scope dealt with are not NCOs in a strictly economic sense.

[4] Ostprignitz-Ruppin (DE), River Guadenå (DK), Mugello (IT), Turew/Koscian district (PL)

Table 2. Regional stakeholder demand for NCOs/functions within the project simulation focus

Regional stakeholder demand for NCOs/functions within project simulation focus	
Rural livelihood	Soil fertility
Provision of jobs	Provision of renewable energy
Increased biodiversity	Diversification of farms
Minimisation of nitrate in drinking water	Minimisation of smells from agriculture
Hydro-ecological equilibrium	

4 The Supply of NCO Indicator Outputs by the MEA-Scope Tool

The MEA-Scope project has developed a multifunctionality framework, which forms the basis of the analyses. The MEA-Scope multifunctionality framework is in line with the OECD, FAO and EU concepts of multifunctionality, and combines elements from all these approaches (for more information see Piorr et al. 2005). After developing the multifunctionality framework, a comprehensive set of NCO indicators was developed to be used in the simulations in the MEA-Scope Tool. These indicators were developed and implemented earlier in other projects as well as in monitoring and evaluation frameworks.

As an enormous number of NCO indicators are available in the literature, the derivation of the final MEA-Scope NCO indicators was therefore an iterative selection process: all NCO indicators were listed and indicators that were not relevant were omitted from the list. Then, the modellers indicated which indicators can be modelled within the MEA-Scope Tool and the regional stakeholders chose the relevant indicators for their regions. After taking into account the policy relevance of the NCO indicator list, the data availability, measurability and scalability, the MEA-Scope team selected the final list with indicators to be simulated in the Tool. This final list with MEA-Scope NCO indicators is presented in the right-hand column of Table 3 below.

One of the activities before the MEA-Scope NCO indicator outputs could be delivered was the MEA-Scope scenario development. The basis for the scenarios to be used in the MEA-Scope Tool is information from the MEA-Scope end-user workshops, but information from the literature and other projects working in similar topic areas was also taken into account. More information on the MEA-Scope scenario development can be found in Piorr et al. (2007).

Table 3. NCO indicators demanded by end-users and the simulated MEA-Scope NCO indicators

NCO indicators demanded by end-users	NCO indicators simulated by MEA-Scope
Economic development	Farm income
	Rental prices
Employment rate	Labour employed in agriculture
Unemployment rate	
Labour productivity	
Population (index) of farmland birds	Population of farmland birds; Index of Goal Attainment
	Beneficial crop patterns for flora and fauna
High Nature Value farmland and forestry	High Nature Value farmland areas
	Natura 2000 area
Area under agri-environmental support	Area enrolled in agri-environmental schemes
	Area of extensive agriculture
	Agricultural land use
	Cropping/Livestock patterns
Abandonment of farming	Abandonment of farm land
Gross Nutrient Balances	Nitrogen balance
Groundwater abstraction	Ground water recharge potential / proliferation; Index of Goal Attainment
Soil: Areas at risk of soil erosion	Soil quality; organic matter content
Soil: Organic farming	
Production of renewable energy from agriculture and forestry	
UAA devoted to renewable energy	
Gas emissions from agriculture	GHG emissions from agriculture
Diversification	
Farmers with other gainful activity	% income from off-farm activities
The number of farms/households	Number of farms
Livestock density index	Animal (livestock) stocking densities
	Livestock composition

The NCO indicator outputs are simulated by the MEA-Scope Tool for various scenarios and case-study regions. For more information see the MEA-Scope website: www.mea-scope.eu. The MEA-Scope Tool is based on three validated agronomic and economic models with which agronomic, environmental and economic changes are shown for seven regions in various ecosystems in Europe. There are extensive opportunities for using the MEA-Scope Tool, and the models are capable of showing the impact of policy changes on many NCOs through the delivery of NCO indicator results. More information about the models can be found in Damgaard et al. (2004).

5 Assessing the Gap Between the Demand and Supply of NCOs

In Table 3 above, an overview is given of the relevant NCO indicators demanded by the end-users and the NCO indicators simulated within the MEA-Scope Tool. Presenting both lists in one table facilitates the comparison in the gap analysis, which is presented in this section. As can be seen, many demanded NCO indicators have their equivalent in the simulated NCO indicators in the MEA-Scope Tool.

Most of the relevant demanded *economically focused NCO indicators* are simulated, examples being the number of farms, the size of farms, cropping/livestock patterns, employment, farm income (profit) and farmers with other gainful activity. As an extra indicator, the AgriPoliS modellers chose to simulate rental prices per soil type; this indicator is important to present because most of the adjustments/policy effects are capitalized in the price of assets, and thus in land prices. However, many demanded NCOs within the economic function have such a scope or scale that they cannot be simulated by the MEA-Scope Tool because the project's focus is different. In Waarts (2007) a list with these NCO indicators is provided.

With regard to the *environmental NCO indicators* demanded by policymakers, it can be concluded that most of the relevant demanded NCO indicators are delivered by the MEA-Scope Tool, namely GHG emissions, soil quality, biodiversity, areas of extensive farming, Natura 2000 area, land abandonment and ammonia loss. Groundwater supply (the potential for groundwater recharge/proliferation) is used as an indicator instead of groundwater abstraction. In addition, more specific land-use related indicators are simulated in the Tool than actually demanded.

Indicators for social NCOs have been difficult to find when listing the available indicators from common indicator frameworks used for agricultural impacts assessments (Waarts 2005). Furthermore, in this respect MEA-Scope's project focus is narrower than the end-user demand for NCO indicators. The reason for this is that existing models, and thus also the models used for the MEA-Scope Tool, are designed for differently focused purposes and are thus not capable of simulating social indicators yet. With this in mind, no social NCO indicator relevant for the MEA-Scope project could be simulated within the social function. Examples of demanded social NCO indicators, which cannot be simulated within MEA-Scope are public health, social cohesion, cultural heritage and food security. The outcome of this analysis indicates that the impacts of CAP reforms on social functions of agriculture constitute an important issue as social NCO indicators are demanded by end-users. The simulation of social NCO indicators therefore requires more attention in future impact assessments of multifunctional agriculture.

One reason has already been given for not simulating demanded NCO indicators in the MEA-Scope Tool namely that the focus of the MEA-Scope project is less broad than the NCOs demanded by the end-users. Another reason is that the MEA-Scope Tool can only simulate a certain number of indicators, to derive meaningful results; this limits the number of indicators that can simulated in the Tool. Therefore, the set of MEA-Scope NCO indicators is comprehensive, but can therefore never be a complete picture of end-user demand.

In Table 4, the relevant NCOs demanded by the regional stakeholders are presented, next to the NCO indicators simulated in the MEA-Scope Tool. "*Relevant*" means that the NCOs presented here fall within the scope of the MEA-Scope project simulations. Six out of the nine relevant NCOs that are demanded by the regional stakeholders are simulated by the MEA-Scope Tool although they do not carry the same name. The only exceptions are the minimisation of nitrate in drinking water, the provision of renewable energy and the diversification of farms. It is interesting to note that these indicators are also demanded by the end-users. It is recommended, therefore, that these NCO indicators be given more attention in future impact assessments with regard to multifunctional agriculture.

Table 4. Regional stakeholder demand for NCOs/functions within the project simulation focus and the supplied MEA-Scope NCO indicators

NCOs/functions demanded by regional stakeholders within project simulation focus	NCO indicators simulated by MEA-Scope
Rural livelihood	Farm income
	Rental prices
Provision of jobs	Labour employed in agriculture
Increased biodiversity	Population of farmland birds; Index of Goal Attainment
	Beneficial crop patterns for flora and fauna
	High Nature Value farmland areas
	Natura 2000 area
	Area enrolled in agri-environmental schemes
	Area of extensive agriculture
	Agricultural land use
	Cropping/Livestock patterns
	Abandonment of farm land
	Nitrogen balance
Minimisation of nitrate in drinking water	
Hydro-ecological equilibrium	Ground water recharge potential / proliferation; Index of Goal Attainment
Soil fertility	Soil quality; organic matter content
Provision of renewable energy	
	GHG emissions from agriculture
Diversification of farms	
	% income from off-farm activities
	Number of farms
	Animal (livestock) stocking densities
	Livestock composition
	Average size of farms
Minimisation of smells from agriculture	NH3 volatilization

6 Conclusions

After assessing the end-user demand for NCO indicators as well as the regional stakeholder demand for NCOs, these demands have been compared with the supply of NCO indicator outputs of the MEA-Scope Tool.

The first conclusion from this research is that many NCOs which are demanded by the end-users and the regional stakeholders fall outside of the scope of the MEA-Scope simulations. Therefore, the MEA-Scope Tool could not provide results for these NCO indicators.

Most of the NCO indicators demanded by *the end-users* that do fall within the scope of the MEA-Scope project are however simulated by the MEA-Scope Tool. Therefore, the MEA-Scope Tool provides information on the impacts of various policies on NCOs linked to agricultural activities, for a representative and comprehensive set of NCO indicators. The reason that some demanded NCO indicators are not simulated by the MEA-Scope Tool is that they are beyond the scope of the MEA-Scope project. Another reason for not including all demanded indicators is that the MEA-Scope Tool can only simulate a certain number of indicators to derive meaningful results. The set of MEA-Scope NCO indicators is therefore comprehensive, as it would be very hard to provide meaningful results for all demanded NCO indicators at the same time.

The NCOs that require more attention in the future through impact assessments are the social NCOs related to multifunctional agriculture. This is because they are demanded, but they are hard to supply as existing models do not take them into account yet. Furthermore, well-developed indicators for social NCOs are difficult to find, units of measurements for the social indicators that do exist are not generally agreed upon, and data is often not available to assess impacts of policies on such indicators.

Many NCOs that are demanded by *the regional stakeholders* are beyond the scope of the MEA-Scope project and are therefore not simulated in the MEA-Scope Tool (e.g. migration, the provision of renewable energy, the diversification of farms, food security, health issues and regional tourism). These demanded NCOs are important to take into account in future assessments, as they are often deemed important by both regional stakeholders and end-users. Six out of nine of the NCO indicators that do fall within the scope of the MEA-Scope project simulations are simulated within the MEA-Scope Tool.

The conclusions from this gap analysis are that, even though many demanded NCOs are not relevant for the MEA-Scope project and are thus not simulated by the models, many of the relevant NCO indicators demanded by the end-users and the regional stakeholders are simulated by the MEA-Scope Tool. Overall, the MEA-Scope Tool forms a good basis for reaching the goals of the MEA-Scope project and in satisfying end-user demand for MEA-Scope relevant NCO indicator outputs.

Based on these conclusions, it is recommended to develop and agree on common social NCO indicators, and to stimulate the development of models that can take them into account. Furthermore, science-policy integration can close the gap between the demanded NCO indicators and the NCO indicator outputs delivered currently by research projects. Also, it is recommended that research on the regional stakeholder demand for functions of multifunctional agriculture is extended to more countries and regions. Then, this regional stakeholder demand could be taken into account by the end-users at the EU level and could be taken up in future impact assessments with regard to multifunctional land use.

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Part IV

Regional and Local Case Study Stories of a Europe in Change

Environmental Impacts of Pillar I and II with Specific Respect to Designated Areas – Results from the MEA-Scope Case Study in Germany

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Abstract

Impact assessment is a procedure that goes along with the preparation of policies and is a key instrument to support political decision-making. An environmental impact assessment (EIA) focuses on the likely environmental effects of a policy option. Of specific interest in this context are effects with respect to environmentally sensitive areas such as Natura 2000 areas. This chapter presents an indicator-based modelling approach for the assessment of environmental impacts of alternative policy scenarios with varying policy settings of pillar I and II of the EU's Common Agricultural Policy (CAP). The application of the modelling approach is presented for a case study region in North Eastern Germany. Results show that decoupling of direct payments leads to a trend towards intensification on arable land, which is associated with negative impacts for most of the analysed environmental indicators. On the contrary, on grassland an extensification takes place, which is beneficial for most of the indicators and can be seen as an effect of cross compliance regulations in pillar II and reduced livestock numbers. In the analysed liberalisation scenarios an intensify-cation on both land cover types, arable land and grassland, can be observed. A large extent of agricultural land is abandoned and land use of

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the land remaining in agricultural production is intensified. This effect gets even more pronounced if pillar II measures are ceased.

Keywords: environmental impact assessment; designated areas, modelling; policy scenario analysis; CAP pillar I and II

1 Introduction

Impact assessment is a procedure that goes along with the preparation of policies and is meant as an aid to political decision-making by gathering and presenting evidence that helps to determine possible advantages and disadvantages of a certain policy option (SEC 2005). This helps to pre-estimate what will happen if a certain policy is put into practice. Impact assessment is a key tool in this respect. An environmental impact assessment (EIA), in this context, focuses on the likely environmental effects of a policy option. The analysed impacts can encompass, for instance, water pollution impacts, soil contamination impacts, air pollution impacts, ecology impacts including endangered species assessment, geological hazards assessment and human health impacts. The legal background in the EU is made up by the EIA-Directive on Environmental Impact Assessment (EC 2003) which was introduced in 1985 (amended in 1997, amended again in 2003) and by the so-called SEA-Directive on Strategic Environmental assessment (EC 2001b), introduced in 2001.

Of specific interest are effects with respect to environmentally sensitive areas such as Natura 2000 areas. Natura 2000 is an ecological network in the territory of the European Union. It aims at the protection of threatened habitats and species across Europe. The establishment of Natura 2000 areas is based upon two directives, the Birds Directive (EC 1979) and the Habitats Directive (EC 1992). The Natura 2000 network contributes to the "Emerald network" of Areas of Special Conservation Interest (ASCI) set up under the Bern Convention on the conservation of European wildlife and natural habitats.

To do an EIA, several methods and tools can be employed, whereat model-based approaches employing indicators to assess possible developments play an important role. (SEC 2005). The assessment of the impacts can be either qualitative or quantitative. The indicator selection should be in line with the set of indicators developed by the European Commission with respect to the implementation of the EU sustainable development strategy (EC 2001a). This chapter presents a modelling approach for the assessment of environmental impacts of alternative policy scenarios with varying policy settings of pillar I and II of EU's Common Agricultural Policy (CAP). The application of the modelling approach is presented for a case study region in North Eastern Germany.

In the following sections, first a brief description about the German case study region is given and the employed modelling approach as well as the analysed policy scenarios are characterised. Subsequently, the environmental trends under the different policy scenarios are exemplified making use of several abiotic and biotic indicators. The results are always compared against the initial period, that is the situation before the policy change. Thereby, special attention is given to designated areas. Finally, some conclusions are drawn from the observed results.

2 Region Portrait

The administrative district Ostprignitz-Ruppin is situated in north-eastern Germany in the state of Brandenburg. The region consists of 23 municipalities with a total area of about 2,500 km². With 109,000 inhabitants the region is only sparsely populated, as there are only 43 inhabitants per km². The overall landscape structure is versatile, including water bodies, heath land and swamp areas. The southern part of the region is rich in grassland, while the northern part is characterised by a high share of woodland, which covers about 34% of the total area. With 56% of the total area in agricultural use, the region is dominated by agriculture (Fig. 1).

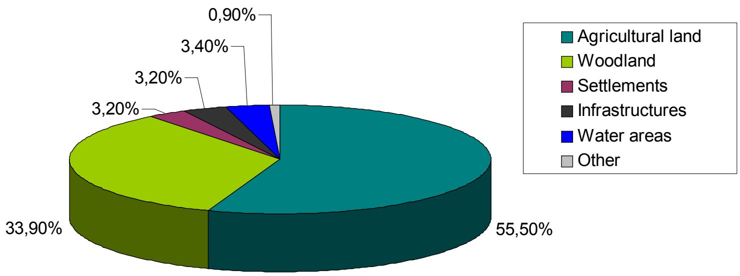

Fig. 1. Land cover in the Ostprignitz-Ruppin region (Source: CORINE land cover data 2000)

This is also expressed in agriculture's share in the gross domestic product of the regions. With 4% it is twice as high as the average calculated for Brandenburg state as a whole (Brandenburg regional 2006).

In 2003, the region counted 585 farms with an average farm size of 200 ha and an average livestock density of 0.5 LU/ha. Livestock raising involves mostly intensive indoor dairy, cattle and pig production, but also extensive suckler cow and baby beef production. The land provides rather disadvantageous conditions for crop production, as soils are poor and the yearly precipitation amounts to only 520 mm on average. The share of grassland and low productive arable land is significantly higher within Natura 2000 sites, which cover 562 km² (22% of the total area). Approximately 41% (228 km²) of Natura 2000 areas are in agricultural use (Fig. 2).

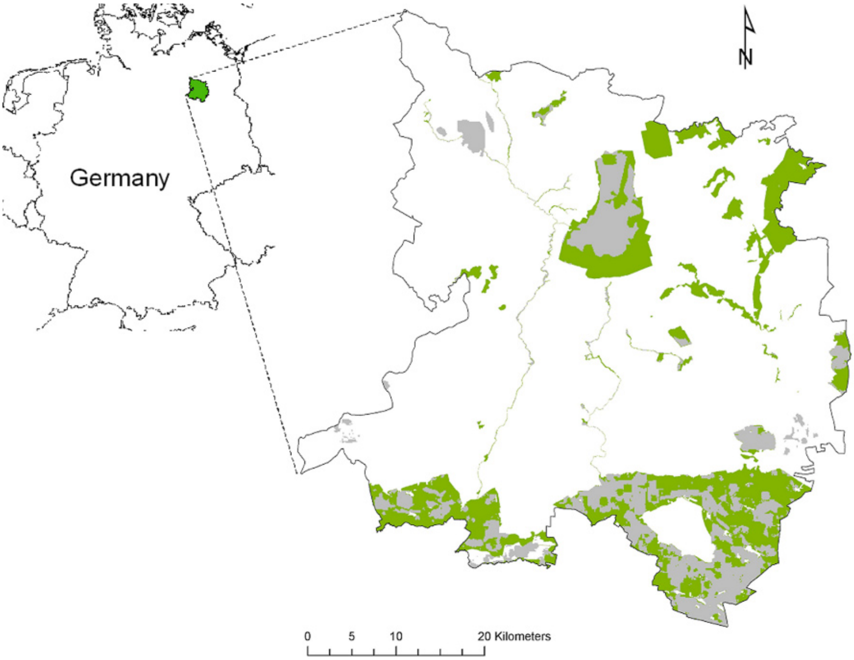

Fig. 2. Location of Natura 2000 areas (*green pixels*) in Ostprignitz-Ruppin and share of Natura 2000 sites in agricultural use (*grey pixels*)

3 Modelling Approach

The overall MEA-Scope modelling approach links together three existing models, namely AgriPoliS, MODAM and FASSET (Piorr et al. 2007; Damgaard et al. 2006). The approach is meant to simulate structural change and change of cropping patterns in agriculture under different policy scenarios. Two out of the three models, MODAM and FASSET, are capable of addressing environmental issues. In this chapter, the focus is on the environmental impact assessment (EIA) as part of MODAM.

The EIA in MODAM is indicator-based and assesses the land use related risks for the selected indicators per region. Indicators can be abiotic or biotic. For the Ostprignitz-Ruppin region 10 indicators have been chosen. For each indicator a respective environmental goal is defined (Table 1). The assessment is of qualitative nature, the result being a dimensionless index value, the Index of Goal Attainment (IGA), ranging between zero and one. The closer the IGA is to 1 the higher is the assessed suitability of a production practice to fulfil an indicator-related environmental goal.

Table 1. Overview on abiotic and biotic indicators and environmental goals

	Abbrev.	Environmental goal/**Indicator**
abiotic	NO3	Lower risk of **nitrate leaching** to groundwater
	NP	Lower risk of **nutrient (N/P) entries** into surface waters
	Pest	Lower risk of **pesticide entries** into ground- and surface waters
	GWR	Improve potential for **groundwater recharge/**proliferation
	WaEro	Lower risk of **water erosion**
biotic	Amph	Improve habitat potential for **red belly toad** (amphibians)
	Sky	Improve habitat potential for **skylarks** (field breeding bird)
	Hare	Improve habitat potential for **field hares** (mammal)
	Hover	Improve habitat potential for **hover flies** (beneficial insect)
	Flora	Improve habitat potential for **wild flora species** (winter annuals)

The IGA is calculated per production practice. A production practice should be understood as the sum of all work steps needed to produce a certain crop on a certain site type. The description of a production practice includes the timing and sequence of all operations involved, such as tillage, sowing, fertilisation, pesticide application, mechanical weeding and harvesting, as well as the characterisation of all inputs used and machineries applied. For the German case study region about 1,200 production practices for 35 crops have been defined in different land use intensities for both, arable farming and grassland management. Land use intensity in terms of input use and employed machinery is adapted to the site productivity. In dependency on the expected yield, low productive sites are more extensively managed while high productive sites are used intensively. The approach is spatially-explicit, which means that for each policy scenario it is known which production practice takes place on which land units represented by a single pixel in a map. Each pixel (one ha in size) is classified by its soil fertility class based upon the soil rating index ("Ackerzahl", Schachtschabel et al. 1992) and other features, e.g. if or if not a pixel is located within a Natura 2000 area. In this way, the IGA can be aggregated for certain site types. As it is also modelled which pixel is owned or rented by which farm, the IGA can also be aggregated at farm level, and finally, also at regional level. The calculation is done by area-weighted aggregation of the index values per production practice taking into account the area each practice is allotted to.

As the knowledge about how different agricultural land-use practices affect the abiotic and biotic environment is often limited, a fuzzy-logic-based approach was employed, as the concept of fuzzy-logic offers the possibility to include uncertain knowledge into an assessment (Zadeh 1994). Fuzzy-logic has been proven as a suitable concept in various aspects in environmental impact assessment (e.g. Mertens and Huwe 2002; Silvert 2000; Mitra et al. 1998; van der Werf and Zimmer 1998; Daunicht et al. 1996).

The EIA of MODAM is made up of rule-based algorithms based upon expert knowledge and data gained from literature reviews. Thus, the approach can be run with comparatively fewer data than process-orientated assessment schemes (Sattler et al. 2006). The rules consist of single if-then-conditions, which define the inter-dependencies between the different influencing factors that have been identified as relevant for each indicator in question. The rule base as a whole conserves all knowledge available, quantitative and qualitative, about how an indicator is affected by agricultural management activities, taking into account factors like type and amount of applied inputs, kind of machinery used, or time overlaps between operations and sensitive periods of the selected indicators.

4 Policy Scenarios

The EIA undertaken in the context of the EU-project MEA-Scope refers to the analysis of environmental impacts caused by the latest CAP-reform of 2003 (scenario REF). The regulations imply that subsidy payments will be granted independently from the volume of production (decoupling, pillar I) and become more and more linked to certain environmental requirements (cross compliance, pillar II) (EC 2004). Additionally, further policy settings are analysed foreseeing market liberalisation and abolishment of subsidy payments, both, in pillar I and/or pillar II (scenarios S01 and S02).

All policy changes are assessed against a no-policy change option referred to as the baseline scenario (BAS), which mimics Agenda 2000 conditions (Table 2).

Table 2. Overview on policy scenarios

Scenario	Pillar I	Pillar II
BAS	Agenda 2000	AEP*, Natura 2000
REF	Decoupled single farm payments	AEP*, Natura 2000
S01	No subsidies	AEP*, Natura 2000
S02	No subsidies	no AEP*, no Natura 2000

*AEP = Agri-environmental programmes

Payments of 130 € per ha from agri-environmental programmes (AEP) were granted for extensive grassland practices. Furthermore, payments for Natura 2000 measures up to 200 € can be obtained for extensive grassland as well as arable farming practices. The simulations were run over 10–15 years, starting with the initial policy situation under Agenda 2000 conditions and introducing a new policy always in the fourth period. To capture the medium term environmental impacts effectuated by a policy change in the following sections always year nine (t=09) is compared to the initial situation (t=00) in scenario BAS. In the presentation of results a specific emphasis is given to the differences arising between Natura and Non-Natura 2000 areas.

5 Results

Figure 3 shows the *cropping pattern* inside and outside Natura 2000 areas per scenario in year nine (*09) and in the initial situation (BAS00).

As a general trend, a substantial higher share of grassland in Natura 2000 areas in all scenarios can be observed, which is mostly under basic management. In regard to arable land, inside Natura 2000 areas, the share of row crops, such as silage corn, potato and sugar beet, is slightly lower. The same applies for oil seeds (winter rape).

The assessed general *environmental impacts* going along with the change in agricultural land use are displayed in Fig. 4.

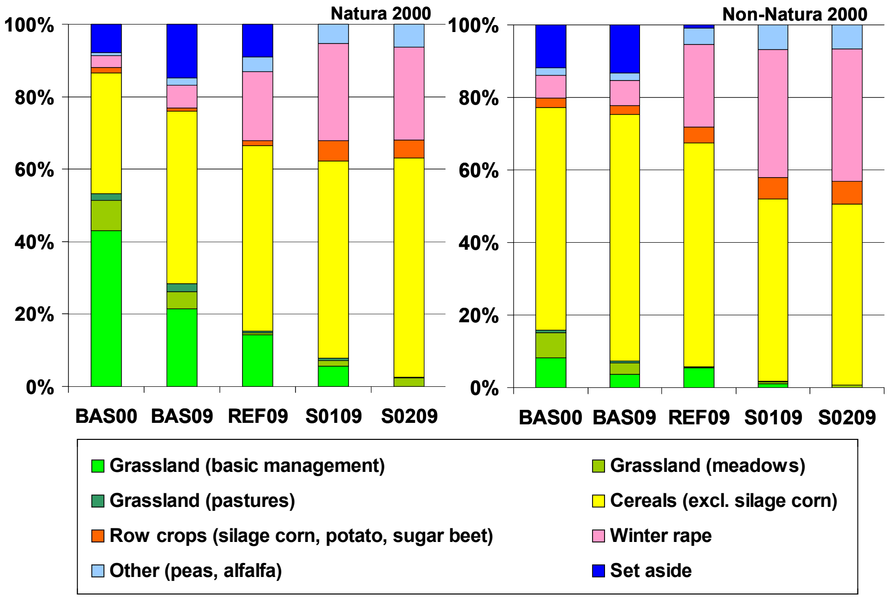

Fig. 3. Cropping pattern per scenario (Natura 2000 vs. Non-Natura 2000 areas)

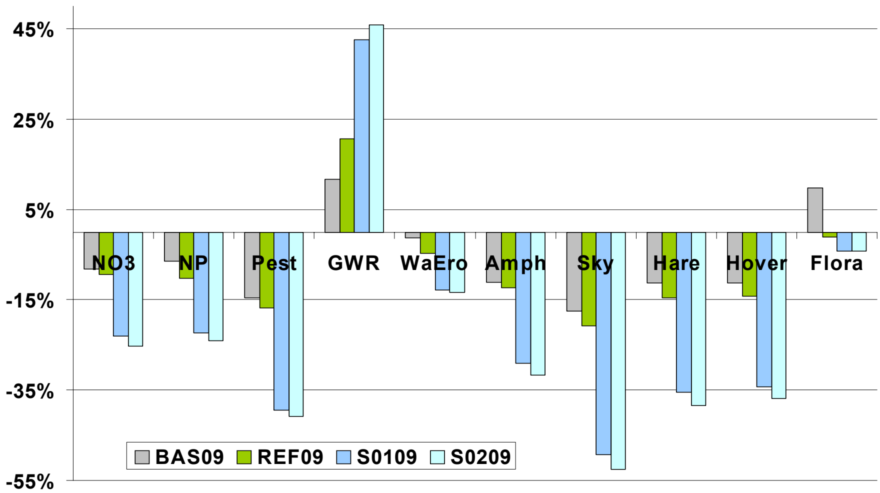

Fig. 4. Environmental impacts per scenario (in general), indicated by the relative change of the average IGA in comparison to the initial situation (BAS00). See Table 1 for indicator abbreviations

The figure shows the relative change of the average Index of goal attainment (IGA) per scenario in year nine (*09) in comparison to the initial situation (BAS00). Any figure above zero indicates an improvement with respect to the environmental indicators, while any figure below zero denotes the opposite effect. At the regional level, in all analysed scenarios, for nine out of 10 indicators the situation gets worse due to changes in the cropping pattern.

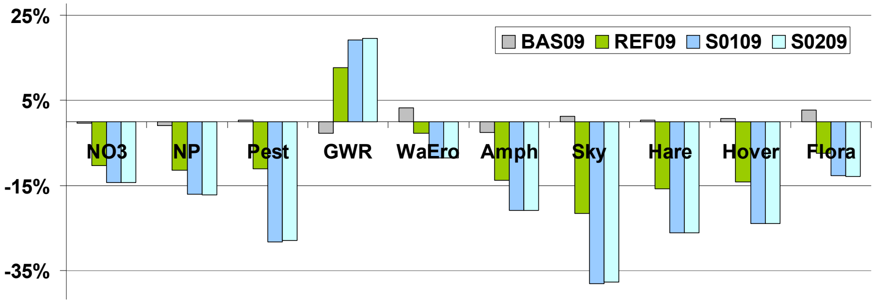

Fig. 5. Environmental impacts per scenario (arable land), indicated by the relative change of the average IGA in comparison to the initial situation (BAS00). See Table 1 for indicator abbreviations

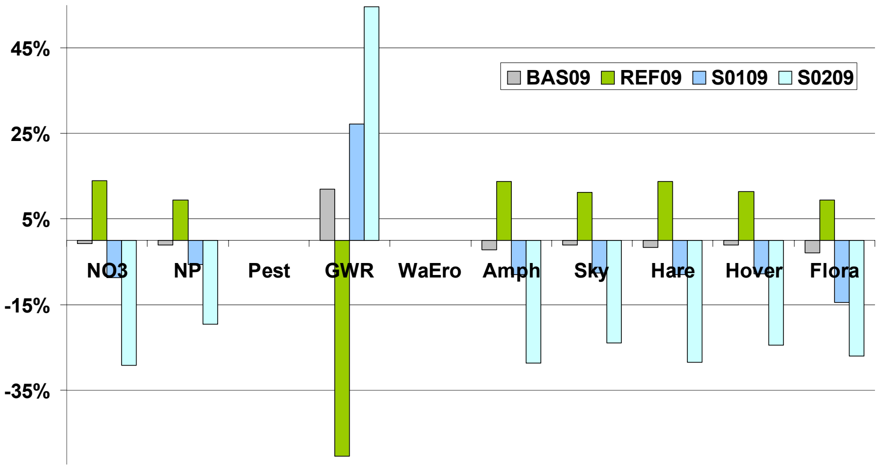

Fig. 6. Environmental impacts per scenario (grassland), indicated by the relative change of the average IGA in comparison to the initial situation (BAS00). See Table 1 for indicator abbreviations

However, a separate analysis of arable land and grassland reveals a more diverse picture (see Figs. 5 and 6). On arable land, similar to the general assessment, mostly negative impacts on selected indicators take place. The same applies to the scenarios S0109 and S0209 on grassland,

and less pronounced also to the scenario BAS09 (Fig. 6). On the contrary, in the REF09 scenario for seven indicators an improvement of the environmental situation can be observed. On grassland, the indicators "Pest" and "WaEro" (cp. Table 1) are not affected, as no pesticides are applied and due to the permanent soil coverage the risk for water erosion is assessed to be zero.

Figure 7 highlights the differences between arable land and grassland inside and outside Natura 2000 areas in the REF scenario. It becomes obvious that on arable land an intensification of the land use takes place resulting in decreasing average IGAs, while grassland is extensified going along with increasing average IGAs for the most chosen indicators, with the exception of ground water recharge (GWR).

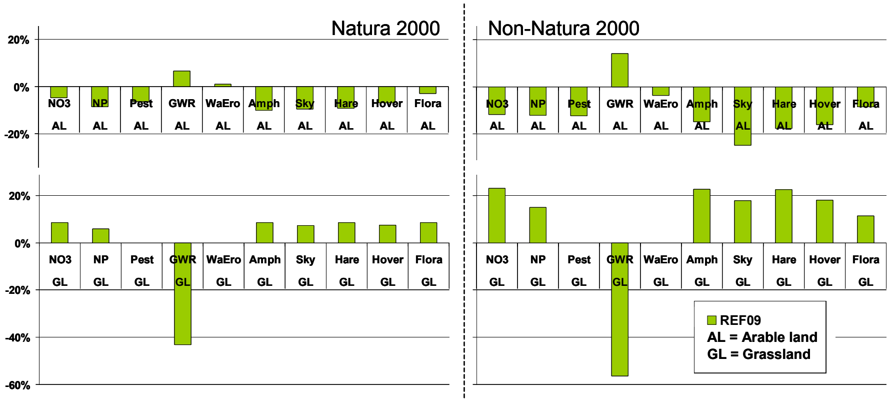

Fig. 7. Environmental impacts per scenario (arable land, AL, vs. grassland, GL, inside and outside Natura 2000 areas), indicated by the relative change of the average IGA in comparison to the initial situation (BAS00). See Table 1 for indicator abbreviations)

For this indicator, on arable land the situation improves, due to the higher share of row crops, (low soil coverage, long periods until crop stand is closed due to slow growth rates in the beginning of the vegetation period) and a smaller share of set aside land and grassland (cp. Fig. 3). On the contrary, on grassland the situation becomes less favourable, as a higher share of grassland is under basic management and thus is less frequently cut, resulting in higher transpiration rates going along with a decreasing infiltration. As the share of grassland inside Natura 2000 is higher than outside, these trends are more pronounced in the designated areas.

6 Discussion

As a first indicator for land use intensity, *land abandonment of grassland and arable land* is depicted in Fig. 8. As a general trend, more grassland than arable land is taken out of production. This can be explained by the decreasing stocking numbers effectuated by the abolishment of livestock-related payments and a consequently reduced need to use grassland for fodder production or for grazing. Thereby, reduced livestock numbers in the first place are related to extensive livestock systems such as suckler cows and extensive beef cattle, while intensive dairy and pig production prevails.

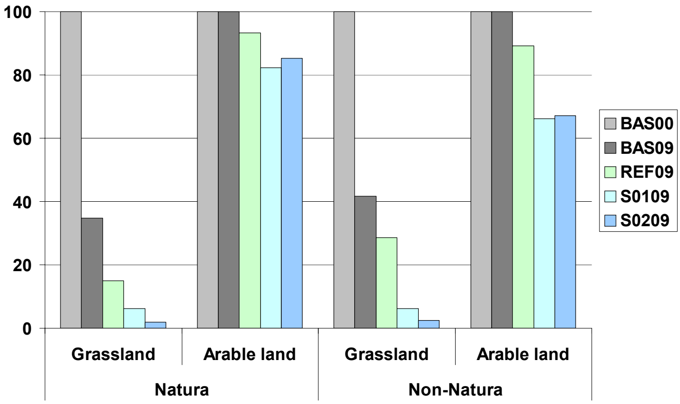

Fig. 8. Land abandonment inside and outside Natura 2000 areas (grassland vs. arable land) per scenario (BAS00 = initial situation).

Within Natura 2000 areas less arable land and more grassland is abandoned, while outside Natura 2000 the opposite effect takes place. This is due to the pillar II specifications, as for arable land only inside designated areas payments can be claimed (cp. Table 2). Hence, it seems a suitable strategy for farms to keep more arable land in production inside the Natura 2000 areas and switch at least for the less productive sites to extensive management to get additional Natura 2000 payments. On grassland outside designated areas also payments can be claimed from the respective AEP.

Figure 9 shows the *farms' participation in pillar II measures* which serves as a second indicator for land use intensity.

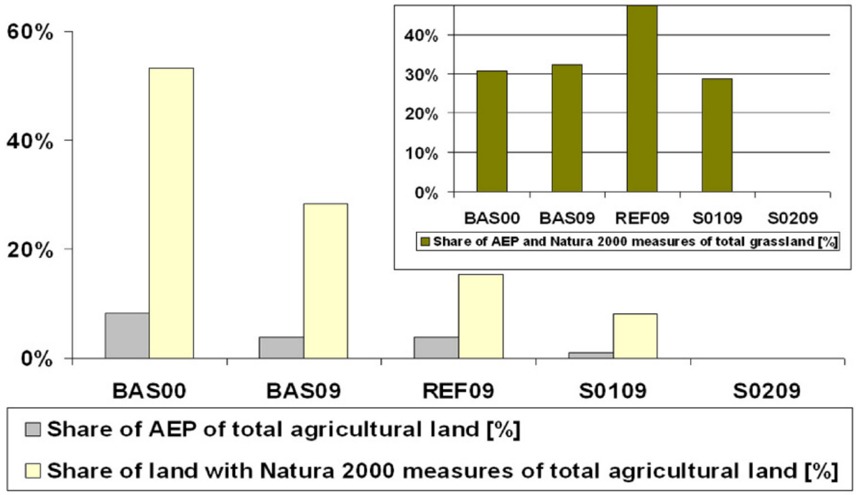

Fig. 9. Participation in AEP and Natura 2000 measures per scenario (total agricultural land vs. grassland only)

Although the share of land that is either covered with AEP or Natura 2000 measures in absolute terms decreases, the share of grassland involved in pillar II measures stays at the same level in BAS09 and in S0109 scenarios or even increases in REF09 (in S0209, participation is zero, as no pillar II measured are offered, cp. Table 2). This behaviour of the farms makes sense from the economic point of view. Although less grassland is needed for forage production due to decreasing livestock numbers, in monetary terms it is beneficial to keep grassland partly in production to obtain environmental payments from pillar II. The higher share of grassland under AEP or Natura 2000 measures in the REF scenario is one of the responsible factors for the improved environmental situation for most indicators in this scenario compared to the baseline scenario.

Input use in terms of applied nitrogen, phosphorus and pesticides is used as a third indicator for land use intensity (cp. Fig. 10).

Input use is increasing for all scenarios compared to the initial situation. While in BAS00 nitrogen input is around 80 kg N/ha on average, it goes up to almost 100 kg n/ha in BAS09, to more than 120 kg N/ha in REF09, and to over 140 kg N/ha in S0109 and S0209. At the same time the number of pesticide applications increases from less than 2 (BAS00) to 3.5 in S0109 and S0209 (2.3 in BAS09 and 2.8 in REF09, respectively). Phosphorus input doubles from around 20 kg P_2O_5/ha (BAS00) to 40 kg (S0209).

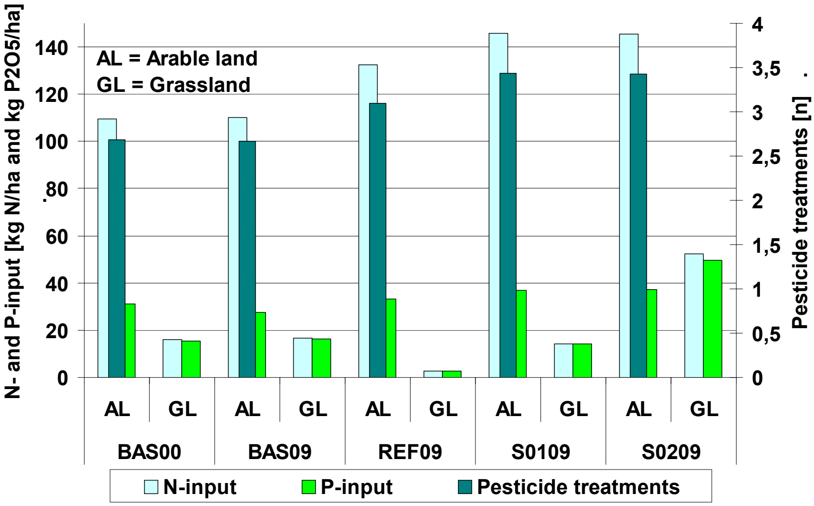

Fig. 10. Input use in terms of nitrogen, phosphorus and pesticide input on average per scenario (BAS00 = initial situation)

Although input use in absolute terms is increasing throughout the scenarios, Fig. 10 reveals that the situation is different between arable land and grassland. Compared to the BAS scenario, on arable land input use is increasing for the scenarios REF, S01 and S02, while on grassland input use either stays at a similar level (S01), decreases (REF) or increases (S02). While the higher share of grassland in AEP and Natura 2000 measures (Fig. 9) brings about the extensification effect in the REF scenario, a total abolishment of these environmental measures leads to the higher input use in S02.

As a fourth indicator for land use intensity the *disturbance potential for biotic indicators* has been considered (Fig. 11). For the calculation of the disturbance potential, the number of critical operations and their overlay with sensitive time periods such as breeding, reproduction or migration periods of the different indicators is taken into account. If a certain operation is considered as critical and to which extend depends on the indicator in question. For instance, cutting operations during breeding periods are very crucial for skylarks, as clutches are destroyed (Wilson et al. 1997), mineral fertiliser application (particularly ammonium nitrate) during migration periods can be highly toxic for amphibians (Oldham et al. 1997), and for wild flora species herbicide treatments and mechanical weeding operations are most relevant (van Elsen 2000).

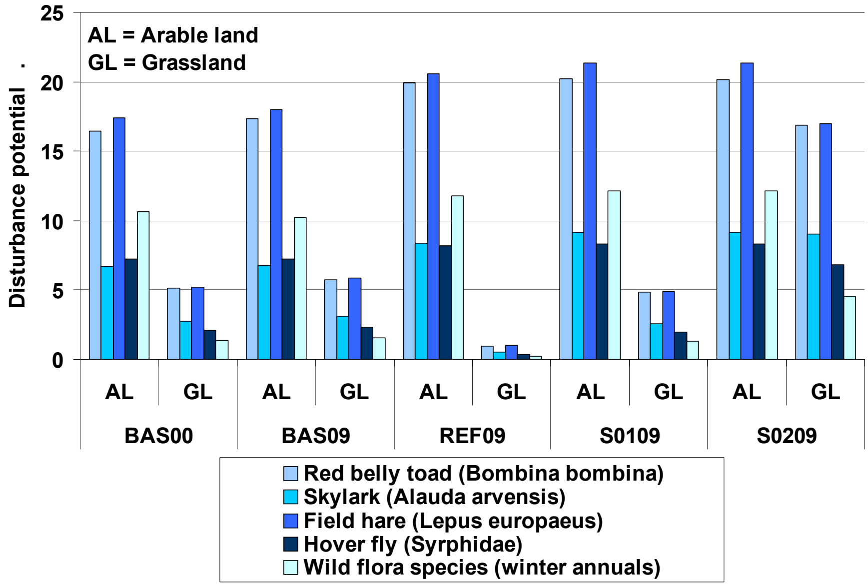

Fig. 11. Disturbance potential per scenario (arable land vs. grassland) for the biotic indicators (BAS00 = initial situation)

Figure 11 shows, similar to the land use intensity indicator (cp. Fig. 10), that the disturbance potential on arable land increases in all scenarios in comparison to the baseline scenario. At the same time, on grassland, the disturbance potential is almost equal to the one in the baseline scenario in the S01 scenario, is higher in the S02 scenario and is lower in the REF scenario. As a result, the environmental situation improves for all biotic indicators in the REF scenario (cp. Fig. 6).

7 Conclusions

The EIA in the MEA-Scope has been conducted to analyse environmental impacts in different policy scenarios.

In the decoupling scenario (REF), compared to the baseline scenario BAS, on arable land a trend towards intensification takes place which leads to negative impacts for most of the analysed environmental indicators. This is due to the change in the land use pattern effectuated by decoupled payments and thus stronger market-orientation in crop production (decoupling effect, pillar I). In contrast, on grassland an extensification takes place, which is beneficial for most of the indicators. In the first place, this is a result of reduced stocking numbers. Furthermore, a higher share of grassland is engaged in AEP or Natura 2000 measures (cross compliance effect, pillar II). In this sense, pillar II measures hold out against abandonment of grassland that is no longer needed for forage production.

In the liberalisation scenarios (S01 and S02), compared to the BAS scenario, an intensification of the land use on both land cover types, arable land and grassland, can be observed which is associated with negative environmental effects (liberalisation effect). A large extent of agricultural land falls out of production. The land that is kept in production is used more intensively, for example in terms of input use of fertilisers and pesticides. In the S01 scenario the environmental deterioration is less pronounced as a certain part of the area is still allotted to the AEP and Natura 2000 measures of pillar II.

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Validation of an Agent-Based, Spatio-Temporal Model for Farming in the River Gudenå Landscape. Results from the MEA-Scope Case Study in Denmark

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Abstract

A validation of the agent-based model AgriPoliS by back casting is presented. The agent-based model AgriPoliS is calibrated to a Danish agricultural catchment. The model was supplied with empirical data on the exact location of individual plots as well as farm characteristics of 2,383 individual farms covering the period 1998–2004. Validation was carried out comparing the results of the simulation to the empirical data. The comparison shows that the model simulates development on the most aggregated level (the number of farms in the catchment) relatively well. There are some variations to the degree of precisions on less aggregated levels of analysis. The overall conclusion is that the agent-based model approach utilized here was effective in regard to prediction.

Keywords: agent-based modelling; AgriPoliS; validation; levels of analysis

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1 Introduction

In this chapter is a validation of the agent-based model AgriPoliS [Agricultural Policy Simulator] Balmann (1993, 1995, 1997) and Happe (2004) by back casting presented. AgriPoliS is a normative spatial and dynamic model of regional agricultural structural development. The model explicitly takes account of actions and interactions (e.g. rental activities, investments, and continuation of farming) of a large number of individually acting agents. The representative farms in a region will be recreated as an individual mathematical programming model that interacts and competes with the other farms in the model through e.g. the land market. It is all embedded within the conditions of the technological and political settings.

Simulation studies have a long tradition in agricultural economics, which can partly be explained by the relatively good access to disaggregate data and the high demand for simulation of policy options by political and administrative bodies. Although validation has been an issue in agricultural economics, simulation models from this part of the sciences have still little tradition for validation. This is even more pronounced within agent-based modelling (ABM) of agricultural development. The ability to replicate empirical evidence is often seen as the only truly decisive criterion for quality of a scientific model. In this view, it is good scientific practice to maximise the empirical testability of a scientific model and the more empirical tests it has resisted without refutation the more it deserves to be called "scientific".

However, the essential purpose of any simulation study is the analysis of non-observable scenarios, such as the implementation of hypothetical policies or new technologies. By their very nature, there are no real-world data available for these situations. The simulation model needs therefore not only to be empirically valid. Stanislaw (1986) suggested that validation of simulation research should include:

- Theory validity (the validity of the chosen theory relative to the investigated system)
- Model validity (the validity of the model relative to the theory)
- Program validity (the validity of the simulator relative to the model)

The total validity of the model is then the combined validity of the three measurements. The list can be extended with justification, e.g. also include the validity of the behaviour of the agents, validity under extreme conditions and the validity of the structures in the model compared to the investigated system. This list is of course by no means complete, but it underlines the importance of judging a model on more than its ability to reproduce historical real-world data sets.

In the case of AgriPoliS, as with most other agent-based models focusing on the agricultural sector, there is a noticeable lack of empirical test of the model's validity in the development of the model. The documentation on the other aspects of the model's validity is not in the form of measurements resulting in a single combined value but in form of reports (Jelínek, et al. 2007; Kellermann et al. 2007), background documentation (Happe, Balmann et al. 2004) and journal articles (Balmann 1993, 1997; Happe et al. 2006), where these elements of model validation have been provided to the scientific community. Providing empirical validation of agent-based models requires that historical data is available for comparison as well as a number of other factors, which should be in place. Providing empirical validation, which is the aim of this study, thus faces some major challenges.

Often when empirical validation of agent-based models is considered, the focus is how to compute comparable results as most agent-based models have incorporated some stochastic processes and have some degree of non-linearity in their results. This is however not an issue of similar concern for AgriPoliS. Although the model can make use of some stochastic processes in modelling, a number of variables in the model are fundamentally deterministic by nature. An advantage of an agent-based model such as AgriPoliS is thus the ability to capture the heterogeneity, found in the empirical data, in the calibration.

The number of degrees of freedom that the model has is tremendously larger than traditional top-down modelling approaches where large groups of farms are described as a single entity. Each farm may act individually and constitutes therefore a possible source of error. As the actions of one farm influence the actions of other farms the empirical validity of the model is depending on the accuracy of each action taken by each individual farm. Although the large number of farms with their individual actions constitutes a potential source of error, size may also be to the model's advantage. If only some of the individual farms actions overshoot the real choices, while others do the opposite they may cancel out each other and lead to a reasonable aggregated result. However as the behavioral motivation for the agents often is the same (profit maximization in the case of AgriPoliS) the model will tend to be biased in a given direction. It has therefore been pointed out that the results of models of this particular type should not be used for predictions (or back castings) but they should be used only to point towards a given direction of the investigated system. Such an argument implies that the scale and details of the dataset that an agent-based model uses is too detailed for a real validation of the results. Although this may be true such a statement needs to be tested before one is able to accept it. Agent-based modelling should however be judged on an independent standard acknowledging the particular characteristics of this modelling approach. At least ABM approaches should be thoroughly scrutinized in terms of strengths and weaknesses.

The many degrees of freedom which are inherently build into the model make it difficult to produce the same accuracy as seen with standard models; however the agent-based model offers an abundance of details other modelling approaches are unable to produce. Some might argue that they would rather like a few accurate values than a large number of inaccurate values and in some cases this is true. One should however remember that such a direct comparison is seldom possible. Though one model might be better than another to reproduce the right number of farms within a region for a given period of time it does not mean that the composition of the farm types in the region which only the less reliable model can produce can not be of use. Such data might help to give a rough but necessary understanding of how the theory is predicting a given situation and is influencing the individual farms or farm types.

2 Introduction to the Study Area

The valleys of "Nørreå" and "Gudenå" are located in the central part of Jutland between three major cities: Aarhus, Viborg and Randers. The area covers over 76,600 ha. 1,871 farms on 72,089 ha of arable land and 5,089 ha of grassland on an average size of 41 ha are for most of them (62%) performing field crop farming. The other farms are then quite equally distributed among dairy farming (11%), grazing livestock farming (6%), granivores (14%) and mixed farming (7%). The study area was chosen partly due to the data availability.

2.1 Empirical Validation

This chapter builds upon the tradition of empirical validation (Sallans et al. 2003; Küppers and Lenhard 2005; Midgley et al. 2007; Windrum et al. 2007). Empirical validation may take its point of departure in a set of empirically observed data of the generic form (Windrum et al. 2007):

$$(\underline{\mathbf{z}})_i = \{\mathbf{z}_{i,t}, \mathbf{t} = \mathbf{t}_0, \ldots, \mathbf{t}_1\}, \mathbf{i} \in \mathbf{I} \tag{1}$$

where the set $\mathbf{I}$ refers to the observed entity (e.g. farms, firms or households) for which empirical observations for the finite set of time-periods $\{\mathbf{t}_0,...,\mathbf{t}_1\}$ in form of *K* variables is contained in the vector $\underline{\mathbf{z}}$. Summarised over the observed entities the data will have the following form (Windrum et al. 2007):

$$\underline{\mathbf{Z}} = \{\mathbf{Z}_t, \mathbf{t} = \mathbf{t}_0,....,\mathbf{t}_1\} \tag{2}$$

The observed dataset(s) may have a number of characteristics in the form of "stylised facts" or statistical properties, which the model tries to explain.

Both datasets $(\underline{\mathbf{z}})_\mathbf{i}$ and $\underline{\mathbf{Z}}$ are the unique outcome of an unknown, real world data-generating process (*rwDGP*). Similarly the model can also be understood as a data-generating process (*mDGP*). The goal for the modeller is that the *mDGP* provides a sufficiently good "approximation" of the *rwDGP* and that this approximation is based on a meaningful explanation of the causal mechanisms generating the observed data. Empirical validation is therefore the process of comparing and evaluating the ability of the *mDGP* to represent the *rwDGP* (Windrum et al. 2007).

3 Calibration of the Model

The calibration of agent-based models will very often involve some kind of adaptation of one or more empirical samples to the model, simply because the details required by agent-based models exceed what is available. Detailed information covering whole regions on a single farm level is seldom accessible. This means that a number of calibration methods have been developed to insure that the calibration of agent-based models is representing the investigated region in an acceptable way. At the same time the known discrepancies between the real region and its virtual representation in the model represent a source of error that is hard to eliminate from the validation results. Although this study also makes use of empirical samples re-scaled to the site, the majority of data is used to characterize the individual farms based on detailed information on a single farm level. The discrepancies between the real region and its virtual representation are thereby reduced to a minimum. This means that the main emphasis of the validation can be placed on the discrepancy between the real development and the simulated development rather than accusing the data used for the calibration for the differences.

In the Danish region we have access to accurate information on the spatial location of the farms and fields, the number of fields and their soil types as well as the number and types of animals. This detailed data originates from the national Danish Agricultural Registers, with the Danish acronym GLR/CHR (DMFAF 1999). The GLR/CHR database is a part of the system used to administer EU area and livestock headage support payments (Holl et al. 2002). The machine capacity of the farm is assumed to fit the current production capacity. Based on the current production the machine capacity is therefore calculated and assigned to each individual farm.

First a sub-sample of the European Farm Accountancy Data Network (FADN)-data was made by adjusting the full FADN sample to the regional statistics through minimizing the quadratic deviations between the regional statistics and the sum of farms characteristics times the new extrapolation factors assigned to the farms. This sub-sample of FADN farms as well as all farms from the region were then classified according to the same farm typology (Kristensen and Kristensen 2004). The typology is developed for Danish farming conditions and contains 31 different farm types. The typology utilises the detailed information on the farms to classify them using a decision tree technique. The economic values in the FADN farms are then converted into /ha. The individual farms with the same farm type according to the farm typology are given this value times their ha of land and thereby converting the values back to values fitting their size of production.

This method assumes that the FADN-farms have to be representative for the regional farms and that the different production types within farming have to be taken into account when transferring economic quantities. Finally it must implement the size of production. This means that each individual farm in the modelled version of the Danish case study area is unique in all its farm characteristics and that most of the values ascribed to the farms are empirically founded.

The technical coefficients, which represent the entire scope of potential production activities present in the location, are the same for the two years assuming that no large technical productivity gains were made on the ordinary farm in the region during the period. So although the sector of course has experienced technical progress within the four years period we are assuming that the technical equipment on the average farm in the region was maintained more or less the same within the period. The model hereby captures the real heterogeneity of the 2,383 farms present in year 1998, respectively 1,865 farms in 2002.

An important modification has however been introduced on the map of the fields belonging to the farms. Danish legislation demands that the individual farms not only have access to enough land to meet the harmonisation requirements but that the farms have enough land at their disposal. This has however the consequence that some of the farms are buying land to meet the harmonisation requirements where the prices are reasonable without considering what is possible to utilise within the production.

Some of the farms within the study area had land on small islands, which they could not access within the duration of a workday. As AgriPoliS includes transportation cost between the farmstead and the field such areas would immediately be abandoned in the model. AgriPoliS is considering harmonisation requirements in the form of maximum livestock density, however not with the special Danish ownership rules specified. The few fields in question have therefore been artificially moved closer to the study area. This has been done so that the relative distance between these plots still indicate which plots originally was furthest away.

The movement of the fields from their real location, is of course at variance with the empirical data. It is done in order to compensate for a discrepancy between the reality and the models abilities. The procedure insures that the farms maintain their real size. There is however a drawback with this procedure. It is difficult to insure that the same fields are moved to the exact same locations in the empirical maps for the different years. Therefore some of these moved fields will not show the same values when spatially analysed. Measures have been taken to reduce this problem to a minimum and the number of fields involved makes it a minor problem. Having said that the issue still exists and should therefore be considered when different results are compared spatially.

As the prices for the period 1998–2007 are known, the price development of the individual commodities and services within the model is following the real trends. The real price trends insure that the farms are optimising each single production period under similar conditions as in the real case.

4 Validation of the Model

Empirical data from the years 1998, 2000, 2002 and 2004 on the exact location of individual plots as well as farm characteristics is used to validate the model by back casting. The procedure is that the structure of the individual farms for the year 1998 is read into AgriPoliS. This farm structure along with regional Geographic Information System (GIS)-maps is used to calibrate the model. The model is then supplemented with price trends based on the real price development. The result of the simulation is compared to the empirical data.

The analysis will mainly compare the simulated results with the real data from year 2002. This is done in order to eliminate any dramatic shifts in the farm structure due to the effects of the 2003 Common Agricultural Policy (CAP) reform. Although the aim of this model is in part to investigate the effects of CAP-reform options such large external events are in the risk of disturbing the results of a validation in an unbeneficial way. Because the model will immediately react strongly on such sudden changes in the framework conditions for the sector and enter a new stable level of structural development. The real farms will not and cannot react in the same dramatic way, shifting the production or closing the production over night.

The structure of the sector will however after some time reflect the same economic conditions and therefore the structures found within the model will hopefully reflect the real situation. To validate this behaviour a longer period of time is needed. The year 2004 will therefore not be used as the main year for the comparison. Comparing simulated results for a single year involves always the risk of that particular year being an outlier, and ideally the trend over several years should be used. This has been done when the data enabled it. In Table 1, data for the real number of farms compared with the modelled number of farms for four years is shown.

Table 1. Real number of farms in the region in the years 1998, 2000, 2002 and 2004 compared to the simulated results and an average value for the years 2000, 2002 and 2004

Year	Real number of farms	Number of farms in AgriPoliS	The difference between the two	The difference as % of the total number of farms
1998	2,383	2,383	0	0
2000	2,173	2,127	–46	2.12
2002	1,871	1,980	109	–5.83
2004	1,959	1,778	–181	9.24
Average 2000–2004	2,001	1,962	–39	–1.95

The value of the real number of farms in the region for year 2004 is surprising, as the sudden rise in the number of farms seems to contradict a long declining tendency seen in the sector. Given the abruptness of the change, the sudden rise in the number of farms in year 2004 gives an indication that changes took place in terms of the reporting procedure of agricultural data or in terms of agricultural legislation. One plausible explanation is that the 2003 CAP reform had the effect that many small or medium-sized farmers, who earlier had rented out most of their land, terminated the contracts with other farmers who had rented the land. The main reason was, that farmers had to manage their own land in order to still be eligible for subsidies.

The difference in the number of farms for this six year period seems acceptable, especially when the nature of agent-based models is taken into account. In particular the difference between the average values for the three years 2000, 2002 and 2004 amounting to only –1.95% gives the model confirmation. It is however a very small sample size and particularly the development in the 2004 numbers helps the average value as it equalizes out the differences. More over, such numbers can conceal differences on the more detailed information such as on the individual farm level. Therefore the differences between the actual farms continuing and the farms found in the model have to undergo a more thorough comparison. Where their individual characteristics such as type of production, location and size of field and number of animals are compared.

The comparison between the real data and the simulated results will be investigated with a regional perspective where the models ability to capture the regional trends such as the area occupied for agricultural production, size of the farms and the type of production can be proved. In Fig. 1 the differences between the real regional map in year 1998 and the simulated map from 2002 is shown.

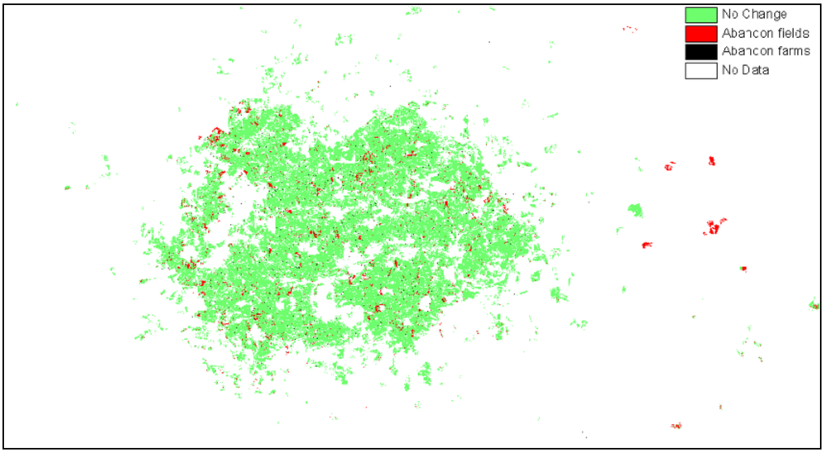

Fig. 1. Differences between actual abandoned farms and fields in the year 1998 and simulated abandoned farms and fields in the year 2002

In Fig. 2 the differences between the real regional map in year 1998 and the real regional map from the year 2002 is shown. This map illustrates two separate issues though without enabling us to differentiate between the two. The real region has undergone changes in the four years period and this is in part the area highlighted in red and black. At the same time the difference is illustrating the effect of the moved areas. The clear majority of fields only present in the map for 1998 lies in the outer areas of the region. A number of these fields are here due to the movement of fields in from areas farther away from the region as described in the previous section. The further way from the core area of the region, the more likely is this explanation for the differences between the maps.

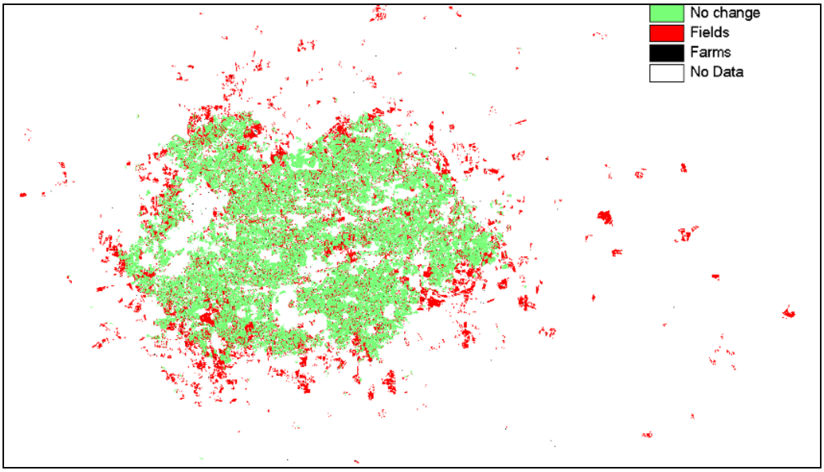

Fig. 2. Differences between actual land use patterns in the year 1998 and in the year 2002

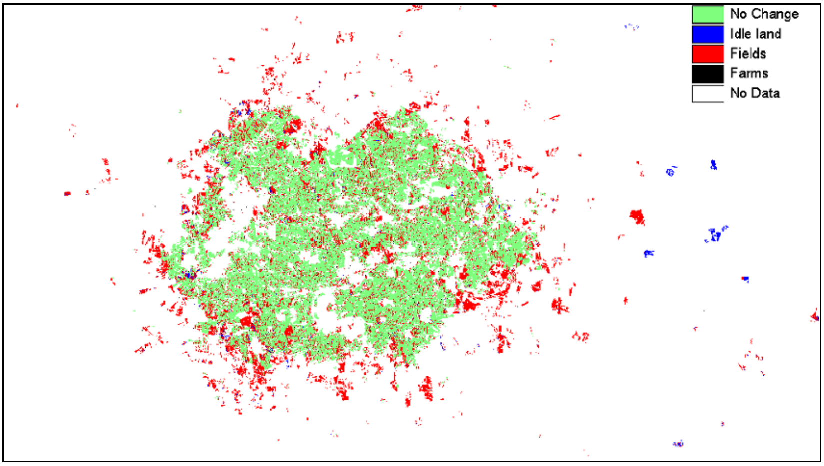

Fig. 3. Differences between actual and simulated patterns of land use in the year 2002

Figure 3 illustrates the differences between the real regional map in year 2002 and the simulated map from the year 2002. What it shows is an important characteristic of AgriPoliS. The model will have a tendency to utilise the whole area that the model was initialised with. The few areas that the model has left idle are likely to improve this particular result as the transportation cost insures that distant areas are abandoned and in this case these areas are likely to be encumbered with errors. The models economic foundation makes the utilisation of the whole available area more likely. AgriPoliS will therefore be likely to predict a too large area under agricultural production.

The model predicted that 91,088[1] ha are in agricultural production in year 2002 whereas in reality only 76,653 ha were cultivated. The difference between the areas in production in the model and in reality amounts to 14,435 ha. This corresponds to 18.9% of the real cultivated area in year 2002. Having 18.9 % too much area in production in the relative short prediction period may seem as a rough overestimation. The figure is however understandable when one considers the implication of the model farms objective of profit maximisation. In the model only 3,546 ha (or 3.7%) of the area used in production in year 1998 are abandoned. This should be compared to the 19.05% seen in the area for the same year. Though the empirical data may have some potential sources of errors such as land bought by farmers with farmsteads located outside the studied region, the main differences arises from the model itself. In the model, the area is divided in to a grid of 1 hectare cells. Each of them can potentially be rented if another farm releases the area. There are no transaction costs associated with buying land in these small bites. This is of course unlike the real situation. Further more the other farms are always willing to bid for an additional plot as long as it can be associated with gains regardless how small. These two elements of the model combined mean that only those plots will be abandoned none of the other farms can utilize for economic gains. This is likely to overestimate the area in production compared to the real situation. This is of course also reflected in the average farm size for the region. Where the average farm size in the model is 46 ha, the average farm size of real farms is 41 ha. The agent-based modelling method means however that this average difference is unequally distributed among the individual farms. The frequency distribution of the farms size in the year 2002 for both the real farms and the farms in AgriPoliS is shown in Fig. 4. The frequency distribution is shown both on a normal- as well as on a logarithmic

[1] The numbers used for this comparison include all fields also the areas located far away as the spatial properties of these plots do not influence the calculations.

scale. The normal scale is shown as bars and the logarithmic scale as curves.

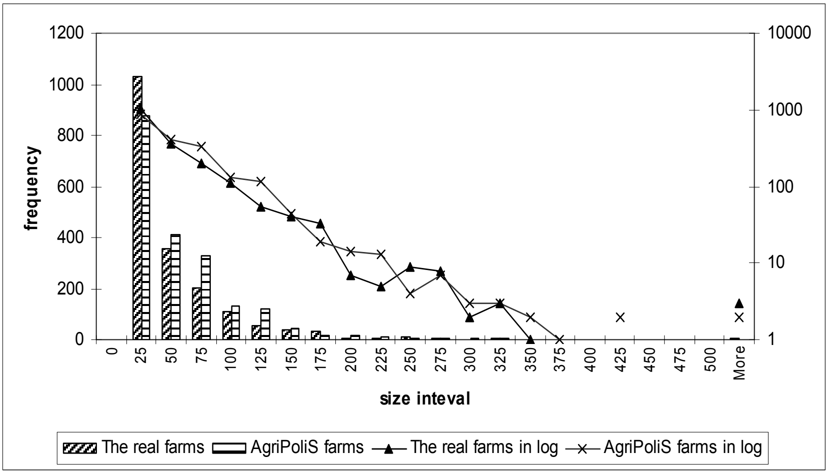

Fig. 4. Frequency distribution of actual and simulated farm size in year 2002

As Fig. 4 shows there is no consistent pattern in how AgriPoliS is displacing the farms. The largest difference in real numbers can be found in the smallest category for farms between 0 and 25 ha. Some of these small farms are properly found in the next category. AgriPoliS has a larger number of farms in the middle range (between 25 and 125 ha), however one has to remember that the model has 109 more farms to display. These 109 farms may constitute a large share of the differences between the two results.

The indication of the model to be underestimating the small (hobby) farms is in line with previous results. The models behavioural foundation is profit maximisation for the individual farm. This means that the model does not capture motives less driven by profit, which can be observed among particular segments within the agricultural community such as hobby (or subsistence) farmers. The farmers falling within this category are often quitting farming faster and in larger numbers in the model as seen in reality. The type of production that the individual farm in the model undertakes compared to the real region is also important for validating the model's predictive power. The environmental and economic effects of the local production largely depend upon the type of farming taking place. As the empirical data do not hold records on the different crops grown on the individual farms, the comparison is focusing on whether the farm is a crop producing farm or runs some animal production and in the latter case which kind of animal production. In Table 2 the number of farms within the different types are listed.

Table 2. Number of farms within different farm type groups

	Number of AgriPoliS farms active in:	Number of empirical farms active in:	Difference between the two
Dairy	401	275	126
Suckle cows/cows	591	786	–195
Beef/ Cattle	830	852	–22
Sows	310	287	23
Pigs	483	101	382
Only crops	545	787	–242

The accuracy of the model is seen to be low for most of the commodities. In the case of dairy, pigs and crop producing farms there seem to be straightforward explanations. The explanation for the large deviation in number of suckle cows is harder to find. Dairy farms are over-represented in the model as the economic returns are likely to be relatively good at the same time as the regulative difficulties for farmers in the study area to start a new dairy production are greater than in the model version. Though the model has also incorporated milk quotas the possibility of leasing the needed quotas is always present. For the simulated farms the investment into dairy production is only a matter of the right economic returns and not restricted in the same way as in the real world.

The production of pigs can also be explained following the same line of arguments. Though pig production does not have the same quotas as dairy production it is still a type of production with legislative and practical difficulties in establishing a new production. The environmental concerns related to pig production have drawn political attention to the production and e.g. the smell related to pig production makes it almost impossible to get permission to establish a new production in semi urban areas.

The present model is unable to take these considerations into account when a farm considers starting or expanding a pig production. As the entry barrier and transaction cost associated with pig production are lower in the model the number of pig producing farms is over-represented. The opposite is of course the case for farms only involved in crop production. As the entry barrier for taking up animal production is relative low more farms are utilizing this opportunity. The majority of small part-time farms fall within this category of production. In the model there is standard opportunity cost associated with time as the farmer can choose to work outside the farm. However in reality the opportunity cost is individually determined. The different valuation of time between part-time farmers and full-time farmers as well as within the two groups will vary considerably. As the model is unable to evaluate the right individual valuation of time it will be more likely choose to engage in a time costly animal production than a small part-time farm normally would. The under-representation of crop-producing farms therefore appears to be understandable as well. In general the values are not ostentatious if one considers the possibilities for each individual farm and the complexity in describing the behaviour of individual decision makers. But on the other hand the values are not discouraging. The validation of the model helps to demonstrate its characteristics and thereby improves the judgment of the scientific community of the model.

5 Conclusions

The comparison shows that the model simulates development on the most aggregated level (the number of farms in the catchment) relatively well. There are some variations to the degree of precisions on less aggregated levels of analysis. As could be observed and perhaps also expected, the model was less effective in regards to reflect behaviour that is less motivated by profit maximisation. This was in particular the case for simulation of small farms below 25 ha, where the model did not incorporate any particular persistence of small farms. This is contrary to what has been observed in many different countries regarding the persistence of small-scale agricultural enterprises such as family-based agriculture (Buttel and LaRamee 1991; van der Ploeg 1993, 1995). The overall conclusion is that the ABM approach utilised here was effective in regard to prediction, but this usage might not utilise the overall potential of ABM approaches very well, since the model's ability to give insight into processes of structural development on the micro-level was not utilised in the present study. Still, the results indicate that ABM approaches to structural development, as in the case of AgriPoliS, do have a potential within a field of research, which to a large degree has been dominated by mainly deterministic farm models.

Acknowledgment

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Impacts of Three Direct Payment Options on Farm Structure, Economic Performance and Production Pattern: Results from the MEA-Scope Case Study in Italy

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Abstract

The Mugello area in the heart of Tuscany, Italy is a traditional region in which the existence of the characteristic cultural landscape is closely linked to quality beef and dairy production. This chapter uses the MEA-Scope modelling approach that is based on the micro-economic models AgriPoliS, MODAM and FASSET, to analyse how different EU policy options affect farm structure, farm profits, and agricultural production activities in Mugello. Simulated scenarios include an assumed continuation of the Agenda 2000 policy, an introduction of a decoupled single farm payment, and a scenario without direct payments.

Dairy farms and specialised field crop farms were better equipped to cope with extreme political changes than grazing livestock or mixed farms. Single farm payments led to more extensification compared to Agenda

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2000, while the no-direct-payments scenario caused intensification expressed in an increased share of cereals and abandonment of set-aside. All scenarios led to considerable loss of mountainous grassland areas, whereby the single farm payment scenario caused the smallest abandonment.

Keywords: Mugello; MEA-Scope; CAP; structural change

1 Introduction

The Italian case study area of the MEA-Scope project, Mugello, is a marginal rural area situated in the northern part of Tuscany in the province of Florence. Permanent grassland and pastures account for more than 40% of the total agricultural area. The territory is composed of nine municipalities and covers two geographical areas that are separated by the central Apennine mountain chain, the "proper" Mugello and Alto Mugello (or high Mugello). The "proper" Mugello is located in the central Sieve river valley (Conca) and communicates directly with the city of Florence. The most important production activities are concentrated in this area. Alto Mugello is located north of the Sieve valley, consisting primarily of high hills and mountains (see Fig. 1).

Mugello has a unique character and offers many high-quality local agricultural products, such as meat and dairy products. An analysis on relevant agricultural functions in the MEA-Scope case study regions by Schader et al. (2007) revealed that agriculture in Mugello, in addition to providing an often supplementary income source, contributes significantly to the unique quality of the local area by preserving its natural landscape and environment. However, several studies have outlined that the cultural landscape in mountainous areas such as Mugello is at risk because of the abandonment of traditional farming and forest activities accompanied by a decrease in landscape diversity with associated negative impacts on environmental indicators (e.g. Garcia-Ruiz et al. 1996; Agnoletti 2007).

In this chapter, a micro-economic modelling approach based on the three computer models AgriPoliS, MODAM and FASSET developed by the EU project MEA-Scope (Piorr et al. 2007) is used to analyse the effects of alternative options of the EU Common Agricultural Policy (CAP) on the agricultural sector in the Mugello area. The chapter is organised as follows: section two describes the methodological and data preparation steps that were necessary to adapt the modelling approach to the Mugello area. The results section compares the impacts of three different CAP scenarios along several indicators related to structural change, economic performance and production pattern. The chapter closes with some concluding comments and recommendations for further research.

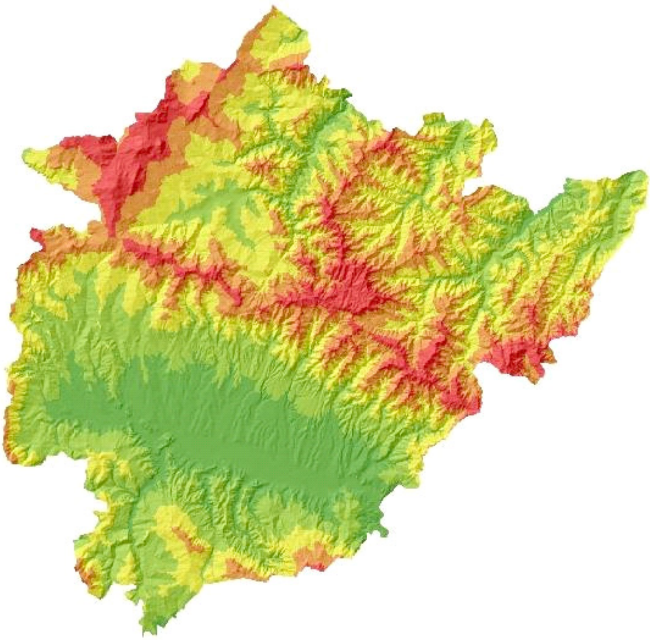


Fig. 1. Digital Elevation Model (DEM) of the Mugello Area: valley (*green*), low hill (*light green*), high hill (*yellow*), mountain (*brown*) (Ungaro et al. 2006a)

2 Adaptation of the MEA-Scope Modelling Approach to the Mugello Area

In order to analyse the reaction of the farm types present in the Mugello area to changes in EU agricultural policies, the MEA-Scope modelling approach was used (Happe et al. 2006). The approach couples three micro-economic models (AgriPoliS, MODAM, FASSET) that together are capable of simulating structural change in the agricultural sector as well as on-farm joint production. The modelling approach requires several statements of assets and liabilities, based upon estimates of the various capital items including land, livestock and plant and machinery and farm structures. Three pre-simulation steps were conducted including (i) recreation of farm structures and spatial localisations in the Mugello area, (ii) data collection on typical plant, livestock and investment options, and (iii) definition of scenarios and indicators to be analysed.

2.1 Recreating Farm Structure and Farm Localisation from Non-individual and Non-spatial Data

The MEA-Scope modelling approach is based on the assumption that spatial characteristics and site conditions determine agricultural production potentials and their influences on the surrounding environment to a large extent. Because individual farm accountancy data sources such as the European Farm Accountancy Data Network (FADN) include no specific information on the spatial location of farms, the MEA-Scope project developed methods of spatially recreating the regional structure including the localisation of single farms in the different case study areas (Kjeldsen et al. 2006). The spatial allocation approach is distinct for each case study region and combines regional statistical data, FADN data on economic size and type of farming of representative farms, and various geo-referenced information (Damgaard 2008). For the Mugello area, this procedure involved three methodological steps.

In a first step (up-scaling), the squared deviation between regional characteristics from the national agricultural census (including e.g. the number, of farms, farm size distribution, the distribution between different production types and ownership structure, the number of livestock), and the sum of individual characteristics of the farms from the FADN-sample was minimized with a pc-based solver by assigning weights to each of the FADN farms (Dalgaard et al. 2007). The individual farms derived through this procedure were labelled “typical farms”. For the Mugello territory, the up-scaling process resulted in a total number of 1,237 farms with a total Utilised Agricultural Area (UAA) of 26,222 ha.

In a second step (land capability classification), a land capability classification (LCC) was conducted in order to classify the soils occurring in Mugello according to their suitability for relevant field crops in the area (Ungaro et al. 2006a). Altogether eight different site types were classified including four arable site types (plain, terraces, low and high hills) and four grassland site types (terraces, low and high hills, high mountain).

In a third step (farm localisation), the land capability classification was used as the foundation for spatially localising the typical farms derived in the up-scaling process. To place the farms in the LCC map, a guided random allocation procedure based on the ratio of arable land and grassland was used (Kjeldsen et al. 2006; Damgaard 2008). The final map of farm-steads is shown in Fig. 2 along with the road network.

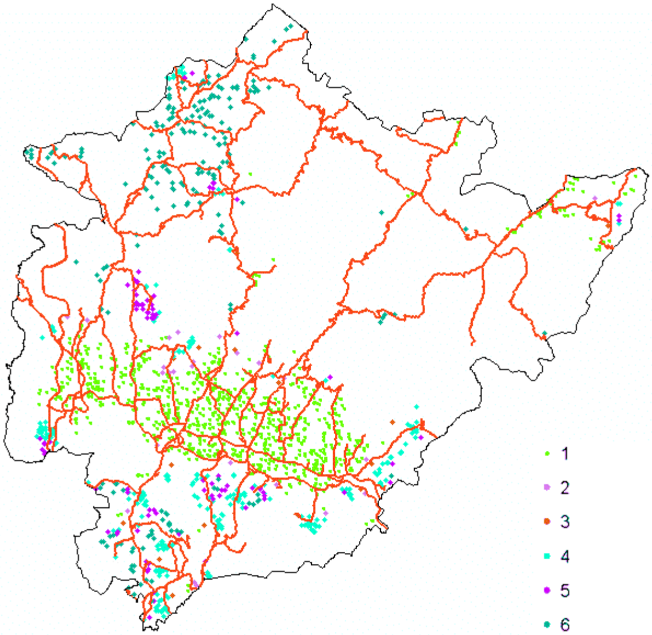


Fig. 2. Map of farm locations and road network (Ungaro et al. 2006b)

2.2 Expert Surveys on Agricultural Production Activities

For each site type identified with the LCC typical cropping practices, rotation rules and financial information were obtained from local experts. A cropping practice thereby involves all single work steps, time spans and inputs that characterize the cultivation of a particular crop with an expected yield level (Zander 2003).

For the Mugello region, the experts defined a total of set 253 plant production activities, out of which 229 for arable site types and 24 for grassland site types (cp. Table 1). All production information was stored in a relational database. Each typical farm type was assigned a subset of the total number of production practices according to its equipment with particular site types resulting from the farm localization procedure.

As regards dairy and beef production, five typical livestock flocks including herd size and structure, stocking rates, fodder requirements (nutrient balance, grazing periods), and production characteristics (e.g. milk production, weight gain, offspring weight etc.) were defined. Plant and livestock production were interlinked through fodder and manure constraints. In order to calculate gross margins, real market prices for plant and livestock production inputs and outputs were collected for 2002 and projected based on historical price trends. Additional data on investment, labour input, land renting and capital availability were collected. From the resulting set of possible activities each individual farm agent in the MEA-Scope modelling approach can chose the portfolio which yields the highest possible aggregate economic benefit under given political framework conditions (= scenarios).

Table 1. Overview of cropping practices for the site types in Mugello

Land cover types	Arable land	Grassland
Elevation classes	High hills low hills valley terraces	High mountain high hills low hills terraces
Crop and usage (n)	17	3
Tillage options	– conventional tillage – reduced tillage	
Fertilization	– mineral fertilizers – with liquid manure – with solid manure	
Production practices (n)	229	24

2.3 Definition of Scenarios and Indicators

The scenarios simulated with the MEA-Scope modelling approach for the Mugello area include i.e. an assumed continuation of the Agenda 2000 policy with coupled crop and livestock payments (Ag2000), an introduction of a decoupled single farm payment (SFP), and a scenario without direct payments (No DP). All three scenarios cover each a time horizon of 10 years. The base or initial year (2002) is characterized by coupled crop and livestock direct payments as defined by the Agenda 2000 policy for Mugello. This start point is always used as reference against which the end-point results of the different scenario paths are compared. For each scenario a set of indicators of particular relevance to the Mugello area was analysed. Change in UAA and change in number of farms were used to analyse structural change related impacts, change in profits to analyse the economic performance of the farms, and changes in cropping and livestock pattern to cover changes in agricultural production.

3 Results

3.1 Structural Change

Structural change of a sector refers to a long-term change of the fundamental structure and can be initiated by policy decisions or permanent changes in resources, population or the society. Important indicators to analyse agricultural structural change are the change in number of farms (reflecting also the exit rate, that is the number of farms that left the sector), and their distribution on different farm types.

Table 2. Indicator performances in the scenarios

Farm group	Scenario	Farms [n]	Farm size [ha]	AL [ha]	GL [ha]	Profit [€/Farm]	Beef cattle [n]	Dairy cows [n]
Dairy farms	Base year	43	50.1	798	1,356	29,200	0	215
	Ag2000	43	61.3	907	1,730	30,521	378	205
	SFP	43	65.0	911	1,886	32,883	0	275
	No DP	43	64.3	1,311	1,455	24,491	0	280
Field crop farms	Base year	521	15.7	6,914	1,288	18,778	108	1,098
	Ag2000	498	17.1	6,825	1,691	19,620	1,912	588
	SFP	507	17.4	6,961	1,873	20,507	990	1,073
	No DP	456	19.5	7,604	1,275	17,841	953	1,157
Grazing livestock farms	Base year	230	18.3	131	4,075	–1,885	107	0
	Ag2000	53	12.5	46	617	–261	21	0
	SFP	65	12.7	78	747	–35	34	0
	No DP	48	13.7	39	617	–354	9	0
Mixed farms	Base year	443	26.3	6,041	5,619	1,223	4,267	188
	Ag2000	225	32.9	6,138	1,257	20,100	3,873	123
	SFP	237	33.1	5,966	1,872	20,723	3,015	212
	No DP	181	31.9	4,962	806	10,757	2,586	213

Table 2 summarizes the performance of the indicators analysed related to structural change, economic performance and stocking numbers in the different scenarios. Land use, by site type, as well as cropping pattern are separately presented in Fig. 4 and 6.

In the initial situation (base year), 1,237 farms (Fig. 3) cultivated an agricultural area of 26,222 ha out of which 53% arable land and 47% grassland (Fig. 4). Specialised field crop farms constitute the biggest group with a share of 42%, followed by mixed crop and livestock farms (36%), grazing livestock farm (19%) and dairy farms (3%).

Figures 3 and 4 show that under all three CAP scenarios, the number of farms and the utilised agricultural area (UAA) in Mugello decreased significantly.

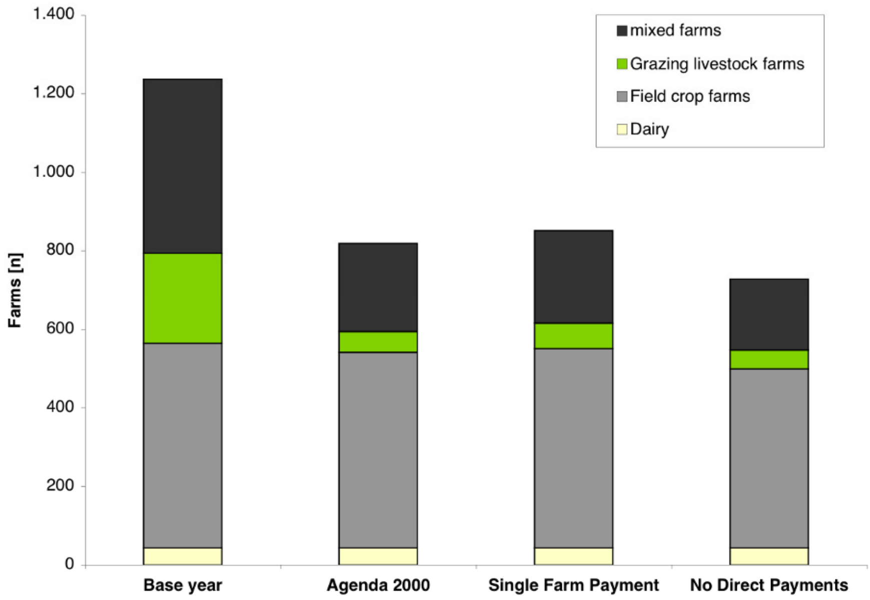


Fig. 3. Number of farms [n], by farm group in the different scenarios

The comparatively smallest abandonment in UAA and reduction in number of farms of all scenarios was caused by an introduction of a decoupled single farm payment (UAA –23%; farms –31%), followed by the Agenda 2000 scenario (UAA –27%; farms –34%), and then the no-direct-payments scenario (UAA –31%; farms –41%). The overall reduction in farm number was mainly due to a decreasing number of grazing livestock farms and mixed farms, while the number of field crop farms and particularly dairy farms remained almost constant across all scenarios (Fig. 3).

With regard to the different site types, across all scenarios a trend towards grassland abandonment could be observed, whereby the single farm payment scenario performed slightly better than the Agenda 2000 and the no-direct-payments scenario (Fig. 4).

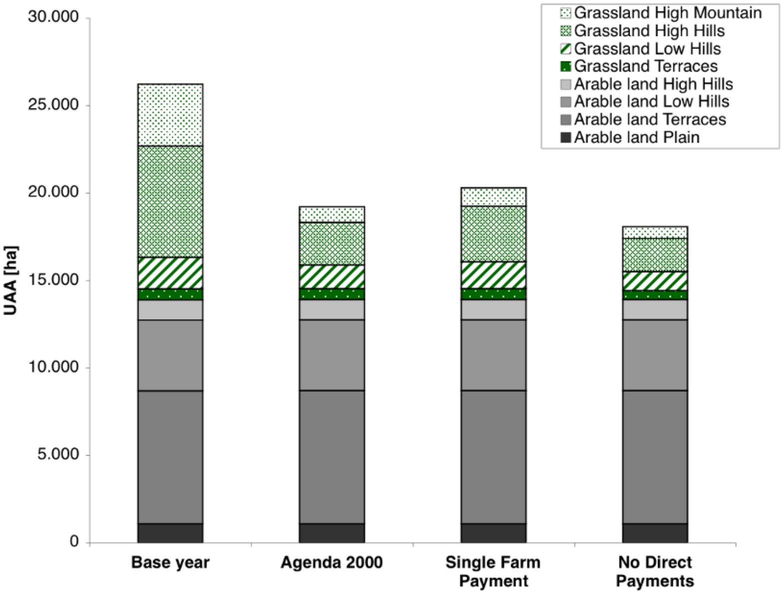


Fig. 4. Agricultural area [ha], by site type in the different scenarios

Particularly high hill and mountainous grassland areas were affected by the land abandonment (base year 9,900 ha). The single farm payment scenario, however, led to the smallest abandonment (–5,674 ha) followed by the Agenda 2000 scenario (–6,567 ha) and the no-direct-payments scenario (–7,338 ha).

3.2 Economic Performance

The dairy farm group was characterised by the highest average profit per farm in the initial situation (29,200 €/farm) and all scenarios (Fig. 5). Single farm payments caused the highest increase in profits of 12.6%, followed by a continuation of the Agenda 2000 payments (+4.5 %) while the no-direct-payments scenario caused a decline by –16.1 %. The behaviour of the field crop type tended to react in a similar direction (Agenda 2000 +4.5 %; SFP +9.2 %; no direct payments –5.0 %). The mixed farm type started with low average profits (1,223 €/farm) in the base year and experienced a strong increase in profit across all scenarios compared to the initial situation. In the base year the total number of mixed farms (n=443) obviously included a large number of less competitive farms that dropped out of the sector in the scenarios. In the Agenda 2000 and the SFP scenario the number of mixed farms was cut in half and in the no-direct-payments scenario even cut by 60% reflecting that under absence of direct payments even more mixed farms became uncompetitive.

The grazing livestock farm group was characterised by negative average profits in the initial situation. In all scenarios, profits improved as a result of uncompetitive farms dropping out of the sector, whereby the single farm payment scenario led to the least negative results. However, in none of the scenarios positive average profits per farm were achieved.

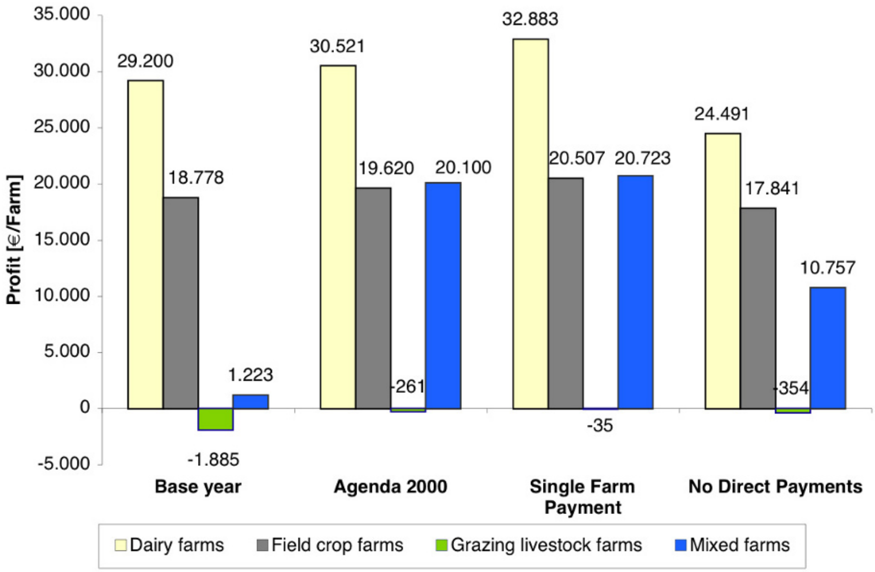
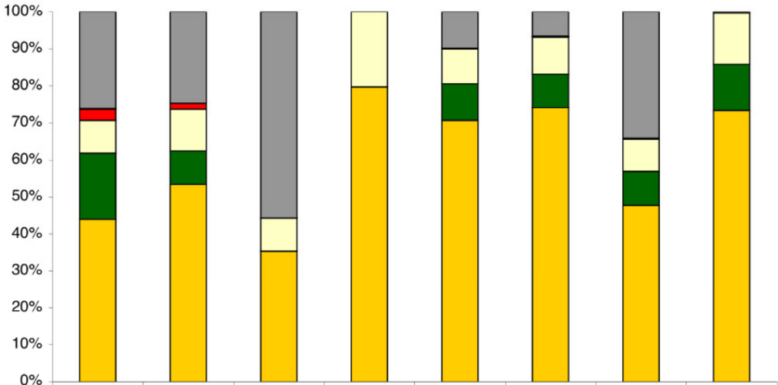


Fig. 5. Average profits [€/Farm], by farm group in the different scenarios

3.3 Cropping Pattern

In the initial situation, the cropping pattern on the arable site types (13,884 ha) in the area included 12 different crop usages out of which winter barley, set aside, grain maize, durum wheat, forage beans and alfalfa constituted the most important ones in terms of area. In total, the share of cereals accounted for 61% of the arable area (7,993 ha including hilly and valley site types), followed by set aside areas (15.1%), forage crops (12.7%), including forage beans and silage maize, and forage legumes such as alfalfa (9.2%). Oilseeds (mainly sunflowers) were cultivated on 145 ha (1.1%) and potatoes on 81.5 ha (0.2%) (Fig. 5).



	hills				valley			
	Base year	Ag 2000	SFP	No DP	base year	Ag 2000	SFP	No DP
Set aside	26,2%	24,7%	55,7%	0,0%	9,8%	6,6%	34,2%	0,0%
Potatoes	0,1%	0,0%	0,0%	0,0%	0,2%	0,2%	0,2%	0,3%
Oilseeds	3,1%	1,6%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Legumes	8,9%	11,2%	8,9%	20,3%	9,4%	10,0%	8,7%	13,9%
Forage crops	17,8%	9,1%	0,0%	0,0%	9,8%	9,0%	9,2%	12,5%
Cereals	44,0%	53,3%	35,4%	79,7%	70,7%	74,1%	47,7%	73,3%

Fig. 6. Cropping pattern [%] in the different scenarios

A continuation of the Agenda 2000 conditions caused an increase in cereals (hills +9.4%; valley +3.5%) and forage legumes (hills +2.4%; valley +0.6%) while other forage crops (i.a. silage maize, forage beans), set aside areas, oilseeds (i.a. sunflowers) and potatoes decreased (see Fig. 6). In the final period of the scenario, the total cereal area had increased by 925 ha and the area legumes by 200 ha to the disadvantage of other crop types mainly forage crops (–454.2 ha) and set aside (–265 ha).

Compared to the base year, the introduction of a single farm payment caused an increase in set-aside areas (hills +29.5%, valley +24.4%) accompanied by a significant decrease in cereals, particularly winter barley and grain maize (hills –8.6%; valley –23%) and a complete disappearance of oilseeds. Set aside areas are thereby not to be confused with "abandoned" land but require basic land care such as mulching. Forage crops were completely abandoned on the hilly site types and reduced in the valley (–0.7%). The no-direct-payments scenario was characterised by a complete disappearance of set-aside areas, while, particularly on the hilly site types, the share of cereals (hills +35.7%; valley +2.7%) and forage legumes (hills +11.4%; valley +4.4%) increased. Other forage crops again completely disappeared from the hilly site types (as in the SFP scenario) and slightly increased in the valley (+2.7%).

3.4 Livestock Pattern

In the base year, the total stock in Mugello included 5,983 cattle heads with 1,502 dairy cows and 4,482 beef cattle (see Table 2). Total cattle decreased slightly in the single farm payment scenario (–6%), and more significantly in the no-direct-payments scenario (–13%). Instead under Agenda 2000 conditions with still coupled livestock payments, stocking numbers increased by almost 20% compared to the initial situation (+1,116 heads). An analysis of dairy and beef cattle separately, reveals that the number of dairy cows decreased under Agenda 2000 conditions (–586 heads), while SFP (+59 heads) and the no-direct-payments scenario (+148 heads) caused a slight increase. On the contrary, beef cattle were negatively affected by both SFP (–443 heads) and the absence of direct payments (–934 heads) while increasing under Agenda 2000 conditions (+1,702 heads). However, the increase in beef cattle was only caused by dairy and field crops farms (which constitute so to say new ‘mixed’ farms), while beef raising in grazing livestock farms was always negatively affected. In the no-direct-payments scenario, the grazing livestock farm type almost abandoned its entire beef cattle stock (base year 107 heads; no-direct-payments scenario 9 heads).

4 Conclusions

The preservation of grazing livestock farms is important to maintain agriculture in the high hill and mountainous grassland areas in Mugello with their important ecological effects on the landscape. The analysis demonstrated that dairy farms and specialised field crops farms constituted the most competitive farming systems in Mugello, while mixed farms and particularly grazing livestock farms were characterised by less stable farming systems and a stronger dependence on agricultural subsidies.

Dairy farming systems require large structural investments amortized over the long term preventing extreme short-term adaptations to changes in the direct payment system. The existence of dairy farms is instead closely tied to the price of milk (mainly dairy farms sell high quality milk through the central region milk station "Centrale del latte") and the structure of the quota system. As the MEA-Scope modelling approach assumes a development of the milk price based on historical trends that allowed comparatively good margins, dairy farms were able to cope best with the extreme no-direct-payments scenario. With regard to grazing livestock farms, the single farm payment scenario offered the least negative conditions reflected in a smaller number of grazing livestock farms dropping out of the sector, while negative profits were more reduced than in the other scenarios. In the no-direct-payments scenario, the grazing livestock farms were the most negatively affected farm type, followed by mixed farms.

Though the general trends towards decreasing farm and stock numbers in these two farm types is in line with the general structural changes in Mugello, it has to be considered, however, that the very strong reaction in the modelling approach is a result of unconsidered influencing factors, such as breeding organisations or the existence of quality trademarks that stabilize sales and farm structures that cannot be incorporated in the MEA-Scope modelling approach.

The analysis of the agricultural production pattern showed that the introduction of a single farm payment produced a positive effect, in terms of extensification, on the agricultural land expressed in a lower share of cereals and a higher share of set aside areas with basic land care management compared to Agenda 2000 conditions or the no-direct-payments scenario. The loss of valuable high hills and mountainous grassland areas was the lowest from all simulated scenarios. A phasing-out of direct payments instead increased the abandonment of these areas the most.

In conclusion, the presence or modification of direct income transfers to farmers alone is not a sufficient political instrument for the maintenance of valuable grassland areas but can at least prevent a further acceleration of abandonment as would occur under absence of direct payments. Better results in maintaining the typical landscape could probably be achieved through additional measures, such as agri-environment schemes. Further analyses are required to analyse whether a combination of direct payments *and* agri-environment schemes is sufficient to maintain Mugello's high hills and mountainous areas, or whether completely new options need to be considered, such as possible efforts by the local administration in supporting the implementation of a structural farm transformation with the goal to increase the competitiveness of grazing livestock farms.

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Possibilities for the Development of Mixed Crop-Beef Farming in the Kościan Region Based on Natural Fodder Resources. Results from the MEA-Scope Case Study in Poland

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Abstract

Ongoing dominance of cereals in cropping patterns in the Kościan region of Poland creates threats to sustainable development because it may induce ecological problems. To reduce environmental pressure caused by simplified agricultural land use and to improve the management of grasslands, the possibility of developing mixed crop-beef farming as an alternative to arable farming is considered. Scenario models were developed for different farming types. The analysis focused on a comparison of economic performance, nitrogen balance and the evolution of soil carbon (C) stock between different models. The general conclusion was that beef-based scenarios for mixed farming were economically viable. They allowed for diversification of farm activities and supported the improvement of environmental performance in terms of better cropping patterns and soil C sequestration. However, an undesirable effect involved is a higher nitrogen (N) emission into the atmosphere due to N losses from manure before its application to a field.

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1 Introduction

New macroeconomic conditions, created after free market economic reforms in Poland in the early 1990s, initiated restructuring processes, which were mainly featured by the changes in number and sizes of farms, differentiation of farm types and adjustments in production intensity (Jankowiak et al. 2006). The dynamics of agricultural restructuring is still too slow to contribute significantly to farm enlargement in Poland's regions. Superimposed on these processes was the strong trend towards the growing dominance of cereals in the cropping pattern. Farms began to specialize in plant production and those specialized in pig farming used cereals for on-farm pig feeding. A distinct differentiation at the levels of income appeared between the arable type of farming and dairy farming. The arable farms surveyed in Wielkopolska were able to reach on average an annual profit of Euro177 per ha, amounting to only 54% of the annual profits per ha of dairy farms (Bieńkowski et al. 2003). At present, around 19% of farms in the Kościan region do not have any livestock. In the Wielkopolska province the number of such farms amounts to around 34%, taking up 19% of total agricultural area (Statistical Office 2003). A multicriteria analysis of sustainable development showed that arable farms have lower indexes of both economic and environmental efficiencies (Bieńkowski et al. 2005).

Directing the farms' operation entirely to the production of marketable products (cereals and industrial plants) means that grasslands present in such farms have not been integrated into the farming system. Lack of management influenced their conversion often into unproductive vegetation, ploughing grassland or degrading the semi-natural properties by changing their original grass species composition. Recent agri-environmental payment schemes tailored for grassland areas after Poland's accession into the EU offer a chance for them to become a productive resource base for farms again under strict grass management regulations imposed participants enrolling in those programs.

The aim of this study is to analyze a possibility for the development of beef production by considering beef-based alternatives available for crop farming in the Kościan region. The analysis is carried out within the principles of a policy of sustainable development. Therefore, the chapter focuses on economic outcomes and on environmental benefits and threats resulting from an adoption of beef activities into crop farms.

2 Land Use Characteristics of the Case Study Area

With regards to the landscape structure in the Kościan region, agricultural ecosystems dominate. Of the total agricultural area, 84% has been used for arable land and the rest for grassland (Fig. 1). The forest area in this region currently equals about 13.3% of the total area, which is well below the average for the whole Wielkopolska province (25.9%). The low occurrence of forests and the small area of grassland, which are the main components of the buffering element of the landscape, may imply that spatial landscape barriers counteracting negative effects of nutrient emission from agricultural sources are not sufficiently established in the region. It seems that it is necessary to rebuild the protection abilities of the environment in agricultural areas. There is a pressing need to introduce special programs targeting the improvement of landscape functions. An example of the efforts already undertaken in this direction is a network of shelterbelts established within the D. Chlapowski landscape park (in the Kościan region). There is evidence showing that besides proper manure and fertilizer management for the protection of waters against nitrate pollution, designing a proper landscape structure could play a favourable role in limiting nitrogen emission into the environment (Ryszkowski 1992).

3 Analytical Approach

Farm-scale empirical models were defined for crop farming farms by using the whole farm budget technique and alternative models based on the integration of beef activities into crop farming. The intensity level of crop production was the differentiating factor for both crop farming and mixed crop-beef farming scenarios (Table 1).

The following assumptions for the considered scenarios were made:

- The size of the model crop farm corresponds with the average statistical farm size in the Kościan region.
- Two levels of crop production intensity, typical and intensive, were distinguished after consulting the local extension officers of the Wielkopolska Agricultural Advisory Centre.
- The analysis of cases and expert opinions indicates that farms of cropping farming type have a generally lower share of permanent grassland, compared to other types. During the limited survey of crop farms (2002–2004) it was observed that the grassland percentage rarely exceeded 16% of agricultural area (AA) and usually only 4% of AA on average was under grassland. To fully utilize the possibilities of beef

production development within a broad range of grassland areas, two cases of scenario models were considered separately. For case 1 – the modelled farm had 4% of grassland, and for case 2 – 16% of grassland in AA.

- For establishing crop patterns in the reference models (crop farming), results of a limited review of the main farming types in Wielkopolska in the years 2002–2004 were used (Bieńkowski et al. 2005). Crop mixtures in crop farming models of typical intensity of production were: 74.6% cereals, 5.3% sugar beet, 1.1% potatoes and 19% winter rape. In farm models of intensive production the crop mixture was: 75.7% cereals, 5.3% sugar beet and 19% winter rape.
- Direct payments (single area payments and complementary national payments) were based on the year 2006.
- The density of beef stock in the analyzed models was fixed at a level slightly above the average for the Kościan region, being equal to 0.9 LAU per 1 ha AA.

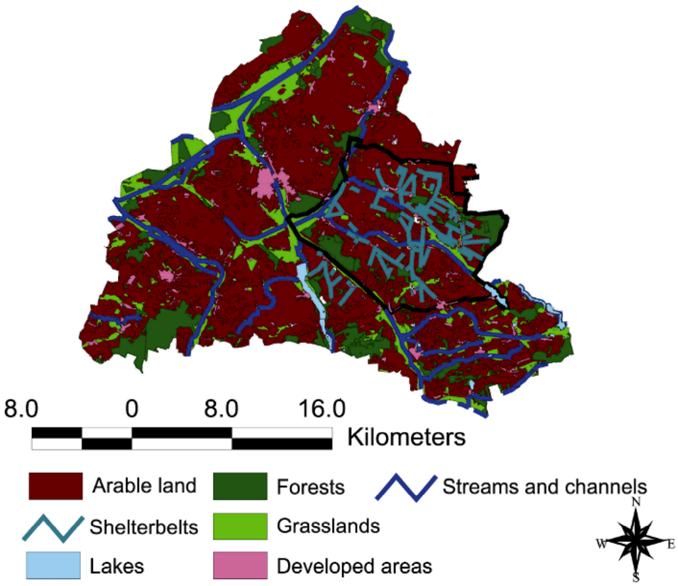

Fig. 1. Spatial land use in Kościan region

Table 1 Characteristics of farm-scale scenario models for farms with permanent grassland shares in agricultural area of 4% (case 1) and 16% (case 2) in Kościan region**.**

Cases	Scenario models	Intensity level of crop production	Land use	Permanent grassland use	Beef cattle	Animals import	Animals stock	Animals sell	Crops sell	Cropping pattern
Case 1 –4% permanent grassland	A. Typical crop farming	Typical	*Case 1:* 17.5 ha AL and 0.7 ha GL	Leased out	No	No	No	No	Yes	Derived from the survey of plant production farms
	B. Intensive crop farming	Intensive			No	No	No	No	Yes	
Case 2 – 16% permanent grassland	AA. Mixed: integrated beef activity into typical crop farming	Typical	*Case 2:* 15.3 ha AL & 2.9 ha GL	Hay and pasture	Yes	No, only bull	10 suckler cows with herd	Yes, weaned steers at 8 month, pregnant heifers at 23-26 months	Yes	Modelled, based on crop farms, adjusted for fodder plants
	BB. Mixed: integrated beef activity into intensive crop farming	Intensive			Yes	No, only bull			Yes	

Data for the economic evaluation of crop and mixed crop-beef farming systems were processed within the different spreadsheets. Input data covered information on: land, prices of inputs and products, labour, cost of buildings maintenance, taxes and insurance, and costs of other external factors. Crop information sheets included: land use, yields, pesticide use, fertilizer rate, seed volume, field machinery operation and cost of operating the machinery and contracting services. In the case of beef cattle data input the sheets contained information on herd management. Output data embraced the whole farm production, income, costs, gross margin and farm profit. The main characteristics of the farm-scale scenarios set up are provided in Table 1.

The different sets of input data were formed in order to calculate nitrogen (N) balances in each analyzed scenario. N uptake and the removal of crops as well as N animal content were derived from Kerschberger et al. (2002). The Granstedt (2000) model was the basis for estimating the N surplus at field level. The extent of N emissions in the form of NH_3 and N_2O from manure and mineral fertilizers was assessed using the emission coefficient accepted by the Atmospheric Emission Inventory Guidebook (EMEP-CORINAIR Emission Inventory Guidebook 2002).

The RothC model was used to model carbon changes under different crop and mixed farming systems (Coleman and Jenkinson 1999). Amounts of organic C were calculated for the 0–30 cm soil layer. Values of soil texture and carbon content, representative for analyzed systems in the region, were taken from Bieńkowski and Jankowiak (2006). To quantify C turnovers within the frames of the scenario models a range of available agronomic and climate data were required. Details of average monthly temperature, precipitation and pan evaporation in the Koscian Region were described in K dziora and Palusiński (1998). As the models differed with regard to field management, crop and residues yields, it was necessary to identify different attributes for each scenario related to fallow periods, yield of crops and residues, residue incorporation, delivery of manure and root mass.

4 Results

4.1 Economic Impact of Farm-Scale Scenarios

Gross margins and farm profits per ha were compared between all scenario models for case 1 and 2 in Figs. 2 and 3. The estimates of the model showed that by adoption of beef into typical crop farming the average gross margin and farm profit grew by 21.5 and 43.3%, respectively. The benefits of developing a new beef branch in intensive crop farming were not so evident, because values of the respective parameters grew only by 8.7 and 8.5% respectively.

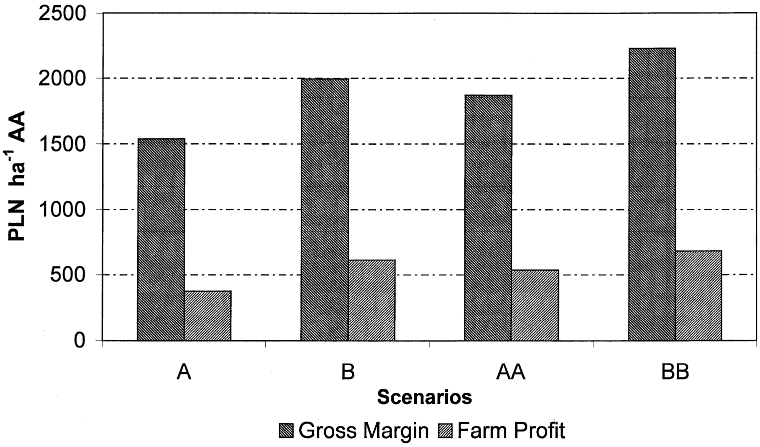

Fig. 2. Gross margin and farm profit per 1 ha AA for different farm-scale scenario models for case 1

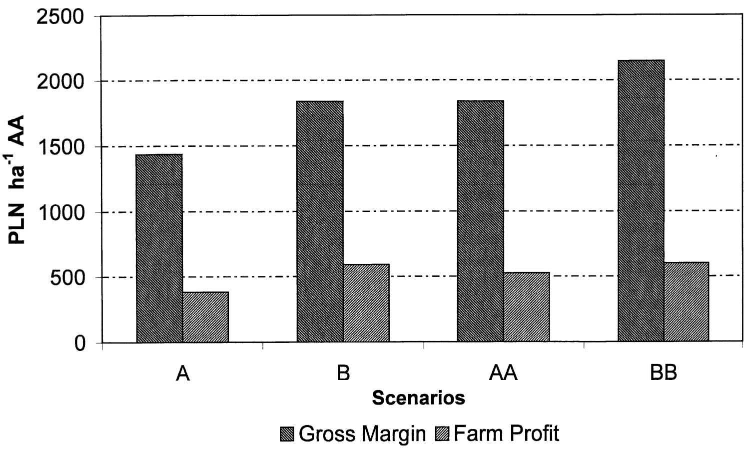

Fig. 3. Gross margin and farm profit per 1 ha AA for different farm-scale scenario models for case 2

Unless there is no change in the intensity level of crop production, the gross margin and income gaps became narrow in mixed crop-beef systems in comparison with crop farming systems of different intensities.

Values of unit gross margin and farm income followed similar trends for cases with high shares of grassland (Fig. 3). A rise in farm income by almost 37% was expected from integrating beef into a typical crop farming scheme. Just a 1.5% increase in income for joint intensive crop management and beef production over intensively managed crop production suggests that beef activity on farms with intensively run crop production is not a viable option to be considered. It could be assumed that highly efficient plant production in combination with extensively raised beef affects the use of resources on the farm, which otherwise could have been diverted into more profitable operations. A higher percentage of natural grassland actually lowers the share of arable land, and on farms with intensive crop production the economic benefits of beef operation do not the loss in revenue from unsold crops compensate to a sufficient degree.

4.2 Environmental Impact of Farm-Scale Scenarios

4.2.1 Cropping Pattern

Apart from providing a broad picture of economic performance, the scenario models with a particular set of resources were used to analyze the changes in environmental impact of the envisaged scenarios. They gave a broad indication of changes in cropping mixture after integrating beef into crop farming (Fig. 4). Alternative scenarios have had a great impact on the readjustment of plant distribution on arable land. After adopting beef the proportion of the cereals area for both cases clearly decreased, at the expense of an increasing proportion of fodder area. The fodder growing area (silage maize, seeded grass for hay and for pasture) was higher in mixed crop-beef systems, which did not intensify crop production. That is why cereal reduction benefits, related to cropping patterns, accrued more significantly in mixed farming with typical intensity of plant production. Here lower crop productivity has demanded that more area must be allocated for fodder compared to mixed farming with high intensity of plant production. Because the primary source of feed for cattle was permanent grassland, the share of natural grass area modulated the size of arable area designated for fodder production. With 16% of grassland the fodder area ranged between 16.9 and 32.3%, while with 4% of grassland it ranged between 25.2 and 39.6%.

4.2.2 Nitrogen Balance at Field Level

The lowest field N balance turned out to be in a scenario of intensive crop production (26.5 kg N ha^{-1} for both cases). Estimated budgets for mixed crop-beef farming scenarios ranged from 36.3 to 47.8 kg N ha^{-1} (Table 2 and 3). At a lower end of this range were N budgets for mixed crop-beef farming with typically managed crop production.

The differences in N budget between the mixed crop-stocked and crop (stockless) systems resulted mainly from manure contribution into N inputs, accounting for 21–28% of the N inputs. The higher surplus of N in the scenario integrating beef with the high intensity crop production system may indicate impact on soil N changes, N volatilization and runoff characteristics.

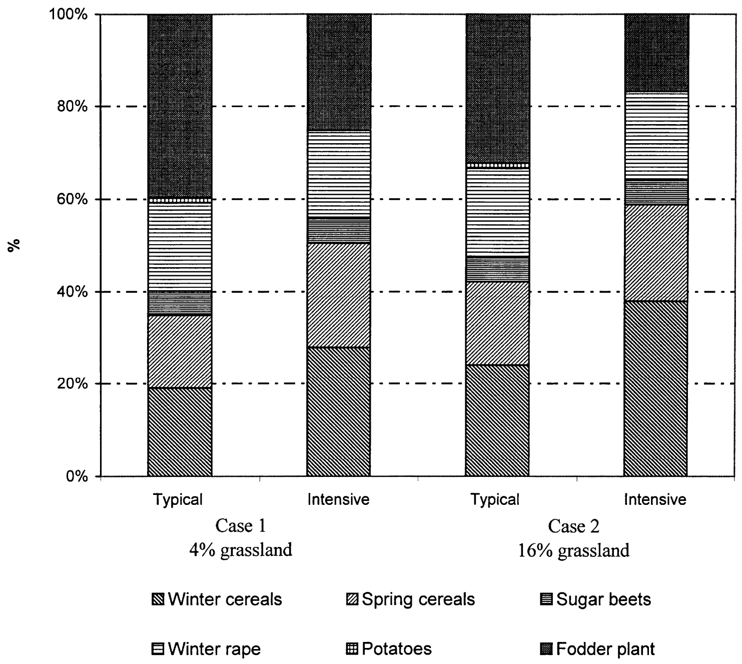

Fig. 4. Cropping pattern in scenario models with mixed crop-beef farming system according to the percentage of permanent grassland and the intensity of crop production

Table 2. Field N surplus (kg ha^{-1}) for different scenario models of farming systems for case 1

Balance components	Scenarios			
	A	B	AA	BB
In:	135.2	172.9	159.4	208.8
Mineral fertilizers[1]	92.4	122.0	87.0	130.0
Manure[1]	0.0	0.0	43.2	43.1
Atmospheric deposition	17.0	17.0	17.0	17.0
Ploughed-in residues	25.8	33.9	12.2	18.7
Out:	102.1	146.4	122.3	162.3
Sales of plant products and feed intake	102.1	146.4	122.3	162.3
Surplus	33.1	26.5	37.1	46.5

[1] After accounting for gas losses before incorporation into soil.

Table 3. Field N surplus (kg ha^{-1}) for different scenario models of farming systems for case 2

Balance components	Scenarios			
	A	B	AA	BB
In:	135.2	173.0	155.0	206.1
Mineral fertilizers[1]	92.4	122.1	84.2	128.8
Manure[1]	0.0	0.0	43.1	43.0
Atmospheric deposition	17.0	17.0	17.0	17.0
Ploughed-in residues	25.8	33.9	10.7	17.3
Out:	102.2	146.5	118.7	158.3
Sales of plant products and feed intake	102.2	146.5	118.7	158.3
Surplus	33.0	26.5	36.3	47.8

[1] After accounting for gas losses before incorporation into soil.

4.2.3 Soil Organic Carbon Under Different Scenarios of Crop and Mixed Crop-Beef Farming Systems

Tables 4 and 5 present the projected soil C changes in arable soils under the different scenarios of farming systems. Simulations using RothC show that a decline of soil C stock takes place in the scenario of typical intensity of crop farming. C organic content was likely to fall to the level of 31.0 t C ha^{-1} and below (–22.0% and –23.7%). The present C organic stock in the system of intensive cropping appears to be at a steady state with no prospect of a major increase. Significant increases of soil carbon stock were expected under scenarios of integrated beef into crop farming.

The combination of intensive crop farming and beef raising supported the highest rise in C stock by almost 32% from the initial level of 39.6 t per ha^{-1}. The projected trends in soil C change for farming with a higher share of grassland in mixed farming scenarios were even higher, ranging from 23 to 43%.

Table 4. Changes in C inflows and soil C status in farm-scale scenario models of different farming systems for case 1

Organic C sources in arable soil (t C ha^{-1})	Scenarios			
	A	B	AA	BB
Mass of organic C in soil	39.60	39.60	39.60	39.60
C inflow from aboveground residues	1.17	1.56	0.42	0.71
C inflow from root mass	0.10	0.14	0.19	0.23
C inflow from manure	0.00	0.00	1.16	1.16
Sum of C inflows	1.27	1.70	1.77	2.10
Modelled C content	31.00	39.80	45.20	52.10

Table 5. Changes in C inflows and soil C status in farm-scale scenario models of different farming systems for case 2

Organic C sources in arable soil (t C ha^{-1})	Scenarios			
	A	B	AA	BB
Mass of organic C in soil	39.60	39.60	39.60	39.60
C inflow from aboveground residues	1.15	1.56	0.42	0.78
C inflow from root mass	0.10	0.14	0.16	0.18
C inflow from manure	0.00	0.00	1.33	1.32
Sum of C inflows	1.25	1.70	1.91	2.28
Modelled C content	30.20	39.80	48.70	56.50

5 Discussion

Our results suggest a better economic performance of mixed crop-beef farming systems in general. Nevertheless, it is questionable if a transition to mixed farming would be a viable option for intensive crop farming systems due to a relatively modest increase in profit. Switching from crop to mixed farming is a more economically justifiable option for cropping systems of typical intensity. However, it could be expected that this target group with a lower income base would struggle during the transition period when it would be confronted with problems of skill acquisition and new investments. Therefore, to facilitate such a transition it would be necessary to give external assistance from the side of agricultural policies.

Scenario models indicated that the adoption of mixed farming was a decisive factor for the reduction of the proportion of area used for cereals. Fluctuations in the share of arable area devoted to cereals were caused by the different intensity of crop production and by the varied share of permanent grassland. Scenarios show that the selection of grassland ranges and arable crop production intensity creates a possible trade-off between: (1) using less arable area for cereals and allocating area to supplement fodder requirement in typical farming intensity both at 4 and 16% of grassland proportion in the total area, and (2) using more arable area for cereals in case of a higher intensity of crop production. Research data demonstrate that arable systems associated with lower concentrations of cereals in farms show higher ecological sustainability (Boatman et al. 1999). It has been shown that agricultural intensification and specialization in cereals cultivation causes loss of wildlife and farmland biodiversity in the cereal ecosystem (Miettinen and Huhtala 2005). For the analysed farm group in the Wielkopolska province, the most important changes towards improvements of the overall ecological performance identified were: increase of the soil winter cover, reduction of the cereal area, and decrease of N leaching potential (Jankowiak and Bieńkowski 2001).

Higher N surpluses both for the low and high share of permanent grassland cases were undesirable effects of mixed crop-beef farming. The proportion of permanent grassland did not markedly influence the N budget values. Lower efficiency of N use in systems with animal production usually contributes to generating the relatively larger N excess on farms. In such systems increased environmental threats are observed by the N emission into the surrounding environment (Bieńkowski et al. 2004). The idea of a mixed system allows more reliance on the use of farm fodder and thereby increases the efficiency of N recycling within the farm area. N balance calculation at the field level for scenarios assuming typical crop and beef production on the farm resembled the average Polish values of 37.2 kg ha^{-1} (Fotyma et al. 2000).

Recent land-use changes and widespread presence of stockless farming with a dominance of cereals in the cropping pattern creates uncertainties about the future trends of soil organic C levels. Soil surveys conducted in a group of 30 commercial farms in the Wielkopolska province showed that soil C concentration in a topsoil horizon was most frequently below 1%, and the average stock of soil C amounted to 39.6 t ha^{-1} (Bieńkowski and Jankowiak 2006), which is rather low and corresponds to areas of soil erosion risk (European Environment Agency 2005).

Combined cropping and livestock in the region could help to reverse the trend of a reduction of soil carbon. Appropriate soil management should, however, be a part of changes in farming systems. To ensure the efficient recycling of organic resources and resist the loss of soil and nutrients, attention should be given to cultivation practices that favour the build up of carbon pool in soils, such as: higher diversity of cropping, incorporating seeded grass into rotation, winter cover crops and minimum cultivation. With regard to the environmental measures available in the Kościan region the agri-environmental programs for soil and water protection have been especially popular, ensuring a higher share of winter soil cover (Bieńkowski 2007). It is established that maintaining the crop cover over winter helps to limit both water and wind erosion on light soils (Chevallier et al. 2004). If present soil management techniques continue across intensive crop farming, stabilizing just the actual soil C level, barriers of productivity growth could appear in the future that will likely affect the farms profitability. Awareness of generally low soil carbon levels in the region means that it is necessary to include organic matter into the whole farm management and regard it as an important factor influencing productivity. Without the conversion into mixed farming systems and integrating special protective measures, soils of the crop systems in the region will be at risk of being a CO_2 source instead of a CO_2 sink. The maintenance of higher soil organic matter content by developing mixed crop-beef systems is also important in achieving sustainable and environmentally friendly agriculture.

6 Conclusions

The scenario models showed that mixed crop-beef farming in the Kościan region are suitable for sustainable development. They incorporated the advantages of economic profitability with improved environmental quality of the agro-ecosystems. In view of the lower profitability and C loss from arable soils indicated by the scenario models, crop farming systems of typical intensity should be transformed into mixed farming, thereby securing higher income potential and discontinued losses of soil organic matter. The implementation of beef activities, as a strategy, in farms of intensive crop farming in the Kościan region is a less pressing issue, independent of the share of grassland, because their economical and environmental improvements are less meaningful. Grassland management on the basis of extensive cattle farming can prevent the loss of semi-natural habitats and a decline in biodiversity. By creating demand for good quality pasture and hay in the region an opportunity to improve the management of semi-natural permanent grassland exists. A general analysis of pros and cons of beef-based scenarios for mixed farming in the Kościan region indicates that they are economically viable, allowing diversification of farm activities while improving environmental performance in terms of better cropping pattern and soil C sequestration. However, an undesirable effect involved is a higher N emission into the atmosphere due to N losses from manure before its application on to a field.

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Multifunctional Farming and Survival Strategies in the Borsodi Floodplain

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Abstract

In this chapter we summarise and interpret results from the multidisciplinary analysis of a marginal socio-economically disadvantageous small farm region in Hungary. We identify a range of survival strategies within the predominantly agricultural local population to summarize how farmers adapt to unfavourable conditions in agriculture with decreasing revenues while suffering from instability of severe economic situation. The historically rooted and increasing tendencies of part time farming, pluractivity, diversification and off-farm activities only recently required the collective action of farmers in order to develop novel rural development networks. Our case study finds that new policy programmes should build more on the local beneficiaries' landscape maintaining activities and diversified land use, which for centuries prevented the loss of semi-natural habitats and biodiversity. Relatedly, the marginal area should further activate local participative capabilities to enhance networks and processes across various local stakeholders to effectively influence rural development.

Keywords: multifunctional agriculture; marginal farms; agri-environmental schemes; rural development; Hungary; sustainability

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1 Introduction

Multifunctionality of agriculture transformed from a much debated issue to social reality in the recent years. As a political buzzword it has attracted considerable research efforts at international level for more than two decades (see Garzon 2005; van Huylenbroek and Durand 2003). Clearly, the notion is often used to sell old ideas by making them look new (Knickel and Renting 2000), still it is increasingly influencing agricultural policy in Europe.

Primarily considered as a new paradigm and normative model of European agriculture (Casini et al. 2004; van Huylenbroek and Durand 2003) multifunctionality is trying to integrate social, spatial and ecological conditions in order to

- provide consumers with secure and stable supplies of healthy quality food & non-food products and to develop the EU's competitive position on the internal and world market based on sustainable production methods;
- safeguard and enhance the countryside and to provide environmental services valued by the public at large; to underpin the infrastructure, the economy and employment in a vast number of villages throughout the European Union and to prevent depopulation and desertification in more remote and difficult areas;
- contribute to reinforcing the economic and social cohesion between groups and regions – reducing disparities between the richer and poorer regions of the EU (CAOEU 1999).

The analytical concept of multifunctionality is not a generally accepted frame for operationalising sustainable development in agriculture. Depending on the research perspective the conceptual frame can be interpreted in a normative and a positivist way (Hagedorn 2004). Indeed, agriculture has from the very beginning always been more than a narrowly interpreted economic or market activity supplying food and fibre. It provides manifold non-marketable outputs, environmental benefits to society, such as recreational amenities and aesthetic values of the rural landscape, non-use values of biodiversity and habitat protection, intrinsic values of ecosystem and watershed functions as well as socio-economic benefits, that is food security, food safety, animal welfare, rural employment and the viability of rural areas, cultural heritage (Ángyán et al. 2002a).

The core element of the multifunctionality concept is the "jointness of production" of goods and services by agriculture, whether being commodity outputs and non-commodity outputs, or private and public goods (Casini et al. 2004). At farm level multifunctional rural development leads to various survival strategies: *broadening* regional characteristics of rural areas (towards agro tourism, landscape management, diversification toward energy production, on-farm care activities), *deepening* agricultural activities (short agro-food supply chains, organic farming, high quality, on-farm processed regional products), and *regrounding* resource mobilisation (pluri-activity, off-farm income, cost reduction by low external input) (van der Ploeg and Roep 2003).

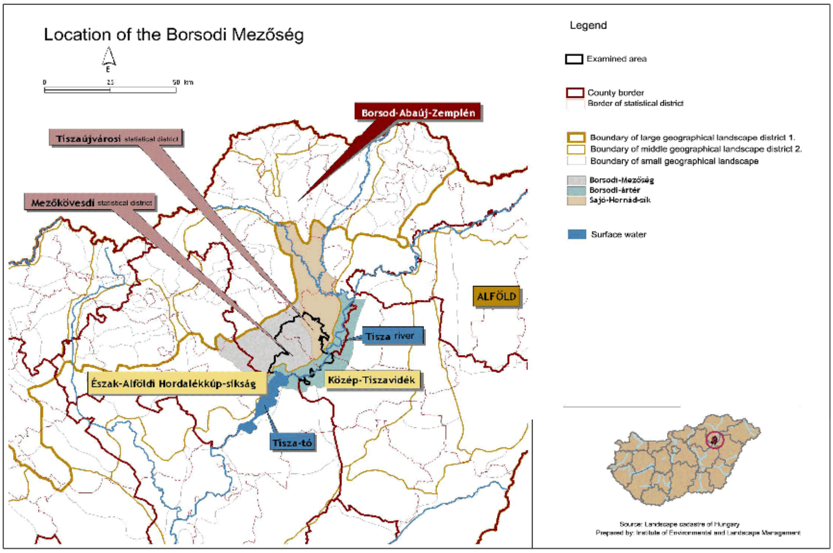
Taken together, the new farm-based activities beyond primary agricultural production and new markets are representing a new balance between agriculture and society, rural and urban; mobilizing new revenues and cooperation; reconfigure farm resources and their relation with rural areas. The main characteristics of these developments are built on local resources and perspectives of local communities, who can acquire the capacity to assume some responsibility for bringing about their own socio-economic development (Ray 1998).

The driving forces behind these rural changes are the European level rural development regulation and policy measures which adapt the concept of multifunctionality as a powerful opportunity to continue the financial support of farmers, not any longer through subsidies but through new farm-based activities beyond primary agricultural production demanded by the society (Baldock et al. 2001). Within the EU, the concept of multifunctionality has consequently experienced an increasing relevancy with regard to diversification strategies (Wiggering et al. 2003). However, rural development policies tend to fail because the top-down control forget to sufficiently promote the reconfiguration of local resources. As a result outside intervention and local aspirations tend to remain unbalanced (Nemes 2005a, 2005b).

In this case study we analyse the complex reality of these farm-based activities in a socio-economically disadvantageous Hungarian micro-region to trace survival strategies in agricultural production, resources, revenues and co-operation forms. The chapter attempts to highlight some social concerns about multifunctional agriculture and assess the impact or contribution of multifunctionality on marginal farms of rural Hungary, with special regard to players who have the most to lose but the least power to influence EU-level policies on rural development. The notion of multifunctionality also extends to zonally and thematically better targeted and implemented agri-environmental policies, thus this chapter will especially consider the potential role of agri-environmental measures in changing the farm structure of a micro-region, or influencing farmers decision making on cropping or husbandry management practices.

2 Case Study Area

The villages of the case study geographically are part of the South-Borsod Floodplain of the Borsodi Mezőség Protected Landscape Area administered by the Bükk National Park Directorate and statistically belong to the socio-economically underdeveloped Mezőcsát Micro-Region (Csatári 1996, 2000). These settlements traditionally have close relationships to each other: e.g. cross-marriages are not rare among the population of settlements. However, the micro-region as the level for local rural development has only few historic roots and weak public, civil and business institutions. The location of the studied community can be seen in Fig. 1.



Source: GIS Studio at SIU-IELM

Fig. 1. Location of the study area

Over centuries, local people settled along the river have developed tools and practices adapted to take advantage of the pulsing patterns of flood and drought. Local environmental knowledge had been based on historical observations of this particular area and it was organised in a form of a traditional resource management system, called "floodplain management". Along the river, people could harness the energy of floods by developing a special economy and culture in the floodplain. Wetland areas increased the number of water birds and wetland plants. However, the logic of modern, industrial agriculture has conquered traditional polyculture and converted the diverse agriculture of a floodplain economy to the monocultures of wheat fields. The introduction of modern industrial agriculture (large-scale crop cultivation) required a dike defence system in order to divert all natural water flows from the area. A dike defence system was constructed as well as all natural water flow resources have been drained from the area. By eliminating the most important natural landscape forming force, all the ecological services which formed the basis of the economic activities of local people were also eliminated. Traditional ecological knowledge of local people was no longer valued either since size of local wetland areas has radically shrank through damming and flood protection embankments.

Dam constructions in the 1930s and 1970s have resulted in aridity and secondary salinity in a major part of landscape. Through damming and flood protection embankments, the Tisza River lost its natural characteristics and huge areas of flood plains dried out.

The region, along with inevitable decline of a collectivised industrial agriculture after the regime change in Hungary, has been spiralling downward into inescapable social and economic depression in the 1990s. Unfavourable demographic conditions, ageing and shrinking population are due to the change in the availability of jobs. Death/birth ratio is the worst in this region, as compared to the same data for the whole county, Borsod-Abaúj-Zemplén. The villages of the South-Borsod Floodplain are officially among the areas in Hungary with the highest degree of disadvantage in economic and social terms with a significant Roma ethnicity in 3 villages.

The research area is home to various protected plants and animal species such as *Armoracia macrocarpa*, *Iris spuria*, *Rumex pseudonatronatus, Aquila heliaca*,*Otis tarda*, *Ciconia nigra, Crex crex*. Unique to the area is *Sicista subtilis trizona*. The area is both under Bonn Convention and Ramsar Convention (Birdlife Reserve Area in Tiszafüred), part of the European Union's Natura 2000 system and Important Bird Areas (IBA).

Significant natural values are therefore directly dependent on agricultural practices. For example extensive grazing prevents the particularly species rich steppe pastures from a reversion to normally species poor forests, and most of the vast marshlands with a high amount of endangered plant and animal species are acutely threatened by invasive species (particularly *Amorpha fructicosa* and *Robinia pseudo-acacia*) replacing the indigenous flora and fauna to a high extent or in some cases completely. Mowing or grazing is able to preserve the original species composition and the high aesthetic values of the marshlands.

In 2002 the Environmentally Sensitive Areas (ESAs) scheme was introduced offering contract-based incentives for farmers for the application of environment-friendly agricultural methods for a period of at least 5 years in order to reduce negative and increase positive externalities of agriculture (Ángyán et al. 2002b).

In 1998, 1999, and 2000 there were catastrophic floods on the Tisza River in Hungary. The last wave of floods threatened the entire Hungarian Great Plain with direct inundation. The recent serious flooding events experienced in previous years have demonstrated that new way of water and wetland management is needed in order to move towards sustainability. Nevertheless, the dominant future scenario for decreasing the risks of flooding is based on very technical water engineering knowledge claims which favour constructing reservoirs along the Tisza River to prevent inundation from high water levels in the event of a high peak flood wave. This approach gives less emphasis on wetland restoration for the benefit of traditional extensive agriculture practices.

3 Data Sources and Methodology

We made an assessment of the multifunctionality and survival strategies in the marginal farms of Borsodi Floodplain. The research extended to four empirical moves:

- desk research on local statistics, experts judgements in order to evaluate agricultural developments on micro-region level
- a marginal farm survey (including 96 household and farm visits) to gather data on land area, land use, production activities, subsidy payments, rural development priorities of the farms in order to formulate a farm typology
- key informant interviews (with 45 farmers) about post-productionist shifting, diversification strategies, in order to understand local people's changing perception and meaning making on the historical relationship between nature, society and economy
- participatory planning forums in 8 villages, 1 small-town and 1 micro-region level to explore the expectations and needs of local inhabitants towards role of local agriculture and farming, and demands on multifunctionality.

Marginal farmers were surveyed as to their experiences and future intentions for capital investment and expectations in farming. The data analysis among 96 farms provides a comprehensive picture of the importance of diversification in terms of the number of farm households involved. It has not been possible in this project to compare typical marginal farm businesses' intentions with actual outcomes. The survey and an analysis of the interrelations between policy and practices lead to some further policy insights.

The study also made use of qualitative interviews with various local stakeholders of farming, the village farm managers (falugazdász) and the representatives of the Agricultural and Rural Development Agency, and the Micro Region Development Agency.

Essential parts of the fieldwork comprised of "Vision-to-Action" community fora where visioning exercises were used to create future rural scenarios based on micro regional initiatives (in eco-tourism, agriculture, community life and local employment opportunities) and introduce participants how to transform their creative capabilities for short and long term actions.

Local people from all walks of life being either resourceful (information and knowledge, expertise, authority and ability to act) or in need (marginal, least power to influence formal decisions) took part in the half or two-times half day planning events with 20–30 participants working in groups of 5–8. Together with researchers, local people have started to embark on various local initiatives, such as re-activating a local agricultural co-operative, increasing access of farmers to floodplain areas, designing a micro-region level environmental education trail, eco-tourism infrastructure and organising a micro-region level festivals and community events with and for local artisans and farmers and their crafts and produce.[1]

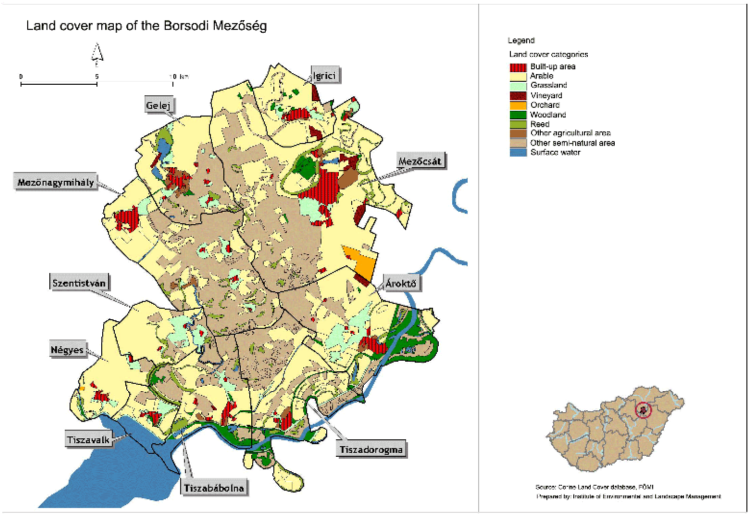
4 Land Use and Characteristics of Agriculture

The land cover map (Fig. 2) reflects the actual land use pattern of the studied area, which is mainly covered with arable lands and to a smaller extent with grasslands. The share of semi-natural areas is also significant. These are already abandoned, low yield, semi-natural grasslands suitable only for temporary grazing. Cadastral survey statistics is somewhat misleading in this respect as it categorises these lands as agricultural areas.

[1] The interdisciplinary undertaking comprised of the Institute of Environmental and Landscape Management, St. István University, Gödöll together with the Faculty of Law, Pázmány Péter Catholic University; the Water Engineering College, Baja; Department of Plant Taxonomy and Ecology, ELTE University; College for Social Theory, Budapest University of Economic Sciences and Public Administration; Department of Anthropology, University of Miskolc. Part of the research team was already familiar with this area due to a research conducted there in the summer of 2002 on the economic evaluation of natural capital of environmentally sensitive areas, on the relationship of local people and wetlands, and on the impacts of the Hungarian agri-environmental payment scheme. We would like to acknowledge and thank all the people, farmers and local stakeholders who participated in this research process.

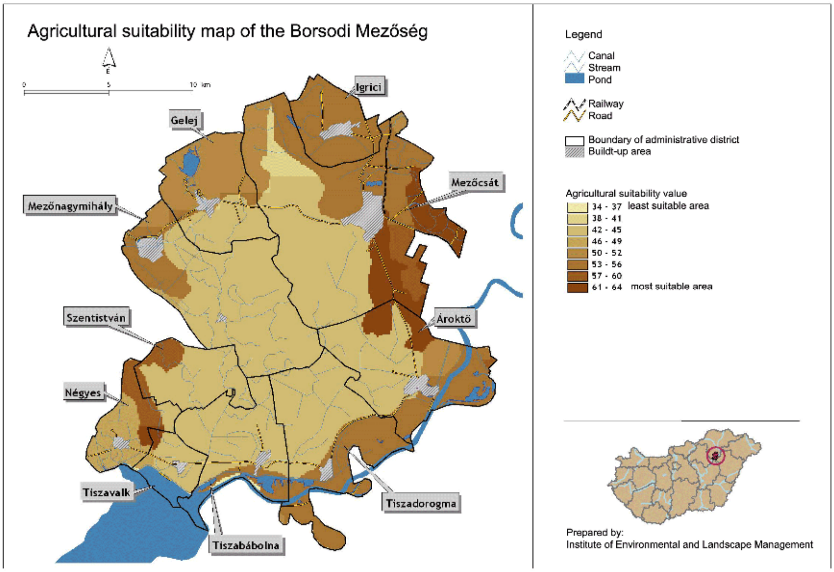
Although the micro-region's agro-ecological characteristics suggest that available agricultural lands are not or only *moderately suitable for arable lands*, as of now 46% (17,000 ha) of agricultural lands are arable lands, while 30% (11,000 ha) is the proportion of grasslands. Fruit orchards give 1.1% of lands (which basically means a 400 ha plantation in Mezőcsát), while grape yards give only 0.65%. Wetlands areas cover 5% of lands, while forests again cover 5% (1,865 ha). Recent trends show a slight increase in aforestation. According to our survey two-third of arable land and one-third of grassland is damaged to various extents by inundation.

Current farming practices, low yields of crops (Table 1) and levels of actual land use of the area can be understood better when the agricultural suitability map (relative to a country wide scale) is plotted (Fig. 3).



Source: GIS Studio at SIU-IELM

Fig. 2. Land cover



Source: GIS Studio at SIU-IELM

Fig. 3. Agricultural suitability

The structure of crop production in the micro-region is far from being diverse, it is typically cash crop orientated with fairly low levels of average yield (Table 1). In the economic year 2005/2006 31% of agricultural land was covered with wheat (with circa 3–4 tons of hectare), 22% by corn (circa 5 tons per hectares), 8% by sun-flower seed (circa 2 tons per hectares), 6% by rape-seed (circa 2 tons per hectares), while 6% by barley (circa 3 tons per hectares), and only 3% by alfalfa (circa 5–6 tons per hectares). The proportion of oil-linen, oil-pumpkin, millet and sorghum hardly cover 1% of arable land (2005–2006, source: survey and Village Farm Manager data, Mezőcsát).

Table 1. Average crop and forage yields in the Mezőcsát Micro-region

Name of crop	Average yield (tons per hectare)
Wheat	2.8-4.5
Maize	5-5.4
Barley	2.2-3.3
Rape-seed	1.4-2.5
Sunflower	1.4-2.2
Triticale	3-4.8
Oil-pumpkin	0.5
Milo	8
Millet	2.5
Alfaalfa	5.5-6
Watermelone	15
Hay	4.5-5
Pea (fodder)	2
Rye	2.5

Source: Own survey results and Village Farm Manager Office data

In sum, the cropping pattern of arable farms on medium soils is characterized by low diversity and cash crop orientation. Soil conditions do not allow for extension of cash crop area, land is rather abandoned than used for less attractive crops.

Animal stocking numbers (Table 2) are by far falling behind the optimal ecological carrying capacities of the micro-region's grasslands (just a comparison: Tiszabábolna, one of the smallest village had 400 milk cattle and 3,000 ewe on the nearby grasslands at the end of the 1980s).

Table 2. Animal stock in the Mezőcsát Microregion (2005–2006)

	Milk cattle	Milk cow heifer	Sow	Porker	Ewe	Suckler lamb	Lamb	Ram	Goat	Hen	Duck	Goose	Horse	Beef cattle	Beef cattle heifer
	Heads														
Ároktő	26	20	12	150	240	100	400	6	18	3,100	500	200			
Igrici*	650+22	450+14	11	180	120	70				2,200	300	140			
Mezőcsát	62	31	34	680	4,000	1,500	8,000	8	40	5,500	1,500	800	15	50	25
Gelej n.d.a.															
Tiszakeszi**	350+14	250+6	100	210	180	60	300	5	8	3,500	500	400			
Tiszatarján	22	16	16	220	250	100	400	6	8	2,100	350	210		56	32
Tiszabábolna			10	110	280	10		4					11		
Tiszadorogma			6	140	110								4	8	2
Tiszavalk			7	120	380	40		9					8	29	8
Microregion	1,110+36	767+20	196	1,810	5,560	1,880	9,100	38	74	16,400	3,150	1,750	38	143	67

*A major portion of the stock belongs to Narivo Ltd.
**A major portion of the stock belongs to one company.

According to village manager data the major tendencies in the animal stock in the micro-region are perplexing. Beef cattle stock started to rise in the past 3 years. Ewe and lamb stock is starting to increase (mostly in the group of family farms and in Mezőcsát) after a big drop in 2000. This is due mostly to the agro-environmental scheme's (grassland program with bustard protection) payments. Milk cattle stock is strongly decreasing in smaller farms (below 100 ha), while in bigger farms (above 200 ha) it is increasing.

5 Farm Types

The survey focused mainly on marginal farms of small-scale and medium-scale up to 100 hectares. The size categories of the surveyed sample can be seen in Table 3.

Table 3. Structure of the sample according to land size

		Frequency	Valid percent	Cumulative
Categories	Under 2 ha	10	10.4	10.4
	2.1-10 ha	16	16.7	27.1
	10.1-50 ha	31	32.3	59.4
	Above 50.1	15	15.6	75.0
	Above 100	23	24.0	99.0
	Above 1,000	1	1.0	100.0
	Total	96	100.0	

Source: Own survey results

75% of farm lands is smaller than 50 ha in our sample, which represents the micro-region average. In average the farm lands are in 7.5 pieces, the most typical land in the area is divided into 4 plots.

There are striking similarities of the farms in management strategies such as their resistance to produce in the wetland areas, or convert to organic farming. In all farms the costs of farming are compensated from agricultural support, and the market integration of their (household) economies is not dominant. While agri-environmental programs are notably popular and successful among the family farms, most of the surveyed farms had no identifiable successor who would take over the business.

According to the survey results of the 96 farms four types of typical local farms can be distinguished based on their surviving strategies and socio-economic situation:

(1) *Part-time*, semi-retired farmers are working alone on their small farm (average 12 ha) keeping several animals. Farming only means part time job for them and in two thirds there is no successor of the activities.

(2) *Off farm* employed farmers gain their revenue at least partly (maximum 80%) from agriculture and employ at least one family member on their farms of 18 ha average. They are typically pursuing a reduced farm activity (low input – low income). Without the direct payments small farms would drop out of production.

(3) *Family farms* gain their revenue predominantly (at least 80%) from agricultural production. The typical size of the farms is 110 ha and they are ready to extend their farms by hiring land from the National Park. They are the most diversified in terms of agricultural activities and income. Livestock production is less profitable and therefore drastically reduced.

(4) *Business farms* employ more than one non-family member and provide employment opportunity for an agriculturally schooled manager. Large arable farms are appropriately mechanised for surviving long term agricultural activity.

The predominantly agricultural small region does not any longer provide enough income for its inhabitants, so historically rooted and increasing tendencies of various forms of out-mobility, pluractivity, agricultural diversification and off-farm activities became the mainstream survival strategies for the local population. Clearly, this state of affairs also reflects the conflicts between – ecological, economic and social – dimensions of sustainable agriculture, the more or less converging conservationist, rural developmental and productivist ambitions of the local society (Huylenbroeck and Durand 2003.). Thus, finding the trade-offs among the environmental benefits, well-being of people and the higher farm income of these local ambitions remains to be the key concern in this rural community.

6 Survival Strategies

When local farmers were asked about potentials of rural development priorities they frequently underlined future possibilities of multifunctional developments. According to the survey results the top four rural development priorities of farmers were: support of young local farmers and intergenerational farm transfer; training and consultation in production, marketing, funding opportunities; improvement of infrastructure (energy supply of farms, storage capacities, quality assessment laboratory for crops, processing capacities), healthy and safe local food.

To sum, since confidence in the farm business is rather in decline farmers prefer further preventive strategies, although the results also refer to some stability in the size and structure of the farm enterprises joining environmental schemes. Farmers are resigned to continuing as before, even though they apparently recognised that this way of life and business is not ultimately sustainable (expressed primarily through the lack of succession). During the community planning fora (in each of the settlements), and a micro-region level planning forum a common understanding of dominant survival strategies were elicited and later interpreted by the research team (Table 4) within the farm level multifunctional agriculture framework (van der Ploeg and Roep 2003):

Table 4. Multifuncionality on farm level

Production related activities – *deepening*	Resource mobilisation – *regrounding*	Rural area – *broadening*
crops: diversified land use animal husbandry organic farming co-operation: vertical integration processing raw materials: local products (generating added value)	Young farmers: supporting young farmers is a key for sustaining agriculture in the area but also a partial solution for preventing outmigration converting to non-agricultural activities, off farm incomes	cultural landscape restoration: landscape management, role of agri-environmental schemes

6.1 Deepening of Production Related Activities

Diversified land use is an important driver for diverse crop production, crop rotation and to avoid one-sided use of local soil, to switch to alternative crops and local landraces taking into account market opportunities. The following crops are especially suitable for the local agro-ecological conditions: potato, spring barley, winter barley, alfalfa, rapeseed, silo maize, sunflower, and vegetables such as sprouts, savoy cabbage, cabbage, kohlrabi, parsley, green beans, carrots, peas, cucumber and fruits such as watermelon, pear, walnut. Community horticultural gardens could serve as an extension of vegetable and fruit production for local and regional markets.

Renting out of floodplain areas from the Water Management Authority for planting forests and fruit orchards are also key concerns for most farmers in the South Borsod Floodplain (especially in Tiszadorogma, Tiszabábolna and Tiszavalk), such as the extension of animal husbandry in wetland areas in order to increase profitability of farming. *Floodplain management with extensive beef farming would in fact prevent the loss of semi-natural habitats and biodiversity loss.*

As for *supply chains* the most important dimension for farmers in selling-decisions is the reliability of the purchaser, this is followed in the order of importance by price, the personal connection with the buyer and transport distance to purchaser. In this sense, agricultural *cooperatives* can offer the necessary level of reliability for farmers and reduce dependency on buyers. Survey results show farmers' openness towards cooperatives: 58% of farmers would join a collective farmers' market initiative; 53% of farmers would join consumption cooperatives; 29% of farmers would join an industrial cooperative.

Farmers' cooperation could be initiated through innovative forms of cooperatives, since establishing reliable and countable markets requires flexibility, activation of local capabilities and new skills from local farmers. Farmer participants in the fora expressed their concern that there is a need to increase farmers' market orientation against their production orientation. Collective farmers marketing initiatives is the individual contribution to a common "product" which result in an increased utility both at individual and organizational level, and in special cases (e.g. in the case of organic production or landscape management) at a wider community or regional level as well. Successful collective actions of farmers are not widespread in Hungary, despite both institutional incentives and individual interests exist. Additionally, the new-type cooperative offers an organizational form that at least in legal terms provides institutionalized guarantees against asymmetric power relations and free-riding that is often said to be the reason for the failure of collective actions.

The dead-alive "Dél-Borsodi Gazdák" purchasing and marketing cooperative established some years ago in the micro-region is a good example for collective action of farmers which seemed to be rational and profitable for all participants, but finally ended up in divergent interests. Reasons for failure in the market extend from heterogeneous membership, the relatively wide territorial extension, through the lack of distinction between organizational and individual managerial roles and other management deficiencies, to understandable distrust in other people and institutional frameworks.

Reactivation and re-establishment of the Farmers Association of South-Borsod could be the basis for further work: to gain better market prices and to reach for better representation of farmers' interests. An important outcome of the research group is that a successful project proposal was submitted by the Micro-Region Development Agency to the micro-fund of the ongoing United Nations Development Programme Global Environment Facility programme for being able to finance the coordination work of reactivation. The project proposal has largely built on the ideas emerged from the small group discussions on the community fora; however, farmers were approached both individually through the preparation of the concrete project plan, and through the meeting of the local farming association, where research results were presented to and discussed by the local farmers (Bodorkós 2007).

Most of the fora participants expressed their needs towards a higher level of *local distribution of their products*. Local products could find their consumers directly in farm shops, local marketplaces, and local specialty shops. However, farmers are still more interested in production-oriented developments such as establishing a slaughterhouse, forage mixer, further crop storage places and crop quality assessment laboratory, meanwhile there are still not any food-processing and manufacturing capacities in the micro-region therefore dependency on buyers is very high.

Exact quantity of high quality local products could not be judged based on the survey, as 35 farmers were not willing or able to provide exact data on the amount of milk, eggs, dairy products, honey they produce. It can be assumed though that they have some local products and use them for own consumption. The rough amount of local products produced by the rest of the farmers (62) can be seen in the Table 5.

Table 5. Rough amount of local products

Product	Own consumption	For sale	Mean (family consumption)	Mean (for sale)
Milk	30,264 l	50,100 l	488 l	808 l
Cheese	Cannot be evaluated	Cannot be evaluated	Cannot be evaluated	Cannot be evaluated
Honey	431 kg	284 kg	6.96 kg	4.58 kg
Meat	114,441 kg	28,742 kg	1,845 kg	463 kg
Eggs	36,320 ps	4,300 ps	585 ps	69 ps
Dry pasta	109 kg	–	1.75 kg	–

Source: Own survey results

Local processing of agricultural raw materials is in essence missing. Most of the sales take place on-farm, but in case of meat farmers (who are) targeting the integrators of the nearby towns. Local dairy and vegetable products can find consumers in Tiszabábolna, which profits most on agrotourism, and considered to be already more of a “holiday village” than a “normal” village. According to the survey 5% of the farmers plan to extend their activities to produce local food such as dairy products, eggs, honey, jam.

Organic farming is underdeveloped in this micro-region: only 2 farms in the micro-region are officially certified as organic. 12 farmers out of 96 expressed their concerns to convert to organic farming in the following years. 78% of farmers find converting to organic farming difficult and economically uncertain. Only 27% of the respondents find it possible to manage farming in an organic way without herbicides. However, 50% of them find it as an outstanding income opportunity in the region; two-third of the respondents finds organic farming necessary to conserve local ecological values. Again, only 32% of the respondents claim that there is sufficient information on organic farming in the region.

The answers to the survey's open questions have shown that even if most of the farmers agree with the production principles of organic farming, they will not dare to commit themselves to organic farming until they see safe market opportunities. There are further critical points and concerns that farmers expressed, such as changing certified seeds, lack of available labour force and low price of hand labour; difficulties in weed control; unavailability of organic forage. However, further development of organic farming (in study tours and training events), management and coordination of demand and supply side of organic products (cooperation with the nearby organic market in Miskolc) with stronger cooperation between farmers in terms of purchasing and selling remain key elements of the local aspirations.

6.2 Re-grounding Resource Mobilisation

Supporting of young local farmers is another key theme of local reconfiguration of resources. Survey results show that farmers are ageing and the new generation of farmers will not be able to take over their parent's farms or embark on a new farm without any strong supporting background. Other than necessary capital, they are mostly in need of various training events, which would be the basis to become eligible for applying for further governmental funding. Supporting young farmers would be a key for sustaining agriculture in the area but also a partial solution for preventing outmigration. It is also true, that pluractivity of farm enterprises is not necessarily considered to be a sign of poverty. It increasingly becomes a preferred combination of living in the countryside farm while enjoying income security of an urban job.

6.3 Broadening the Rural Area

As all villages in the micro-region plan to open up to *eco-tourism*, a market for local agricultural products can be created through tourism. A micro-region level environmental education trail aims to introduce the newly rehabilitated wetlands, special habitats, main ecological processes, the nature transforming human activities of the micro-region and the cultural values both to local people and eco-tourists.

Farmers, indeed, seem to be more open and plan to diversify their activities related to renewable energies: there have been quite significant interests shown towards biogas plant and biomass plants.

Agri-Environmental Programmes are well received by the farmers in the Mezőcsát Microregion: 53% of the respondents take at least one type of agri-environmental subsidy (mostly for arable crop production programs and grassland programs with bustard protection). Without this and other type of payment schemes, agriculture would not be profitable in the region: as of now as in each of the farmers' types at least 50% of the agricultural income is originating from government subsidies (See Fig. 4). Subsidies reach mostly family farmers and non-family farmers, who have the highest proportion of their income from agriculture.

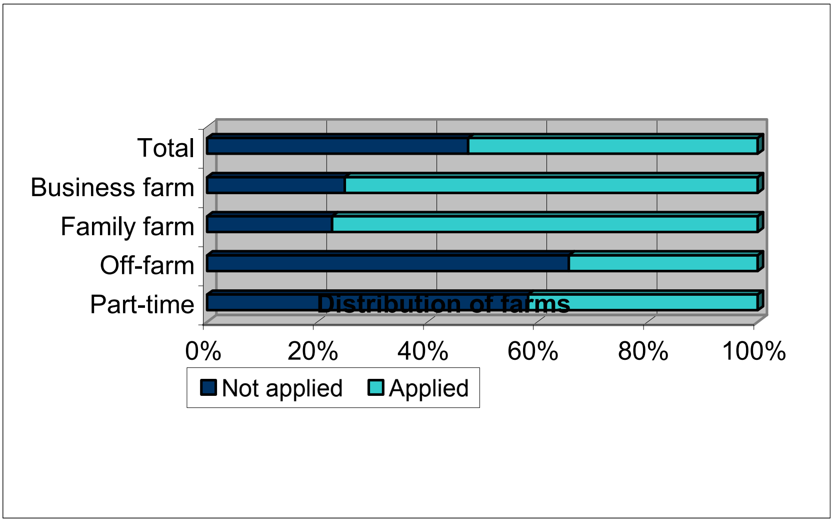


Fig. 4. Share of farms in agri-environmental schemes by farm types

Cultural landscape restoration and establishment of community gathering places in nature are important part of local initiations, since due to the installation of the dam system in the 1970ies, the villages along the Tisza have lost important community gathering places. The banks of the Tisza river are quite deserted, in many cases invaded by invasive species, and garbage is thrown around; therefore unpleasant for local people. Some small forest areas in the "puszta" part of the micro-region as well used to be important community gathering places such as the "Nagyerdő" in Gelej. Restoration of landscape specific architecture elements such as wooden wells as envisioned by local people through the fora would not only contribute to the improvement of the local cultural landscape, but also mobilise local communities to act together.

Converting to agro tourism is a key expectation of local communities towards local farmers. Finding cooperation between agriculture, tourism and regional handicrafts industry and pursuing a less production oriented lifestyle would be a crucial factor to diversification. As the recent trends continue it is expected that diversification could offer extra incomes for farmers, such as the establishment of demonstration farms (sweep, animals, meat and cheese production, horse riding, handicrafts workshops etc.), shepherd contest, local food festival, Cheese Day to celebrate local cheese and wine (Gelej), watermelon festival (Igrici), lamb stew cooking competition, barbecue (Tiszakeszi). Many of the poor people in the region are already collectors of forest herbs and fruits in order to increase their income. However, currently collection is organized by from outside of the area; therefore the extra revenue is exported by wholesalers from the area and does not remain with local people.

7 Conclusion

Rural development in Hungary is traditionally non-participatory, excludes local people and their plurality of perspectives, resources, initiatives from decision-making processes (Nemes 2005a, b). In this chapter we have shown, that this predominantly agricultural and socio-economically underdeveloped microregion with ageing farmers, outmigrating young people does not any longer provide enough agricultural income for its inhabitants, so historically rooted and increasing tendencies of various forms of part time farming, out-mobility, pluractivity, agricultural diversification and off-farm activities became the mainstream – curative or preventive – survival strategies for the local population.

In the first place, multifunctional agriculture is now compensated from agricultural support. The market integration of farm enterprises is very vulnerable, without the direct payments farm income will become negative, without Agri-Environmental Schemes small farms drop out of production. Nonetheless, effective landscape maintaining activities of these marginal farms still safeguard the predominantly landscape maintaining role of local agriculture. Rural characteristics, landscape specific features could be turned into farm income only if local agricultural products finally regain local markets, whereas landscape management could gain further subsidies.

Secondly, livestock production is deemed unprofitable to a large extent and therefore drastically reduced. However, it is clear that diversified land use and extension of animal husbandry in wetland areas with extensive beef farming would prevent the loss of semi-natural habitats and biodiversity loss. Shortening of supply chains, reactivation agricultural cooperatives could be sources of successful collective actions of farmers to reach also higher level of local sale and on-farm processing of local products. Supporting the new generation of farmers would be a partial solution for preventing outmigration.

Thirdly, as a precondition for an integrated rural development various local survival strategies and the support system for extensive agricultural practices should be balanced and harmonised to facilitate emerging rural development networks. The future of sustainable agriculture in this lagging rural area is still heavily dependent on privately owned multifunctional farms, and also requires multidisciplinary knowledge and plurality of perspectives. Thus a more effective, integrated system of rural development would pursue stronger bottom-up, participative character of negotiations on natural resource management solutions involving all relevant stakeholders of the locality. As a result, local products, town-countryside relations, local players' initiatives could guide multifunctionality and rural development processes.

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