Modelling the CAP reform at the regional level with ProLand

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Abstract

The reform of the European Common Agricultural Policy (CAP) will fundamentally affect the decision behaviour of land users. So far transfer payments were coupled to specific forms of land use. The reform encourages land users to make decisions concerning production based solely on market aspects.

The effects of the CAP reform on the Lahn Dill region in Germany are simulated with the spatially explicit land use model ProLand. The results show that land use decisions will be based stronger on site specific natural conditions than was the case in the Agenda 2000 scenario. The transfer payment volume directed into the region increases considerably.

Keywords:

Modelling, decision support, land use, spatially explicit; Q01

1 Introduction

Changes in the agricultural sector policy affect the appearance and functionality of landscapes. The current political and public discussion on farming reflects the close connection. The European Council initiated a landscape convention (Council of Europe, 2000) with one key concept of the CAP being the preservation of the rural environment (Heißenhuber and Lippert, 2000). Society becomes increasingly aware of landscape's essential role in individual and societal well-being and people's quality of life (Council of Europe, 2000). These aspects are also discussed in the context of multifunctionality. This concept emphasises the fact that landscapes used for food production may have multiple outputs and may contribute to several of society's objectives at once (European Commission, 1999; OECD, 2001). Landscapes are evaluated to a growing extent with this concept in mind.

Changes in landscapes arise from technological innovations, as well as from socio-economic and political forces (Rounsevell et al., 2003; Stoate et al. 2001). These changes often impact landscape's appearance, soil degradation, decline in water and air quality, raised suspicions of adverse health effects, and negative changes in flora and fauna habitats (Hansen et al., 2001; Stoate et al., 2001).

Agriculture itself undergoes strong structural changes as well. For example, the total number of farms in Germany decreased by 11 % over the past five years (DESTATIS, 2004). Consequently, agriculture has lost its function as a main employer of human labour in rural areas (Vos and Meekes, 1999). Marginal sites are removed from production, natural succession follows.

These trends will be backed by the CAP's orientation towards production under world market conditions. The enlargement of the European Union, as well as technical and social changes will aggravate this trend (Rounsevell et al., 2003).

1.1 Problem statement

These developments call for decision support to avoid adverse effects both on landscapes and society. Planners and policy makers influencing these processes need new and significant information showing the consequences of different courses of action (Antrop, 2004). In terms of landscape evaluation with respect to economic benefits, as well as to societal objectives, spatially explicit decision support systems turn out to be most helpful tools. Employing such tools may be seen as the best approach to better understanding of land use dynamics (Lambin et al., 2000). Moreover, they are a prerequisite for weighing objectives to decide as democratically as possible about further developments (Stomph et al., 1994). To do so requires land use models because environmental changes almost always trace back to land use changes (Lambin et al., 2000). Hence, a spatially explicit land use model is an essential toll for sound multifunctional landscape evaluations (Bockstael, 1996).

Conventionally, land use models cover only economic components. But society is also interested in problems e.g. concerning biodiversity and hydrology as well.

Two relevant options appear to satisfy these requirements. First, the combination of a land use model with biodiversity and hydrology models, and second, extending the land use model with biodiversity and hydrology components.

Independent from the selected option, the spatial component of land use is of outstanding relevance, accurately described by Bockstael:

„Likewise, it is not just the total forested land in a region that matters for species abundance and diversity, but its size, shape and the conflicting land uses found along its edges.” (Bockstael, 1996)

Accordingly, modern land use models should provide spatially explicit prognoses. Of course, many models, generating predictions on the spatial allocation of land use systems, and on socio economic indicators like added value or rate of employment, exist already (see Münier et al., 2004). With the main focus on economic aspects, the spatial consideration in these models is of minor interest. This mainly distinguishes them from ecological models, which stress explicit spatial information (Bockstael, 1996).

So in this context, models generating spatially explicit land use distributions may be differentiated from those approaches which only generate frequency distributions of land use systems with coarse or no spatial allocation.

The first group has a broad coverage combining an economic analysis with the ability to enrich the model results with sets of indicators derived from other models, like e.g. habitat or water balance models. Here, spatially explicit land use distributions are essential. Major criticism of these models focuses on the demanding data requirements and the strong dependence on data availability when transferring the models to other regions. Generally, a wide array of information has to be acquired. Particularly challenging is the projection of local data into space. Nevertheless this modelling approach is indispensable when expanding the economic analysis to an evaluation of landscape’s multifunctionality.

The second group predicts land use by modelling farms in some aggregate manner. Usually, the main incentive for constructing such models is data availability. In most cases official statistics provide the necessary database. So, as a rule, transferring these models to other regions is relatively uncomplicated. A typical example is the almost 200 years old Thünen model, which explains the spatial distribution of land use as dependent on transportation costs. Spatial equilibrium models developed since the 1960s may be regarded as an enhancement of this approach. They are based on the assumption that a region can be divided into punctiform, homogenous demand and producer subregions. The spatial distribution of agricultural land use is than calculated based on an economic efficiency criteria (see Henrichsmeyer, 1994; Bork et al., 1995; Weingarten, 1995; Henrichsmeyer, 1995; Balmann et al., 1998; Moxey and White, 1998; Rounsevell et al. 1998; Bernhardt and Ahrens, 1999; Dabbert et al., 1999). The spatial component is secondary in these approaches. This, however, has to bee seen in context to the level of consideration (Gibson et al., 2000).

Local differences play only a minor role, e.g. for highly aggregated country level investigations. When working at the farm level, however, minimal differences at the field level have a significant impact. In case of landscapes it is a challenging task to decide about the level of investigation. On the one hand, surveying all farms and their field locations is not feasible; on the other hand, a punctiform homogenisation is inappropriate to cover spatial differences.

With the newly developed model ProLand (**Pro**gnosis of **Land** Use) we claim to have solved several of the above described conflicts. The model operates at the regional level and provides spatially explicit predictions on land use systems. It can be combined with other models and as such be used as a toolbox for multifunctional landscape evaluations.

2 The model ProLand

ProLand is a comparative static, deterministic programming model that simulates regional land use patterns.

2.1 Modelling concept

The basic rationale for ProLand is that land use patterns are a function of site specific natural, economic, and social conditions. Changes in these conditions have an influence on land use patterns.

Based on small-scale information on the spatial distribution of physical, biological and socio-economic characteristics in a region, the allocation of land use systems can be predicted by the model.

The basic rationale for ProLand is that land use patterns are a function of site specific natural, economic, and social conditions. Changes in these conditions influence land use patterns. To obtain information on the ecological consequences of land use changes, cropland, pasture, forestry and abandoned land are considered to be feasible land use systems. Urban areas, traffic areas and miscellaneous land uses are assumed as external constants and are not modelled. Pork, egg and poultry production is assumed to be spatially independent and therefore without effect on regional land use patterns.

Prior to the description of the methods used for the construction of ProLand, the requirements of the modelling approach have to be clarified because of their strong influence on data input and calculation time. The model should cover regions of 1.000 km^2 and more, characterised by inhomogeneous natural conditions and widespread marginal agricultural land. Thus, the "Lahn-Dill-Bergland" in Hesse, Germany (see figure 3) was selected for methodological research and initial model testing. Modelling a region of this size requires significant simplifications when capturing the natural and economic situation. New approaches need to consider that it is impossible to gain primary information on the size, type, organisation, ownership and especially the location of agricultural land with a particular use and – at the same time – give a high resolution prognosis on regional land use. However, information on both, economic and ecological consequences, requires a prognosis of the land use systems' distributions in a given region with a high spatial resolution.

The combination of a large region as modelling object and the necessity of a high spatial output resolution requires some methodological peculiarities as described below.

ProLand is designed as a comparative static model, meaning its results have to be interpreted as endpoints of adaptation processes. Costs of adaptation, however, are not considered yet.

The model's basic behavioural function is the maximisation of land rent. To measure the potential economic performance of land, the concept of land rent is an appropriate and useful approach (comp. van Kooten, 1993, p. 15 et sqq.). Accordingly, the model chooses the land use system with the highest land rent on a specific site.

In reality though, farmers will employ a certain combination of the production factors land, labour and capital to maximise the farm income. In order to take this into account, the basic hypothesis for ProLand is therefore that farmers maximise the land rent ($LR_{max,pos}$) on condition that the factors labour and capital achieve a certain level, measured as realistic opportunity costs. The land rent is calculated for a decision unit (pos) as follows:

$$(1)\ LR_{max,pos} := \left[\overline{LR}_{1,pos},...,\overline{LR}_{n,pos}, LR_{n+1,pos},...,LR_{n+k,pos}, LR_{n+k+1,pos},...,LR_{n+k+m,pos}\right]$$

where

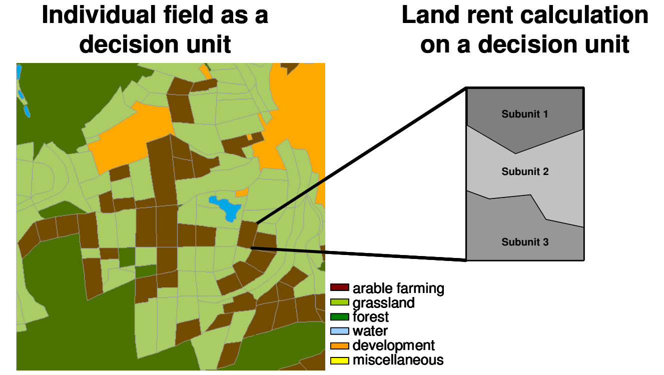
$pos = \text{decision unit}$

$\overline{LR}_{1,pos},...,\overline{LR}_{n,pos} = \text{average land rent of crop rotation}$

$LR_{n+1,pos},...,LR_{n+k,pos} = \text{land rent of forest activities}$

$LR_{n+k+1,pos},...,LR_{n+k+m,pos} = \text{land rent of grassland activities}$

The land rent is defined as the sum of revenue including all subsidies minus input costs, depreciation, taxes, as well as opportunity costs for employed capital and labour (Kuhlmann et al., 2002). The model ProLand, as equivalent to the real land user, selects the land use program from a set of possible land use activities. They include, as stated in equation (1), different crop rotations $\overline{LR}_{i,pos}$ evaluated by the model for every decision unit, different types of forest ($LR_{n+1,pos}$,…, $LR_{n+k,pos}$), and grassland activities ($LR_{n+k+1,pos}$,…, $LR_{n+k+m,pos}$). A decision unit can be raster or vector elements of discretionary size but also individual fields, depending on data availability. Typically ProLand operates with individual fields as decision units as shown in figure 1.



$$\text{Land rent}_{\text{decision unit}} = \text{area}_{\text{subunit 1}}\ \text{Land rent}_{\text{subunit 1}} + \text{area}_{\text{subunit 2}}\ \text{Land rent}_{\text{subunit 2}} + \text{area}_{\text{subunit 3}}\ \text{Land rent}_{\text{subunit 3}}$$

Figure 1. Individual fields as decision units.

In order to take varying natural conditions on a single field into account, the land rent is calculated on every subunit with homogenous natural conditions. Summing up the area-weighted sum of the subunit´s land rent yields the land rent on a decision unit (compare equation 2).

$$LR_{i,pos} = \sum_{a=1}^{n} A_{pos,a}\left(R_{i,pos,a} - C_{i,pos,a}\right). \tag{2}$$

$$LR_{i,pos} = \sum_{a=1}^{n} A_{pos,a}\left(\left(\sum_{k} c_{i,k}\, y_{i,pos,a} + \sum_{l} s_{i,l,pos,a} + \sum_{m} s_{i,m,pos,a}\, y_{i,pos,a}\right) - \left(\left(\sum_{n} cy_{i,n}\, py_{n}\right) y_{i,pos,a} - \sum_{p} ca_{i,p,pos,a}\, ca_{p}\right)\right)$$

where

$LR_{i,pos}$ = the land rent (LR) for land use activity i on decision unit pos expressed in €/ha,

$A_{pos,a}$ = area share of subunit a of decision unit pos expressed in percent,

$R_{i,pos,a}$ = the revenue of land use activity i on subunit a of decision unit pos expressed in €/ha,

$C_{i,pos,a}$ = the costs for land use activity i on subunit a of decision unit pos expressed in €/ha,

$c_{i,k}$ = coefficient determining the monetary yield per unit for the k-th yield component of land use activity i expressed in €/dt,

$y_{i,pos,a}$ = the maximal realisable yield of the land use activity i on subunit a of decision unit pos expressed in dt/ha,

$s_{i,l,pos,a}$ = l-th area payment for subunit a of decision unit pos for the land use activity i expressed in €/ha,

$s_{i,m,pos,a}$ = m-th yield dependent subsidy of land use activity i on subunit a of decision unit pos expressed in €/ha,

$cy_{i,n}$ = coefficient determining the consumption of the yield dependent production factor n of land use activity i expressed in quantity unit per yield unit,

py_{n} = costs of the yield dependent production factor n expressed in € per quantity unit,

$ca_{i,p,pos,a}$ = coefficient determining the consumption of the area dependent production factor p of land use activity i on subunit a of decision unit pos expressed in quantity units per hectare,

ca_{p} = costs of the area dependent production factor p expressed in € per quantity unit.

The following explanation refers to an individual field but applies to all fields as the above stated equations are calculated for each unit.

The revenue $R_{i,pos,a}$ of a production process i on subunit a of a decision unit pos is the product of the maximal realisable yield $y_{i,pos,a}$ on subunit a of decision unit pos and the monetary yield per unit $c_{i,k}$ of the maximal realisable yield component. Subsidies and premiums, separated into area dependent $s_{i,l,pos,a}$ and yield dependent components $s_{i,m,pos,a}$ are added.

Production costs $C_{i,pos,a}$ of production process i on subunit a of decision unit pos consist of yield and area dependent cost components. The yield dependent costs are the sum of the product's input-output coefficients $cy_{i,n}$ and the prices of the yield dependent production factors py_{n} multiplied by the maximal realisable yield. Pesticides and fertilizers mainly account for these costs.

The area dependent costs are equal to the sum of the products of the area dependent production factors' input-output coefficients $ca_{i,p,pos,a}$ and the area dependent production factor prices ca_p. They comprise mainly machinery and labour costs.

According to equation 2 land rent is calculated for every subunit of the decision unit pos. Multiplying the land rent with the subunit's area share $A_{pos,a}$ of the decision unit and summing up over all subunits results in the decision units land rent $LR_{i,pos}$.

As shown in figure 2 the model estimates the land use with the highest land rent by taking into account physical features and calculating the yield potential of various possible crops.

Determining the land use for a decision unit takes several steps (comp. Weinmann, 2002). First, the land rent is calculated for every crop as shown in figure 2, performing a site specific yield estimation (maximal realisable crop yield) in the process.

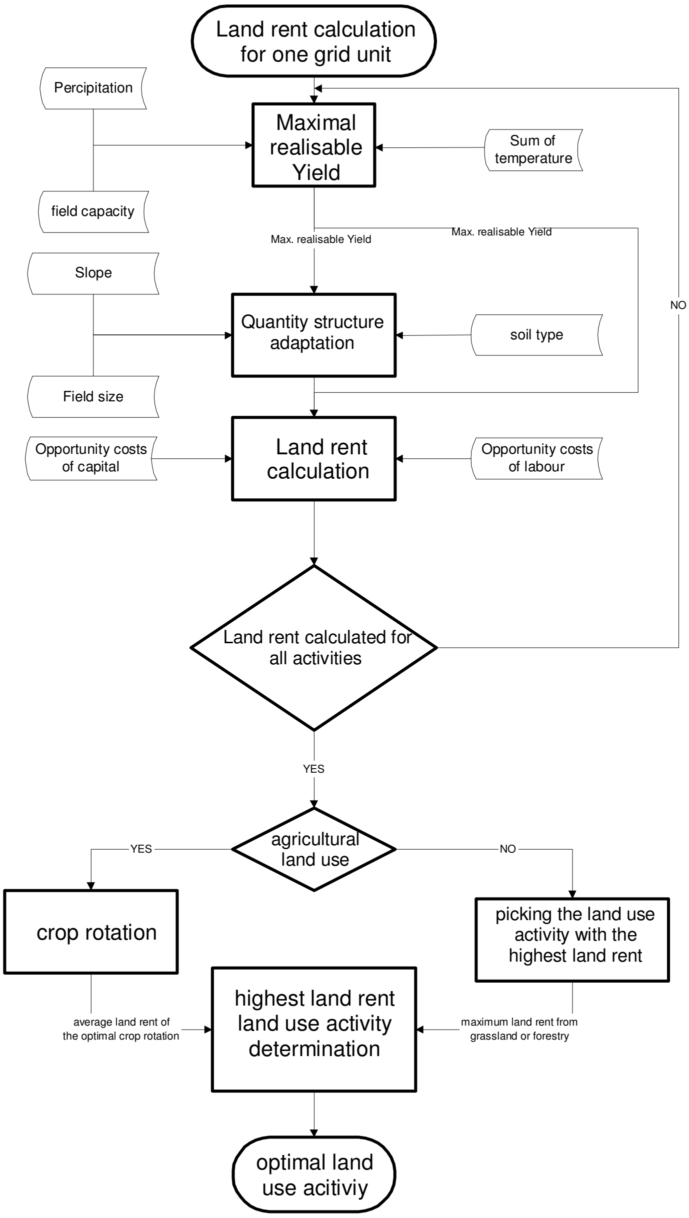


Figure 2. Land use estimation procedure.

The maximal realisable crop yield is calculated using linear-limitational yield functions. The functions describe the influence of the non-controllable growth factors yearly precipitation, usable field capacity, and yearly temperature sum on the crop yield. The maximal realisable yield is either limited by plant available water, the temperature sum or genetic potential.

When calculating the production costs according to equation (2), the land user is assumed to employ the controllable production factors such that the estimated potential yield is attained. The calculation of consumed nutrients and pesticides, as well as of necessary machinery and labour, is based on this assumption. At least on type of field operations is associated with every crop. Each type has a predefined input-output structure capturing the amount of production factors necessary on an indefinitely large plain with 0 % slope and average soil composition. The input-output structure is adjusted to specific site conditions using correction factors for field size, slope and soil composition.

The land rent is calculated using the maximal realisable yield and the adjusted input-output structure. Marketable products are valued using the market price, while self-produced fodder is valued using the market price for the processed product to calculate the value added by animal production. Transfer payments are also added to the land use system's performance.

The described procedure is repeated for all land use activities stored in an underlying database. According to the behavioural function, the land use system resulting in the highest land rent is considered optimal and assigned to the element. This process is repeated for all decision units.

ProLand thus generates a map showing the spatial allocation of land use systems and a set of economic key indicators describing the region's economic performance.

To calculate the land rent according to equation (2), all production factors have to be calculated based on one spatial unit. This implies assumptions on the divisibility and availability of labour and machinery.

The value of the factor labour is determined by its opportunity costs, assuming that labour is totally divisible and not limited. These assumptions of total factor mobility seem to be adequate considering the facts that a) the use of private contractors increases, b) opportunities of alternative activities in rural areas e.g. in tourism, landscape conservation, etc. on an hourly basis are available, c) mobility retarding factors like sociological specifics, personal preferences and commuting costs can be incorporated into the opportunity costs of labour and d) complete mobility is given in the long run.

Considering the above stated requirements, all costs of production have to be calculated corresponding to the cultivated area, and at the same time, with limited information on farm characteristics. Assumptions regarding the depreciation rate and capital costs for machinery have to be made. It is assumed that all machinery is employed at 100 % of the depreciation threshold. Consequently, the depreciation rate is performance-related and solely depending on the cultivated area. For further discussion on this assumption see Kuhlmann et al. (2002).

2.2 Database concept

The necessary information to evaluate equation (2), production process specific figures, and correction factors are stored in a dedicated database. The database was developed using an entity-relationship model for agricultural and silvicultural land use systems and implemented with a relational database management system (Schroers and Sheridan, 2004).

Descriptions of agricultural or silvicultural land uses require information on crops, field operations and animal husbandry and are determined by political, socioeconomic, natural and technological conditions. Additionally, environmental aspects such as erosion coefficients may be covered as well.

Land is used through land use systems, which are groups of independent but interrelated elements comprising a unified whole. Applying the entity-relationship data model, a land use system at the primary level consists of the entity sets crops, field operations, and animal husbandry and their relations. These entities are described using biological and technological attributes, specific to each entity.

Land use systems are determined by political, socioeconomic, natural and technological conditions and their relations. A land use system at the secondary level is thus extended by these entity sets and the relations between all these sets. The model and database capture information on the entity sets, members, value sets, and attributes, and their relations while accounting for constraints set by the conditions listed above.

Consider the example of dairy cow keeping to illustrate this approach. To describe the corresponding land use system one needs information what fodder crops are grown (entity set crops), how these crops are produced (entity set field operations), and how the animals are kept (entity set animal husbandry). However, to comprehensively describe the system, additional information is required, e.g. transfer payments, interest rates, wage rates, production quotas etc.

The land use systems database reflects the biological, socioeconomic and political attributes of agricultural production. However, spatially explicit land use modelling requires additional site specific information on natural, structural and political attributes that influence the costs and benefits of land use systems.

Using a geodatabase to store site specific data on natural and political conditions, and landscape structure with the required attributes satisfies these requirements. Attributes include plant available water and temperature as non-controllable growth factors, site specific transfer payments, slope, and field size. The spatial resolution varies with the type of information stored. While the polygons containing information on natural conditions were derived from a 25 m by 25 m raster, fields are stored as polygons with their actual shape and size. Associating the higher resolution raster information with the field polygons allows to retain high accuracy while capturing the actual landscape structure. During the simulation process, each associated sub-polygon is estimated, one land use system is selected for the entire field polygon.

The generated results are stored in relational databases which are then associated with the corresponding spatial units in the geodatabase. This structure allows to perform further analysis. In addition to the land use distribution of a specific scenario economic performance figures are generated, stored, and can be visualized as maps, tables or charts. Also, results can be passed on to e.g. ecological or hydrological models.

The above described approach has several advantages compared to flat file or single table databases: It allows to store information without data redundancy, provides a means to integrate virtually all land use systems including energy farming, and conservation measures, and makes it possible to generate scenarios regarding markets, policy instruments and technological progress. Combining data on land use systems, e.g. transfer payments, with spatial data produces information that is essential for viable land use modelling.

3 ProLand as a Decision support system

The model ProLand can be used as an economic laboratory showing the consequences of different courses of action (see Möller et al., 1998; Möller et al., 2000; Weber et al., 2001). Besides the predicted land use, the model also calculates key economic indicators describing the economic performance of a region. Due to ProLand´s spatially explicit land use prediction these results can be combined with ecological as well as hydrological indicators provided by specialised models (Möller et al., 1999, Weber et al., 2001).

The relational database and the direct link to a geographical information system (GIS) enables ProLand to simulate interventions in agricultural structure, policy, and socio-economy. Any sub-region of a landscape can be selected in the GIS for simulation. This allows to consider land use limitations or land use change restrictions. The direct connection to the relational land use systems database allows to restrict the available land use systems in selected sub-regions. Since the emphasis of this paper is on the effects of the CAP reform the following paragraphs elaborate how specific policy measures are incorporated into ProLand.

The first pillar of the CAP employs the instruments market price support, area payments and animal premiums. These interventions influence the economic decisions of land users regarding their choice of land use systems.

Variable options of market price support are incorporated as scenario based price structures for marketable cash crops and processed products such as milk and beef. These price structures can be entered and altered directly in the database.

Coupled as well as decoupled area payments are stored for every crop respectively every decision unit and can be associated with spatial information. They are added to the monetary yields of the individual crop according to equation (2).

Animal premiums are stored with the description of the animal production processes and directly affect the value added by animal production. This structure enables simulations with a spatial reference of coupled and decoupled animal premiums and area payments. Covering effects of individual transfer payments at the farm level is not possible or only for the region in its entirety, due to the spatial rather than farm based approach.

3.1 Region of interest

The model ProLand is applied in a simulation example to the Lahn-Dill region located in the central part of Hesse, Germany (compare figure 3). It is a less favoured low mountain region with poor natural conditions in terms of field capacity.

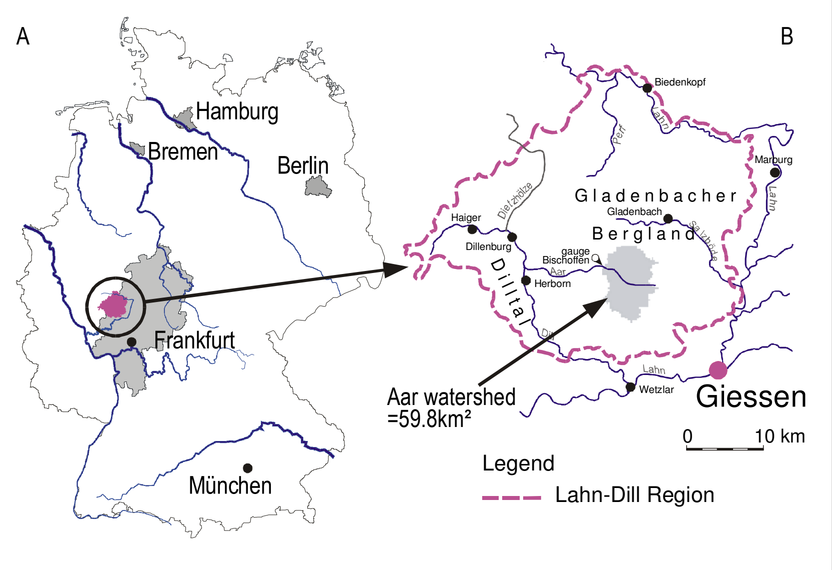


Figure 3. Location of the investigated region in Central Germany. (A) dark coloured the German state Hesse and the study area Lahn-Dill hill country. (B) dark coloured the Aar watershed test area.

The Lahn-Dill region covers a total area of 1.100 km^2 with an average elevation of 380 m above sea level and 900 mm/a average precipitation. The share of plots having a low field capacity (below 100 mm) is almost 70%. The share of the land use systems with the model calibrated to satellite images recorded in 1994 reflects these natural conditions. More than 50% of the area is forest, whereas grassland takes a 20% share and a minor part of 6% is used for arable farming.

3.2 Scenario description

The model ProLand is used to simulate the influence of the Agenda 2000 and the projected CAP reform on the land use in the research area. The evaluation is performed using the indicators share of area of the respective land use types, transferred animal premiums and area payments as well as employed labour.

The German government has adopted the national implementation of the CAP reform starting in 2005. Key elements are the decoupling of transfer payments from the production programme, requirements in terms of „Cross Compliance“ and the redirection of funds from the first to the second pillar („Modulation“) (BMVEL, 2005).

The decoupling of direct payments from the production programme is an important modification for the evaluation of land use systems based on land rent. The economic potential of systems which previously yielded the maximum land rent on a spatial unit only because of coupled animal and area payments has to be reassessed.

Since the level of transfer payments depends on assigned area dependent payment claims and not on the production programme, i.e. payments for arable farming are also paid for grassland, payments have no influence on a land user’s decision for a certain land use system.

By the year 2013 area payments for grassland and arable farming will be aligned in a regional model using a combinatory model as intermediate step. Coupled animal payments will be replaced by homogenous area payments putting an end to an important incentive for beef and cattle production.

Alternative methods of grassland use which previously received no payments become economically more attractive. The uniform area payment in the regional model causes no production incentives.

Considering the new payment criteria, a land user may choose among four options: (1) He may maintain the existing land use programme. (2) He may change land use and decides on a different product generating land use system. (3) He may cease production and keeps the fields in a “good agricultural and ecological condition” in accordance with the Cross Compliance requirements. (4) He may leave the fields to natural succession and waive the area payments.

Transfer payments from the second pillar that are not affected by the reform, such as payments from conservation programmes, are not altered when predicting the effects of the CAP reform on the land rent maximizing spatial distribution of land use systems.

The general political conditions of the research region reflect those in the state of Hesse. The following table 1 lists the different transfer payments in the Agenda 2000 and CAP reform scenario.

Table 1: Comparison of transfer payments for Agenda 2000 and CAP 2013 scenario for the state of Hesse.

Notation	unit	Agenda 2000	CAP 2013
Coarse grains	€/ha	347	302
Grassland	€/ha	0	302
Oil seeds	€/ha	347	302
Set aside	€/ha	347	302
Slaughter premium male cattle	€/Tier	210	0
Suckler cow premium	€/Tier	200	0
Suckler sheep premium	€/Tier	26	0
Milk premium	€/kg FCM	0	0,035

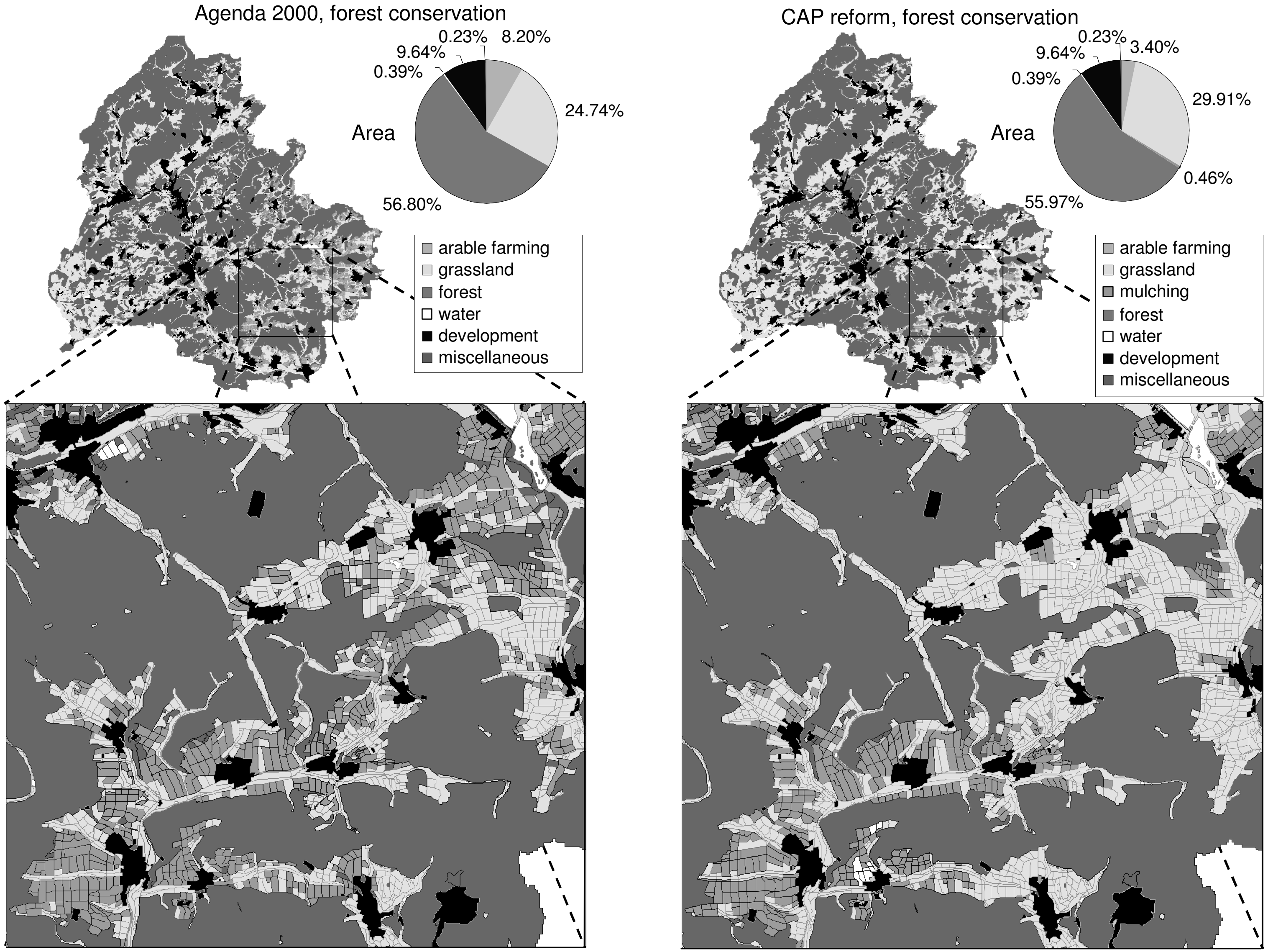
The assumptions made concerning production technology have a decisive influence on the economic evaluation of land use systems. Output generation using different technology requires varying amounts of factors and different factor combinations. Standardized mechanizations typical for the region are assumed for all outdoor operations in the investigated scenario. They conform mostly with the mechanization published by the German “Association for Technology and Structures in Agriculture”(KTBL, 2002) for a 2 ha plot.

Self-produced roughage is valued by taking the value of the animal products less its production costs (except the costs for the roughage).

The factor requirements of animal husbandry are simulated for every livestock unit based on KTBL data from 2003/04 (KTBL, 2002). Using the yearly requirement of roughage and the potential yield of the site allows to transfer the factor consumption in the animal husbandry process to the investigated spatial unit. Analysis of economic profitability of individual land use systems in dependence on general political conditions are performed in the comparative static model ProLand under ceteris paribus conditions.

Time series data of market prices for all relevant marketable agricultural products were calculated from data provided by the “German agricultural market and price recording agency” and stored in the database (ZMP, 2002a-2004a; ZMP, 2002b-2004b). Market prices for agricultural products and production factors were kept constant in order to analyse the influences of the changes in agricultural policy on land use.

Factor prices for labour and capital are fixed in both scenarios but are generally variable between scenarios. The wage rate in the presented scenarios was set at 11 € per hour, the interest rate at 3.5 %.


Agenda 2000, forest conservation

CAP reform, forest conservation

Figure 4: Land use for Agenda 2000 and CAP reform scenario.

Table 2: Area of land use types and economic indicators for Agenda 2000 and CAP reform scenarios

Agenda 2000, forest conservation

Land use type	Area	Share	Land Rent	Transfer Payments	Material Costs	Labor	Labor Costs	Capital Costs
arable farming	5.296,36 ha	8,20%	2.913.787,31 €	1.740.207,76 €	3.340.597,14 €	181.509,46 h	1.996.604,10 €	25.473,95 €
grassland	15.977,73 ha	24,74%	9.121.083,12 €	1.062.489,26 €	5.774.574,32 €	663.326,33 h	7.296.589,50 €	96.983,52 €
forest	36.687,61 ha	56,80%	2.033.786,47 €	0,00 €	1.427.261,32 €	27.987,39 h	307.861,31 €	21.516,57 €
water	254,33 ha	0,39%	0,00 €	0,00 €	0,00 €	0,00 h	0,00 €	0,00 €
development	6.227,75 ha	9,64%	0,00 €	0,00 €	0,00 €	0,00 h	0,00 €	0,00 €
miscellaneous	145,94 ha	0,23%	0,00 €	0,00 €	0,00 €	0,00 h	0,00 €	0,00 €
sum	64.589,72 ha	100,00%	14.068.656,90 €	2.802.697,02 €	10.542.432,78 €	872.823,18 h	9.601.054,91 €	143.974,04 €

CAP Reform, forest conservation

Land use type	Area	Share	Land Rent	Transfer Payments	Material Costs	Labor	Labor Costs	Capital Costs
arable farming	2.197,38 ha	3,40%	975.565,71 €	624.702,07 €	1.458.648,20 €	35.952,68 h	395.479,44 €	8.071,59 €
grassland	19.320,13 ha	29,91%	14.819.066,83 €	5.193.158,85 €	7.003.844,39 €	821.590,73 h	9.037.497,96 €	120.739,69 €
mulching	294,06 ha	0,46%	77.829,97 €	88.804,69 €	8.552,02 €	215,53 h	2.370,83 €	51,95 €
forest	36.150,14 ha	55,97%	1.655.507,47 €	0,00 €	1.213.542,74 €	22.311,96 h	245.431,60 €	17.153,33 €
water	254,33 ha	0,39%	0,00 €	0,00 €	0,00 €	0,00 h	0,00 €	0,00 €
development	6.227,75 ha	9,64%	0,00 €	0,00 €	0,00 €	0,00 h	0,00 €	0,00 €
miscellaneous	145,94 ha	0,23%	0,00 €	0,00 €	0,00 €	0,00 h	0,00 €	0,00 €
sum	64.589,72 ha	100,00%	17.527.969,99 €	5.906.665,60 €	9.684.587,36 €	880.070,89 h	9.680.779,82 €	146.016,55 €

3.2 Model results

The scenario examines the long-term effects of general agricultural policy conditions on land use and the economic indicators in the simulated region. Legislative constraints such as the prohibition of converting forest to cultivated land are taken into account. Conversion of grassland to crop land is allowed but in the Agenda 2000 scenario these sites receive no area payments.

Figure 4 shows the endpoints of land use for both Agenda 2000 and CAP reform as predicted by ProLand. As only agricultural and silvicultural land uses are modelled, developed area remains constant, as does water and miscellaneous. Forested area shows only a marginal difference, mainly attributable to the strict legislative protection of forests. Grassland area in the CAP scenario would be about 5 % higher, while arable farming area would be lower by about 5 %.

Although these differences appear small compared to the overall ratio of land use systems, they may be more pronounced in certain sub-regions. As the upper part of figure 4 shows, some areas exhibit small differences, for example the south west corner, while others show significant variation, such as the north east to east corner. The magnification of the rectangular area marked in the overview map shows that the two simulated policies result in different land uses and thus different landscape structures in the sub-region. Arable farming systems would account for around 59.4 % of cultivated land, grass land systems for about 40.6 % in the Agenda 2000 scenario. Note that arable farming systems are found throughout the region, i.e. also in the lower left and upper right corner. In the CAP reform scenario, the landscape differs. Arable farming retreats mainly to the lower left corner and is replaced by grassland systems. Arable farming systems are found on only 27.1 % of the area, grassland systems on 72.9 %. Inspecting the natural conditions in the region shows that the average temperature is lower in the northeast part of the sub-region in comparison to the southwest while plant available water is higher.

An important component of the achievable land rents are transfer payments. They influence the farmers' allocation decision. The example illustrates the distorting effect of transfer payments in the Agenda 2000 scenario as arable farming is more profitable than grassland at cooler sites with higher water availability. This distortion is removed by the CAP reform, hence the corresponding differences in the land use allocation as shown above.

Objectives of the CAP reform include redirecting transfer payments into regions with less favoured production conditions while removing production distorting components, increasing or stabilizing the area share of grassland, and providing rural employment opportunities. As table 2 and figure 4 show these objectives are clearly accomplished. The share of grassland increases as does the land rent. Transfer payments are redirected into the region, the simulated increase amounts to 111 %. Labour demands show no considerable difference, as do the remaining indicators.

In the land use model the CAP reform is more successful than the Agenda 2000 in terms of achieving the above stated objectives for the investigated region. These positive results may not hold for regions with intensive agricultural production, especially arable farming. Additionally, other landscape functions and ecological indicators where not considered in the presented simulation study. These components have to be included in a comprehensive policy evaluation, however. The collaborative research centre SFB 299 at the Justus Liebig University has developed appropriate models which are linked to ProLand and may thus provide the corresponding information.

4 Summary

The orientation of the European Unions Common Agricultural Policy reflects the increasing importance of landscape functions. Functions affecting individual and societal welfare as well as landscapes' role as species habitat move into focus.

Landscapes undergo a permanent reshaping through technological and socioeconomic changes which strongly affect landscape functions. Agricultural policy plays a key role as it has a direct influence on the economic profitability of particular land use systems in many cases. Associated with changes of profitability are changes of landscape functions as these are directly linked to the land use. Therefore, it is essential for political decision makers to obtain reliable conclusions on the effects of specific agricultural policy measures.

Numerous approaches to model land use exist. They cover varying spatial aggregation levels depending on the investigated problem. If the objective is a complete landscape evaluation predictions not only on land use but also on biodiversity and hydrologic aspects are needed. The spatial component is of particular importance in such an extended approach. While the exact spatial allocation is of great importance in ecological analysis, it is of less interest in strictly economic investigations.

This paper presents the bio-economic simulation model ProLand for spatially explicit prognosis of land use. The model operates at the level of decision units that can be raster or vector elements of discretionary size but also individual fields, depending on data availability. The model evaluates the natural conditions on every decision unit. They are functionalised in form of yearly precipitation, temperature sum and the usable field capacity to predict the potential yield of the respective crops. Slope, field size and soil composition are employed to calculate production costs. The fundamental assumption of ProLand is that land users maximise the land rent on their available plots. Accordingly, they will select the land use alternative that generates the highest possible land rent on a decision unit.

The consequences of the CAP reform with fully decoupled transfer payments are simulated for a region in Hesse, Germany. The results reveal that the prevailing natural site conditions have increasing influence on the land use decision after the CAP reform compared to Agenda 2000. Many typical grassland sites that were used as crop land under Agenda 2000 conditions will be used as such under the new CAP. Overall, the reform has positive economic effects in the region. Especially transfer payment volume increases substantially.

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