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# Impact of the CAP reform on small-scale grassland regions

## Auswirkungen der GAP-Reform auf kleinstrukturierte Grünlandgebiete

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### Abstract

This paper presents a regional land-use model that conceives farms as independent agents aiming at maximum individual utility. Farm agents optimize their utility with the help of a linear-programming algorithm that takes into account natural, economic and personal restrictions. Interactions between farms take place on the land market, which is modelled as an equilibrium market. The model is applied in three typical grassland regions in southern Bavaria. The results indicate that the CAP reform of 2003 has various significant consequences for grassland use. In particular, the decreasing profitability of dairy farming will lead to low-intensity forms of grassland use, including mulching. In general, land rents will increase due to the effects of decoupling.

### Key words

CAP Reform; linear programming; land-market simulation; agent-based modelling; farmers attitude; policy analysis

### Zusammenfassung

Gegenstand der Untersuchung ist ein neues Landnutzungsmodell, welches Betriebe als unabhängig voneinander handelnde Agenten abbildet. Die Modellbetriebe werden als Nutzenmaximierer betrachtet. Das Betriebsziel wird mit Hilfe der linearen Programmierung ermittelt, wobei natürliche, wirtschaftliche und individuelle persönliche Restriktionen berücksichtigt werden. Wechselwirkungen zwischen den Betrieben werden mit Hilfe eines Pachtmarktmodells, das diesen als Gleichgewichtsmarkt auffasst, abgebildet. In diesem Beitrag werden mit Hilfe des Modells die Auswirkungen der GAP-Reform von 2003 auf drei typische bayerische Grünlandstandorte abgeschätzt. Die Ergebnisse zeigen vielfältige Einschnitte für die Landnutzung und Tierhaltung. Insbesondere begünstigt die sinkende Wirtschaftlichkeit der Milchviehhaltung extensivere Formen der Grünlandnutzung. Allgemein kann gezeigt werden, dass die Entkopplung, insbesondere auf marginalen Flächen, zu steigenden Landrenten führt.

### Schlüsselwörter

GAP-Reform; lineare Programmierung; Landmarktsimulation; agentenbasierte Modellierung; Betriebsleitereinstellung; Politikanalyse

## 1. Introduction

The CAP reform of 2003 is expected to have far-reaching consequences for future land use. Small-structured and marginal regions might be particularly affected because the profitability in such regions is low and a general withdrawal of agriculture is probable. Because of the multifunctional character of agriculture, such a development is of consequence not only for farmers, but would also be relevant to the public in general, as it would have an effect on the quality of biotic and abiotic resources and the landscape's aesthetic values (HEIBENHUBER et al., 2000). In Germany, the

agricultural use of grasslands is strongly linked to cattle farming. In this sector the consequences of the CAP reform are expected to be of extraordinary importance because until now, cattle farming has been supported by a wide variety of policy measures that promoted selected activities through various means, such as the quota regime for milk and production-linked premiums for bulls and suckler cows. In contrast, some activities such as heifer fattening were rarely subsidized. With the CAP reform, the level of subsidies and the level of environmental standards are largely homogenized, altering the relative competitiveness of farming activities. But land use is not determined only by economic factors. There are a huge number of further determinants such as agricultural structure, natural site-conditions and non-agricultural factors. For instance, alternative employment opportunities and family structures greatly influence farmers' decisions to either continue with the prevailing farming system, to change, or to abandon production and lease farm land (BALMANN, 1997).

The objective of the paper is twofold. Firstly, it presents an approach that allows for the consideration of farmers' individual attitudes which are rooted in empirical data in a multi-agent model. Exactly such individuality is often of great importance for future land use, because even comparable farms will react differently to identical changes of economic conditions; and the measures taken to adapt to the new conditions will depend to a large extent on the attitudes of the farmers concerned (cf. VAN DEN PLOEG, 2003). Secondly, it tries to assess the consequences of the CAP reform for land use in grassland regions. Bavarian grassland regions that form a transect from the "Tertiäre Hügelland" to the Bavarian Alps serve as the study area. The areas show significant differences with respect to essential agronomic and ecological characteristics. Among the agronomic traits are the plot structure and the accessibility, the productivity of the stands, the farm size, and the socio-economic structure. The regions also differ in the economic importance of the landscape's aesthetic values and their importance for habitats and species under the NATURA 2000 scheme. The model is based on previous works by KANTELHARDT (2003) and SCHEMM (2004).

## 2. A regional land use model

### 2.1 Structure of the model

In order to assess the impact of currently changing policies, a wide variety of agri-economic land use models is applied (cf. LAMBIN et al., 2000; AGRARWAL et al., 2002; PARKER et al., 2001 and HARE and DEADMAN, 2004). In general,

two types of models can be distinguished. The first type does not explicitly consider economic interactions amongst land users on markets (e.g. ZANDER, 2003; WEINMANN, 2002; ROUNSEVELL et al., 2003; FLURY, 2002). In contrast to that, the second type does directly model these interactions (e.g. HAPPE, 2004; BERGER, 2000; CYPRIS, 2000). In the selected study areas, a large number of farms compete with each other for various resources, especially land. Consequently, we chose a model framework that considers market interactions amongst farmers. An equilibrium market model was implemented as a technical solution (cf. CYPRIS, 2000; BALMANN et al., 1998).

Agri-economic land use models represent agricultural land either in a topological way (e.g. HAPPE, 2004; BERGER, 2000), in a spatial representative way (e.g. WEINMANN, 2002; ROUNSEVELL et al., 2003), or they cluster the land into homogenous groups irrespective of their location (e.g. FLURY, 2002; DABBERT et al., 1999). The regional settlement structure with all farms located in a central village surrounded by agricultural land allows for the clustering of land into homogenous groups according to farm-plot distance, plot size, productivity, slope and the designation into grassland or arable land. For each study region the different land qualities are depicted by up to five different land markets. Land markets are interconnected and resulting land rents are contingent on one another.

Typical time horizons of land-use models range from one year with a gross margin maximisation (e.g. ZANDER, 2003; DABBERT et al., 1999) to several decades with a farm profit optimisation (e.g. BERGER, 2000; HAPPE, 2004). We chose a time horizon of five to ten years which permits farmers to make fundamental decisions. For this time horizon assumptions about future policies and product prices can be made with some confidence. Such a medium-term time horizon allows for strategic planning by the farmers. Thus changes in the agricultural structure, such as growth or shrinkage of farms, concentration processes and abandonment of farms can be considered in the model calculations. But at this point it must also be taken into account that it is only barely possible to include the effects of unique occurrences such as the generational handover of a farm which is often accompanied by a change of farmers' attitudes. Furthermore, farmers' reactions to strong shifts in political and economic conditions are fairly unknown and therefore difficult to model.

In general, land-use models consider only labour as non-physical factor. This factor is accounted for by considering the average capacity of available man power per farm in a standardised form such as 'fulltime equivalents' (AWU). But one must be aware that, particularly on family farms, the working time that a farmer is willing to dedicate to agriculture is limited by the extent of the farmer's off-farm employment, the personal desire for leisure and the time needed for regeneration. Therefore, the farm organisation and the actions taken by the farmer depend not only on the economic excellence

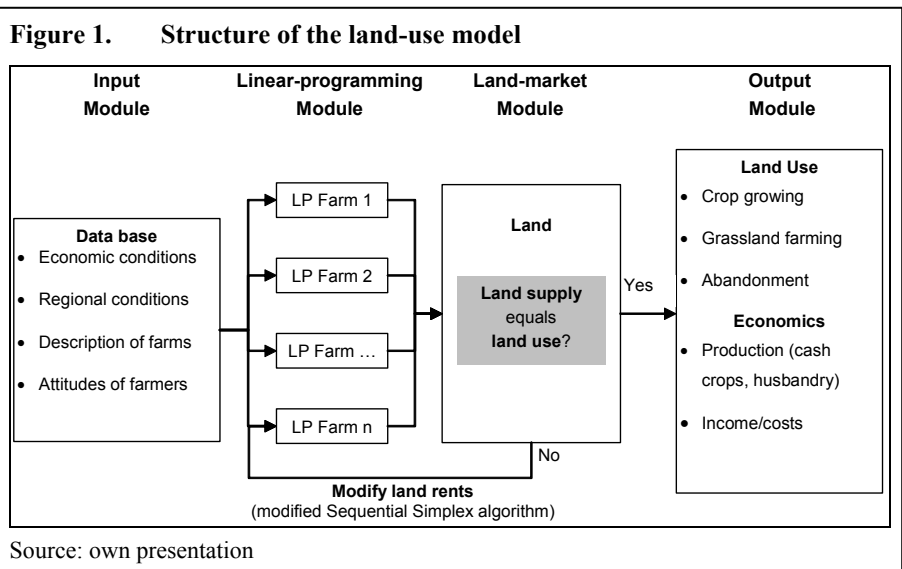
but also on personal values, rules and norms (ROMERO and REHMAN, 1989: XI). These aspects can even result in make the farmer "subsidising" his farming activities (SCHÄFERS, 2004; LEHNER-HILMER, 1999).

But empirical data on personal values and norms is hard to obtain and it is even harder to quantify the impact of certain settings for economic models. Consequently, only a few models integrate non-physical factors into the optimisation process of the modelled land users. ROUNSEVELL et al. (2003) account for risk aversion in a standardised way. HAPPE and BALMANN (2002) differentiate the capabilities among the modelled farmers, while BERGER (2000) does the same with respect to adaptation thresholds. In most cases the implementation of these factors is based on ad-hoc assumptions. Like EVANS and KELLEY (2004), we opted for a different approach. We assume that the farm is currently optimally organized and derive a set of variables describing the farmer's current attitudes. Principally we regard the farmer's attitudes as a black box that consists of several manipulated variables. These variables are set to ensure that the acreage, management intensity, endowment with assets and labour demand of each modelled farm corresponds to its real world counterpart. In the course of policy-analysing scenarios the values for the manipulated variables remain unchanged. The manipulated variables reflect decisive attitudes of farmers such as their personal planning horizon, farm income, leisure demand and wages.

## 2.2 Technical implementation

Regarding the technical structure, the model basically combines linear programming (LP) and market modelling. All in all the model consists of an input module, a linear-programming module allowing the calculation of optimal farm organisation, a land-market module deriving land rents and distribution of land among the farmers, and an output module (fig. 1).

The **input module** contains all important data about the conditions that influence agriculture in the study region. One of the most important attributes on farm level is the farmer who is characterised by his personal attitude and the amount of labour he is prepared to devote to farming. Each farm is in possession of various types of agricultural land and production rights such as milk quota. Further important



features of farms are their endowment with technical equipment consisting of buildings and machinery. Data on a regional level is valid for all farms. These data sets include production methods, investment alternatives and the amount of available agricultural land in the study region. Production methods are described by various variables such as potential yields, costs, demands on labour and machinery. Reflecting the local conditions, the production methods vary in the degree they utilise private contractors to fulfil designated tasks. But some of this data also depends on other data sets. For instance, the potential yield in cropping is site-dependent and the labour demand is dependant on the individual farm mechanisation. Farmers, of course, can conduct certain production methods only if they own the appropriate technical equipment. For instance, in order to produce milk a farmer must be in possession of grassland mechanisation and a dairy-cattle stable. Stables and mechanisations are classified into different production units according to their size class and the production techniques they enable. Units of the same type allow for the same set of production techniques but differ with respect to their costs, labour productivity and the extent of provided capacities. A combination of stables and mechanisations is called a farm type. Changing the farm type induces changes in costs that depend on the new farm type as well as on the situation before the investment. The modification of a farm type can occur in three ways. Firstly, the agent can purchase new units that induce additional fixed costs. If an agent intends to buy a unit with a certain capacity it must already possess all smaller unit of the same type. Secondly, certain types of units can be converted, e.g. a dairy cow barn into a suckler cow barn. This activity induces conversion costs. Thirdly, if the agent ceases to use certain units the fixed costs of these units are no longer accounted for.

The determination of the production methods and the derivation of farm organisation take place in the **linear-programming module**. In this module, all farms are simulated individually; they act independently of each other and maximise their individual utility by adjusting the organisation of their farm. Each farm's land demand is restricted only by the regionally available area of the respective land quality. The farms react to incentives such as changes of prices and subsidy levels. These reactions lead to a change of the land use on a regional level (cf. ROUNSEVELL et al., 2003; compare also HANF and NOELL, 1989). Since farms are modelled individually, they can be conceived as individual agents. Model calculations are limited to a comparative-static analysis.

The results of the linear programming module are merged in the **land market module**. Land market is modelled as an equilibrium market in which each land quality (e.g. grassland, arable land) is compiled as separate land market. In a first step, the market module takes up the land demand of the different farms calculated in the linear-programming module. In this first step the initial land rents for all land qualities are assumed arbitrarily. In the next step the demand is added up on a regional level. If the aggregated demand for any land quality is unequal to the supply in the region, the land-market module recalculates a new set of land rents. These prices are fed back to the linear-programming module and the demand for land is recalculated. This process is repeated until demand equals supply in all land quality classes.

The consequence of the interdependency amongst the various land markets is that the market calculation has to be carried out simultaneously for all land qualities. Since the number of potential land-rent combinations increases exponentially with the number of markets, the determination of the equilibrium land rents by trial and error will result in an unreasonably high calculation effort. Therefore, the Sequential Simplex Optimisation (SSO) is applied. The SSO is an evolutionary operation method that is widely applied in process optimisation (WALTERS et al., 1999: 6). It aims to find an optimal combination of different variables. In our case the optimum is achieved when, for all considered land qualities, the land demand equals the supply.

Finally, the function of the **output module** is the conditioning and the analysis of the model results. The results are transmitted to a database that edits and analyses the data on a farm and regional level. The aim is to provide an overview of agriculture and land use in the studied region. The results on the farm level as well as the regional level include economic, ecological and social key figures. On the farm level, the output data focuses on land use and animal husbandry. In addition, the analysis of a single farm's investments allows the quantification of socio-economic criteria on this level, such as the transition from full-time to part-time farming or vice versa. On the regional level, social and ecological questions are of main concern. In this context it is important to mention that the region is conceived as the aggregate of the modelled farms. The objective at the regional level is the analysis of the effects of certain policy measures. In addition to land use developments, changes in socio-economic criteria can also be shown. For instance, it is possible to identify possible concentration processes or the danger of land abandonment.

### 2.3 Calibration of the model

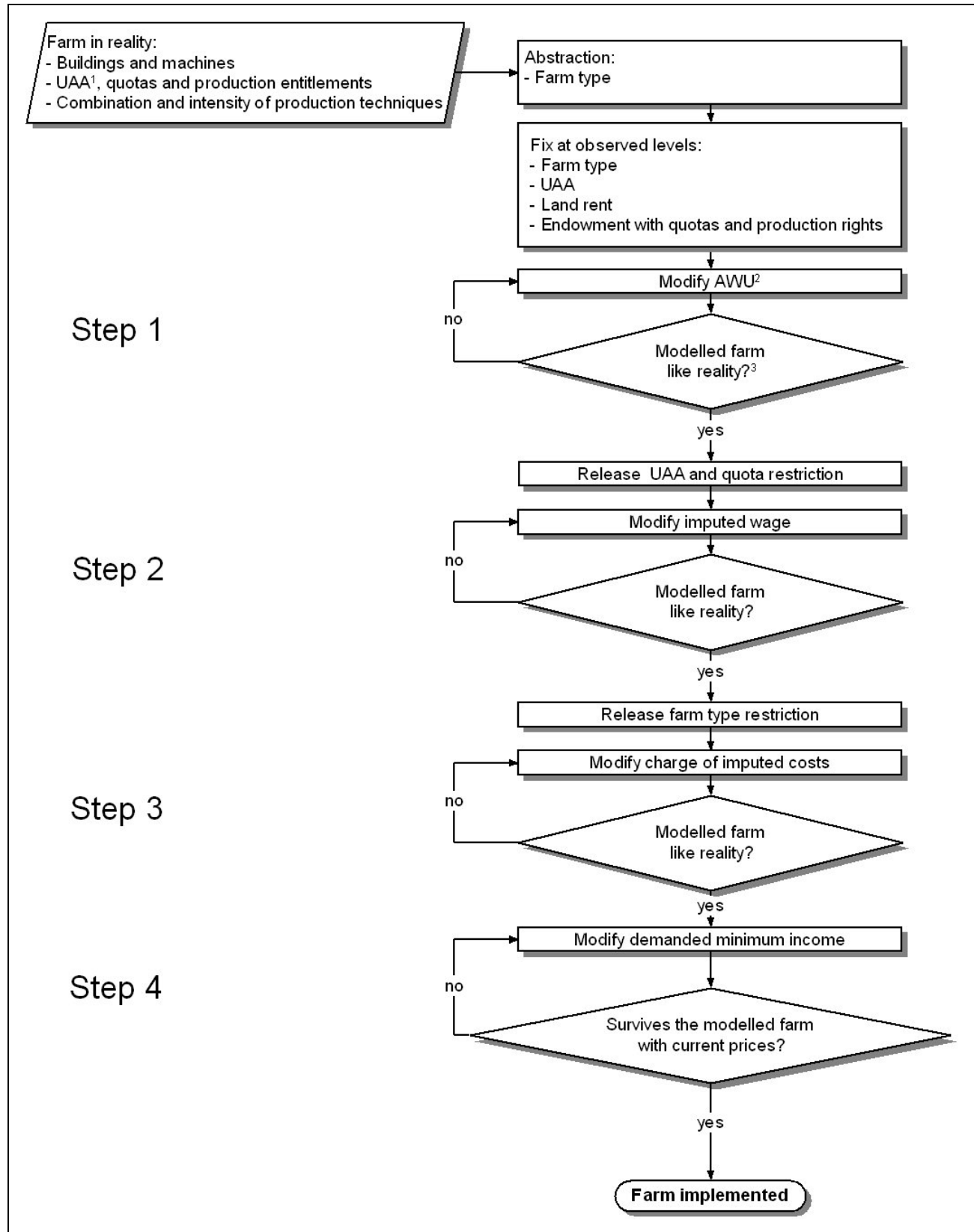
Before using the land use model described above, it is necessary to calibrate the model. During the calibration process the observed land rent for the different land qualities and the observed organisation of each individual farm are the target variables (compare to section 2.1). The respective values describing the farm organisation of the different agents and the calculated land rents are the control variables. When the control variables differ only slightly from the target variables, the model is assumed to work with sufficient accuracy. In this context the personal attitudes of farmers are of particular importance. Farmer's attitudes are used as manipulated variables in order to calibrate the land use model. It is assumed that all farmers are realizing their personal aims without any external restrictions being in force. Data of the regionally adapted set of production techniques such as yields, costs etc. is not modified within the calibration process.

In order to implement the 'real' farms with the farmer's attitudes in the model, every farm is optimised independently several times without using the market module (fig. 2). In the first calibration step, farm type and utilized agricultural acreage (UAA) are fixed for all farms on the level observed in reality. This also applies to land rents which are derived from real data and kept constant. The labour input of the farm is derived in a way that the modelled farm realises the observed combination, extent and intensity of production methods. In a second step, the mod-

elled farm can theoretically modify its UAA, but the imputed wage is calibrated in such a way that the observed extent is optimal. In a third step, the level of imputed costs

is set to a value that ensures that the modelled farm is actually implementing the farm type observed in reality. In the last calibration step, the minimum income required by the

Figure 2. Scheme for the implementation of farms in the model



<sup>1</sup>) UAA: utilised agricultural acreage

<sup>2</sup>) AWU: 1 AWU (agricultural working unit): 2,380 working hours

<sup>3</sup>) With respect to farm size, farm type and extent, intensity and mix of production techniques

Source: own presentation



respective farmer is calculated. This time the market module is used and farm minimum income is set at a level guaranteeing that the modelled farm still corresponds to the real farm and a realistic land rent is achieved. Finally, a supplement of twenty percent of the cash flow of the respective farm is deducted from the minimum income since we assume that farmers would accept this income reduction before abandoning farming.

Grassland use in Type I regions is represented by a small village covering ca. 220 ha grasslands in the 'Upper Bavarian Alps' (UBA). In addition to the privately owned 220 ha, farmers can also use co-operatively owned rough pastures,

### 3. Input data

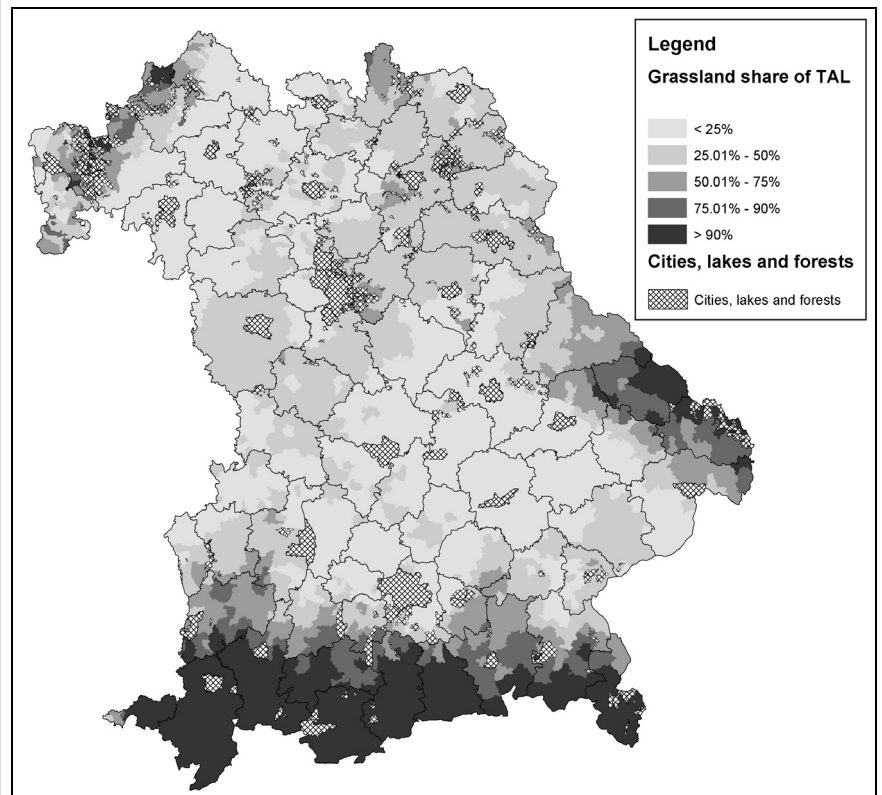
#### 3.1 Study regions and data basis

Figure 3 describes the regional importance of grassland in Bavaria. It is obvious that areas with a high share of grasslands are particularly concentrated on the perimeter of the Alps in the southern part of Bavaria. Another concentration of grassland is the mid-mountain range area 'Bavarian Forest' in the eastern part of Bavaria. Due to their mountainous character both regions show a high percentage of inclined farmland in combination with sufficient rainfall for grassland cultivation. In the remaining parts of Bavaria, grasslands are of minor relevance.

Figure 4 depicts the share of dairy farming that represents – from the economic point of view – the most important form of grassland use. Obviously, the percentage of dairy farming does not correspond directly to the spatial distribution of grassland. Due to economic reasons, dairy farming is concentrated in regions where grassland use still dominates agricultural land use but where a significant share of arable land also exists. Such areas are located in the pre-alps and at the fringe of the Bavarian Forest.

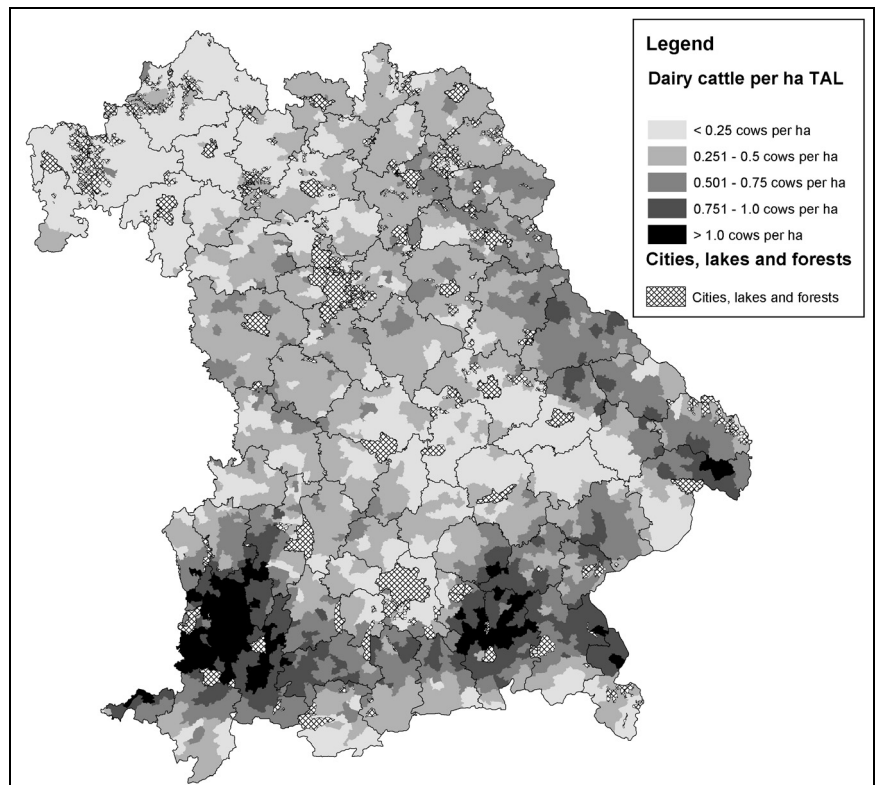
The information of these two figures allows for the distinguishing of three types of grassland regions with a high relevance for agriculture. Type I characterises regions with a high share of grassland and a comparably low or negligible share of dairy farming. In contrast, Type II covers all those regions where, in addition to grasslands, dairy farming is of great importance. The last combination that is relevant from the grassland cultivation perspective is Type III where dairy farming is of great importance and there is a relevant percentage of arable land. Three study regions are selected based on these different types of grassland regions (fig. 5 and tab. 1).

**Figure 3. Grassland share in Bavaria**

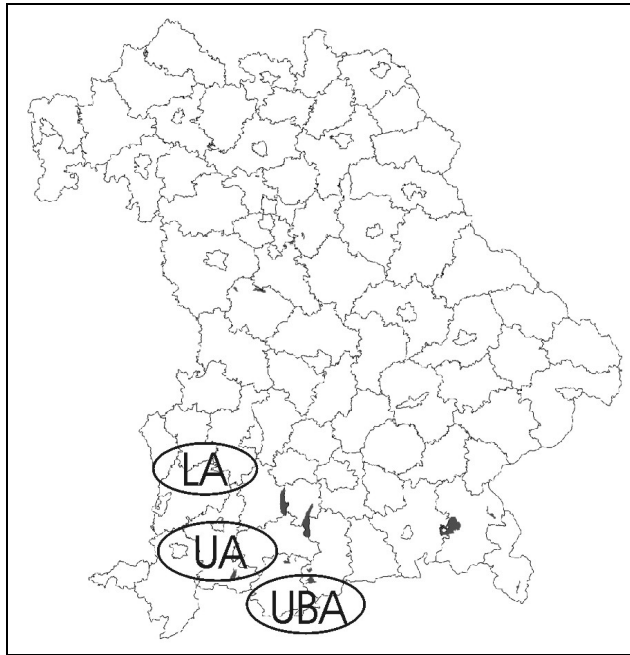


Source: BAYLSTAD (2006); own presentation

**Figure 4. Share of dairy farming in Bavaria**



Source: BAYLSTAD (2006); own presentation

**Figure 5. Location of the study areas**

Source: own presentation

however, these rough pastures will not be directly considered in the model calculations for the following reasons. Firstly, this land is of minor quality from the agricultural perspective. Secondly, a high percentage of the grazing livestock on these rough pastures are boarded animals, and thirdly farmers, cannot decide individually about the use. According to the regional habitude, the local farmers have the opportunity to raise their heifers and suckler cows during the vegetation period free of charge and without any labour demand on these rough pastures. In the UBA region there are 20 farms with an average size of 11 ha. Agriculture is of hardly any economic relevance but it is important in order to maintain scenery for tourism and provide habitats for endangered species. All farms are part-time and farm types are very heterogeneous, ranging from dairy and

suckler cow farming to heifer fattening and mixed farm systems.

The Type II grassland region is represented by the 'Upper Allgäu' (UA). The region covers an area of 730 ha grassland and contains no arable land. As with the Type I region, farmers working in this area can use rough pastures cooperatively for summer grazing. For the same reasons as above, this land is not directly considered in the model. The grassland is currently cultivated by 25 farms, 15 of which are full-time and the other 10 part-time. Farm types in this region are more homogenous, with most farmers concentrating on milk production. There are only two farms that can be distinguished; one suckler-cow and one heifer-fattening farm. The average farm size regarding animal husbandry is three times as big as in the UBA region. Tourism and nature conservation are again important factors.

Type III grassland is represented by a sample region situated in 'Lower Allgäu' (LA). The region is 500 ha grassland and 200 ha arable land. Farms are mainly full-time (14 farms), and part-time farming is of minor relevance. Farm types are not as diverse as in other regions because most farms concentrate on milk production. However, three farms run mixed farm systems. The average farm size is 66 LU per farm larger than in the other regions. Tourism and nature conservation in this region are of minor importance.

As one part of the data basis, surveys involving local farmers were conducted in all regions. Furthermore, an analysis of corresponding IACS data (Integrated Administration and Control System of the European Union) took place. This data set contains statistical information concerning land use and livestock husbandry. Costs of buildings and machinery as well as the data on labour demands and yields have been calculated with the help of the following sources: BAYSTMELF / BAYSTLU, 2003; BAYSTMELF, 2002; LBA, 1996; LBA, 2000; LBA, 2001; LBP, 1997; LFL, 2003a, b, c; KIRCHGESSNER, 1992; KTBL, 2002a, b, c, d, e; KTBL, 2004; REGMFR, 2003. It is important to add that the definition of production methods considers local conditions. For instance, grassland in UBA cannot be used

more than three times. This is in contrast to Upper Allgäu where four cuts are possible and to Lower Allgäu with up to five.

### 3.2 Definition of scenarios

The central question of this paper is to assess the consequences of the CAP reform on grassland use. In order to have a reference point, a first scenario describes the initial situation before the start of the reform. Two further scenarios, which mainly differentiate the price levels for agricultural products, describe probable situations after the full implementation of the reform in the year 2013. At this point in time, direct payments will be fully decoupled and an area payment of about 300 EUR/ha will be implemented.

In the initial situation, product prices are set to the average price level of the years between 2000 and 2002 (tab. 2). Consequently, there are high prices for milk and milk quota, but only a medium price level for meat. Due to the fact that the CAP reform in this scenario is not considered, there is no area

**Table 1. Description of the study regions**

	Upper Bavarian Alps (UBA)	Upper Allgäu (UA)	Lower Allgäu (LA)
Area grassland [ha]	220	730	500
Area arable land [ha]	0	0	200
Farms full-time / part-time	0 / 20	15 / 10	14 / 6
Fam Type Dairy / Suckler / Heifer / Mixed	7 / 2 / 3 / 8	23 / 1 / 1 / 0	17 / 0 / 0 / 3
Average Farm Size [LU/farm]	11	33	66
Importance of tourism	extremely high	medium to high	no tourism
Natura 2000 relevant	yes	yes	no
Compensatory allowance [EUR/ha]	180	150	50

Source: own census

	<b>Initial Situation</b>	<b>Scenario I</b>	<b>Scenario II</b>
Price level for agricultural products	Medium price level for beef and very high price level for milk <sup>1)</sup>	Medium price level for beef and high price level for milk <sup>2)</sup>	High price level for beef and low price level for milk <sup>3)</sup>
Area payment	0	300	300
Direct payments	coupled	decoupled	decoupled
Cultural landscape program	up to 200 EUR	100 EUR	100 EUR
Compensatory allowance	locally defined	locally defined	locally defined
Additional Premium for keeping 'Murnau-Werdenfelser'	150 EUR/cow	150 EUR/cow	150 EUR/cow

<sup>1)</sup> 2.6 EUR/kg beef; 35 cent/kg milk; <sup>2)</sup> 2.6 EUR/kg beef; 31 cent/kg milk; <sup>3)</sup> 3.2 EUR/kg beef; 26 cent/kg milk;  
Source: own data

payment and direct payments are coupled to production. Participating at the cultural landscape programme, farmers can obtain a subsidy payment for grassland cultivation. In order to receive the payment, in particular a minimum stocking density of 0.5 LU/ha is necessary. Additionally, a compensatory allowance is granted. Similarly to the cultural landscape program, a minimum stocking density is assumed. Farmers in the UBA region can obtain an additional subsidy payment if they raise the endangered cattle breed 'Murnau-Werdenfelser'.

In Scenario I, the CAP reform is fully implemented. This means that direct payments are decoupled and a general area payment of 300 EUR/ha is granted for grasslands and arable land. The minimum requirement farmers must fulfil regarding land use is to mulch the plots once a year. With the implementation of the CAP reform and the introduction of an area payment, it is assumed that the grassland-related area payment within the Bavarian cultural landscape program has to be reduced. Consequently, this payment will be limited in model calculations to 100 EUR/ha. In contrast, the compensatory allowance and the premium for raising Murnau-Werdenfelser are kept constant. Regarding the price structure for agricultural products, it is assumed that the beef price stays stable and has the same level as in the initial situation. The milk price is reduced slightly in correspondence to the price cuts determined in the CAP reform. Consequently, Scenario I reflects a situation with a still high milk price and a medium-level beef price. In contrast, in Scenario II it is assumed that the beef price increases 20% and the milk

price decreases significantly. All other assumptions made in Scenario II correspond to those made in Scenario I.

## 4. Results

An intermediate result of the model calculations are the derived farmers' attitudes. Table 3 gives an overview of the variation of the non-physical farm properties among and within the three study regions. The average availability of labour on a single farm ranges from 1 600 Wh in Upper Bavarian Alps to 4,200 Wh in Lower Allgäu. The Upper Allgäu with 3,600 Wh has an intermediate position. In all three regions there is at least one farm with a capacity of only 1,000 Wh. Average farm income, which considers minimum income and minimum marginal wages, ranges from minus 200 up to 29,000 EUR per year. Again, the Upper Bavarian Alps is the region with the lowest demands. It seems obvious that agricultural conditions are not favoured in this region and farmers can barely subsist on their work. Substantially better conditions prevail in Upper and Lower Allgäu where the expected minimum farm income can reach up to 74,000 EUR. The last attitude concerns the imputed costs. They show a wide range and there is no typical correlation to the different regions. All in all, these results are confirmed by the stated responses of the respective interviewed farmers. They fit into the picture of small part-time farmers who continue farming mainly for traditional reasons in UBA and full-time farmers with a market orientation in the Upper and Lower Allgäu. It should not be forgotten that even within a region the values for these manipulated variables vary considerably between the modelled farms.

In the **Upper Bavarian Alps** the implementation of the agrarian reform particularly influences the level of land rents (tab. 4). The average level increases from 70 EUR/ha in the initial situation to 240 EUR/ha in Scenario I and 460 EUR/ha in Scenario II. This increase is a consequence of decoupling direct payments from production in combination with a low yield and stocking level. Due to these specific conditions, the decrease in the milk price is overcompensated by the introduction of the area payment. Nevertheless, the stock of dairy cattle is increasing in Scenario I. The stock of suckler cows decreases only slightly. This is due to the fact that most farmers in the initial situation do not claim suckler-cow premiums. In consequence, the CAP reform does not lead to a substantial decrease in the profitability of suckler-cow farming. In cases where farmers

	<b>Upper Bavarian Alps</b>	<b>Upper Allgäu</b>	<b>Lower Allgäu</b>
Labour [1,000 Wh/farm and year]: average (low - high)	1.6 (1.0 - 2.7)	3.6 (1.0 - 5.1)	4.2 (0.8 - 6.1)
Farm income: [1,000 EUR/farm and year]: average (low - high)	-0.2 (-3.7 - 10.2)	22.0 (-1.5 - 41.0)	29.1 (-10.0 - 74.1)
Considered share of imputed costs [%]: average (low - high)	30 (10 - 50)	40 (20 - 70)	20 (10 - 60)

Source: own calculations



would currently receive these premiums, it is assumed that suckler-cow farming would be affected much more by the CAP reform. Also in Scenario II, the average cattle stock is maintained on a comparably low level but due to higher beef prices, mulching is not competitive and is replaced by heifer fattening. However, it is important to point out that heifer fattening is profitable only because of the low wage demands of farmers in this region.

Land use in UBA is dominated in the initial situation by medium-intensively used meadows. Rotational pasture and 1-cutting meadows also exist but are of minor importance. In Scenario I the overall land use intensity decreases. Medium-intensity meadows are replaced by low-intensity meadows. Mulching also occurs but is not higher than a level of 7%. In Scenario II the overall land-use intensity reaches almost the same level as in the initial situation. Mulching does not appear in this scenario. Despite the fundamental policy changes, the calculations further show that the farm structure is almost conserved and farms do not abandon agriculture. The minimal reaction to the new agrarian policy is attributed to the fact that a fundamental part of subsidy payments in this region remains decoupled. This applies to payments within the cultural landscape program as well as the compensatory allowances. In both cases it is assumed that a minimum stock density of 0.5 LU/ha is required. Furthermore, the option of using co-operative rough pastures stabilises animal husbandry. Due to technical (wet and inclined plots) and legal constraints (Natura 2000 obligations) these rough pastures cannot be mulched.

In the **Upper Allgäu (UA)**, land use in the initial situation is dominated by mowing pastures (45% meadows and 34% pastures) that are used with a high intensity (tab. 5). At about 20%, low and medium intensity grassland is of minor importance. In Scenario I, after implementation of the CAP reform, mulching gains in importance and reaches a level of 22%. This affects pasture land and meadows to almost the same extent. In Scenario II, due to the decreasing milk price and increasing beef prices, the structure of animal husbandry changes dramatically: dairy farming is almost entirely replaced by heifer fattening. This also affects land use where medium-intensity hay production is clearly extended. At the same time high-intensity grassland cultivation decreases. This means that employment in agriculture is shrinking. Consequently some farms are abandoned.

It is important to add that due to the lower profitability of dairy farming and a constantly high availability of labour, some farms grow substantially. But the resulting increase of heifer fattening is so extensive that model results should be interpreted with care. The main argument is that heifer fattening takes place in UA during summer periods on the co-operatively used rough pastures. As already mentioned, these pastures are not directly included in the model due to their co-operative character. It is assumed that such an extension of heifer fattening might lead to an overgrazing of these pastures. A

second argument is that if farmers in other regions react in a similar way, prices for female calves would increase significantly. This would cause a lower profitability of this production type.

In the **Lower Allgäu (LA)**, grassland use is dominated in the initial situation by high-intensively used meadows (tab. 6). This high intensity of fodder production can also be observed on arable land where, at 49%, the cultivation of silage maize dominates land use. Dairy farming is by far the most important type of agricultural production. Scenario I does not provoke fundamental changes. Despite a slightly

**Table 4. Model results in the Upper Bavarian Alps**

Results Upper Bavarian Alps		Initial situation	Scenario I	Scenario II	
Grassland use (in % of total area)	Low	Meadow	8	32	25
		Pasture	0	0	0
	Medium	Meadow	79	49	70
		Pasture	13	12	5
	Total	Meadow	87	80	95
		Pasture	13	12	5
Mulching		0	7	0	
Average land rent		70	240	460	
Livestock (LU/ha UAA)	Dairy cattle		0.25	0.36	0.27
	Suckler cows		0.59	0.46	0.46
	Heifer fattening		0.00	0.00	0.09
	Total		0.84	0.82	0.82

Source: own calculation

**Table 5. Model results in the Upper Allgäu**

Results Upper Allgäu		Initial situation	Scenario I	Scenario II	
Grassland use (in % of total area)	Low	Meadow	5	7	7
		Pasture	2	1	1
	Medium	Meadow	13	8	70
		Pasture	0	0	7
	High	Meadow	45	36	6
		Pasture	34	28	5
Total	Meadow	64	50	83	
	Pasture	36	29	13	
Mulching		0	22	3	
Average land rent		50	260	310	
Livestock (LU/ha UAA)	Dairy cattle		1.22	1.00	0.07
	Suckler cows		0.04	0.03	0.00
	Heifer fattening		0.05	0.00	0.55
	Total		1.31	1.03	0.61

Source: own calculation

**Table 6. Model results in the Lower Allgäu**

Results Lower Allgäu		Initial situation	Scenario I	Scenario II	
Grassland use (in % of total area)	Meadow	94	99	34	
	Pasture	6	1	6	
	Mulching	0	0	60	
	Total	100	100	100	
Arable land use (in % of total area)	Silage maize	49	27	19	
	Cash crops	42	65	68	
	Set aside	9	8	13	
	Total	100	100	100	
Land rent		300	350	230	
Livestock (LU/ha UAA)	Dairy cattle		1.32	1.28	0.36
	Suckler cows		0.16	0.01	0.00
	Bull fattening		0.04	0.00	0.19
	Pig fattening		0.00	0.54	0.34
	Heifer fattening		0.00	0.00	0.15
	Total		1.52	1.83	1.05

Source: own calculation

decreasing milk price, dairy farming remains the most profitable production method for the majority of the farmers. Mulching of grassland, therefore, does not appear in this scenario. On arable land silage maize is replaced with cash crops due to the fact that some farmers convert to pork production. In Scenario II the modification of product prices shows a major impact on land use. Dairy farming is given up to a large extent and is replaced by bull, heifer or even pig fattening. The consequences for grassland use are dramatic; it is almost abandoned and replaced by mulching (60%). Similarly, set aside is gaining slightly in importance on arable land and replaces, together with the extension of cash crops, the cultivation of silage maize.

It must be pointed out that pig fattening is currently a rare production method in the LA region. In contrast, the model results predict that pig fattening will fundamentally gain in importance. But introducing pig fattening on a farm means a substantial change for the farmer. It is therefore doubtful whether all farmers would take such a decision even if the opportunity was offered. Instead, it is expected that farmers will keep dairy farming as long as they are able to realise their personal aims. Otherwise, there is a high probability that they will give up farming rather than re-structure their farms for pig fattening.

## 5. Discussion

The model calculations show that the CAP reform has significantly different impacts on grassland cultivation in the different study regions. In the Upper Bavarian Alps, the most marginal study area, there will be some changes in animal husbandry but farm structure and land use will be stable. This is a consequence of current farmers' attitudes: agriculture is of very low economic relevance in this region and, therefore, a hobby rather than employment. On the other hand, shifts of farmers' attitudes to a more economic perspective would lead to a substantial abandonment of farms. In such a case the CAP reform is a means to ensure land use even at low quality (mulching). Therefore, it helps to maintain the current cultural landscape since land will not be totally abandoned.

In the Upper Allgäu, the CAP reform leads to a significant lower intensity of grassland use as a consequence of declining milk prices. In Scenario I dairy farming is slightly reduced but still the most important production opportunity. Due to the fact that low-intensive cattle husbandry is in most cases not profitable, land that is no longer demanded for dairy cattle will be idled. In Scenario II, as a consequence of the drastically reduced milk price, dairy farming will disappear completely. On the other hand heifer fattening gains in importance because of higher beef prices.

An important reason for the high stability of animal husbandry in these first two regions is the fact that a relevant share of subsidies will still be coupled to animal husbandry even after the implementation of the CAP reform. This applies in our calculations to the grassland-related area payment in the Bavarian cultural landscape program and to the compensatory allowance. Further calculations show that the decoupling of the area and compensatory allowance from livestock leads to a significant increase of mulching with a conservation of the currently existing farm structure.

In the Lower Allgäu, the most productive study area, the CAP reform does not induce important land use shifts as long as the milk price does not decrease to world market level. It is important to mention that this applies only if farmers' attitudes do not change. A very low milk price leads to dramatic land use shifts in this region. 60% of grassland is mulched and the rest is used for low-intensity heifer fattening. Pig, bull and heifer fattening will be the most important source of agricultural income. The fodder for these production types is produced on arable land.

As other models, our calculations predict substantially increasing land rents on land of low agricultural value (cf. HENNING et al., 2004: 169; HÜTTEL, 2005). This is a consequence of the decoupling of subsidies from production, the introduction of an area payment and a coupling of this payment to land. The high land rents indicate that financial supports benefit mainly the landowner but not the persons cultivating the land. However, it is expected that the high rent level predicted by the model results will not be realized in reality. With increasing profitability farmers' attitudes towards wage will shift towards higher wages and higher profits. Consequently, it is assumed that the higher profitability will be shared by landowner and tenant and price levels will be lower than the model results indicate. Furthermore, it is important to point out that the market simulated within this model is limited to agricultural land and does not include payment entitlements. However, payment entitlements are marketable and this may influence land rents as well as land use. In this context GAY and OSTERBURG (2005) assume that payment entitlements will move to areas with favourable agricultural conditions.

In general, the model results indicate a declining stock of roughage feeders in all study areas. This result is principally backed by various other studies (cf. HENNING et al., 2004: 160ff., GAY and OSTERBURG, 2005; HÜTTEL et al., 2005). HENNING et al. (2004) point out that this reduction will concern mainly the more intensively cultivated regions and support our results. In contrast GAY and OSTERBURG (2005) assume that this reduction will mainly affect marginal areas. In both studies most of the reduction can be attributed to a massive decline in the number of suckler cows. Similar to HENNING et al. (2005) and WEINMANN et al. (2005) we conclude that the intensity of forage production will decline.

As demonstrated, individuality of farms is often of great importance for future land use. So it is assumed that even comparable farms will react differently to an identical change of the business environment and the adaptation process to the new conditions will depend to a large extent on the attitudes of the concerned agents (JAGER et al., 2000). This applies in particular to small-structured regions with high heterogeneity with regard to farm structure and farmers' attitudes. With our approach we integrate elusive factors such as farmers' attitudes into a land use model.

In our view, the integration of farmers' attitudes demands the modelling of individual farms attempting to achieve their individual interests. In order to cope with this problem, a multi-agent technique that allows for the consideration of individual farms is the means of choice. Regarding the layout of the applied model, some aspects must be challenged. This concerns in particular the integration of farmers'

attitudes. Due to the fact that we consider farmers' attitudes to be a black box, we avoided surveying personal aims in detail. Although the application of this method does increase the quality of the results (cf. KANTELHARDT et al., 2005), it is obvious that this way of implementing farmers' attitudes indirectly is not sufficient for entirely describing farmers' decision making processes. Even if this approach explains previous developments, it is questionable if this data can be extrapolated into the future. This applies in particular for to date unique occurrences such as the decoupling process in the current CAP reform. In order to predict future developments it is not sufficient to change only the economic and policy framework but it is also necessary to estimate changes in farmers' attitudes. Otherwise model results tend to be trapped in historic situations. The most relevant change of attitudes takes place during the generational handover of farms.

To summarize, it can be said that the model is suitable to derive the land use developments of smaller regions and helps to identify relevant factors influencing such developments. The model may become especially important during the next decade when the European NATURA 2000 guidelines have to be implemented. This particularly concerns small- and medium-sized regions.

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