Impact of Agri-food Systems on Landscape Appearance

Kapfer M. [1], Ziesel, S. [2] and J. Kantelhardt J. [1]

[1] University of Natural Resources and Life Sciences, Vienna, Austria
[2] WGF Landschaft, Nuremberg, Germany

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Abstract — **Our study examines the potential developments of cultural landscapes, taking into consideration various economic and social conditions (scenarios). The study takes place in three project regions which represent typical landscapes in Southern Germany and Austria. In each project area, the influence of a changing agri-food environment is analysed. The following scenarios are defined: (1) status quo (current economic and agri-political framework); (2) high-producer prices and constant (or even increasing) direct payments; and (3) low-producer prices and no (or very low) direct payments. In all three regions, potential production responses are estimated for all farms and aggregated on a regional level. The estimation takes into account social and economic parameters such as cash flow, size and type of farms, age of farmers and workload.**

The results show that the impact of the changing agro-economic environment differs in particular on the level of the study regions. Due to a lack of production alternatives, agricultural production in grassland areas is very unstable – especially if site conditions are unfavourable and economic conditions are disadvantageous. As a result, large-scale abandonment of agriculture is likely in low-yield grassland areas and consequences for landscape appearance might be dramatic. In high-yield grassland areas, agriculture is much more stable. However, under very disadvantageous conditions the extent of farms giving-up production is as high as in marginal grassland regions. Nevertheless one cannot expect large-scale set aside, because remaining farmers use the possibility of growth and lease a considerable quantity of land In contrast to this, farm structure in the arable regions is stable due to a high potential of production alternatives. However, landscape appearance may also change dramatically in this region due to the increasing importance of maize.

Keywords **— scenario analyses, structural change, landscape visualisation**

I. INTRODUCTION

Cultural landscapes can be defined as visible features of an area of land, determined by natural conditions such as climate, geology and geomorphology and types of vegetation – as well as human influences. These are the result of continuing anthropogenic activities such as agriculture or settlement. Social, religious and historical circumstances also have an impact on landscape appearance [1]. Although the landscape is often conceived as a static ideal state, it is subject to permanent change [2].

Agricultural landscapes are characterised by the type of land use and animal husbandry, the parcelling-out of the area, the forms, arrangement and positions of the residential and farm buildings. Changes in the appearance of landscapes can be considered as a response by farmers to changing social, technological, natural, economic and political conditions. In accordance with the concept of multi-functionality, one can say that agriculture produces – beside food and biogenic raw materials – other goods such as cultural landscapes [3], while agricultural landscapes can be interpreted as a "by-product" of agricultural production [2]. This applies even today, when the economic importance of agriculture is decreasing; agriculture is still one of the most important "landscape architects".

II. METHOD AND DATABASE

A. Description of the basic idea

The basic idea of the landscape model is that farmers will react with a delay to changing economic, political, and social environment. For instance, farmers might expand or decrease production, they might invest or they even might give up their farm entirely. These reactions will differ from farm to farm,

even if a similar framework of conditions faces each one of them. The specific reaction depends on the initial situation of the farm as well as on the individual objectives of the farmer.

In order to describe the impact of changing economic conditions on the agricultural structure, individual decisions of farm have to be aggregated and interaction between the farmers has to be considered (cf. Fig. 1). The resulting agricultural structure becomes manifest in the appearance of the agricultural landscape.

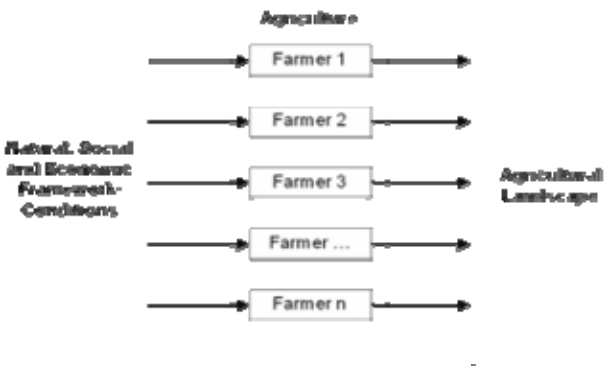

Fig. 1 Schematic representation of the basic idea of the development of agricultural landscapes; [4] - modified

B. Study regions

The study regions are situated in the northern alpine regions, in Austria (Losenstein) and in Bavaria (Obergessertshausen and Münchdorf, cf. Fig. 2). All regions represent small-structured situations which are typical for western Austria as well as for southern Germany.

Fig. 2 Location of the study regions

The study region of Losenstein is rich in small-structure elements such as hedges, orchards and thickets/copses. The mean annual rainfall (MAR) reaches nearly 1,350 mm. Therefore, the land is almost completely used as permanent grassland (cf. Fig. 3). More than 90 % of the UAA (utilised agriculutural area) is used as meadows, with two or three cuts a year or low-intensive pastures. In addition the inclination of the fields – almost 80 % of the UAA has a slope from over 25 %, 40 % is even steeper than 35 % – hinders agricultural land use.

Due to the natural site conditions, animal husbandry concentrates on low-intensive beef production (suckler cows, heifers and steer fattening). In addition, 19 of the examined 48 farms keep dairy cows. The study region comprises about 580 ha UAA. The agricultural structure of Losenstein is small-scale: the average farm size reaches 12.1 ha, most farmers are part-time farmers.

Fig. 3 The study region of Losenstein (LS)

The study region of Obergessertshausen is situated about 100 km west of Munich in the Swabian tertiary hills. It is a “Riedel”-landscape whose plateaus are forested, while the flat slopes and valley area are used for agriculture. Natural and richly structured landscape elements are concentrated along the riverside on the valley bottom. From an agricultural point of view, grassland use and cattle farming is dominant (cf. Fig. 4). In contrast to Losenstein, natural site conditions permit very high grassland yields. Precipitation allows only a limited degree for crop farming.

Consequently, intensive dairy farming is of primary importance. The share of grassland reaches 75 % (260 ha) of the UAA. Intensive four- to five-cut meadows dominate, while pastures and cash cropping are of minor importance. Cereal production is mostly used as fodder within the farm. Silage maize is – despite the comparatively good site conditions – of minor importance. The 30 farms analysed in this study produce with their 1,100 dairy cows 7.3 million kg of milk per year. The average farm size reaches 37.1 ha. More than two thirds of the holdings are full-time farms.

Fig. 4 The study region of Obergessertshausen (OG)

Many branched becks characterise the smooth, hilly landscape of the study region of Münchsdorf. The region is located in Lower Bavaria and is dominated by arable land (85 % of the UAA) with medium-to-good site conditions (cf. Fig. 5). Three-cut meadows and abandoned grassland can be found in the wet areas near the Kollbach River. With regard to agriculture, cash cropping is of major economic importance. Cereals, especially wheat, grain maize and canola are the most important crops. In contrast, animal husbandry is of minor importance; however, one can find some dairy as well as intensive beef production on the base of maize silage.

The average farm size of the 43 farms included into the study is ca. 30 ha. Almost two thirds of the holdings have already given up animal husbandry and concentrate on cash cropping. These holdings are mostly part-time farms.

Fig. 5 The study region of Münchsdorf (MD)

Table 1 gives a short overview about the site conditions, agricultural production and structure of the three study regions.

Table 1 Characterisation of the study regions

	LS (A)	OG (D)	MD (D)
Altitude (m ASL)	360 – 760.	520 – 550	350 – 420
MAT (°C)	8.2	7.5	8.5
MAR (mm)	1,350	850	750
Soils	shallow cambisol, gravel alluvial soils	gleyic cambisol, gley	cambisol, luvisol, alluvial clay glay
Slope (%)	> 25 (80% of UAA) > 35 % (40% of UAA)	< 25	< 25
Site quality	very low	low - medium	medium -high
Permanent grassland (%)	>95	75 %	15 %
Main field crops	-	silage maize, clover-grass cereals	cereals, grain maize, canola
Husbandry	suckler cows, dairy	dairy	dairy, bull fattening
Stocking rate (LU/ha)	1.01	1.,42	1.25
Number of farms	48	30	43
Ø UAA/farm (ha)	12.1	37.1	31
Workload (AWE/100 ha)	6,2	5,5	3,3

C. Scenarios

In order to estimate the future development of landscape appearance it is necessary to take into account the economic framework which farmers are faced with in the future. Therefore, the following different scenarios, describing transfer-payment levels as well as commodity-market trends are defined. The time horizon of the scenarios is ten years.

- *"Status quo" scenario*: this scenario describes the development of agricultural structures, land use and landscape appearance, if economic and political conditions stay stable.
- *"High price" scenario*: it is assumed that prices for agricultural commodities rise about 30 % in comparison to the price level of 2004 to 2008. Transfer payments stay stable in the Obergessertshausen and Münchsdorf regions. For Losenstein it is assumed that transfer payments increase by 40 % in order to achieve the local political aim of "maintaining and developing a multi-functional, area-wide, sustainable agriculture". Costs for leased land increase by 50 % in comparison to the *status quo scenario*. Other costs like prices for operating capital such as seeds, fertilizer, pesticides and purchased forage, services and variable machine costs are held constant.
- *"Low price" scenario*: within this scenario a development is modelled which will take place if farmers are confronted with significantly deteriorating economic and political conditions. It is assumed that the government largely withdraws from supporting agriculture. Only in Losenstein does 50 % of the area-linked direct payments remain. In addition, the commodity-price level decreases by 30 %. Consequently, it is assumed that land rents drops by 50 %. All other economic indicators remain constant.
- *"Energy production" scenario*: this scenario corresponds closely to the *status quo scenario*. However, energy crops gain importance. Therefore, it is assumed that farmers reduce food and forage production in favour of large-scale cultivation of silage maize for biogas production. The high competitiveness of maize for biogas production is represented in the model calculations by changing relative prices. While the price of silage maize will increased by 20 % from baseline level, prices for other agricultural commodities are 20 % lower than assumed in the *status quo scenario*. Transfer payments as well as the other prices remain constant.

Table 2 shows, which of the four scenarios are adopted in which study region.

Table 2 Study regions and scenarios adopted

Scenario	LS (A)	OG (D)	MD (D)
Status quo	X	X	X
High price	X		
Low price	X	X	X
Energy production			X

D. Modelling landscape development

To estimate possible future developments of landscape appearance, a multi-step approach is applied. Fig. 6 gives a schematic overview of the most important procedural steps.

ICAS data and digital field maps serve as the basis for the analysis of the initial situation on a farm level. Considering site quality, slope of grassland plots and the production system (organic or conventional), yields of arable crops and grassland were estimated for each single plot. Data concerning animal production were derived from ICAS data. However, to assure an equalised feed balance, the extent of grazing stock was adjusted on the calculated forage production.

Another basis for the cost-benefit analysis are the mean prices for operating material and agricultural products for the years 2005 (German study areas) resp. 2008 (Austrian study area). In order to simplify calculations, direct payments, agri-environmental and animal welfare payments and natural handicap payments were aggregated to one position. They were transferred into "single-area payments", which vary according to study region and production scheme. In Losenstein, suckler-cow premiums (230 EUR/suckler cow) are accounted separately.

Within the cost analysis, a distinction is drawn between variable and fixed costs. The determination of

the number of annual work units was calculated in line with [5]. For each scenario, a wage rate for unpaid family labour force of 12.5 EUR/h wage rate is assumed.

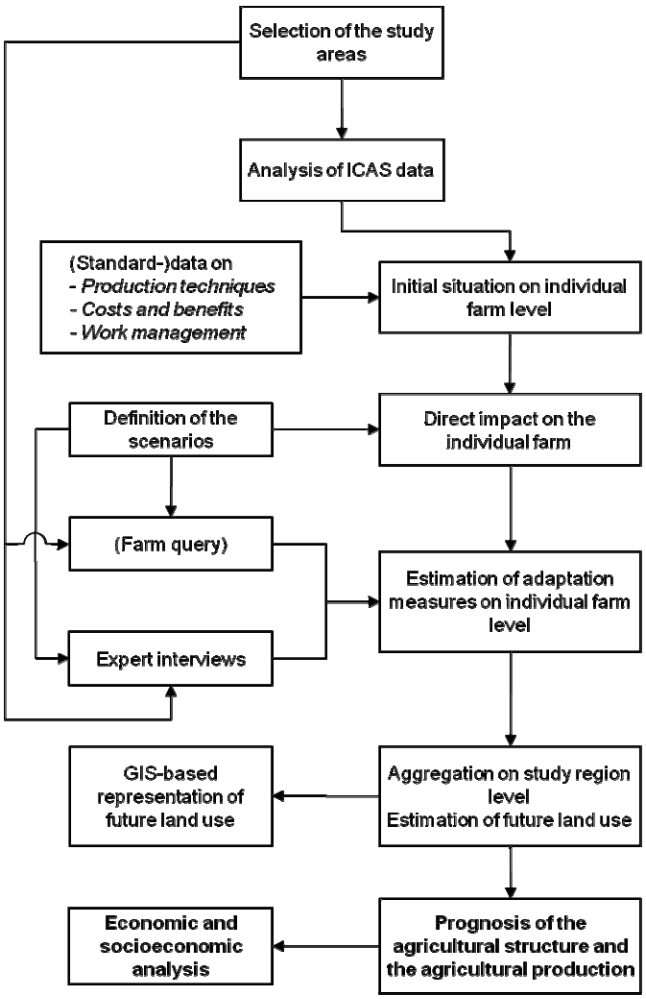

Fig. 6 Diagram of the procedure

The calculation of the economic indicators is repeated by taking into account the assumptions for costs and prices defined within the different scenarios. At this initial stage farmers do not react to changing economic conditions; this means that production and farm organisation remain constant. As a next step, farmer responses are estimated. Possible adjustment reactions are listed below.

- Lease arable land or grassland
- Lease out the entire arable land resp. the entire grassland area
- Give up farming
- Change farm organisation (e.g. quit husbandry and focus on the cash cropping and area growth)
- Give up full-time farming and become a part-time farmer (in combination with a reduced workload)
- Specialise in husbandry, e.g. give up bull fattening and concentrate on milk production
- Convert to organic farming or (re)convert to conventional farming
- Maintain crop rotation, husbandry, farm area and farm organisation

A qualitative method was used to estimate the adaptation responses on a farm level. Farm surveys (in the German study regions), as well as expert interviews, serve as a basis for this step of the procedure. The following example illustrates how the responses are determined. Imagine a mixed full-time farm (dairy and cash cropping), situated in a region dominated by arable land, faced with the situation of transition from one generation to the next. The current economic situation is as follows: the generated cash flow is sufficient to cover cost of living and to make replacement investments. However, the workload is very high. It is assumed that the inheritor of the farm demands a higher remuneration and more time for recreation. Even if economic and political conditions are stable (*status quo scenario*) a change in farm organisation is to be expected. High investment costs impede an increase in the dairy herd. Nevertheless, giving-up agriculture seems unlikely, due to the fact that the arable land could be used for cash cropping. In consequence, the inheritor will concentrate on cereal production, cease dairy farming, plough up grassland if possible and lease or abandon permanent grassland. The holding becomes a part-time farm.

After defining the individual adaptation responses for all farms, the aggregation of the individual farm responses to the level of the study region takes place. Therefore, it is necessary to verify the feasibility of the adaptation responses on a regional level: due to a limited amount of agricultural area, the demand for land may outweigh the supply. Therefore, a simple

procedure is applied: the farms are divided into two groups, one group demanding land, the other supplying land. The “demand group” is ranked according to its economic strength, the “supply group” according to the amount of land supply, weighted according to site quality. The fields of the first farm in the “supply group” are subsequently transferred to the best ranked of the “demand group”. This procedure is repeated until either no agricultural land is available (*excess demand*) or the demand of all farms in the “demand group” is satisfied (*excess supply*). Such surplus fields fall fallow. The result of this procedure is transferred to GIS (cf. Fig. 7).

Fig. 7 Property structure in Obergessertshausen

The aggregation of adaptation measures on a farm level, taking into account the new property structure leads to the “new” land use. It is the basis for further analysis, describing the future economic and socio-economic situation under the conditions of the different scenarios as well as a land-use map (cf. Fig. 8).

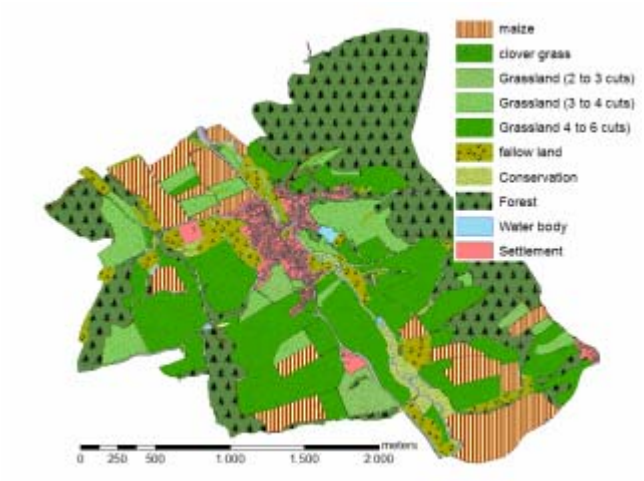

Fig. 8 Land use in Obergessertshausen – Low-price scenario

E. Photo manipulation to visualise landscape developments

Photo manipulation is a way of altering original photos by the application of image-editing techniques (cf. Fig. 9). In this context, it offers the possibility to visualise possible future landscape appearances by editing photos. A digital photo is required for each study region. It serves as a basis for the editing process. This photo has to meet the following requirements:

- representative of the character of the study region
- possible to illustrate the most important characteristics of all the scenarios
- intensive and spatially staggered
- visible characteristic effect of the vegetation and land use in the landscape (period of recording),

Furthermore, a set of material to manipulate the original photos is necessary. It should include all future vegetation types and types of land use taking place in the scenarios. The first step of the manipulation process is to mark the visible triangle of the basic photo in the land-use map. This determines the picture composition. The next step is to identify the plots and landscape elements, which differ from the actual land use. These segments are marked in the

base photo. Landscape elements suited to the new land-use pattern are isolated from the set of material for manipulation. One has to ensure that the perspective and the time of recording match the base photo. The new vegetation and landscape elements are used to fill the marked segments in the base photo.

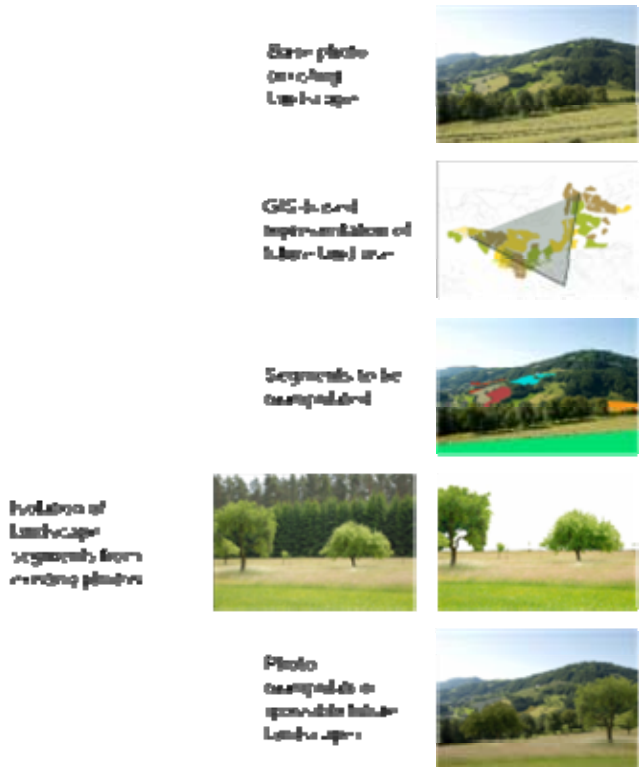

Fig. 9 Photo manipulation

III. RESULTS

A. General trends

- *Status quo scenario*: Even under stable economic conditions, landscape appearance will change in the future. One reason is technical progress: for example, the decline of grazing in favour of all-year-round silage feeding in dairy farming. In cash cropping, narrowing of crop rotations will take place in order to implement the mechanical-technical and biological-technical progress. Another reason is the increasing social demands of the successive generation. Therefore it is necessary to look at the individual initial situation of farms. Small and medium full-time farms are often unable to grow, land for leasing is rarely available and investment costs are high. As regards part-time farms, it is obvious that dairy farms find themselves in a difficult situation concerning workload. In the event of a generational farm handover, a giving-up of farms is probable. This applies especially to grassland regions.
- *High price scenario*: A more favourable economic and political framework will stabilise the agricultural structure. In contrast to the *status quo scenario*, small full-time dairy farms do not give up in the event of a generational farm handover, but instead they switch over to low-intensive methods of animal husbandry such as suckler cows. The same applies, to a lesser extent, to part-time farms. Because of the slow structural change, land to lease is rarely available, even in marginal regions. On the other hand, the increase of income stimulates medium and larger full-time farmers to invest, especially in labour-saving technology. If possible, land use will be intensified.
- *Low price scenario*: Under deteriorating economic circumstances, only very large and economically efficient farms in favourable areas can operate as economically sustainable. The others will remain in agriculture only if there are non-economic reasons present, such as tradition. Therefore, we can expect progressive abandonment by the majority of farms. This opens the opportunity for large farms to grow substantially in the area.
- *Energy production scenario*: According to the assumptions, maize for biogas production becomes more profitable than the “classical agricultural production”. Thus, most farmers will expand maize production up to restrictions on crop rotation. Consequently, livestock production will drop sharply.

B. Losenstein

The study region of Losenstein is disadvantageous in respect of site qualities and agricultural structure. Almost half of the farms are faced with a handover situation within the next ten years. One can expect that most of these part-time farms cease agriculture due to

high work demand and insufficient profitability. According to the calculations, 20 of the 48 farms give up under conditions of the *status quo scenario* (cf. Table 3). The remaining larger farms have only little intention to grow, because of the lack of working capacity. The "new" average farm size is more the consequence of the small farms giving-up than the remaining farms growing. The same applies to the working capacity. Regarding land use, it should be noted that almost 20 % fall fallow. Husbandry decreases slightly. Because the weaker farms give up, market revenues and cash flow increase slightly but they remain insufficient. The profit in cost-benefit analysis rises by 4,000 EUR/AWU. Despite it remaining negative, capital and work are not fully remunerated.

The consequences for the landscape appearance are moderate (cf. Fig. 10). No great shifts in land use are visible; furthermore, the forest to open-land ratio is nearly constant. The patchwork of meadows and pastures in varying degrees of intensity remains, but fallow land may disturb the familiar landscape appearance.

Fig. 10 *Status quo scenario:* Landscape appearance in Losenstein

A more favourable economic and political environment delays structural change – only a few very small holdings give up; the others profit from the conditions by abandoning dairy farming and establishing low-intensive, beef-production systems, which are of little labour demand. In general land use, husbandry and farm structure do not differ a lot from the initial situation. At first glance, it is surprising that the economic situation does not improve more (cf. Table 3); this is because weaker farms still exist.

The most obvious change in landscape appearance is the result of an increasing number of suckler cows associated with pasture use (cf. Fig. 11). On the one hand, landscape appearance gains attractiveness but on the other hand, fences restrict accessibility to the landscape. In general, the character of the landscape does not change a lot.

Fig. 11 *High price scenario*: Landscape appearance in Losenstein

If the economic and political environment develops as assumed in the *low price scenario*, agriculture in the study region of Losenstein is hard hit. In addition to the development described in the *status quo scenario*, full-time farmers are also forced to give up because agricultural income is not sufficient to cover cost of living (cf. Fig. 10). Even a ranch system is not economically sustainable. Less than 10 % of the farms will survive by using niches like horse ranches. Nevertheless, agriculture land use almost disappears from the study region; almost 95 % of the UAA falls fallow. In addition, traditional cattle husbandry loses importance.

With the abandonment of land use, forest encroachment will take place. The forest to open-land ratio, which is about 50:50, will shift to an almost totally forested landscape. This process will take a few years where transmission stadiums have to be passed. From the point of view of nature conservation and ecology, these stadiums are of high quality. They are rich in structure and often show a high biodiversity. In the end, this richness will decrease.

Fig. 12 *Low price scenario:* Landscape appearance in Losenstein

The character of the landscape will change totally. What was originally a richly structured, half-open and "proper" landscape will become an "untidy" character which may be rejected by the majority of society. Large-scale abandonment can also be judged critically from another point of view: The landscape loses its function as cultural memory.

Table 3 Results for the study region of Losenstein

Scenario	Today	Status quo	High price	Low price
Agricultural land use (share in %)				
Cereals	0.3	-	-	-
Clover grass	1.2	0.9	0.7	-
Managed grassland	92.6	70.7	86.8	3.8
Extensive grassland	3.3	10.1	12.0	1.4
GAEC-areas	2.6	-	-	-
Abandonment	-	18.3	0.4	94.9
Husbandry (pc. per 100 ha)				
Dairy cows	31.5	28.6	29.6	-
Suckler cows	27.2	21.9	29.5	0.9
Heifers / steers for fattening	17.8	10.8	15.4	0.2
Farm structure				
Number of farms	48	28	37.	4
av. farm size (ha)	12.1	17.0	15.7	7.6
AWU/farm	0.7.	1.0	0.9.	1.1
Economical analysis (EUR/AWU)/				
Market revenues	20,051	25,385	29,281	20,701
Transfer payments	13,642	14,839	21,178	3,317
Cash flow	9,516	14,883	24,976	12,764
Profit in cost-benefit analysis	-41,195	-37,258	-34,149	-24,903

C. Obergessertshausen

The study region of Obergessertshausen shows a fairly good structure: most of the holdings are full-time farms and therefore larger than the Bavarian average. The natural conditions are well suited to dairy farming. In grassland use, up to six cuts per year are possible and silage maize yields are comparably high. Under conditions of the *scenario status quo*, only few changes in agricultural structure will take place. Farms remain, even in a handover situation. As one can see in Table 4, agriculture on average can achieve a satisfying cash-flow level. Although economic analyses show a negative profit in cost-benefit evaluation, a closer look at the calculations reveals the reason: the capital costs reach 20,000 EUR per AWU on average.

With regard to the farm query there will be only small development in farm structure. Most of the farmers want to continue and to grow their farms. This will lead to excess demand; farm growth is almost not possible and the average farm size increases only a little to 38.5 ha. Because growth in farm size is not possible, farmers intensify their production: silage maize replaces cereals; all-year-round silage feeding dominates. Even though Table 4 shows only little changes in land-use patterns, this intensification has a great impact on landscape appearance (cf. Fig. 13). Short-cut, intensive meadows form a more uniform landscape. In husbandry, milk production increases by 25 % due to the higher quality of fodder, better management and biological-technical progress. Market revenues rise, therefore, by about one quarter while state payments per AWU remain almost constant (cf. Table 4). On the other hand, intensification raises the variable costs by 6,000 EUR per AWU and therefore cash flow and profit increase only by about 6,000 EUR per AWU.

Fig. 13 *Status quo scenario:* Landscape appearance in Obergessertshausen

Fig. 14 *Low price scenario:* Landscape appearance in Obergessertshausen

A very disadvantageous agri-food system, such as in Losenstein, results in an abandonment of agriculture for most of the existing farms. The number of farms decreases from 30 to 12 (cf. Table 4). Although fields of low quality fall fallow, there is no large-scale abandonment of agricultural land. Fallow land concentrates along the water bodies. They represent about one quarter of the UAA. As in the *status quo scenario*, the rest of the UAA is intensified. Remaining farmers take the chance to lease land cheaply with the result that farm size almost triples. In addition, average herd size increases from 37 to almost 110 dairy per farm.

Landscape separates in intensively used grassland – maize plots on the one hand, and succession areas near the water bodies on the other hand (cf. Fig. 9). Forest encroachment takes place in the valley bottom; the open character of the landscape disappears. The shallow slopes remain in use, but today's diverse mosaic of plots will be lost.

Plots become larger; landscape elements are removed in order to simplify management. The largely homogeneous grassland use with high cutting frequency also has an impact on landscape. It will lose its attraction and becomes "boring".

The more effective farm structure more than compensates for the price drop – market revenues per AWU almost double (cf. Table 4).

Cash flow per AWU also increases. As regards the profit in cost-benefit analyses, profit per AWU remains almost constant in comparison to the initial situation. This means, that the changes in agri-food systems are compensated by structural change.

Table 4 Results for the study region of Obergessertshausen

Scenario	Today	Status quo	Low price
Agricultural land use (share in %)			
Cereals	13.2	-	-
Silage maize	4.4	15.2	24.2
Clover grass	2.9	3.0	-
Managed grassland	76.5	80.3	48.5
Extensive pastures	1.5	-	-
GAEC-areas	1.5	-	-
Abandonment	-	1.5	27.3
Husbandry (pc. per 100 ha)			
Dairy cows	101,5	116,7	86,4
Suckler cows	4,5	16,7	25,8
Farm structure			
Number of farms	30	28	12
Av. farm size	37.1 ha	38.5 ha	92.6 ha
AWU/farm	1.4.	1.7	3.1.
Economical analysis (EUR/AWU)/			
Market revenues	53,590	66,470	100,740
Transfer payments	7,360	7,590	0
Cash flow	26,450	33,120	34,460
Profit in cost-benefit analysis	-23,460	-15,870	-14,300

D. Münchsdorf

Münchdsorf's agricultural structure is characterised by part-time farms. Farmers often focus on cash cropping; therefore the average workload is lower than in the other study regions. One can describe Münchsdorf as small structured; the average farm size is about 30 ha and the number of dairy per herd varies from three to 39. Under conditions such as in the *status quo scenario*, the process of continual abandonment of husbandry will continue. Both dairy cows and fattening bulls will reduce by about one third (cf. Table 5). With this reduction, grassland is ploughed where possible; otherwise it is abandoned.

The number of farms decreases by one quarter; older farmers in particular will abandon if they have no successor. As a consequence, average farm size increases to 41 ha. These holdings are mostly part-time farms with 0.6 AWU per farm (cf. Table 5). Due to farm growth, market revenues and state subsidies increase by 16 %. But in addition, costs increase, so that the cash flow improves only slightly. If one also takes into account the costs for capital and workload, the situation becomes even worse: profit in cost-benefit analysis decreases, which means that remuneration for non-paid family workers is lower than currently.

The impact of these changes on landscape appearance is marginal, land-use pattern does not change a lot and fallow land is small-scale and widespread.

Fig. 15 *Status quo scenario:* Landscape appearance in Münchsdorf

Disadvantageous economic and political conditions accelerate structural change in the study region of Münchsdorf. Nevertheless, it does not reach the same degree as in Losenstein or Obergessertshausen. While in grassland-dominated areas part-time farming is difficult because of comparably high workload and inflexibility in labour organisation in husbandry, cash cropping is easily to combine with non-agricultural employment. Therefore, it is estimated that at the start of development, farmers will give up husbandry completely; some smaller farms give up; and others lease their arable land and concentrate on cereal production. Grassland will fall fallow because there is no need for it. Ploughing grassland is, in contrast to the *status quo scenario*, not necessary because the supply of arable land is sufficient. The remaining farms will grow in amount of land, until their machinery is run at nearly full capacity. Farmers who give up later in this progress cannot lease their land because of a non-existent supply for grassland as well as for arable land. This excess supply will lead to further land abandonment, so that nearly a third of the UAA falls fallow.

All in all, 16 of the 43 farms in the initial situation remain in production. Their average size reaches about 50 ha of arable land. Market revenues increase with regard to farm growth and efficiency to 110,000 EUR/AWU (per ha they drop from 2,100 EUR to 1,150 EUR).

The price drop more than compensates the more effective farm structure – cash flow per AWU decreases over 80%. Even if it is possible to reduce imputed costs, such as depreciation and capital costs for husbandry, average loss in cost-benefit analysis rises to 70,000 EUR per AWU. This result is the opposite of Obergessertshausen. The structural change in Münchsdorf is too slow to achieve competitive structures. The possibility of part-time farming entices farmers not to give up, even if it is uneconomical.

In landscape, one will notice larger, uniform plots. This leads to a loss of variety, which is enhanced by the removal of landscape elements. In contrast to this development, which takes place on plots with comparably good site conditions, grassland and arable land of lower quality next to the water bodies are left to their own. Alluvial forests will grow. A separation in landscape appearance is the consequence:

intensively used, monotonous arable land on the one hand and natural vegetation along the running waters on the other.

Fig. 16 *Low price scenario:* landscape appearance in Münchsdorf

Site quality in Münchsdorf is well suited to silage maize production. Because of the method of production and marketing silage maize for biogas plants - it is normally sold standing on field - the production of silage maize does not require cost-intensive investments and requires low labour. Therefore, it is suitable for part-time farms. According to the farm survey, 90 % of farmers would start maize production with a share from 25 % to 75 % in crop rotation. As regards the whole study region, 68 % of the UAA is used for silage maize while other crops and husbandry lose importance (cf. Table 5). Agricultural structure is comparable to the *status quo scenario*, but the workload is reduced by a third. Market revenues are 35 % higher than in the *status quo scenario*. Taking into account the lower labour demand, market revenues reach 106,000 EUR per AWU, (compared to the *status quo scenario*: 43,000 EUR/AWU).

Although the average cash flow is double than in the *status quo scenario*, it is not possible to remunerate all production factors appropriately (cf. Table 5).

Structure is comparable to the *status quo scenario*. Therefore long-term landscape shaping factors like plot size or forest to open land ratio. Nevertheless, landscape appearance will change totally (cf. Fig. 10). This is due to the increase in the share of maize up to 65 %.

Fig. 17 *Energy production scenario:* Landscape appearance in Münchsdorf

The open landscape character with its extensive views will change significantly. From July to late autumn, the maize fields restrict the view. To that extent, the temporary vertical orientation of the landscape with maize fields has no aesthetic gain. In fact, it is perceived as a disturbance of the vast landscape (cf. Fig 10).

Table 5 Results for the study region of Münchsdorf

Scenario	Today	Status quo	Low price	Energy production
Agricultural land use (share in %)				
Land use				
Wheat	28,6	31,9	29,7	12,1
Other cereals	17,6	15,4	11,0	8,8
Canola	4,4	5,5	9,9	-
Grain maize	8,8	15,4	18,7	-
Silage maize (energy)	-	-	-	58,2
Silage maize (fodder)	14,3	15,4	-	6,6
Other crops	2,2	2,2	-	-
GAEC-areas	4,4	-	-	-
Abandonment	-	5,5	29,7	11,0
Managed grassland	18,7	4,4	1,1	3,3
Extensive grassland	1,1	4,4	-	-
Husbandry (pc. per 100 ha)				
Dairy cows	23.2.	15.5	-	10.7
Fattening bulls	50.1	36.5	-	10.7
Farm structure				
Number of farms	43	32	16	33
Av. farm size	31.0 ha	41.0 ha	50.1 ha	40.4 ha
AWU/farm	0.6.	0.6	0.4.	0.4
Economical analysis (EUR/AWU)/				
Market revenues	63,020	71,760	110,860	106,260
Transfer payments	9,660	11,270	0	8,280
Cash flow	17,710	18,860	2,990	39,330
Profit in cost-benefit analysis	-43,930	-45,310	-71,530	-23,690

IV. DISCUSSION AND CONCLUSION

Within this study it has been possible to outline the strong relationship between agricultural land use, agricultural structure and landscape appearance. The study, which focuses on typical Austrian and Bavarian landscapes and agricultural structures, shows that the character of cultural landscapes has been and will continue to be shaped by agriculture. Technical progress, changes in the relative competitiveness of agricultural commodities, the economic and political environment and structural change are the principal causes for changes in land use. Modifications to the landscape are often not seen in their full light: structural change is a gradual process since farmers respond at different speeds and in different ways to changing conditions, even though structural change is a single event on an individual farm level. This applies especially to the abandonment of agriculture. In order to analyse the wide spectrum for possible future developments it is necessary to define several future conditions (*scenarios*).

In order to obtain realistic results, structural change and, as a consequence, area and land use were shown using a qualitative method. In particular, the farm survey showed that non-economic aims like tradition or social aspects have a great influence on farmers' decisions, which differ from individual to individual. Combined with the interviews with the experts, the method leads to viable results. In contrast to knowledge gained, mathematically exact methods can barely cope with this complex system. Agent-based models focus unilaterally on profit maximisation as the sole objective of all holdings [6], or they do not allow site-specific observations [7]. Other modelling approaches abstract from the individual farm and regard agriculture "as a whole", as a landscape-shaping agent [8]. However, this study shows that landscape appearance is not only dependent on natural site conditions. Important parameters on an individual farm level, such as farm organisation, share of part-time farmers, available workforce, handover situations etc., also play an important role. Thus, the initial situation has a decisive influence on future development.

Comprehensive production-related, economic and socio-economic analyses allow a deeper insight into the connections between the social and economic pressures which farmers are faced with and which therefore have an effect on the landscape appearance. It should be mentioned that imputed costs such as capital costs or depreciation are overestimated because of the use of standard data. In reality, farmers often buy second-hand machines or use machines and farm buildings beyond their depreciation period in order to reduce costs.

As regards the results, landscapes develop in totally different ways under similar conditions. In Münchsdorf, short-time (and non-permanent) production decisions, as with increase of silage maize described in the *Energy production scenario*, have a high impact on landscape appearance. On the other hand, when one considers long-lasting landscape determining factors like the open-land forest ratio, this

landscape is quite stable. In contrast, in Losenstein long-term developments are more crucial. Forest encroachment takes place under disadvantageous conditions. In Obergessertshausen the magnitude of intensification of grassland management is also linked to the structural change in agriculture. Besides the economic and political environment, three internal factors determine future development of land use, agricultural structure and landscape appearance:

- local natural conditions;
- the prevailing farm structure and farm organization; and
- the full-time to part-time farm ratio.

In those regions dominated by arable land, the danger of large-scale fallow land is low. However, an intensification of land use is only gradually conceivable because the intensity of the land use already matches the economic optimum. A further decline in livestock levels is to be expected and is accompanied by a withdrawal of grassland, which is ploughed or abandoned. The impact of this development on landscape appearance is dependent on how far this withdrawal has already advanced.

This is comparable to high-yielding grassland regions. Even if one expects no withdrawal of husbandry, large-scale fallow land will remain an exception. But in contrast to cash cropping, where the implementation of biological and technical progress is easy in husbandry, intensification is often combined with cost-intensive investments. Therefore, in small-structured regions, the optimum specific degree of intensiveness is not achieved. Further intensification is possible and will take place in the long term.
In marginal landscapes, like the mountain region of Losenstein, area-wide land use is not certain, even under stable economic and political conditions. Agriculture in low-yield grassland regions is especially dependent on state transfer payments. A reduction of subsidies will lead to withdrawal of agricultural land use and therefore to large-scale fallow land.

In general, these are the resulting trends in landscape appearance:

- Even under stable economic conditions, landscape appearance will change. This is due to technical progress and social changes. In this context, it is necessary to point out that the structural change occurs with a time lag. This applies particularly in small-structured regions with dominating dairy farming, because of high investment costs in new stable technologies.
- High prices for agricultural commodities and stable state-transfer payments guarantee land use and slow down structural change. Where possible, agriculture is intensified. Dairy farming will concentrate on high-yield grassland areas, whereas in regions dominated by arable land, reduction in husbandry and concentration on cash cropping will take place. In mountain regions, livestock production of low intensity offers an economic and (according to workload) feasible production alternative, even for part-time farmers. However, when structural change slows down, farm growth is inhibited and the development of sustainable structures is difficult. Investments are, in the event of a reasonable economic situation, easy to realize and often concentrate on the implementation of labour-saving technologies.
- A disadvantageous economic and political framework will intensify structural change. This is independent of site conditions. However, the result in landscape appearance differs from region to region. In arable areas, the impact of structural change is quite low and often reversible. In contrast, irreversible forest encroachment takes place in marginal mountain regions.
- New production alternatives are discussed within the *energy production scenario*. The regions, dominated by arable land profit from these new possibilities, while the energy use of grass is hardly economical. In mountain regions in particular, energy use of grassland is almost unthinkable. This is due to the high labour demand of the management in hilly areas.

With the method of photo-realistic picture communication, it is possible to depict landscape appearance as a dynamic process. A viewer who is familiar with the landscape can easily realize and assess landscape development. Therefore, it is a useful means, for decision makers as well as for the local

population, of visualizing the consequences of economics and politics on the landscape. The analysis on an individual farm level which is applied in this study proves the strong link between agriculture and landscape appearance. Therefore it avoids over-representation while at the same time showing clearly the most important trends in landscape development.

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(martin.kapfer@boku.ac.at; ziesel@wgf-nuernberg.de; jochen.kantelhardt@boku.ac.at)