

Integrating ecological and economic aspects in land use concepts for agricultural landscapes

Integration ökologischer und ökonomischer Aspekte in Landnutzungskonzepten für Agrarlandschaften

Heinz Ahrens

Martin-Luther-Universität Halle-Wittenberg

Jochen Kantelhardt

Technische Universität München

Zusammenfassung

Vor allem in naturschutzfachlich bedeutsamen Gebieten muss die landwirtschaftliche Flächennutzung vielfach auch nicht-landwirtschaftliche Gesichtspunkte berücksichtigen. So wird von der Landwirtschaft beispielsweise erwartet, dass sie neben der Produktion hochwertiger Nahrungsmittel auch zur Erhaltung der Kulturlandschaft sowie weiterer ökologischer Leistungen beiträgt.

Landnutzungskonzepte für ökologisch sehr sensible Agrarlandschaften setzen häufig einen Schwerpunkt auf ökologische Aspekte in bestimmten Gebieten und vernachlässigen dabei sozioökonomische Auswirkungen, insbesondere Einkommenseffekte und einkommensmotivierte Anpassungsmaßnahmen landwirtschaftlicher Betriebe außerhalb dieser Gebiete.

Der vorliegende Beitrag zeigt auf der Grundlage einer empirischen Untersuchung, dass (1) die Ziele und Anpassungsmaßnahmen der landwirtschaftlichen Betriebe wegen der möglichen kontraproduktiven Wirkungen auf die Erreichung der Umweltziele in Landnutzungskonzepten für Agrarlandschaften einbezogen werden müssen, und (2) wie ein solches, vorwiegend ökologisch ausgerichtetes Nutzungskonzept für eine ökologisch sehr sensible Agrarlandschaft mit Hilfe einer multikriteriellen Analyse in ein umfassenderes Konzept weiterentwickelt werden kann, das den Anpassungsmaßnahmen landwirtschaftlicher Betriebe und den sozio-ökonomischen Zielen der Gesellschaft Rechnung trägt. Es wird verdeutlicht, wie die Einbeziehung sozio-ökonomischer Zielsetzungen zur Erhaltung von Einkommen und Beschäftigung beitragen kann, ohne die ökologischen Wirkungen allzu stark abzuschwächen.

Schließlich werden Konsequenzen einer Umsetzung von Agrarlandschafts-Nutzungskonzepten für die Politik – insbesondere die Agrarumweltpolitik – diskutiert und einige Fragen aufgeworfen, die sich stellen, wenn die Politik bei der Entwicklung solcher Konzepte stärker auf die Methode der multikriteriellen Analyse zurückgreifen will.

Schlüsselwörter

Agrarlandschaft; Landnutzungskonzepte; multikriterielle Analyse

Abstract

Especially in environmentally sensitive agricultural landscapes, agriculture cannot define its aims by itself - it has to account for a number of demands of different groups of society. For example, agriculture is expected to produce food and at the same time contribute to the protection of cultural landscapes and to further ecological services.

Land use concepts for ecologically particularly sensitive agricultural landscapes are often focussed on the attainment of specific environmental objectives in specific areas, neglecting both socio-economic effects, in particular income effects, and the farmers' income-driven production responses outside these areas.

The paper illustrates, on the basis of an empirical study, (1) that the farmers' objectives and production responses need to be integrated in land use concepts for agricultural landscapes because of their potentially counterproductive effects on the attainment of environmental objectives, and (2) how multi-criteria decision analysis (MCDA) can be used to transform a primarily ecology-oriented concept for an ecologically very sensitive agricultural landscape into a more comprehensive one that makes due allowance for the farmers' responses and society's socio-economic objectives. The authors show that the integration of socio-economic objectives can contribute to the maintenance of incomes and employment without overly harming the attainment of ecological goals.

Finally, the paper discusses policy implications resulting from the implementation of land use concepts for agricultural landscapes, in particular in the field of agri-environmental policy, and raises some practical issues that come up if policy makers apply MCDA more widely in the design of such concepts.

Key words

agricultural landscapes; land-use concepts; multi-criteria decision analysis

1. Introduction

Particularly in environmentally sensitive areas agriculture cannot define its aims on its own but has to account for a number of demands of different groups of society. For instance, agriculture is expected to produce food and at the same time to contribute to the protection of cultural landscapes and to the maintenance of ecological services.

Land use concepts for ecologically particularly sensitive agricultural landscapes are often focussed on the attainment of specific environmental objectives in specific areas, neglecting both socio-economic effects, in particular income effects, and the farmers' income-driven production responses outside these areas.

The present paper is aimed to illustrate, on the basis of an empirical study, (1) that farmers' objectives and production responses need to be integrated in land use concepts for agricultural landscapes because of their potentially counterproductive effects on the attainment of environmental objectives, and (2) how multi-criteria decision analysis (MCDA) can be used to transform a primarily ecology-oriented land use concept for an ecologically particularly sensitive agricultural landscape into a more comprehensive one that makes due allowance for the farmers' responses

and society's socio-economic objectives. Finally, we will discuss (a) the issue of regionalisation of agri-environmental policy, designed to support land use concepts for agricultural landscapes, and (b) some important points involved in the use of MCDA for the development of such land use concepts by policy makers.

Section 2 discusses the concrete problems of land use in the agricultural landscape under study, the *Bayerisches Donauried*, a region of particularly high value for both nature conservation and agriculture. Section 3 presents the ecology-oriented land use concept that was developed for specific areas of this agricultural landscape some years ago. In section 4 we introduce the notion of the farmer as an economic actor and discuss three alternative production responses to the proposed conservation-oriented measures, with respect to their impacts on both ecological and socio-economic variables. Section 5 is dedicated to a multi-criteria evaluation of the three enlarged versions of the land use concept mentioned above, and to the selection of the "optimal" one. Section 6 derives some policy implications, referring in particular to agri-environmental policy, and discusses some practical issues that come up when MCDA is used more widely by policy makers for the design of land use concepts for agricultural landscapes.

2. Problems of land use in the *Bayerisches Donauried*

The region covers the Danube valley between the cities of Neu-Ulm and Donauwörth. Its landscape is mainly characterised by the influence of the water, which largely determines the possibilities of land use as well as the occurrence of species and habitats in this region. Thus, at the beginning of the 19th century the Danube was a widely meandering river without a fixed riverbed and with numerous major and minor bayous. As the entire region was flooded regularly and was generally characterised by a high ground water level, agricultural use was almost entirely restricted to grassland.

The reconstruction of the Danube considerably reduced the influence of the water in the *Bayerisches Donauried* during the last two centuries (ZETTLER et al., 1999). The drawdown of the ground water table and the lower frequency of flood occurrence made possible an expansion of arable cultivation to 84% of the total agriculturally used area (AUA) and an accompanying intensification of agricultural cultivation. While on the remaining grassland in most cases only low yields can be achieved, the arable land is high yielding and is primarily used for forage cultivation. The cultivation of silage maize represents the main basis of milk and beef production.

On the other hand, the above-mentioned interferences with nature had negative ecological effects: today the quality and even the existence of valuable habitats as well as their function for the natural environment are in jeopardy. However, the *Bayerisches Donauried* still fulfills important ecological functions. For example, it is an internationally highly appreciated habitat of endangered species of the wild flora and fauna. In addition the region serves as a large surface retention zone with a great water storage capacity and can therefore make an important contribution to water retention in the case of floods.

Another non-agricultural function of the *Bayerisches Donauried* is the supply of drinking water. The withdrawal of an annual quantity of 34 million m³ of ground water per year by the Water Authority Stuttgart (ZETTLER et al., 1999) plays a particularly important role. Finally, the region is of central importance for local recreation.

3. The ecology-oriented land use concept

The concept was developed by a group of researchers on the basis of a profound analysis of the region's ecological status and its problems, and in-depth discussions with experts, administrators and decision makers. The most important ecological objectives formulated in the expertise are (ZETTLER et al., 1999): the reestablishment of the natural floodplain dynamics, the protection of the remaining fen areas, and the improvement of the living conditions of meadow birds. To attain these objectives the researchers suggest various conservation-oriented measures and changes in agricultural land use practices. Most of them do not pertain to the entire *Bayerisches Donauried* but to selected areas in this region. In *fen areas and riverine forests* the groundwater level is to be raised to 40 to 50 cm below the surface. In *meadow bird areas* the share of grassland is to be raised. At the same time living conditions of meadow birds are to be improved by subjecting farmers to legal requirements concerning cutting dates as well as site-specific water logging for certain periods. Remaining *floodplain forests* are to be supplemented by afforestation on farms. In addition, environment friendly farming according to the requirements of "good agricultural practice" is to be enforced *in the whole area*.

4. The farmers' alternative responses

As a consequence of these changes in land use, farmers would, above all, have to (1) transform arable land into grassland and (2) extensify the management of existing grassland. In the first case they would suffer a net loss of production potential for the production of animal feed, in terms of feed energy (lower productivity of grassland). In the second case as well, the result would be a loss of feed energy. In the region there would definitely not be any possibilities to lease additional land in order to compensate these losses because the proposed conservation-oriented measures would affect almost all farmers. For the same reason it would not be possible for farmers to buy forage from their neighbours.

The ecology-oriented concept does not discuss farmers' production responses to these problems. In an economic analysis of the proposed measures KANTELHARDT and HOFFMANN (2001; also HOFFMANN and KANTELHARDT, 2003) derived three main production responses. The most direct response, with the lowest requirements regarding a reorganisation of farms, would be the reduction of the number of livestock. From the conservationist point of view, the expectation might be that this response would yield high ecological results. However, from the point of view of farmers there are more realistic responses. In order to mitigate income losses farmers could try to compensate the feed losses mentioned above by expanding the production of clover-grass or silage maize, on arable land that is not transformed into grassland.

On the basis of these considerations, the major ecological and socio-economic effects of the following land use options will be assessed:

- (1) "Status Quo" (SQ): Continuation of the traditional mode of cultivation, without applying the measures defined in the ecology-oriented land use concept.
- (2) "Reduction of livestock" (RL): Implementation of the measures defined in the ecology-oriented land use concept, and reduction of the number of livestock.
- (3) "Compensation by clover-grass" (CG): As under (2), but compensating the loss of animal feed by an expansion of the cultivation of clover-grass.
- (4) "Compensation by silage maize" (SM): As under (2), but compensating the loss of animal feed by an expansion of the cultivation of silage maize.

In order to compare these land use options we use the concept of "landscape functions". Landscape functions express the services, defined in the broad sense of the word, rendered to society through land use (DE GROOT, 1992: 13 et sqq.).

The landscape functions, and the indicators chosen to measure them, are shown in table 1, columns 1 and 2. These five "ecological" and four "socio-economic" functions were chosen mainly on the basis of the present land use in the region and the relevant land use objectives underlying the above-mentioned expertise. Further, more global objectives such as climate protection were included.

The functions and their indicators can briefly be characterised as follows. *Water protection* is of special relevance because the *Donauried* is an important centre for the pro-

duction of drinking water. As indicators, the extents of nitrogen and pesticide application are used. *Soil protection* derives its importance from the relatively high flooding risks and therefore not only serves the interests of farmers but also contributes to the protection of surface water. The C-factor used for measurement is the cover and management factor of the Universal Soil Loss Equation (USLE). The importance of the *protection of species and habitats* can be seen from the fact that the *Donauried* is a Ramsar bird sanctuary and thus of international importance. The function *Climate protection* needs no further explanation. *Protection of resources* considers the global issue of renewable fossile resources; for simplicity, the indicator used by us refers only to the energetic use of such resources. The *maintenance of employment* is an important objective in the region, to which agriculture may make a modest but differentiated contribution (capital intensive production methods implying less employment than less capital intensive ones, in the agricultural sector as well as in the upstream and downstream sectors). The *maintenance of agricultural income* is a highly valued objective in the region, the consensus going far beyond the agricultural sector. The selected indicator is the change in the income of affected farms and was calculated using a direct cost calculation (which may be justified by the relatively short time horizon considered). The *production of food* derives its importance from the fact that the production and marketing of "regionally produced" food is an important goal within the region. Finally, although the *reduction of public expenditure* is not a "landscape function" in the proper sense of the word it may be a relevant secondary objective in a land use concept.

Table 1. Land use options in Bayerisches Donauried: Landscape functions, expected indicator values, and scores

| Landscape function | Indicator | Indicator value | | | | Score | | | |
|------------------------------------|--|-----------------|-------|-------|-------|-----------------|------|------|------|
| | | Land use option | | | | Land use option | | | |
| | | SQ | RL | CG | SM | SQ | RL | CG | SM |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| ECOLOGICAL | | | | | | | | | |
| Water protection | Nitrogen use (t N) | 2 825 | 2 589 | 2573 | 2604 | 0.00 | 0.94 | 1.00 | 0.88 |
| | PSM use (t active component) | 21.5 | 19.7 | 18.2 | 19.2 | 0.00 | 0.54 | 1.00 | 0.68 |
| Soil protection | Erosion potential (C-Faktor) | 2 223 | 2 037 | 1 998 | 2 240 | 0.07 | 0.84 | 1.00 | 0.00 |
| Protection of species and habitats | Intensive area * (1 000 ha) | 22.0 | 19.1 | 19.1 | 19.1 | 0.00 | 1.00 | 1.00 | 1.00 |
| Climate protection | Greenhouse potential (kt CO ₂) | 127.7 | 117.6 | 123.4 | 123.7 | 0.00 | 1.00 | 0.42 | 0.40 |
| Protection of resources | Use of primary energy (TJ) | 343.5 | 321.5 | 329.4 | 326.7 | 0.00 | 1.00 | 0.64 | 0.76 |
| SOCIO-ECONOMIC | | | | | | | | | |
| Maintenance of jobs | Employment in agriculture (1000 labour hrs.) | 927.5 | 885.9 | 938.0 | 932.4 | 0.80 | 0.00 | 1.00 | 0.89 |
| Maintenance of agricultural income | Agricultural income (Mio. EUR) | 22.0 | 20.2 | 20.5 | 21.1 | 1.00 | 0.00 | 0.16 | 0.48 |
| Production of food | Value of production (Mio. EUR) | 46.7 | 43.2 | 45.1 | 45.4 | 1.00 | 0.00 | 0.54 | 0.63 |
| Reduction of public expenditure | Public payments to farms (Mio. EUR) | 11.2 | 10.4 | 10.6 | 10.9 | 0.00 | 1.00 | 0.78 | 0.32 |

* area not used as extensive grassland

SQ = Status Quo – RL = reduction of livestock – CG = compensation by clover-grass - SM = compensation by silage maize

Source: KANTELHARDT, 2003

The ecological and socio-economic effects of the four land use options (the indicator values) are given in table 1, columns 3 to 6. Evidently, for several landscape functions there is an inverse relationship between the extent to which the function is fulfilled and the value of the indicator. This is true of all ecological landscape functions and one of the “economic” ones, namely the “reduction of public expenditure”. Indicator values were determined on the basis of comprehensive material flow calculations. The latter are oriented at the chain of an ecobalance and comprise a definition of objectives, a life cycle inventory (LCI) analysis and an impact analysis of the agricultural production methods.¹

The comparison of the land use options reveals:

- SQ: The results of our assessment confirm the currently strong orientation of agriculture towards economic productivity. Concerning the socio-economic landscape functions, SQ performs very well; merely the high strain on the public budget turns out to be a disadvantage. On the other hand, option SQ is characterised by the lowest values regarding the ecological landscape functions - except that for soil protection the performance of option SM is even worse.
- RL: This option assumes that farmers meet the demands of the ecology-oriented land-use concept without trying to mitigate their income losses. Consequently it is characterised by a good ecological performance but a poor achievement of socio-economic objectives (except that it implies a low strain on the public budget). The underlying reason is that animal husbandry is of extraordinary economic importance but requires a comparatively high-energy input and causes a comparatively high output of greenhouse gases.
- CG: Through the extension of the production of clover grass, animal husbandry can be maintained at the same level as in SQ. Therefore, in comparison to RL, the CG option is clearly advantageous from a socio-economic point of view. This goes in particular for the maintenance of jobs since agricultural employment would even exceed that of the current situation. Regarding the ecological landscape functions, CG also shows a comparatively good performance. This applies in particular to the conservation of abiotic resources.
- SM: Due to the high competitiveness of silage maize this option would contribute to a far-reaching conservation of agricultural income. However, there would be certain ecological disadvantages. Compared to CG, the extension of silage maize cropping would entail a higher risk of soil erosion and water pollution.

As the behaviour of farmers is mainly determined by the motive to maximise income their best response to the conservation-oriented measures would be to opt for SM. It is only realistic to assume that, under the prevailing economic and legal conditions, they would not refrain from doing so. The problem is that this would considerably counteract the ecological objectives of the ecology-oriented land use concept.

5. Multi-criteria decision analysis of the land use options

From a political point of view, however, the question is a normative one: which of the three land use options – RL, CG, or SM - is best for society as a whole, from an overall welfare point of view, taking into account all relevant ecological and socio-economic effects? Theoretically at least, even SQ, i.e. the total rejection of the ecology-oriented land use concept, might be the superior one.

In the following we will use multi-criteria decision analysis (MCDA) to evaluate the land use options. MCDA - also known as multi-attribute decision making (MADA) - is aimed to serve, in the context of complex problems, as an aid to thinking and decision making, not to take the decision. (For the classical exposition of MCDA cf. KEENEY and RAIFFA, 1976; cf. also: OLSON, 1995; YOON and HWANG, 1995.) Of the major methods of multi-criteria analysis (MCA) that have been developed so far – the linear additive evaluation model, the Analytical Hierarchy Process (AHP), outranking methods, and models based on fuzzy sets - the linear additive model will be used. This model combines several features that are most useful in supporting decision making: internal consistency, transparency, ease of use, and the ability to provide an audit trail. MCDA methods based on the linear additive model have “a well-established record of providing robust and effective support to decision makers” (DCLG, 2001: 21). They are widely used by governmental agencies at local, regional and central level, in particular in the United States (idem: 39), including the field of land use planning.

5.1 The method

The basic steps of MCDA are: (1) Identification of options; (2) Identification of objectives and indicators; (3) Description of the expected performance of each option against the indicators (description of the indicator values); (4) Scoring of the indicator values; (5) Weighting of the objectives; (6) Derivation of an overall weighted score (“utility value”) for each option by applying a model combining scores and weights; and (7) Sensitivity analysis.

5.2 Options, objectives, and expected indicator values

Steps 1 to 3 have already been done. The options to be appraised (SQ, RL, CG, and SM), the objectives (9 landscape functions) as well as the indicators used to measure them, and the options' expected indicator values, are all given in table 1, columns 1 to 6.

5.3 Scoring the land use options against the landscape functions

The next step is to transform the indicator values into scores (the score representing the relative strength of preference) on a uniform scale from 0 to 1. Transformation was done on the assumption of linearity between indicator values and preference scores; the reason was that for all landscape functions, the differences between the highest and the lowest indicator value are not great enough to suggest diminishing marginal scores. Calculated scores can be seen in table 1, columns 7 to 10.

¹ For a detailed account of these calculations cf. KANTELHARDT, 2003.

5.4 Weighting the landscape functions

The weights given to the landscape functions, or the indicators, are supposed to reflect “the” preferences of the major decision makers and stakeholders of the region. To be more precise, the weight on an indicator should reflect both the range of difference of indicator values between the options, and how much “that difference matters”.² Usually preferences vary considerably from one group of interviewees to another. We organised written interviews of 25 focus persons. Among them, according to their own assessment of their major professional or other involvement, eight persons can be said to belong to the group of “conservationists”, eight to the group of “promoters of regional development”, and nine to the category “agriculturists”. The group of “conservationists” comprises local experts working on nature conservation; they represent the local authorities for nature conservation and water protection, or non-governmental organizations such as the *Bund Naturschutz*. The “promoters of regional development” are professionally engaged in fostering regional development; they work in institutions like the local authority for rural development or the association for local recreation. “Agriculturists” basically represent the interests of farmers; most interviewees come from the regional department of agriculture or the local farmers’ union.

As the interview was conducted in written form it was not possible to use the method of “swing weighting” to elicit the weights from the interviewees.³ However, in the letter accompanying the questionnaire particular care was taken to make clear to the recipients that the weight to be allocated to a landscape function is not supposed simply to reflect the relative importance of the landscape function as such but the relative importance of the difference between the highest and the lowest indicator value (see above).

The result of the interviews is given in table 2. It is evident that the preferences of the “conservationists” and “promoters of regional development” are very similar to one another while at the same time diverging considerably from those of the “agriculturists”. While the latter consider the ecological landscape functions to be much less important than the socio-economic ones, the “conservationists” and “promoters of regional development” value “ecology” more highly than “socio-economy”. Out of the ecological landscape functions, the “agriculturists” value the protection of species and habitats least whereas the two other groups assign

Table 2. Land use options in Bayerisches Donauried: weights of the landscape functions

| Landscape function | Group of interviewees | | | Ø of all interviewees | Ø of the three groups of interviewees |
|------------------------------------|-----------------------|--------------------|--------------------------------------|-----------------------|---------------------------------------|
| | „Con-servati-onists“ | „Agri-cul-turists“ | „Promoters of regional develop-ment“ | | |
| ECOLOGICAL | | | | | |
| Water protection | 0.14 | 0.07 | 0.16 | 0.12 | 0.12 |
| Soil protection | 0.13 | 0.06 | 0.09 | 0.09 | 0.09 |
| Protection of species and habitats | 0.19 | 0.04 | 0.15 | 0.12 | 0.13 |
| Climate protection | 0.06 | 0.05 | 0.08 | 0.07 | 0.07 |
| Protection of resources | 0.08 | 0.06 | 0.09 | 0.07 | 0.07 |
| SOCIO-ECONOMIC | | | | | |
| Maintenance of jobs | 0.09 | 0.18 | 0.09 | 0.12 | 0.12 |
| Maintenance of agricultural income | 0.14 | 0.31 | 0.10 | 0.19 | 0.19 |
| Production of food | 0.12 | 0.17 | 0.18 | 0.16 | 0.16 |
| Reduction of public expenditure | 0.06 | 0.06 | 0.07 | 0.06 | 0.06 |
| TOTAL | | | | | |
| Sum Total | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| of which: | | | | | |
| Ecological | 0.59 | 0.28 | 0.56 | 0.47 | 0.48 |
| Socio-Economic | 0.41 | 0.72 | 0.44 | 0.53 | 0.52 |

Source: authors’ interviews

to this landscape function the highest and second highest importance, respectively. Note that the “reduction of public expenditure” does not play an important role in the minds of any of the three groups. The burden placed by EU agricultural policy on the taxpayer is considered to be largely irrelevant, probably because payments to farms of this region are primarily financed by taxpayers of the *other* regions of the European Union (principle of “financial solidarity”, or – in less euphemistic terms – “externalization of costs”).

In order to determine the “average” weights, for each landscape function two alternative values were calculated: (1) the arithmetic mean of the weights given by all interviewees, and (2) the arithmetic mean of the 3 group weights. The result is given in table 2. Obviously, these averages do not differ much because of the similar size of the three groups. For the subsequent calculations the second value was used.

5.5 Derivation of the utility values of land use options

To derive the utility values of the options, the linear additive utility function was used:

$$(1) \quad U_i = \gamma_1 z_{i1} + \gamma_2 z_{i2} + \dots + \gamma_n z_{in} = \sum_{j=1}^n \gamma_j z_{ij}$$

with $\gamma_1 + \gamma_2 + \dots + \gamma_n = 1$,

where

U_i = total utility of land use option i

γ_j = weight of landscape function j

z_{ij} = score of land use option i concerning landscape function j.

² This means that an indicator (e.g. for the selection of a car) that is widely regarded as “very important” (say safety) will have a similar or lower weight than another “less important” indicator (say maintenance costs). This would be the case if all the options (cars) had a very similar level of the first indicator (safety) but varied widely in the second one (maintenance costs) (DCLG, 2001: 52).

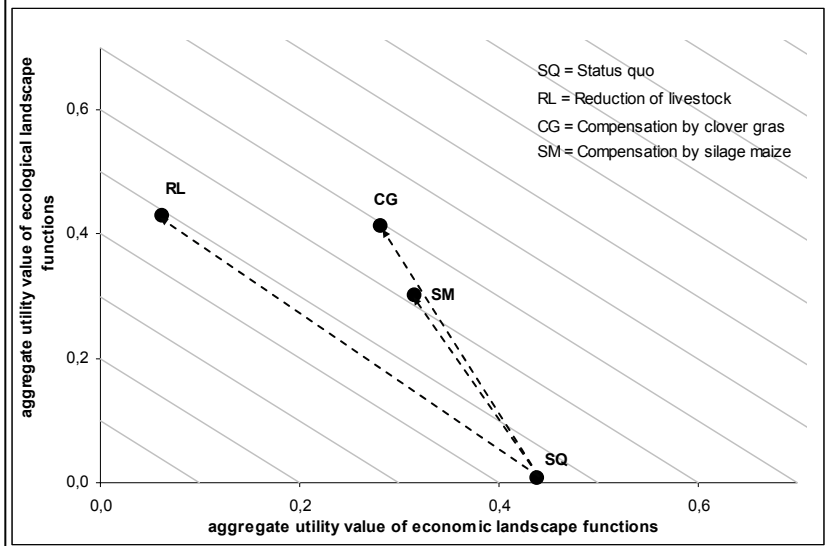
³ cf. EDWARDS and BARRON, 1994. This method serves to find out how, in the interviewee’s mind, the swing from 0 to 1 on the preference scale for one objective (in footnote 2: safety) compares to the 0 to 1 swing for another objective (minimising maintenance costs).

This utility function assumes, for all indicators, mutual preference independence in the sense that the preference scores assigned to all options on one indicator are not influenced by the preference scores on any other indicator. (However, this does not exclude that there may be a causal link or a statistical correlation between the scores on two indicators.) This requirement does not appear to be unrealistic in the case at hand; indeed, it had already governed the choice of landscape functions. As there was agreement that the lower score on one indicator can be compensated by a higher score on another one there was no need to include multiplicative elements in the model.

5.6 Results

The result of these calculations – the *basic solution* – is shown in table 3. Here, the second column gives the above-mentioned weights for the reader’s information. The four next columns, in the two upper parts of the table, show the land use options’ “partial utility values” (the score of the respective landscape function, multiplied by the weight of the latter), and in the lower part give the total utility values, including the sub-aggregates for all ecological and all socio-economic landscape functions. On the basis of the given preference structure, the CG option has the highest total utility value by far, followed by SM. A long way behind comes option RL. The least desirable option is SQ.

Figure 1. Results of the multi-criteria decision analysis, aggregated by classes of landscape functions



Source: authors’ representation

Figure 1 serves to interpret this result. The diagonal lines are “iso total utility lines”. If farmers change from the traditional mode of cultivation to one of the three other options this will in every case lead to (a) a gain in aggregate utility from the ecological landscape functions and (b) a – less pronounced – loss of aggregate utility from the socio-economic landscape functions (simply called “economic landscape functions” in the figure). The net effect, however, is strongest when the mode of cultivation is changed to option CG.

When comparing the three land use options we notice two things. First, changing from RL to CG implies a considerable increase in the aggregate utility derived from the socio-economic landscape functions (the rise in public expenditure being of little effect) while causing relatively little harm to aggregate ecological landscape functions; for option CG has lower scores regarding the protection of the atmosphere and of resources but higher ones concerning the protection of water and the soil). Second, changing from CG to SM would again benefit the socio-economic objectives, but this would be more than offset by the harmful effects on the ecological ones.

5.7 Sensitivity analysis

To obtain a more differentiated picture the model was also run for each of the three groups of interviewees separately. The results are shown in figure 2. The “conservationists” would have the highest preference for option CG, and would consider SQ to be by far the most undesirable one. The same goes for the “promoters of regional development”. In contrast, the “agriculturalists” would rank SQ highest; in their view, RL would be by far the most unfavourable one.

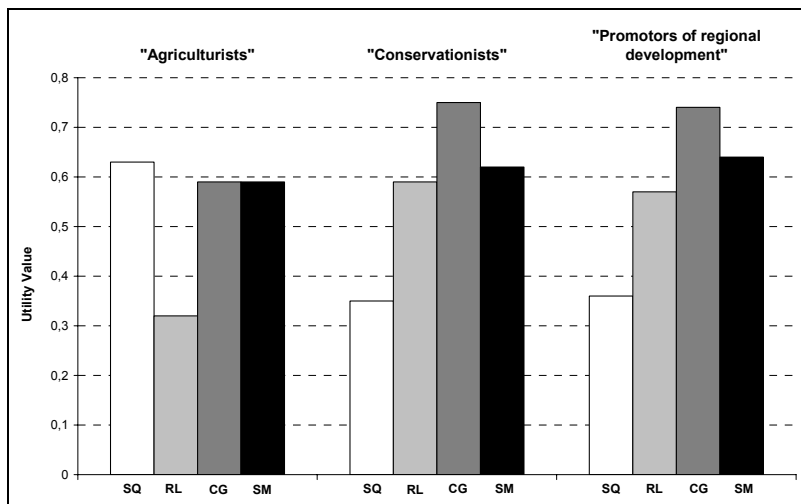
The difference between the two views is illustrated by figure 3. From the conservationists’ point of view, moving from SQ to any of the other three options brings about positive ecological effects that outweigh the negative socio-economic ones so much that total utility increases. The reverse is true for the agricultural

Table 3. Land use options in Bayerisches Donauried: Results of the multi-criteria decision analysis (basic solution)

| Landscape function | Weight | Utility values of option ... | | | |
|------------------------------------|--------|------------------------------|--------|--------|-------|
| | | ... SQ | ... RL | ... CG | ...SM |
| ECOLOGICAL | | | | | |
| Water protection | 0.12 | 0.00 | 0.09 | 0.12 | 0.09 |
| Soil protection | 0.09 | 0.01 | 0.08 | 0.09 | 0.00 |
| Protection of species and habitats | 0.13 | 0.00 | 0.13 | 0.13 | 0.13 |
| Climate protection | 0.07 | 0.00 | 0.07 | 0.03 | 0.03 |
| Protection of resources | 0.07 | 0.00 | 0.07 | 0.05 | 0.06 |
| SOCIO-ECONOMIC | | | | | |
| Maintenance of jobs | 0.12 | 0.10 | 0.00 | 0.12 | 0.11 |
| Maintenance of agricultural income | 0.19 | 0.19 | 0.00 | 0.03 | 0.09 |
| Production of food | 0.16 | 0.16 | 0.00 | 0.08 | 0.10 |
| Reduction of public expenditure | 0.06 | 0.00 | 0.06 | 0.05 | 0.02 |
| TOTAL | | | | | |
| Sum Total | 1.00 | 0.44* | 0.49 | 0.69 | 0.62 |
| of which: | | | | | |
| Ecological | 0.48 | 0.01 | 0.43 | 0.41 | 0.30 |
| Socio-economic | 0.52 | 0.44 | 0.06 | 0.28 | 0.32 |

* Rounding error
 SQ = Status Quo – RL = reduction of livestock – CG = compensation by clover-grass - SM = compensation by silage maize
 Source: authors’ calculation

Figure 2. Utility values of land use options, by group of interviewees



Annotation: SQ = Status Quo - RL = reduction of livestock - CG = compensation by clover grass - SM = compensation by silage maize

Source: authors' representation

point of view, which assigns to the socio-economic objectives a much higher priority so that total utility goes down as a consequence of any change away from SQ. From this standpoint, option RL is particularly harmful because it is here that the negative socio-economic effects are most pronounced.

These considerations suggest that the results of the basic solution were largely determined by the weighting of the three groups' preference structures, which was one third each and implies an aggregate weight of 0.48 for the ecological landscape functions (cf. table 2). Performing a sensitivity analysis in which the weight of the "agricultural" preference structure is systematically raised (postulating an equal weight for each of the two other groups), we obtain the results summarised in table 4: Over a wide range, CG remains at the top. Only if the "agricultural" preference structure is assigned a weight of more than 0.9 (which implies an aggregate weight of less than 0.31 for all ecological

existing setup of agri-environmental policy, this would imply that farmers who change to the clover grass option need to be given financial compensation under a regional agri-environmental programme that supplements the one of the federal state of Bavaria (which is co-financed by the EU). The question which of the existing regional funds could – or should – be tapped for this purpose has been discussed among regional actors from the beginning of the discussion of the ecology-oriented land use concept. One idea is to use the regional fund which is financed by the federal state *Baden-Württemberg* and aimed to compensate the negative ecological effects of the withdrawal of drinking water. The wider objective of this fund is to contribute to the conservation and development of the riparian landscape along the Danube. For this purpose, the region has established a working committee of regional actors such as farmers, conservationists, local communities and water suppliers (ARGE DONAUMOOS, 2006).

Table 4. Land use options in Bayerisches Donauried: sensitivity analysis - influence of the weight assigned to the group "agriculturists" on the ranking of the land use options

| Weight of group „Agriculturists“ * | Rank of land use option ... | | | | Weight of the ecological landscape functions |
|------------------------------------|-----------------------------|--------|--------|--------|--|
| | ... SQ | ... RL | ... CG | ... SM | |
| 0.33 | 4 | 3 | 1 | 2 | 0.48 |
| 0.40 | 4 | 3 | 1 | 2 | 0.46 |
| 0.50 | 3 | 4 | 1 | 2 | 0.43 |
| 0.80 | 3 | 4 | 1 | 2 | 0.34 |
| 0.90 | 2 | 4 | 1 | 3 | 0.31 |
| 0.95 | 1 | 4 | 3 | 2 | 0.30 |
| 1.00 | 1 | 4 | 3 | 2 | 0.28 |

* Assumption: equal weight for the groups "Conservationists" and "Promoters of Regional Development"

SQ = Status Quo – RL = reduction of livestock – CG = compensation by clover-grass - SM = compensation by silage maize

Source: authors' calculation

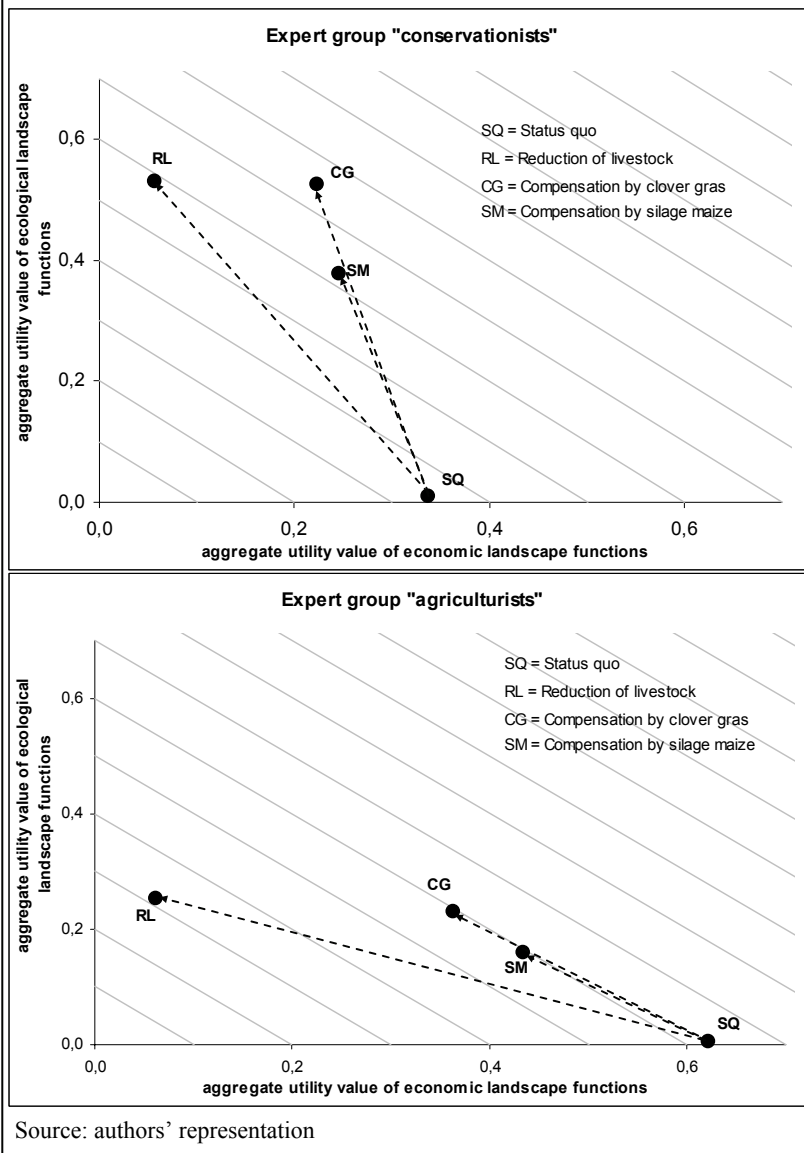
6. Policy implications

As mentioned above, most probably the *Donauried* farmers' production response to the conservation-oriented measures would be to expand the cultivation of maize on the remaining arable land. On the basis of our MCDA, however, the socially "optimal" response would consist in the expansion of the cultivation of clover grass. If these results are accepted, agri-environmental policy should aim to contribute to the realisation of such a desirable development. This applies even after the recent reform of the CAP as the competitiveness of silage maize still exceeds that of clover grass.

To the extent that the allocation of property rights remains unchanged, and given the existing setup of agri-environmental policy, this would imply that farmers who change to the clover grass option need to be given financial compensation under a regional agri-environmental programme that supplements the one of the federal state of Bavaria (which is co-financed by the EU). The question which of the existing regional funds could – or should – be tapped for this purpose has been discussed among regional actors from the beginning of the discussion of the ecology-oriented land use concept. One idea is to use the regional fund which is financed by the federal state *Baden-Württemberg* and aimed to compensate the negative ecological effects of the withdrawal of drinking water. The wider objective of this fund is to contribute to the conservation and development of the riparian landscape along the Danube. For this purpose, the region has established a working committee of regional actors such as farmers, conservationists, local communities and water suppliers (ARGE DONAUMOOS, 2006).

In the long run, however, the question arises as to the desirability of a general regionalisation of agri-environmental policy, including the agri-environmental programmes of the federal states. In the case of the *Bayerisches Donauried*, where an ecologically very valuable and at the same time highly sensitive agricultural landscape is concerned, it seems evident that the regional land use concept requires the concrete agri-environmental measures to be tailored to the needs of the region, including the surrounding land that is occupied by the same farms. For agricultural landscapes with a similarly remarkable ecological value and sensitivity, concepts for changes in land use could also be tailor-made - a process that has already begun. In a similar way, MCDA can be used in these regions to assist decision makers (HORLITZ et al., 2004). Whether agri-environmental policy should generally be regionalised, even beyond the particular agricultural landscapes mentioned above, is a more complex question that involves many cost benefit

Figure 3. Results of the multi-criteria decision analysis for the groups “conservationists” and “agriculturists”, aggregated by classes of landscape functions



aspects, including transaction costs, that are beyond the scope of this paper.

It is clear, however, that in the long run the development of land use concepts for agricultural landscapes should be geared to, or part of, the process of rural development planning. If integrated rural development planning is to play a greater role in the European Union in the future, the question of a vertical redistribution of public budget resources, from the supra-national and national level to the regional and local one, should be raised. In this context, the funds for agri-environmental programmes would also be regionalised. One advantage would be a more efficient allocation of these funds to – now tailor made – agri-environmental measures. Furthermore, under this approach it would be logical to transform such *sectoral* funds into *regional* ones, which would give a greater chance to competing non-agricultural land uses such as reforestation or the creation of local recreation infrastructure. This would contribute to the generalization of the European Union's LEADER approach that has been suggested by several authors (for example BAUER, 2006).

Returning to the role of multi-criteria decision analysis in agricultural landscape planning, it should be re-emphasised that the aim of MCDA is not to make the decision but to assist policy makers in the process of decision-making. It may be said in passing that the same goes for other evaluation methods like conjoint analysis (CA) and discrete choice experiments (DCE) that may also contribute to the development of land use concepts.⁴ The purpose of MCDA is to clarify the possible consequences of alternative options, to reveal conflicts between objectives, and to prepare the ground for the selection of the most desirable option. In this context, our study has highlighted two aspects that are of particular relevance in agricultural landscape planning. First, when, assessing the consequences of – essentially site-specific – nature conservation measures, it is important to account for the farmers' production responses *in the surrounding areas* since these might offset, at least partially, the positive ecological on-site effects. Second, it can be useful to *differentiate between different groups of stakeholders* as this may help reveal conflicts between their preferences; the insights gained in this way can be used in the moulding of the land use concept, at least in the stage of fine-tuning the conservation and agri-environmental measures.

Finally, if MCDA is to be used more widely in agricultural landscape planning, one question needs further consideration: in the process of developing the land use concept, what should be the role of politicians, scientists, engineers, experts, administrators, and stakeholders? And who is to decide on (1) the selection of the land use functions and the relevant indicators, and (2) the choice of the stakeholders and experts to be interviewed?⁵

viewed?⁵ In the case of the land use concept for the *Bayerisches Donauried*, the MCDA was performed by the authors, on the basis of several scientific analyses and region-wide discussions between the above-mentioned groups. The results will be made available to decision makers. The first feedback we received from local actors is very encouraging. Clearly, MCDA could be even more useful if political decision makers explicitly commissioned a group of researchers, experts and stakeholders to work out the input, and if – in analogy to the procedure practised by KIRSCHKE et al. (2004) to determine the optimal allocation of funds earmarked for agri-environmental programmes –

⁴ For the parallel use of the linear additive MCDA model and adaptive conjoint analysis (ACA) cf. HORLITZ et al. (2004), and AHRENS and HARTH (2004).

⁵ Obviously, the answer to this question has a certain bearing on the procedures to be used in MCDA. For example, if local actors are to be integrated systematically in the selection of the landscape functions, it would be useful to apply the repertory grid method (for this method, cf. FRANSELLA et al., 2003).

they then took an active part in MCDA, working together with the researchers. One of the advantages of MCDA is that decision makers can easily understand its logic. Their own preferences would be included in the planning process at an earlier stage. And they would tend to be committed more deeply to the ultimate concept and more motivated to seek the necessary ways and means for its implementation.

References

- AHRENS, H. und M. HARTH (2004): Präferenzanalyse mit der Adaptiven Conjoint-Analyse (ACA). In: Wycisk, P. und M. Weber (Hrsg.): Integration von Schutz und Nutzung im Biosphärenreservat Mittlere Elbe - Westlicher Teil. Weißensee Verlag, Berlin.
- ARGE DONAUMOOS (Arbeitsgemeinschaft Schwäbisches Donaumoos e.V.) (2006): Informationsseite zur Arbeitsgemeinschaft Schwäbisches Donaumoos e.V. URL am 8.8.2006: http://www.arge-donaumoos.de/infoseite_arge.html.
- BAUER, S. (2006): Back to principles. Dezentralisierung und Neuausrichtung der ländlichen Regionalpolitik. In: Agrarwirtschaft 55 (3): 137-141.
- DE GROOT, R. (1992): Functions of Nature – Evaluation of nature in environmental planning, management and decision making. Wolters-Noordhoff, Groningen.
- DCLG (Department for Communities and Local Government) (2001): Multi-criteria Analysis. URL on 1.8.2006: <http://www.communities.gov.uk/index.asp?id=1142251>.
- EDWARDS, W. and F.H. BARRON (1994): SMARTS and SMARTER: improved simple methods for multiattribute utility measurement. In: Organizational Behaviour and Human Decision Processes 60 (4): 306-325.
- FRANSELLA, F., R. BELL and D. BANNISTER (2003): A Manual for Repertory Grid Technique. 2nd ed. Wiley, Chichester.
- HOFFMANN, H. und J. KANTELHARDT (2003): Gesamtökologisches Gutachten Donauried - Wirtschaftliche Folgen für die Landwirtschaft. In: Landnutzung und Landentwicklung 44 (3): 108-113.
- HORLITZ, Th., H. AHRENS, M. HARTH, D. HILLERT und A. SANDER (2004): Nutzwertanalytische Betrachtung der Szenarien. In: Wycisk, P. und M. Weber (Hrsg.): Integration von Schutz und Nutzung im Biosphärenreservat Mittlere Elbe - Westlicher Teil. Weißensee Verlag, Berlin: 175-187.
- KANTELHARDT, J. (2003): Perspektiven für eine extensive Grünlandnutzung. Modellierung und Bewertung ausgewählter Landnutzungsszenarien. Sonderheft Agrarwirtschaft 177. Agrimedia, Bergen/Dumme.
- KANTELHARDT, J. und H. HOFFMANN (2001): Ökonomische Beurteilung landschaftsökologischer Auflagen für die Landwirtschaft - dargestellt am Beispiel Donauried. In: Berichte über Landwirtschaft 79 (3): 415-436.
- KEENEY, R.L. and H. RAIFFA (1976): Decisions With Multiple Objectives: Preferences and Value Tradeoffs. John Wiley, New York, reprinted, Cambridge University Press, 1993.
- KIRSCHKE, D., A. HÄGER, K. JECHLITSCHKA and S. WEGENER (2004): Priority Setting for Rural Development: An Interactive PC-Based Programming Approach. In: Petrick, M. and P. Weingarten (eds.): The Role of Agriculture in Central and Eastern European Rural Development: Engine of Change or Social Buffer? Studies on the Agricultural and Food Sector in Central and Eastern Europe. Vol. 25. Institute of Agricultural Development in Central and Eastern Europe – IAMO, Halle (Saale): 398-412.
- OLSON, D. (1995): Decision Aids for Selection Problems. Springer, New York.
- YOON, K.P. and C.L. HWANG (1995): Multi-Attribute Decision Making. Sage, Beverly Hills.
- ZETTLER, L., B. MUNZ, R. HETTRICH, A. WINTERHALTER, C. HÄFNER, B. SPRENGER and J. BILLWITZ (1999): Gesamtökologisches Gutachten Donauried. Unveröffentlicht.

Acknowledgement

The authors wish to thank two anonymous referees for helpful comments on an earlier version of this paper.

Corresponding author:

PROF. DR. HEINZ AHRENS

Martin-Luther-Universität Halle-Wittenberg, Faculty of Agriculture,
Department of Agricultural Economics and Rural Planning
06099 Halle (Saale)

phone: 03 45-55 22 400, fax: 03 45-55 27 112

e-mail: heinz.ahrens@landw.uni-halle.de