Presented at:
The Agricultural Economics Society's 81st Annual Conference, University of Reading, UK 2nd to 4th April 2007

Integrating Ecological And Economic Aspects In Land Use Concepts.

Some Conclusions From A Regional Land Use Concept For *Bayerisches Donauried*

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Abstract

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 on the land use in the southern German region *Bayerisches Donauried*, (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 analysis (MCA) can be used to transform a primarily ecology-oriented land use 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 such integration of socio-economic objectives can contribute to the maintenance of incomes and employment without overly harming the attainment of ecological goals.

As far as the MCA is concerned, two methods are applied: The linear-additive model, and the outranking model ELECTRE. The models serve to evaluate four different land use options. Nine criteria are used, derived from the relevant landscape functions. Weights are based on written interviews with major decision-makers, and stakeholders of the region. The major assumptions underlying the models are discussed. The authors interpret the results of each model on the basis of sensitivity analyses, and compare them.

Finally, the paper discusses policy implications resulting from the implementation of land use concepts for agricultural landscapes, in particular the question of a "regionalisation" of agri-

environmental policy, and raises some administrative and practical issues that come up if policy makers apply MCA more widely in the design of such concepts.

1. Introduction

Land use planning for agricultural landscapes plays an increasing role in European countries. This is largely due to the growing awareness of the externalities involved in the private and public use of such landscapes. The paper discusses the application of an regional, ecology-oriented land use concept, which has been designed for the Bayerisches Donauried region. The focus of the paper is on two issues, namely (1) the practical one of the "optimal" and intensity pattern of land use in the region, and (2) the theoretical one of the methods to be used for such planning.

As methods for analysing the consequences of the application of the ecology-oriented land use concept, we apply two different approaches from multi-criteria decision analysis, the (a) linear-additive model, and the (b) outranking model ELECTRE. Both methods serve to evaluate four different land use scenarios, using criteria mainly derived from landscape functions and weights gained from interviews with major stakeholders. Section 2 hereby analyses problems and options of land use in the region under study. In section 3 we apply the two different methods of multi-criteria decision analysis. Section 4 draws some conclusions regarding the desing of a landscape concept for a primarily agricultural landscape.

2. Problems and options of land use in *Bayerisches Donauried*

In the following we briefly present the study region *Bayerisches Donauried* and characterise the problems and options of land use. In particular we provide information about the historical development of its land use and the current situation. The chapter is mainly based on studies published by ZETTLER et al., 1997, KANTELHARDT and HOFFMANN (2001) and HOFFMANN and KANTELHARDT (2003).

Background

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. 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. 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 21.5 million m^3 of ground water per year by the Water Authority Stuttgart plays a particularly important role. Finally, the region is of central importance for local recreation.

Public Action

On the basis of a profound analysis of the region's ecological status and its problems, and in-depth discussions among experts, administrators, researchers and decision makers, public action is being considered necessary. The most important ecological objectives are (a) the reestablishment of the natural floodplain dynamics, (b) the protection of the remaining fen areas, and (c) the improvement of the living conditions of meadow birds.

Public action is to consist mainly in a bundle of conservation-oriented measures aimed to bring about the required changes in land use.. Most of these measures pertain to the entire *Bayerisches Donauried* 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 increased. At the same time living conditions of meadow birds are to be improved by subjecting farmers to legal requirements concerning mowing 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*.

Farmers' responses

Farmers' responses to these problems have an important bearing on the success of the measures mentioned above. responses to these problems. 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 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 profitable 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.

3. Multi-criteria decision analysis

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 silage maize. The problem is that this would considerably counteract the ecological objectives of the ecology-oriented land use concept. From a political point of view, the question is a normative one: Which of the uses of agricultural landscape is best for the region as a whole, from an overall welfare point of view, taking into account relevant ecological and socio-economic effects? What follows is the authors' contribution to the decision-making process which is under way in the region.

In the following we will use multi-criteria decision analysis (MCDA) to evaluate the above-mentioned land use options. MCDA is aimed to serve, in the context of complex problems, as an aid to thinking and decision making. (For the classical exposition of MCDA cf. KEENEY and RAIFFA, 1976; cf. also: OLSON, 1995; YOON and HWANG, 1995). The most important methods of multi-criteria decision analysis (MCDA) are: (a) the Linear additive model, (b) the Analytical Hierarchy Process (AHP), (c) Outranking methods, and (d) models based on fuzzy sets.

In the following, we will use method (a) and from method (b) the most widely used model, ELECTRE II. In spite of their differences, both require the definition of (1) options and (2) criteria as well as the quantification of (3) performance values.

Land use options

Three of the possible land use options have been mentioned above. Theoretically at least, there is a fourth one, namely the total rejection of the ecological measures. Therefore, the foolowing four options will be evaluated:

(1) "Status Quo" (SQ): Continuation of the traditional mode of cultivation, without applying the conservation-oriented measures.

(2) "Reduction of livestock" (RL): Implementation of the conservation-oriented measures, 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.

Criteria

To define the criteria, 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. They were chosen mainly on the basis of the services rendered to society by the region's land use and land use objectives. 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 production of drinking water. *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 being 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. *Maintenance of employment* is an important objective in the region, to which agriculture may make a certain - though modest - modest contribution. The *maintenance of agricultural income* is a highly valued objective in the region, the consensus going far beyond the agricultural sector. 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.

Performance values

The ecological and socio-economic effects of the four land use options (the perfomance, or 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. Indicator values were determined by KANTELHARDT (2003) 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.

4. The linear-additive model

Methodology

The "best" options is the one with the highest utility value. To derive the latter, the linear additive utility function was used:

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

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

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.

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 the 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.

Scoring

The next step is to transform the indicator values into scores 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.

Weighting

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".[1] 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".

[1] 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).

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.[2] 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". 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, the arithmetic mean of the 3 group weights was used. The result is given in table 2.

Results

The result of the calculations – the *basic solution* - is shown in table 3. 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 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.

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[2] 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).

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.

Group preferences

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 "agriculturists" 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 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 landscape functions), then option SQ becomes the "optimal" one. Evidently, with respect to the weighting of the landscape functions the results are rather robust.

5. ELECTRE II

Methodology

The aim of this method is to rank options from best to worst. Technically speaking, the objective is to be able to obtain a subset N of options such that any option which is not in N is outranked by at least one option of N. N will be made as small as possible. To each ordered pair of options (*a,b*) is also associated a concordance index "that can be seen as measuring the arguments in favour of '*a* outranks *b*' " and a discordance index that may shed some doubt upon the latter statement" (VINCKE, GASSNER, 1992).

Combing the concordance and discordance matrix

Assuming that the weights used in the linear-additive model also reflect the absolute importance of the landscape functions, the concordance matrix for the four land use options discussed in this paper is given in table 5. The concordance index for option RL as compared to SQ (0.54) was calculated as the sum total of the weights of those landscape functions where RL performs better than SQ (0.54=0.12+0.09+0.13+0.07+0.07+0.06; cf. tables 1 and 2). Tables 6 and 7 show the normalized indicator values and the discordance matrix derived from them. The discordance index for RL as compared to SQ (0.022) is the maximum normalized disadvantage of RL as against SQ (agricultural income; cf. table 1 and 6). The two matrices were combined in the following way: For the concordance indices, two thresholds, a strong and a weak one, were set: As the average concordance index is 0.47, the strong threshold was set at a higher level (0.52), and the weak one at a lower one (0.42). The discordance index threshold was set at 0.022 which is the average discordance index. To derive the ranking, the usual procedure (ROY and BERTIER, 1971, 1973) was applied: Determine set B of options which are not strongly outranked by any other option; inside that set, determine the set A^1 of options which are not weakly outranked by any other option of B. Define set A^1 as the first class of the ranking and start the procedure again in the remaining set, thereby obtaining a complete preorder v'. Build a second complete preorder v'' in an analogous way but starting with the class of worst options (those which outrank no other option). If the two preorders are not the same but relatively close, suggest a "median preorder" (ROY and BERTIER, 1971) to the decision-maker.

Results

The ranking obtained for our four land use options is shown in the second row of the first column in table 8. Option CG ranks first, SM and RL third, and option SQ comes last. Next, in a kind of sensitivity analysis, the discordance threshold was changed to the weaker level of

0.027 and then to 0.032. It can be seen that the result besomes more differentiated. Note that this ranking is identical with the one derived with the linear-additive model.

In analogy to the linear-additive model, the ranking was calculated for each of the three interest groups, taking into account their specific preferences (weights) for the various landscape functions. The groups' concordance matrices are given in table 9. The resulting rankings are shown in columns 2 to 4 in table 8. For the conservationists and the promotors of regional development we obtain the same rankings as in the linear-additive model. Here again, the lowering of the discordance requirement reveals the difference between options SM and RL.

However, for the group of agriculturists we obtain a ranking which is very different from the one derived from the linear-additive model: As compared to the latter, SQ has dropped from the first to the last rank, and CG has moved from the middle position up to the first or second one.

The reason for this may partly lie in the fact that the discordance index, which is based solely on the physical effects of the options and is thus identical for all groups, do not reflect the latter's diverging preferences for the landscape functions. The matrix of *weighted* discordance indices is given in table 10. Table 11 shows the resulting ranking. The one for the agriculturists is now very close to the one of the linear-additive model.

One may wonder why, for the entire group ("Total"), options RL and SQ now take the same rank. A closer look reveals that under a pairwise comparison of the two, RL is superior to SQ, both with respect to the concordance and the discordance index (cf. tables 5 and 10a); however, RL's discordance index does not meet the reqirements of the thresholds used. If one loosens this requirement further (to 0.041, cf. table 10a), then option RL will dominate SQ.

It might be suggested that the rankings under ELECTRE II get even closer to those of the linear-additive model if the discordance index was no longer defined as the absolute value of the maximum differentiated performance but as the absolute value of the sum of differentiated performance. The idea that decision-makers might prefer to use the latter was first presented by HUNAG and CHEN (2005). However, in the case of our study the results were exactly identical. It seems that differences in rankings between the two methods are partly due to the fact that the concordance index does not account for the extent of the differences in indicator values.

6. Conclusions

Three kinds of conclusions can be drawn from the case study presented above: (1) Those on the specific aspects of *agricultural* landscapes as objects of land use planning; (2) those on the relative suitability of the two MCDA tools discussed above, and (3) those on the policy implications of using *regional* concepts as a tool of agricultural landscape planning.

(1) As our study has shown, when we assess the consequences of – essentially site-specific – nature conservation measures, it is important to account for the farmers' production responses in the surrounding areas. For these might offset, at least partially, the positive ecological on-site effects. Secondly, in assessing the strength of regional preferences for landscape functions it is useful to differentiate between different groups of stakeholders, in particular "conservationists" and "agriculturists". This will help reveal conflicts between them. 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 concrete conservation and agri-environmental measures.

(2) The linear-additive model and ELECTRE II yielded fairly similar results with respect to the ranking of the land use options. Each of the two methods has its strengths and weaknesses, both from the analytical and the practical point of view. However, when it comes to contributing to land use planning for agricultural landscapes, the linear-additive model appears to be particularly suitable. It combines several features that are most useful in supporting this type of planning: internal consistency, transparence, ease of use, and the ability to provide an audit trail. Furthermore, with the linear-additive model it is possible to differentiate the results between different groups of indicators. In our case this feature did allow to show transparently the weighting of ecological and economic aspects. All these features are of particular importance when regional landscape concepts are developed in a participatory way, actively involving stakeholders whose preferences are very divergent, and where political and administrative decision makers take part in the process from the very beginning.

(3) On the basis of our MCDA the socially "optimal" farmer response to the conservation-oriented measures would not be to expand the cultivation of maize but to go for the production of additional clover grass, on the remaining arable land. If these results are accepted, agri-environmental policy should aim to contribute to the realisation of such a desirable development. 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 less profitable option need to be given financial compensation under a *regional*

agri-environmental programme that supplements the one of the federal state or the national government (which is co-financed by the European Union). Here the question of financing arises.[3]

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 or national states. In a region like 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. 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. Whether agri-environmental policy should *generally* be regionalised is a more complex question that involves many cost benefit 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, building on the the basic LEADER approach, 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.

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[3] In the region under study, the question which of the existing regional funds could - or should - be tapped for this purpose has been discussed among regional actors from the very beginning. 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).

References

Ahrens, H., Harth, M., 2004. Präferenzanalyse mit der Adaptiven Conjoint-Analyse (ACA). In: Integration von Schutz und Nutzung im Biosphärenreservat Mittlere Elbe - Westlicher Teil, Hrsg.: Wycisk, P. , Weber, M., Weißensee, Berlin, pp. 187-198.

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., Barron, F.H., 1994. SMARTS and SMARTER: improved simple methods for multiattribute utility measurement. Organizational Behaviour and Human Decision Processes, 60, pp. 306-325.

Hoffmann, H., Kantelhardt, J., 2003. Gesamtökologisches Gutachten Donauried - Wirtschaftliche Folgen für die Landwirtschaft. Landnutzung und Landentwicklung 44 (3), Blackwell, Berlin, pp. 108-113.

Horlitz, Th., Ahrens, H., Harth, M., Hillert, D., Sander, A., 2004. Nutzwertanalytische Betrachtung der Szenarien. In: Integration von Schutz und Nutzung im Biosphärenreservat Mittlere Elbe - Westlicher Teil, Hrsg.: Wycisk, P. , Weber, M., Weißensee, Berlin, pp. 175-187.

Huang, W.C., Chen,C.H., 2005. Using the ELECTRE II Method to Apply and Analyze the Differentiation Theory. Proceedings of the Eastern Asia Society for Transportation Studies, Vol. 5, pp. 2237-2249.

Kantelhardt, J., 2003. Perspektiven für eine extensive Grünlandnutzung. Modellierung und Bewertung ausgewählter Landnutzungsszenarien. Sonderheft Agrarwirtschaft 177. Bergen/Dumme, 272 pp.

Kantelhardt, J., Hoffmann, H., 2001. Ökonomische Beurteilung landschaftsökologischer Auflagen für die Landwirtschaft - dargestellt am Beispiel Donauried. Berichte über Landwirtschaft 79 (3), pp. 415-436.

Keeney, R.L., Raiffa, H., 1976. Decisions With Multiple Objectives: Preferences and Value Tradeoffs, John Wiley, New York, reprinted, Cambridge University Press, 1993.

Olson, D., 1995. Decision Aids for Selection Problems, Springer, New York.

Roy, B., Bertier, P., 1971. La méthode ELECTRE II. Working Paper 142, SEMA.

Roy, B., Bertier, P., 1973. La méthode ELECTRE II. Une application au média-planning. OR 72, M. Ross (ed.), North-Holland, pp. 291-302.

Vincke, P., Gassner, M., 1992. Multicriteria Decision-Aid. John Wiley, Chichester.

Yoon, K.P., Hwang, C.L., 1995. Multi-Attribute Decision Making, Sage, Beverly Hills.

Zettler, L., Munz, B., Hettrich, R., Winterhalter, A., Häfner, C., Sprenger, B., Billwitz, J., 1997. Gesamtökologisches Gutachten Donauried, Entwurf - Stand Juli 1997. Memmingen, 372 p.

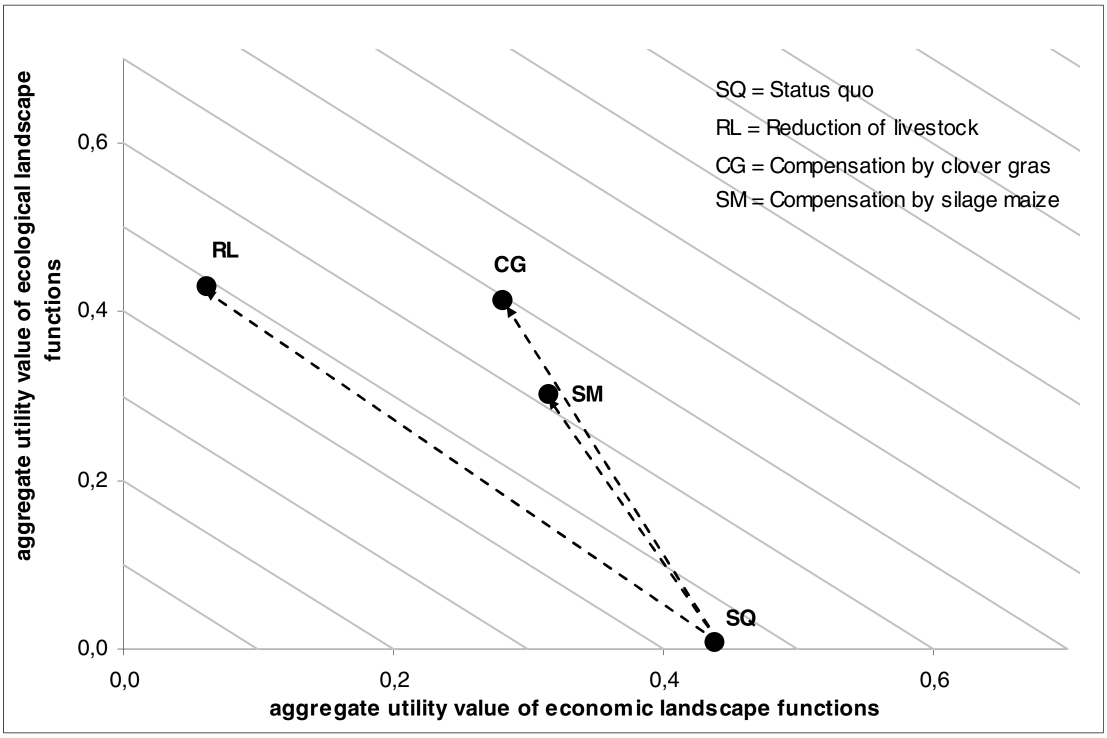
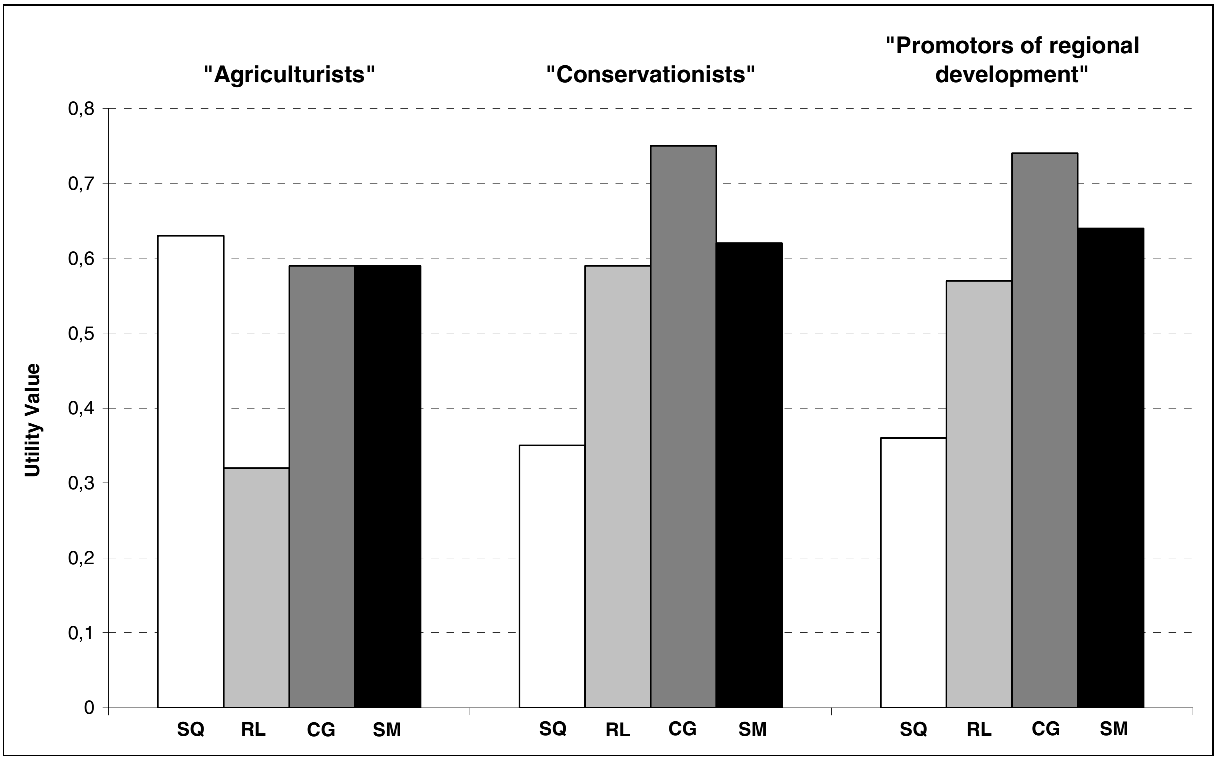


Figure 1: Results of the multi-criteria analysis, aggregated by classes of landscape functions



Annotation: SQ = Status Quo; RL = Reduction of livestock; CG = Compensation by clover grass; SM = Compensation by silage maize

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

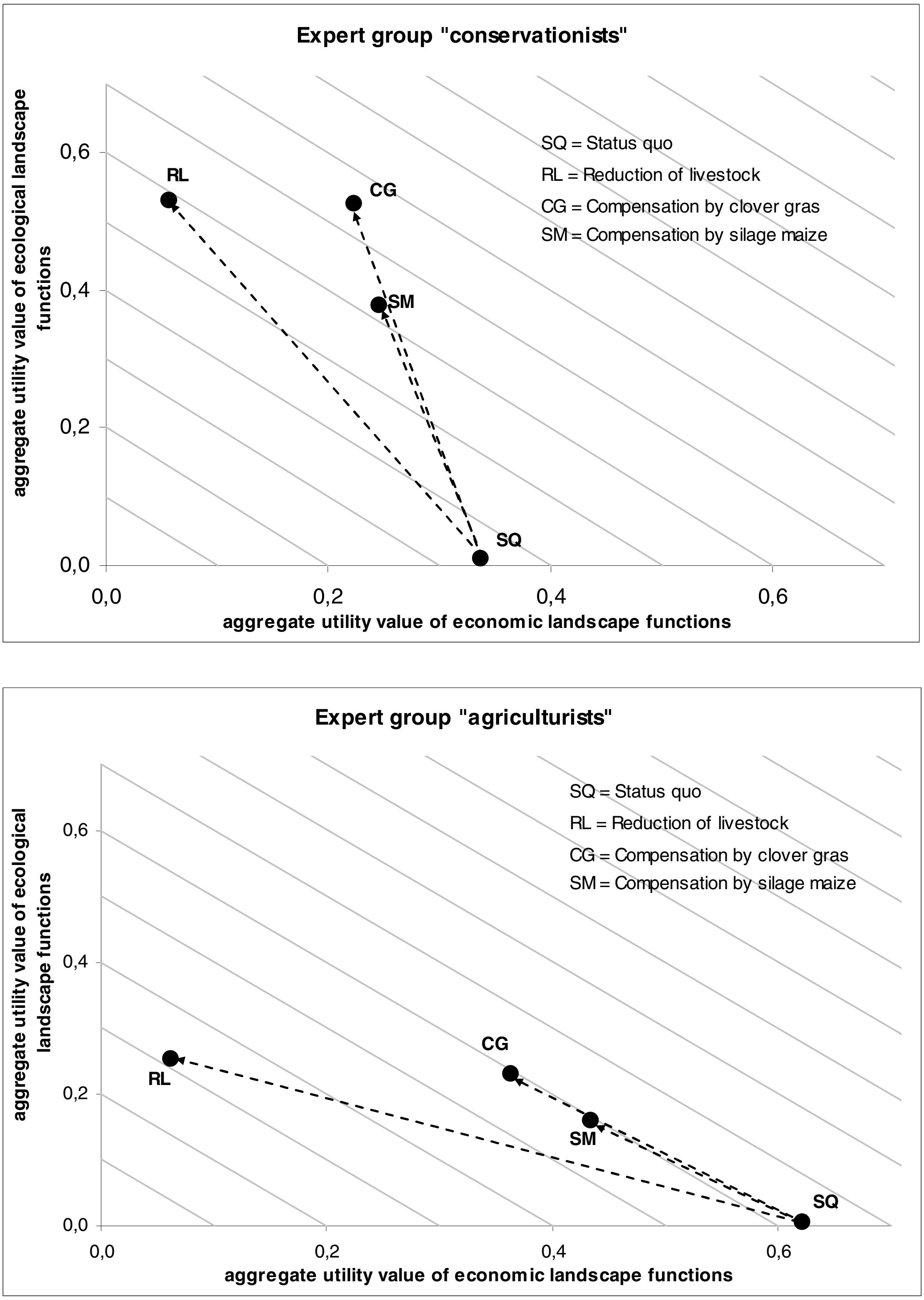


Figure 3: Results of the multi-criteria analysis for the groups "conservationists" and "agriculturists", aggregated by classes of landscape functions

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) PSM use (t active component)	2 825 21.5	2 589 19.7	2573 18.2	2604 19.2	0.00 0.00	0.94 0.54	1.00 1.00	0.88 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.

Presented at:

The Agricultural Economics Society's 81st Annual Conference, University of Reading, UK

2nd to 4th April 2007

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-servatio-nists“	„Agricul-turists“	„Promoters of regional development“		
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

Presented at:

The Agricultural Economics Society's 81st Annual Conference, University of Reading, UK

2nd to 4th April 2007

Table 3: Land use options in *Bayerisches Donauried*: Results of the Multi-criteria 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.

Presented at:

The Agricultural Economics Society's 81st Annual Conference, University of Reading, UK

2nd to 4th April 2007

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.

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2nd to 4th April 2007

Table 5: Land use options in *Bayerisches Donauried*:

Concordance matrix

	SQ	RL	CG	SM
SQ		0.46	0.34	0.43
RL	0.54		0.20	0.35
CG	0.66	0.67		0.46
SM	0.57	0.52	0.41	

Table 6: Land use options in *Bayerisches Donauried*:

Normalized performance values

Landscape function	Land use option			
	SQ	RL	CG	SM
Water protection	0.270	0.248	0.237	0.245
Soil protection	0.262	0.240	0.235	0.264
Protection of species and habitats	0.278	0.241	0.241	0.241
Climate protection	0.259	0.239	0.251	0.251
Protection of resources	0.260	0.243	0.249	0.247
Maintenance of jobs	0.252	0.240	0.255	0.253
Maintenance of agricultural income	0.263	0.241	0.244	0.252

Production of food	0.259	0.239	0.250	0.252
Reduction of public expenditure	0.260	0.241	0.245	0.254

Source: Table 1

Table 7: Land use options in *Bayerisches Donauried*:

Discordance matrix

	SQ	RL	CG	SM
SQ		0.037	0.037	0.037
RL	0.022		0.014	0.013
CG	0.019	0.012		0.007
SM	0.011	0.024	0.028	

Table 8: Land use options in *Bayerisches Donauried*: Ranking of options[a]

Discordance index threshold	Total	Conservationists	Agriculturists[b]	Promotors of regional development
0.022	CG-SM,RL-SQ	CG-SM,RL-SQ	*CG-RL,SM-SQ*	CG-SM,RL-SQ
			CG-SM-RL,SQ	
			CG-SM-RL-SQ	
0.027	CG-SM-RL-SQ	CG-SM-RL-SQ	CG-SM-RL,SQ	CG-SM-RL-SQ
0.032	CG-SM-RL-SQ	CG-SM-RL-SQ	*SM-CG-RL,SQ*	CG-SM-RL-SQ
			CG,SM-RL,SQ	
			SM-CG-RL,SQ	

[a] Concordance index thresholds: 0.52 (strong) - 0.42 (weak).

[b] In the case of three rankings the upper one is preorder v', the middle one preorder v'', and the lower one the "median" preorder.

Table 9: Land use options in *Bayerisches Donauried*:

Concordance matrix

a. Agriculturists

	SQ	RL	CG	SM
SQ		0.66	0.48	0.54
RL	0.34		0.17	0.27
CG	0.52	0.79		0.42
SM	0.46	0.69	0.54	

b. Conservationists

	SQ	RL	CG	SM
SQ		0.36	0.26	0.39
RL	0.64		0.19	0.39
CG	0.74	0.62		0.48
SM	0.61	0.43	0.34	

c. Promotors of regional development

	SQ	RL	CG	SM
SQ		0.38	0.28	0.37
RL	0.63		0.23	0.40
CG	0.72	0.62		0.48
SM	0.63	0.45	0.37	

Presented at:

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Table 10: Land use options in *Bayerisches Donauried*:

Weighted discordance matrix

a. Total

	SQ	RL	CG	SM
SQ		0.0047	0.0047	0.0047
RL	0.0041		0.0017	0.0020
CG	0.0035	0.0008		0.0014
SM	0.0021	0.0022	0.0026	

b. Conservationists

	SQ	RL	CG	SM
SQ		0.0070	0.0070	0.0070
RL	0.0032		0.0014	0.0015
CG	0.0027	0.0007		0.0010
SM	0.0017	0.0030	0.0036	

c. Agriculturists

	SQ	RL	CG	SM
SQ		0.0016	0.0023	0.0017
RL	0.0070		0.0025	0.00334

CG	0.0059	0.0006		0.0023
SM	0.0036	0.0014	0.0017	

d. Promoters of regional development

	SQ	RL	CG	SM
SQ		0.0056	0.0056	0.0056
RL	0.0036		0.0019	0.0023
CG	0.0019	0.0009		0.0007
SM	0.0013	0.0020	0.0024	

Table 11: Land use options in *Bayerisches Donauried*:

Ranking of options using the weighted discordance matrix[a]

Discordance index threshold	Total	Conservationists	Agriculturists	Promotors of regional development
0.029	CG-SM-RL,SQ	CG-SM,RL-SQ	SQ-SM-CG-RL	CG-SM-RL,SQ
0.034	CG-SM-RL,SQ	CG-SM-RL-SQ	SQ-SM-CG-RL	CG-SM-RL,SQ
0.039	CG-SM-RL,SQ	CG-SM-RL-SQ	SQ-SM-CG-RL	CG-SM-RL-SQ

[a] Concordance index thresholds: 0.52 (strong) - 0.42 (weak).

Presented at:

The Agricultural Economics Society's 81st Annual Conference, University of Reading, UK

2nd to 4th April 2007