Modelling the value of a multifunctional landscape
– A discrete choice experiment –

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Abstract

In the context of today's intensive discussion of landscape multifunctionality, one primary objective of the current European Union policy is to support the implementation of multifunctionaly within the EU. In order to assess the economical feasibility of the implementation of a multifunctional land use in the Wetterau region in Germany this study addresses the question whether the local population, which is above all affected by the degradation of landscapes, benefits from a change from today's landscape dominated by intensive agricultural production towards a multifunctional landscape. Based on data obtained by discrete choice experiments in the Wetterau region, a cost-benefit-analysis is carried out using the modelling and assessment framework CHOICE. The results show that the local population of the Wetterau region assigns a high value to a landscape that takes into account ecological aspects of landscape composition. In fact, the CHOICE model suggests that the willingness-to-pay for the multifunctionality scenario is higher than for all other scenarios under study. Moreover, taking implementation costs into account a regional cost-benefit-analysis indicates that the provision of a multifunctional landscape will lead to a positive net benefit for society.

JEL-Codes: Q24, Q51, Q57

Keywords – Landscape multifunctionality, CHOICE, Discrete choice experiments, Willing-ness-to-Pay, Cost-benefit-analysis, Germany

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1 Introduction

Today's intensive agricultural production affects environmental and societal attributes of landscapes. In highly productive regions with intensive land use, biodiversity loss and a decreasing quality of water and soil can lead to a deterioration of landscape multifunctionality. In addition, these landscapes may have little recreational, cultural and aesthetic value and therefore may provide a low use value, not only for the region's population but also for tourism.

Given these negative impacts of intensive land use on society and environment the current European Union policy intends to stimulate multifunctional agriculture. However, in order for the implementation of multifunctionality in agriculture to be economically feasible the benefits have to be weighted against the implementation costs, which is commonly done by cost-benefit-analysis. To conclude whether a policy intervention is remunerative both the populations' preference and the supply cost for a multifunctional landscape therefore has to be known. In this context, this paper addresses both the demand and supply side of multifunctionality, based on a survey in the Wetterau region in Hesse, Germany. In order to asses the demand for a multifunctional landscape the willingness-to-pay is calculated. Afterwards, the results are used in a cost-benefit-analysis. By the additional use of cost-benefit-analysis, the study at hand goes beyond other studies investigating multifunctionality most of which entirely focus on calculating the willingness-to-pay for multifunctionality.

The paper is structured as follows. The survey design is explained in Section 2, including a brief review of specific characteristics of the Wetterau region and the survey sample. In the third Section the methodological framework is introduced, thereby addressing different landscape scenarios as well as the econometric approach. The empirical results are presented and discussed in Section 4. Finally, major implications and conclusions of the study are drawn.

2 Survey Design

For the survey the Wetterau region, located in the German federal state of Hesse, was chosen. The region is dominated by arable cultivation which accounts for 70% of the agricultural land, the most important crops being wheat, maize and sugar beet (in short crop rotation). Given a high level of fertilization and pesticide application, the high land-use intensity adversely affects the landscape multifunctionality in the Wetterau region. In the past, intensive agricultural production led to a degradation of abiotic resources (e.g. high nitrate concentrations in rivers, heavy metal enrichment in arable soils) and biodiversity, expressed in a considerable decline of population sizes and occurrence frequencies of region-specific wildlife species. Due to a monotonous landscape, the region further becomes less attractive for recreational purposes and tourism (Waldhardt et al. 2008).

In order to assess the local populations' attitude towards a multifunctional landscape a split sample survey was conducted in the more urban city of Friedberg (FB) and in the smaller and more rural town Rockenberg (RB), both located in the Wetterau region. In total 420 structured, personal interviews with citizens aged between 18 and 75 have been conducted in November 2007. A summary of demographic characteristics of the survey sample is given in Table 1.

Table 1
Summary Statistics of Demographic Variables

Variable Name	Description	Observations		Mean		Std. Deviation	
		FB	RB	FB	RB	FB	RB
Gender	0 = male 1 = female	206	205	0.55	0.56	0.50	0.50
Age	in years	207	133	50.9	49.2	14.1	13.6
	1 = graduation 2 = elementary school 3 = secondary school 4 = ATCEQ 5 = A-levels 6 = university degree 7 = other	207	213	4.25	3.88	1.49	1.55
Household type	1 = single 2 = married 3 = family 4 = partnership 5 = flat share 6 = multiple generation	207	213	2.65	2.92	1.15	1.31
Household income	in €	207	213	2685.6	2450.1	2083.9	1468.0
Children < 18 years living in the household	0 = no 1 = yes	187	202	0.47	0.30	0.47	0.46

Notes: ATCEQ = Advanced Technical College Entrance Qualification. *Source*: Authors' own composition.

Within the survey each respondent answered either eight or twelve choice sets. Each set included four different landscape options, each of it was described by the four above mentioned landscape functions. Additionally a price was attached to each option that had to be paid on a yearly and household basis in order to allow for the provision of the option (see also Table 2). One option in each choice set described the status quo of landscape as it is found nowadays (for description see Table 4). During the interviews, the different scenarios of the landscape scenery considered were visualized using maps and photos.

The average interview length was about 55 minutes. Interviews took place in rooms of the municipality to allow for a neutral place of interview. For people not being flexible to come to the municipality the interview took place at the respondent's home. Respondents were paid 15 or 10 Euro, respectively, as allowance for their participation.

3 Modelling Framework

A. Scenarios

This study makes use of ex-post (status quo) and ex-ante (scenarios of future land use) evaluation of multifunctionality landscapes. That is to say, we compare today's land use as the base scenario (BS) with a normative multifunctional landscape scenario (MS) as a reference. Focus is given to the results of the indicator "landscape scenery", i.e. on the local populations' willingness to pay for alternative landscape sceneries. Moreover, we calculate the consumer surplus per household resulting from a change from BS to MS and relate this consumer surplus to the respective opportunity costs.

For the evaluation of landscape functions in the Wetterau region the most important landscape characteristics – modelled by the ITE²M (Integrated Tools for Ecological and Economic Modelling) framework – have been assessed (Waldhardt et al. 2008). Besides the integration of the most relevant characteristics from a scientific point of view, it has to be considered that the attributes chosen are also relevant for the respondents and communicated in a simple and understandable way (Schmitz et al. 2003, Schmitz 2008). Table 2 gives an overview of the indicators for the four landscape functions included in the analysis, i.e. plant biodiversity, animal biodiversity, landscape aesthetics, and water quality, as well as its parameter levels. Each of the characteristics chosen can take different values (given in column two) – based on a range of possible levels of the indicators, given by expert knowledge and estimation. This approach ensures that all relevant changes of the landscape functions under investigation can be considered in a cost-benefit-analysis.

By defining the attributes and levels the research results within the ITE²M projects were used. Nevertheless these results could be used as basis for definition of attribute levels the description that is used within the choice experiments study is of crucial interest. Here the bridge needs to be built that translates the sometimes very abstract wording of scientists into a language that can be easily understood by any person who is not confident with the scientific basics.

It has also to be considered that only such attributes that have a utility value for the respondent can be surveyed. The relevance of the contents that are investigated and the ability to communicate them in an adequate way are therefore two important issues when designing a choice experiments study.

Table 2

Indicators for the included Landscape Functions

Landscape function/characteristic	Values/Levels	Explanation
Plant biodiversity	170 plants/km² 190 plants/km² 205 plants/km² (status quo) 225 plants/km² 255 plants/km²	Absolute number of plants investigated per km²
Animal biodiversity	50% of desired population 70% of desired population (status quo) 80% of desired population 90% of desired population 100% of desired population	Percentage of desired population of eleven indicator bird species
Water quality	Less than 10mg Nitrate/l 10-25mg Nitrate/l 25-50mg Nitrate/l 50-90mg Nitrate/l More than 90mg Nitrate/l	Water quality measured as the content of nitrate/l due to communication with respondents
Landscape aesthetics	Status Quo (as described in Section 2) Multifunctionality scenario Grassland dominated scenario Intensity scenario (with increased field sizes) High price scenario (with increasing percentage of cereals)	Landscape options were presented with images in the survey. Pictures are available on request.
Price variable	0/€/household/year 40€/household/year 80€/household/year 120€/household/year 160€/household/year 200€/household/year	Costs for provision of presented landscape options per household and year.

Source: Authors’ own composition.

For the plant biodiversity the total number of plants per km² was used as indicator. Photos underlined differences within the landscape to illustrate what is behind the figures. The animal biodiversity was defined on basis of an indicator. This indicator is based on several bird species that are considered to indicate the quality of a landscape from the animal biodiversity perspective. Here the levels were defined in terms of a benchmark value of 100%. Water quality was described in terms of content of nitrate per litre water. A threshold value defined by government makes it easier for respondents to evaluate the local water quality.

The price vector was defined based on results of previous research within the project. As the status quo option that is already realized, a price of 0Euro/household and year was attached to that option in each choice set. All other options were labeled with another price.

B. Methodology

The modelling and assessment framework CHOICE (Borresch et al. 2005) attempts to valuate the results of the single models of ITE^2M in monetary and therefore comparable terms. The methodological approach is based on the well established tool of cost-benefit analysis (e.g. Just et al. 2004). A positive (negative) result of a cost-benefit analysis indicates the assessed measure to have a positive (negative) impact on social welfare. In the case of multifunctionality, the cost and benefit components of private goods have to be added by the components of public goods represented by ITE^2M. Deterioration of the environmental quality will result in a cost component, amelioration in a benefit component. These values are determined by applying Choice Experiments as a modern valuation technique. This approach – which was first developed by Thurstone (1927) – assumes that each good can be described by its characteristics with a value assigned to each of them. By defining a price variable, monetary values for changes of characteristics can be derived.

Major advantage of the methodology is the fact that not only quantitatively defined variables can be considered but qualitative attributes as well. For this study the attribute “landscape aesthetics” is not defined quantitatively. The applied multinomial logit analysis is based on likelihood analysis that asks for the probability that a certain output will occur. For example, it can be asked for the probability that the respondent will decide to choose an option with multifunctionality landscape aesthetics. In order to also allow for an unlimited range of outcomes outside the probability range of $0<p<1$ a double transformation ensures the desired range of value of $-\infty < x < +\infty$. Depending on the assumptions that are made a number of models can be applied in order to analyze the collected data. A minimum number of observations are required in order to make use of the advantages of the approach. As in each choice experiment a different number of attributes with a certain number of levels and a chosen number of sets (number of choice decisions the respondent has to face) are surveyed, this minimum number of observations depends on all of these mentioned factors. Additionally, the definition of the variables (quantitative or qualitative) is important is it influences the degrees of freedom of analysis.

The underlying random utility theory assumes that each choice corresponds with a utility for the chosen option. The respondent will choose the option with the highest utility according to his preferences. Within each choice situation the respondent has to consider and trade off between the offered options and levels of all attributes. By asking the respondent to make a certain number of choices with varying combinations of levels it is possible to derive the implied utility that the respondent assigns to the attributes and levels. The choice set is composed in a stratified way that ensures that all levels can be estimated. Roughly speaking, the more similar the shown options are in terms of the underlying utility the more information can be gained from the decision that is made by the respondent.

The data that is obtained by the choice experiment study is analyzed using the maximum likelihood method. Different algorithms allow for the estimation of a number of varying logit models. The most common used model is the multinomial logit model. Multinomial refers to the fact that the choice includes more than two (binomial) options. The nested logit models e.g. implies a two-step (or more) decision process. Mixed logit models allow for analysis of parameters with a certain distribution across respondents (Train, 2002).

Similar to OLS regression the model fit can be described using the Pseudo-R^2. The range of values is $0<R^2<1$. Values of $R^2 \geq 0.2\text{-}0.4$ are considered to give a very good model fit (Bennett, 1999, p.17).

In the survey each respondent had to either answer eight or twelve choice sets. The inclusion of the status quo or another reference option (that could for example describe a future scenario) ensures the compliance of results with the random utility theory and therefore allows for the deviation of willingness-to-pay or (consumer) surplus estimates.

4 Results and Discussion

A. Discrete Choice Experiments

Due to defining all attributes in a quantitative manner, here as linear functions, only for the attribute landscape aesthetics single parameters for each level were calculated. For all other landscape function a linear relationship between improvement per unit and resulting implicit price was assumed. A multinomial logit model was estimated with a Pseudo-R^2 of 0.18 that implies a good model fit. That assumption of linear variables could be validated by estimating single parameters for each level of that attributes, too. Here a better "value" was corresponded with a higher implicit price. Nevertheless this relationship cannot always be found in a choice experiments study. Adamowicz et al. (1998) stated that sometimes a so called status quo effect can be found. Is implies that the respondent attaches the highest utility to that level of an attribute that is realized in the status quo situation. This result could not be approved in this study and can be an evidence for the quality of the study design.

In general, the relative importance of the four assessed landscape functions clearly shows that the local population is willing to pay for shift from an intensive land use towards a more multifunctional landscape. Among all landscape functions considered in the analysis, water quality with a relative importance of 34.5% has the highest importance for the decision of a landscape option, followed by the animal biodiversity with 28.2%. The price has a relative importance of about 20%, the landscape aesthetics of 10.6% and the plant biodiversity of 6.4%. This shows that above all respondents want to ensure a good water quality, before they additionally focus on the animal biodiversity and the underlying costs of that option.

Marginal changes of single landscape functions can also be expressed in monetary terms as implicit prices, shown in Table 3. As water quality, animal and plant biodiversity were given in numerical form they are estimated as linear coefficients indicating that the change of one unit results in a fixed implicit price. More precisely, the relative importance of the landscape functions outlined above refers to an implicit price of 4.24€ for an increasing water quality. For an increase in plant and animal biodiversity, respectively, the local population is sill willing to pay 1.58 and 3.26€ per species saved (plant biodiversity) and per percent of saved species (in terms of animal biodiversity).

Table 3
Implicit Prices of Landscape Functions

Landscape function	Implicit price	Explanation
Plant biodiversity (per plant species)	1.58€	Positive values give the respondent's implicit price for a change to the next better level.
Animal biodiversity (per % animal species)	3.26€	
Water quality (per mg/l nitrate)	4.24€	
Landscape aesthetics (change from current landscape aesthetics to)		
Grassland dominated landscape	48.48€	Implicit price to get a grassland dominated landscape and "multifunctional" landscape, respectively
Multifunctionality scenario	87.68€	
High price scenario (with high rate of cereals area)	-16.43€	Negative values indicate that the respondent has to be compensated to accept the change to this landscape aesthetics (corresponds to willingness to accept for total scenarios).
Intensive scenario (with larger fields)	-13.17€	

Source: Authors' own calculations.

As landscape aesthetics is concerned, the results strongly suggest that a shift from the status quo to a higher rate of cereals area (high price scenario) and an even more intensive land use with larger field sizes is not favoured by the local population. In fact, the negative implicit price of these two scenarios implies that the respondents have to be compensated in the amount of 16.43€ and 13.17€ in order to accept an increase in cereals area and larger field sizes, respectively. In contrast, the local population prefers both the grassland dominated scenario and the multifunctionality scenario over the currently intensive land use. For a shift from the status quo to the grassland dominated landscape the implicit price amounts to 48.48€. However, the results clearly show that the demand for the multifunctionality scenario is the highest as respondents are willing to pay 87.68€ per household and year for a shift from the status quo to a multifunctional landscape. With that result it can be underlined that the locals prefer a more diverse landscape in comparison to the recent one that is dominated by a high rate of cereals area. The multifunctionality scenario re-integrates more structural elements into the landscape that got lost by having several land consolidations within the Wetterau region.

B. Cost-benefit-analysis

To give an answer to the valuation question in the presence of trade-offs, it is necessary to derive a value for the simultaneous change of several landscape functions. For doing so, the cost-benefit analysis carried out by CHOICE is a helpful tool. The scenario was therefore adapted to the characteristics assessed in the survey. Table 4 describes the status quo and the normative scenario in terms of surveyed landscape functions.

It should be mentioned that the normative MS merely represents a snapshot of landscape multifunctionality. Given the fact that indicators of landscape multifunctionality are multifaceted, the landscape function presented in this paper is only one possibility of a large number of possible solutions to landscape multifunctionality (Waldhardt et al. 2008).

Table 4
Indicators for Status Quo and Multifunctionality Scenario

	Status Quo	Multifunctionality Scenario
Plant biodiversity	205 species	230 species
Animal biodiversity	52%	83%
Water quality	Between 10-25mg/l and less than 10mg/l nitrate	Between 10-25mg/l and less than 10mg/l nitrate
Landscape aesthetics	Recent landscape aesthetics	Multifunctionality scenario

Source: Authors' composition based on results of ITE^{2}M.

Due to an already satisfying level of water quality no changes of the water quality are recorded in the multifunctionality scenario, as shown Table 4. However, plant and animal biodiversity and landscape aesthetics change simultaneously if assuming a shift from the current situation to the multifunctionality scenario. As the method allows for estimation of consumer surplus the willingness-to-pay for a change from status quo to the multifunctionality option can be estimated. This change is resulting in a consumer surplus of 228.35€ per household per year. Related to the study area, these benefits can be converted by number of households and agricultural area into 551€ per ha and year, i.e. society is willing to pay 551€ per ha and year for the land use change described in table 4. On the other hand, this land use change will induce opportunity costs. More precisely, land rent will decrease by 111€ per ha and year and state payments will increase by 111€ per ha and year. Thus, the resulting net benefit amounts to 389 € per ha and year. Besides the annual opportunity costs, the introduction of multifunctional land use measures will have non-recurring costs of provision. As far as the discounted annual net benefit of 389 € per ha and year exceeds these initial costs of provision, the scenario leads to a benefit for society. However, input and output prices as well as societal demands change over time, meaning that both the preference towards the MS and the opportunity cost of implementation are expected to differ (Alcamo et al 2005, Huber et al. 2007, Jongeneel et al. 2008). As these changes eventually affect the outcome of cost-benefit analysis, the result of the present analysis may change over time.

5 Conclusion

The intensive land use for agricultural production as it is widely spread today leads to a degradation of environmental and societal attributes of the landscape scenery. One primary objective of the current European Union policy is therefore to support the implementation of multifunctional landscapes with in the EU. However, before making implementation efforts the demand for a multifunctional landscape as well as the implementation costs have first to be assessed. In this context, this study sheds light on the question whether the local population, which is above all affected by the degradation of landscapes, benefits from a change from today's landscape dominated by intensive agricultural production towards a multifunctional landscape. Based on a cross-section survey in the Wetterau region in Germany, the study employs choice experiments and multinomial logit analysis to assess the local populations' willingness-to-pay for a multifunctional landscape. In addition, a cost-benefit-analysis is carried out to evaluate the economic feasibility of implementing multifunctionality in the Wetterau region.

Besides all limitations of scope of indicators included in the choice experiments, it can be shown that the local population of the Wetterau region assigns a high value to a landscape that takes into account ecological aspects of landscape composition. In fact, the CHOICE model suggests that the willingness-to-pay for the multifunctional scenario is higher than for all other scenarios under study. As the multifunctional scenario is preferred by the local population as an alternative future to today's intensive land use it has to be taken into account in a regional cost-benefit-analysis. The latter shows a positive net benefit per year for society. However, in order to draw a final conclusion further investigations to valuate the initial costs of provision are needed.

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