# Agri-environmental measures as an instrument to enhance sustainability – theoretical considerations and practical implications for a German case study region

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## Abstract

The EU sees agri-environmental measures as a policy instrument to cope with future challenges caused by e.g. WTO negotiations or new scarcities in the field of resources and environment. As it is highly complicated to evaluate the effects of management-oriented measures, for example their environmental effects are seldom an observable state of nature, when defining agri-environmental measures, policy makers face a conflict between optimal realization of society's objectives (e.g. optimal ecological output) and available budget to spend for alternative agri-environmental measures. In order to make the design of agri-environmental measures more transparent and to allocate public expenditures more efficiently, we discuss the methodological steps that should be incorporated in a suitable decision support tool: To fulfill the mentioned requirements with respect to (target) effectiveness and (budget) efficiency, and thus to match society's demand, we discuss in a first step two possible impact assessment methods that assess the impact of agri-environmental measures on given political objectives. In a second step, average opportunity costs that result to farmers from the agri-environmental contracts have to be calculated. Given the assumption that there is a consensus that the level of compensation has to match average opportunity costs plus a small financial incentive, this second information can serve as orientation for payment rates. All information are used to describe agri-environmental measures as mathematical functions that continuously relate goal attainment values (step 1) to public expenditures (step 2) and thus to interpret budget allocation as a continuous multi-objective linear optimization problem (step 3) which helps to find the optimal budget allocation mix for different agri-environmental measures. Taking a case study area in Germany as example, we critically discuss for a reference year differences between the observed and the optimal budget allocation.

**Key words:** agri-environmental measures, goal programming, spatial areas, budget allocation, efficiency

# 1 Introduction

Agri-environmental measures (AEM) began in a few Member States in the 1980s on their own initiative, and were taken up by the European Community in 1985, but remained optional for the Member States. In 1992 they were introduced for all Member States as an “accompanying measure” to the Common Agricultural Policy (CAP) reform (COM 2005). They became the subject of a dedicated Regulation, and Member States were required to introduce agri-environment measures “throughout their territory”. In 1999, the provisions of the Agri-environment Regulation were incorporated into the Rural Development Regulation as part of the "Agenda 2000" CAP reform. EU expenditures on agri-environment measures have grown rapidly since their first obligatory introduction in 1992 and amounted in 2002 to nearly EUR 2 billion per year. The total spending on agri-environment is in fact significantly higher as the Member States have to add their co-financing part of 15 % in high-priority areas (Objective 1) and 40 % in others. About one fifth of the agricultural land in the EU is covered by agri-environment contracts, which support specifically designed farming practices that help to protect the environment and maintain the countryside. Farmers commit themselves, usually for a five-year minimum period, to adopt environmentally friendly farming practices that go beyond usual good agricultural practice. In return they receive payments that compensate for additional costs and loss of income that arise as a result of altered farming practices.

Agri-environmental measures have become the principal instrument for achieving environmental objectives within the CAP. However, agri-environmental measures are also viewed critically as on the one hand they are expected to reduce the pressure on natural resource and bring the CAP in line with the WTO negotiations as they are regarded less-market distorting and therefore belong to the green-box measures while on the other hand the recently conducted mid-term review evaluations have shown that AEM partly fail to contribute to the desired environmental outcomes and sometimes overcompensate farmers for the comparatively low adaptation in management they require. Over the past 20 years, a great variety of AEM has been evolved in the EU. Examples of commitments covered are: (i) the environmentally favorable extensification of farming; (ii) the management of low-intensity pasture systems; (iii) integrated farm management and organic agriculture; (iv) the preservation of landscape and historical features such as hedgerows, ditches and woods or (v) the conservation of high-value habitats and their associated biodiversity. One general differentiation of the measures has been described as “broad and shallow versus deep and narrow” measures. “Broad and shallow” or horizontal measures tend to include a large number of farmers, cover a wide area, make relatively modest demands on farmers' practices, and pay correspondingly little for the environmental service provided. "Deep and narrow or dark green" measures tend to be targeted on site-specific environmental issues, therefore include fewer farmers (COM 2005).

One basic principle is that the political objectives of agri-environmental measures should be achieved with the most equitable and efficient use of financial resources. Monitoring efficiency is therefore of increasing importance as regards agricultural policy in the EU and has been the main impulse for the mid-term review evaluations in 2003. Thereby conducted analyses have shown that current CAP measures in part lead to considerable inefficiencies from an allocative perspective. AEM partly fail to achieve in particular the envisaged environmental objectives, and can in any case be at least improved in terms of their ecological effectiveness (COM 2004; Matzdorf et al. 2003; see also Kleijn et al. 2006; Kleijn and Sutherland 2003) especially because of their often sub-optimal spatial allocation (de Longueville et al. 2007; van der Horst 2007). The mid-term review evaluations also revealed that the design of agri-environmental measures is not only subject to planning uncertainty due to the great variety of offered measures. In addition, the administration effort has become very demanding and time consuming due to the elaborate reconciliation of designated areas. The administration also often lacks knowledge and technology resources that could help prevent a possible imperfect mapping of agri-environmental measures. Designing and implementing AEM is therefore a complex planning and management problem in the Member States of the EU. Effective decision support is needed when it comes to decide how to finance alternative AEM to realize politically set multiple objectives with a limited budget in an optimal way and also to determine the optimal spatial allocation of the measures. Synthesized, there is a need for a decision support approach that considers impacts, budgetary costs and spatial areas simultaneously.

This paper will discuss theoretically the methodological steps that should be incorporated in such a decision support tool including (i) the objectives of the measures, (ii) possible impact assessment approaches, (iii) the appropriate consideration of the spatial dimension of the measures, (iv) the calculation of adequate payment rates, (v) the use of goal programming approach and (vi) the advantages of scenarios for practical decision-making. The second part of the paper presents a practical application of the previously discussed and shows spatial and budgetary consequences taking the German federal state Brandenburg as example.

## 1.1 Objectives of the measures

To provide effective decision support with regard to budget allocation for alternative policy measures it is in a first step necessary to reveal the political preferences and intentions they are expected to serve. The identification of the objectives is essential for the impact assessment of the measures. In a second step, the costs at which the envisaged effects can be provided have to be identified to determine the least cost-intensive and thus efficient way of achieving the desired objectives. The identification of the political objectives of agri-environmental measures can be accomplished easily, as all underlying regulations for agri-environmental measures comprise some mandatory elements including their objectives. Policy makers formulate the objectives of a whole support programs (e.g. protecting species, support small farms, etc.) and append suitable agri-environmental measures. Participation conditions determine the eligible target group (e.g. livestock farms only). The central part of agri-environmental measures finally are the adaptations in management the farmers have to make (e.g. no use of pesticides, no grassland use before a fixed date, etc.) as it is expected that these changes in management cause the production of various positive externalities or help reduce the production of negative externalities.

## 1.2 Environmental impact assessment

Assessing environmental impacts involves a comparing of intentions with performance (EEA 2001). In an ideal situation, reliable agri-environmental indicators were available for all AEM to measure their multiple environmental benefits (Kirschke et al. 2004). In reality, causality between for example a changed land use induced by agri-environmental measures and improved environmental impacts is often difficult to prove for which environmental indicators often hardly can be made operable for decision support, at least not in quantitative terms. In such a situation, an evaluation on intermediate outputs and outcomes can serve as a rough proxy for impact (EEA 2001). The challenge thereby lies particularly in the level of detail of the assessment, which has to be aggregated enough to make the assessment helpful for decision makers but also scientifically sound enough to adequately cover the complexity of the problem and deliver meaningful results. Spatial equivalence plays the foremost important role to evaluate the effectiveness of AEM. Landscapes are very heterogeneous with respect to soil, climate and elevation. This implicates that environmental vulnerability varies considerably between different landscapes and so does the spatial suitability of agri-environmental measures. It is assumed, that a social demand for agri-environmental measures exists only in ecologically sensitive zones. For example, erosion-reducing measures only make sense on sites with a medium or high risk for erosion. Otherwise, compensatory payments fail to internalize the externality they were supposed to and public expenditures are wasted. Another example is measures with the objective to maintain grassland. They are only to compensate in areas with a defined need to maintain of grassland due to conservation issues or landscape-planning reasons (Piorr and Matzdorf 2005). As regards the impacts of agri-environmental measures on the identified environmental objectives, two possible expert-based impact assessment approaches that explicitly consider spatial aspects in their assessment will be discussed in the following: (i) an expert assessment based on multi-criteria analysis as used for the mid-term review evaluation and (ii) an expert assessment fuzzy logic based on which is usually applied at farm level.

***Mid-term review evaluation approaches***

In the course of the mid-term evaluations (and their up-dates), all Member States of the EU-15 were to develop suitable methods to evaluate their AEM. The used approaches involved established multi-criteria techniques based on various primary and secondary data such as various monitoring data, environmental planning data and other geo-referenced environmental data. After identifying the objectives of the measures and relevant impacts to be evaluated, criteria and sub-criteria had to be defined, scored and weighted to come to a final assessment of the performance of the measures. In principle, the assessed performance levels can then be interpreted as the measures' contributions to the prior identified objectives (see e.g. Matzdorf et al. 2003 and 2005). The excessive amount of thereby considered criteria and the differences in data quality and availability make it in many cases impossible to determine a uniform procedure and assessment for the variety AEM and objectives as required according to classic multi-criteria analysis (MCA). To achieve the goal of making the environmental impacts operable for political decision making nonetheless and also use the same measurement scale for all objectives and measures, the evaluation outcomes therefore often have to be synthesized in an additional expert assessment.

***Farm-level risk assessment approaches***

Although the previously discussed approach appears logical and practical under the given circumstances, it is also a very aggregated and debatable way of measuring environmental impacts. An alternative possibility to introduce a more substantiated impact assessment method might lie in the management-orientation of the majority of agri-environmental measures which can provide a link to risk-assessment approaches for agricultural production practices, as presented by Sattler et al. (2006) implemented within the MODAM modeling system. Their approach objectively evaluates all relevant characteristics of agricultural management such as cropping pattern, site characteristics, input/output quantities, work steps, time spans, machinery used etc. that characterize agricultural management to eventually calculate indices of goal achievement (IGA). Interpreting agri-environmental measures as a special case of agricultural production practices makes it possible to calculate the 'benefit surplus' in comparison to 'standard' practice. The ecological assessment in MODAM is indicator-based and makes use of a fuzzy-logic-based assessment approach that can be run with comparatively fewer data than process-orientated (quantitative) models. However, the approach provides only limited access to targeted measures or production-system-oriented measures such as the promotion of organic farming and has also difficulties in meeting the challenge of aggregation. For political decision-making the impacts on the identified objectives have to be assessed in an aggregate way. Current analyses using risk-assessment show for example that an overall biodiversity objective cannot adequately be covered by the risk assessment approach as different indicators species (field birds, amphibians) can be influenced very differently by a certain measure. Considering an increasing the number of objectives is also not unproblematic. On the one hand, there is the danger of acting arbitrarily (which species to chose), on the other hand is a decision problem easier to handle the fewer objectives are considered and the easier is it to ensure the necessary independence between the different objectives. However, despite the limitations in application, risk-assessment techniques can be a valuable tool to verify the before addressed mid-term evaluation approach.

## 1.3 Integration of designated areas

Part of the inefficiencies related to the implementation of AEM also result from a wrong decision on payment eligibility. So-called targeted AEM are geographically limited to special designated areas, e.g. protected areas for meadow birds, flood-endangered areas etc. An important and often elaborating task of the authorities therefore is the exact reconciliation of cadastral maps with the designated areas to ensure that only parcels inside the designated areas receive the payments for targeted AEM. An aggravating factor is that a lot of spatial data is gathered independent by different authorities. To improve this situation and reduce the administration effort, all available GIS data should be gathered in one data pool.

## 1.4 Payment calculation

The demanders of AEM, the farmers who are the agents through which the government aims to deliver environmental protection and enhancement, so far have been left unconsidered but if the uptake of support programs is not sufficiently high enough the envisaged political objectives won't be achieved. In reality, a complex of business, personal, contract and external contextual factors can reduce the effective adoption of agri-environmental measures by farmers considerably. Reasons for non-participation may be limited conservation interests, the goodness of fit of schemes and, in particular, inadequate payments (Wilson and Hart 2000). The design of AEM is therefore also a question of cost-effectiveness. The assessed impacts of AEM have to be put in relation to the costs that are necessary to obtain target levels of participation. The conventional way of determining payments is to calculate the compliance costs based on the income forgone plus additional (incentive) costs.

Although this practice has earned some criticism, for example the low uptake in some measures has sometimes reflected apparent misjudgments of farmer's costs because the method fails to take adequate account of transaction and other less tangible costs that are accounted for in more comprehensive willingness-to-accept approaches. However, the income-forgone-approach is still dominating in practical policy-making although there are discussions on varying the payment rates according to the real performance costs to reduce the deadweight or environmental auctions which try to make use of the information asymmetry of farmers with regard to their real opportunity costs.

In a time of 'health check' and overall liberalization of agricultural markets discussions that may change the political framework drastically beyond 2013 in the EU, it is very likely that first pillar direct payments are going to be further reduced, adversely making agri-environmental measures as remaining sources of income more attractive and making payment adjustments obsolete. Centralized, payment calculation is a complex and debatable task. In the following existing payment levels will be taken as given and treated as external influencing factors.

## 1.5 Goal programming

Based on the identified objectives of the rural development plans in the Member States or administrative regions, their set up AEM and assessed impacts, various spatial information including environmentally sensitive zones at the most disaggregated level possible (currently the land parcel), the payments for each AEM and the total budget available, a mathematical optimization problem can be formulated. The problem takes into account both the benefits and costs of each AEM on each land parcel and evaluates all possible combinations that lie within the specified budget constraint and selects the portfolio which yields the highest possible aggregate ecological benefit over all considered objectives.

Let i = 1, 2,…., I denote an index for various agri-environmental measures. Let j = 1, 2,…., J denote an index for various parcels of land. Let k = 1, 2,…., K denote an index for considered objectives and l = 1, 2,…, L an index for various constraints. A linear objective function maximizes the aggregate benefit over all considered objectives. Beside optimal activity levels, the main outcome of the optimization is $TGA_{Total}$, the Total Goal Attainment level over all objectives, which the model determines by calculating the optimal output per measure. The TGA for each considered objective is calculated as a sum over $c_{ij}$ representing the assessed impact of the measures with respect to objective k multiplied with $x_{ij}$ representing the optimal activity level [ha] of a specific AEM on a specific land parcel.

$$\max TGA_{Total} = \sum_{k=1}^{K} \sum_{i=1}^{I} \sum_{j=1}^{J} c_{kij} x_{ij}$$

In reality, decreasing marginal ecological benefits are more likely than constant ecological benefits. However, since the shapes of the actual benefit functions are unknown and cannot fully be incorporated in the environmental impact assessment process, the assumption of linearity is considered a tolerable simplification. To complete the optimization problem, a set of mandatory constraints is added represented by the vector $b_l$. It comprises both aggregate constraints (e.g. total budget, share in budget spent for land cover types, costs of AEM i on parcel j, grassland area of parcel j, arable area of parcel j and designated area of parcel j etc.). A is a matrix of coefficients $a_{lij}$ that relates activities $x_{ij}$ to the constraints $b_l$.

Subject to

$$\sum_{i=1}^{I} \sum_{j=1}^{J} a_{lij} x_{ij} \begin{Bmatrix} \leq \\ = \\ \geq \end{Bmatrix} \leq b_l$$

where

$x_{ij} >= 0$

Because the payment of each AEM is known and the budget is a limited resource, another outcome of the specified optimization problem is the optimal public expenditures for each AEM. Additional constraints such as minimum finance volume for certain measures or minimum levels to be delivered for $TGA_{Total}$ or respective sub-TGA may be added if the context requires it.

### 1.6 Scenarios

Scenarios are a possibility to systematically develop alternative development paths and future states (Van den Berg and Veeneklaas 1995). Different from prognoses, scenarios cannot predict the future based on comparatively firmed statistical data to extrapolate current development trends, and different from utopias they still have a plausible reference to reality. With the help of scenarios, decision makers should be enabled to vary modeling settings and experience the consequences of doing-so, to re-adjust priorities and objectives based on resulting model solutions, and eventually make a decision. It is assumed that by visualizing *ex post* inefficiencies and connections of a planning problem, policy makers are enabled to derive *ex ante* the policy steps needed to optimize budget allocation for AEM in the future. A graphical user interface is then helpful to allow the user to access and edit relevant input parameters and compare the consequences of doing so.

## 2 Exemplary application

**Model specification for a case study region**

The proposition that there is no theory without measurement is well enough known. In this section therefore, exemplary results and implications of the previously discussed will be presented. Case study region is the federal state of Brandenburg in the east of Germany with the German capital Berlin in its centre. The region is divided into fourteen (rural) counties (Landkreise) and characterized in particular by its varied, relatively sparsely populated rural areas (43 inhabitants/$km^2$). The utilized agricultural (UAA) area covers 1.34 mill. hectares.

Brandenburg’s rural development plan is to guarantee a sustainable development with a view to maintaining, tending and further developing the cultivated landscape. The set up AEM (n=22) comprise both horizontal and targeted measures and focus on the extensive agricultural use of grassland, the performing of organic, extensive, erosion-reducing cultivation methods, integrated horticultural cultivation methods, the maintenance of species diversity in general and the tendance and maintenance of small water bodies used in fishery

(MLUR, 2000a). Payments for arable AEM range from 49 to 405 Euro/ha (mean payment 170 Euro/ha) and for grassland AEM from 105 to 720 Euro/ha (mean payment 220 Euro/ha). The overall budget for AEM amounts to approximately 42 mill. Euro/year (MLUR, 2000a).

From a wide-ranging review of AEM regulations in Brandenburg it can be concluded that the objectives of the measures are to (i) to reduce the risk of biodiversity loss on agricultural area (BIO); (ii) to maintain and improve habitat quality (HAB); (iii) to reduce the risk of water and wind erosion (ERO); (iv) to reduce the risk of nitrogen entries into ground and surface water (NO3); and (v) to maintain and improve visual diversity of the landscape (DIV).

To analyze possible inefficiencies in the budget allocation but also in the spatial allocation of the measures, the situation in a reference year (2004) is compared to a 'what-if-the budget-had-been-allocated-optimally'-scenario (MODEL). In addition to the optimal spatial allocation of the AEM the model is also allowed to change the allocation of financial resources, and thus change the AEM portfolio, if this is more beneficial for the considered objectives. The model still exhibits some additional constraints. It is assumed that the observed equal proportion between AEM on arable land and grassland in 2004 is a fixed constraint and therefore was also added to the basic model. Besides, for each of the five objectives the model scenario must at least deliver the same TGA level as in 2004 (no decline is allowed). Following designated areas have been considered as spatial constraints in the model: protected areas for meadow birds, valuable biotopes designated by nature conservation authority, flood-endangered areas next to relevant water bodies/rivers, locations of traditional fruit orchards, parcels inside the 'Spreewald' region, former mining areas and small water bodies used in fishery. With regard to the environment-related impacts of the measures, the impact assessment has been adapted form the mid-term review evaluations (Matzdorf et al. 2003, 2005) and have been synthesized into four rank values (high impact: 1, medium impact: 0.5, low impact: 0.3 and no impact: 0). For the objectives ERO and NO3, a vulnerability classification (VC) for wind and water erosion and N-pollution for groundwater has been conducted using SIte COmparison Method (SICOM) (Deumlich et al., 2007; Kersebaum et al., 2006). SICOM analyses primary site conditions and provides the possibility to objectively compare and judge different ecological questions. Objects (= land parcels) with heterogeneous contents are pooled in comparison groups or classes. Altogether, six classes of erosion risk (E) and five classes of N-pollution risk (N) ranging from high to no risk have been incorporated. The evaluated intensity of the AEM contributing to the objectives ERO or NO3 and site-specific vulnerability have been linearly combined.

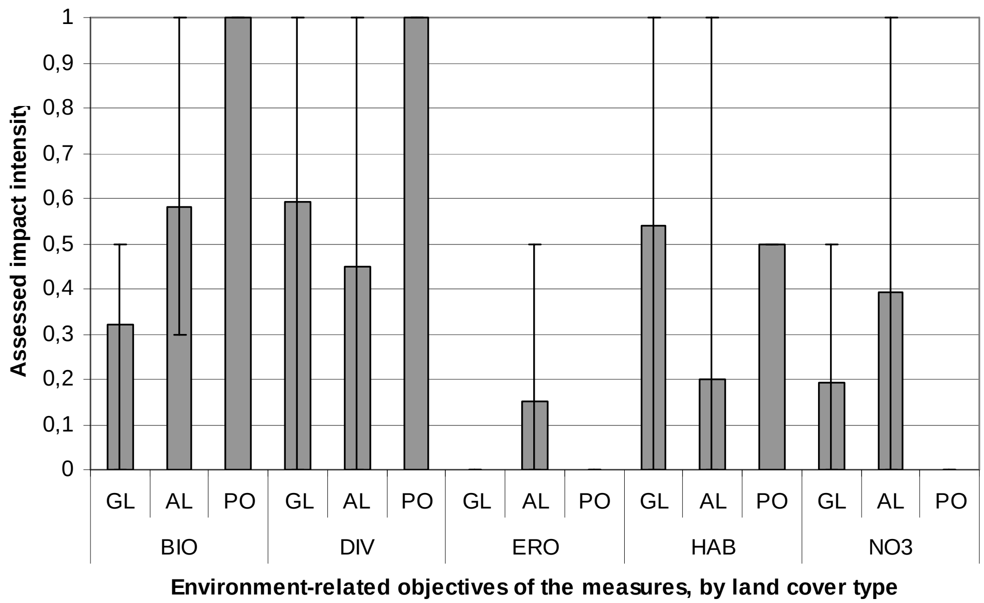



**Figure 1: Average assessed impact intensities of the agri-environmental measures in Brandenburg**

Figure 1 shows the average assessed impact intensities of the set up measures in Brandenburg on the five environment-related objectives. The measures have been grouped by the land cover type they address: GL – grassland (13 measures), AL- arable land (8 measures) and PO – ponds (1 measure). Both grassland and arable land measures contribute to the objectives BIO, DIV, HAB and NO3 whereby the arable-land measures on average are more favorable with regard to BIO, while for the other three objectives, the grassland measures achieve higher average impact intensities. The objective ERO is only relevant on arable land, as grassland provides permanent soil coverage and erosion-reduction is of less importance. Accordingly, the grassland measures are assessed with an impact intensity of zero with respect to ERO, the same applies for the single measure ‘maintenance and conservation of ponds’.

As suggested before, the management-orientation of agri-environmental measures provides a link to risk assessment approaches as used in the bio-economic farm modeling system MODAM (Sattler et al. 2006). The approach is based on dimensionless so-called indices of goal achievement (IGA) that are calculated for several environmental indicators. The results from the risk assessment can be used as a validation of the MCA approach. Table 1 compares the expert-based assessment impact intensities from the MCA approach and the benefit surplus from the risk assessment approach for the measure “extensive grassland management” which is an important horizontal grassland-related measure in Brandenburg. Apparently, the objectives used in the MCA and the indicators used in the risk assessment approach do not always correspond. Table 1 can therefore only make the attempt to relate both approaches. The objectives BIO and HAB both treated separately in the MCA approach were combined to one objective to provide at least some link to the risk assessment which does not exhibit the explicit differentiation between biodiversity and habitat quality but tries to cope with the assessment challenge by specifying indicator species. The landscape-related objective DIV cannot at all be incorporated in the risk assessment approach while the two abiotic objectives NO3 and ERO find a direct matching partner. As regards the results for those objectives that find a matching partner both approaches point at least in the same direction. With regard to ERO both approaches show the exact same judgment, while for the objective NO3 the risk assessment comes to a lower overall judgment.

**Table 1: Comparison of MCA results and MODAM risk assessment**

| MCA approach | | MODAM risk assessment | | | |
|---|---|---|---|---|---|
| *Objectives* | *benefit surplus* | *Indicators* | *AvgIGA traditional management* | *AvgIGA extensive grassland management* | *benefit surplus* |
| BIO/HAB | 0,39 | Habitat potential for field hares | 0,74 | 0,87 | 0,13 |
| | | Habitat potential for hover flies | 0,82 | 0,92 | 0,1 |
| | | Habitat potential for red belly toad | 0,78 | 0,8 | 0,02 |
| | | Habitat potential for skylarks | 0,79 | 0,87 | 0,08 |
| | | Habitat potential for wild flora species | 0,71 | 0,77 | 0,06 |
| NO3 | 0,23 | Risk of nutrient entries into surface waters | 0,73 | 0,84 | 0,11 |
| ERO | 0 | Risk of water erosion | 1 | 1 | 0 |
| DIV | 0,23 | -- | | | |

Since the risk assessment approach does not entirely fit to the before identified objectives, in the following solely the MCA assessment have been further used in the optimization.

## Results

Given the considered objectives and the optimal model situation targeted measures would gain in importance both in relative and absolute terms compared to the situation in 2004 as the supported area nearly doubles (cp. Figure 2). In the model they account for 30.72 % of the budgetary resources, which is nearly twice as much as in 2004 (17.08 %).

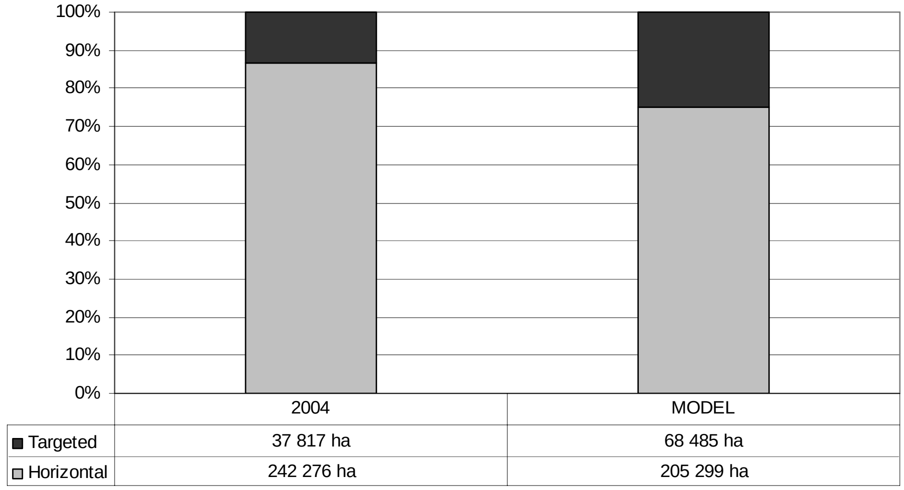



**Figure 2: Share of targeted and horizontal measures**

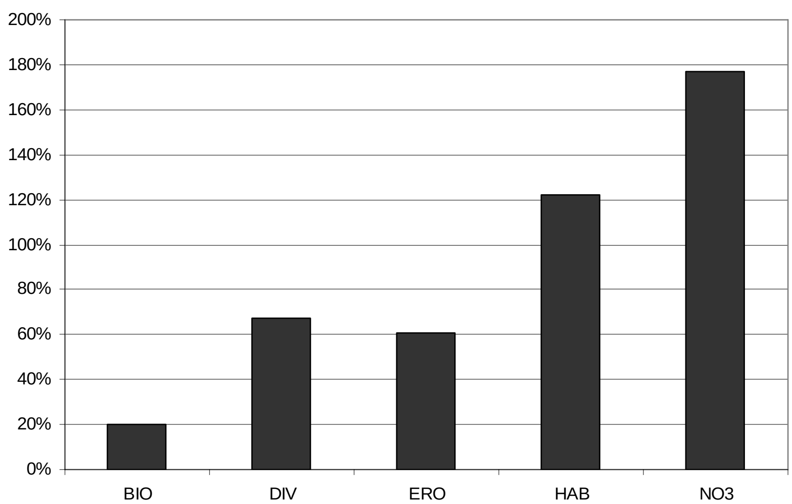
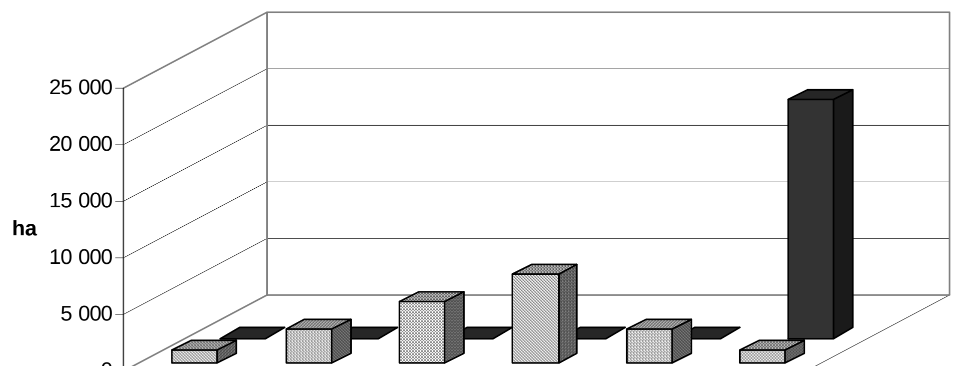



**Figure 3: Benefit surplus for the five objectives under optimal conditions in comparison to the reference year 2004**

In comparison to the reference situation in 2004, all five objectives would benefit from the optimization (Figure 3). Without any additional public expenditure, the shift of financial resources towards targeted measures would bring a great gain especially for the objective HAB and to a lesser extent BIO. At the same time, the objectives ERO and NO3 would also benefit simply because of the better spatial allocation of the respective AEM to parcels of higher vulnerability. Figure 4 shows the area supported with AEM that have been assessed with an impact intensity greater than zero with regard to the objective ERO ('reduce the risk of water and wind erosion') and the total area available in the six considered erosion vulnerability classes of the land parcels (E0 to E5). The figure demonstrates that in the reference year 2004, approximately 50 % of the erosion-reducing AEM were conducted in areas with a low to medium erosion risk (E0 to E2), which reduces the efficiency of the budget spent on these measures considerably. In the model situation, respective measures would solely be shifted to land parcels in the highest erosion risk class (E5). However, the total supported area amounts to only one third of the total area in the SICOM class E5, leaving scope for a possible expansion of respective measures should the reduction of erosion be a high priority objective of political action.




| | E 0 | E 1 | E 2 | E 3 | E 4 | E 5 |
|---|---|---|---|---|---|---|
| 2004 | 1 211 | 3 077 | 5 423 | 7 854 | 3 044 | 1 167 |
| MODEL | 0 | 0 | 0 | 0 | 0 | 21 033 |
| Total area | 118 323 | 144 134 | 347 543 | 441 491 | 173 598 | 68 085 |

**Figure 4: Area supported with erosion-reducing agri-environmental measures [ha] by erosion-vulnerability class of the land parcels**

Figure 5 shows the allocation of budgetary resources among the 14 communities (LKR – Landkreise, serially numbered) in Brandenburg for 2004 in comparison to the modeling results. Both tiers deviate from each other as budgetary resources are shifted to communities which are rich in designated areas and environmentally sensitive zones. In these areas, budgetary resources bring a greater benefit regarding the considered objectives and are thus used more efficiently than in the reference situation.

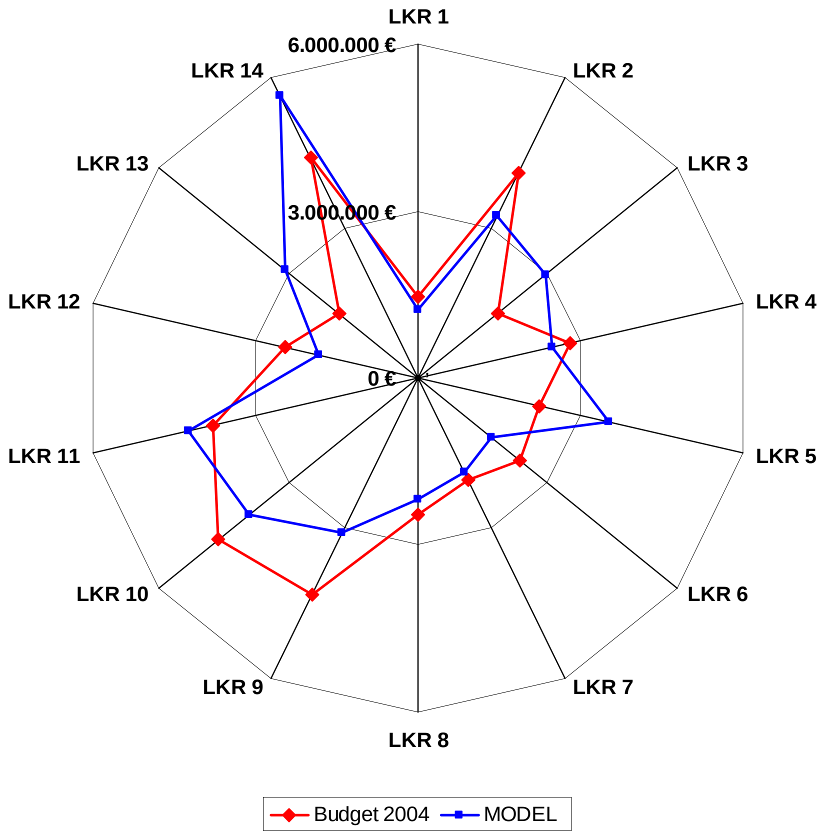



**Figure 5: Budget allocation among the communities in Brandenburg**

## 3 Discussion

The effectiveness of policy measures expresses the ability to achieve stated objectives and judges the impacts in terms of both output and impact. An efficient policy measure achieves given objectives at the lowest costs possible. As regards the environment-related impacts of agri-environmental measures in the current situation in the EU both the effectiveness and the efficiency of the measures can be improved. Effectiveness relates to the design of the measures while efficiency is related to the societal costs caused by the measures. The effectiveness of the measures directly depends on the spatial equivalence of the measures. Therefore, when optimizing the budget allocation for agri-environmental measures based on explicit political objectives as stated in the corresponding regulations, a different mix of measures and a different spatial allocation would be resulting as shown for our case study region. Other reasons for the apparent misallocation of financial resources in the current situation in the EU is probably hidden preferences that influence the design of the measures and as a result budget allocation is often not only subject to the explicit objectives stated in the regulations. In can be assumed that some of the measures also serve implicit objectives, such as income and labor support, which are not explicitly stated in any of the regulations as this would run contrary to the general environmental orientation of the measures. The political intentions pursued with AEM are therefore not only of allocative nature but to some extent also of non-allocative nature as they also serve the distributive (inter-personal, inter-regional and inter-temporal distribution) or socio-economic objectives (mitigate negative impacts of structural change, slow migration processes from rural to urban areas etc.). Adding a possible rather socio-economic objective such as ‘to ensure an area-wide cultivation and keep jobs in rural areas’ to the optimization problem might certainly lead to a different picture regarding the efficiency of the measures. A considerable part of the inefficiencies related to agri-environmental measures would then be the result of a violation of the Tinbergen postulate, which claims that any vector of (independent) targets can only be achieved by an appropriate vector of instruments if and only if the number of independent instruments is equal to, or greater than, the number of targets.

However, under optimal conditions and the given set of objectives, the presented results show that it is to be expected that the share of the budget spent on targeted measures should be increased to the disadvantage of horizontal measures. Horizontal measures, which usually have quite high participation rates have the smallest environmental benefits in comparison to the whole range of measures. Their popularity can be explained by the few management adaptations that are needed for participation. Often, the ecological effect provided by these measures even tends towards zero. Although horizontal measures are often a part of the discussion, at least amongst nature conservation groups, they are usually not the ones to be excluded when overall public expenditures are cut.

This behavior can also be explained by the fact the equity of financial resources is also a major principle for the implementation of political measures. Horizontal measures are open for all farmers, while targeted measures ‘privilege’ farmers that are better equipped with sensitive areas. Another influencing factor is transaction costs and administration effort related particularly to targeted measures. Although both can be reduced through the presented approach, targeted measures will always have more side costs in comparison to horizontal measures. In addition, the reallocation of budget among the communities based on ecologically defined regions and relationships would be a challenging and radical departure from standard practice but can at least be an impulse for discussions on a possible reallocation of financial resources among the communities.

However, the presented approach help can help determine the optimal mix and the optimal spatial allocation of AEM with resulting positive impacts on the cost-effectiveness of public expenditures. The approach also makes the attempt to act as a bridge between science and policy. The integrated view of the mid-term evaluation data in combination with GIS-based information allows for a more substantiated judgment of the environmental effectiveness of the measures. By gathering evaluation data and GIS data at the spatial resolution of the land parcel in one data pool, all in combination with financial aspects, data management and data analyses get more facilitated or become even possible in the first place and scenario results also become more realistic. However, scenario results are always extremes as the scenario settings represent a necessary simplification of the real circumstances. With regard to decision making extremes can help channeling and highlighting key interconnections and interdependencies to allow for the weighing out possible alternatives which can eventually support the decision process with regard to the budget allocation for the measures.

## 4 References

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