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Impact of Environmental Objectives on Optimal Budget Allocations for Agro-environmental Measures — A Case Study for Poland

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Abstract

Several studies have analyzed the importance of biotical and abiotical aspects to be considered in the evaluation of agro-environmental policies. However, only a few of them have addressed the problem of targeting agro-environmental policies. In this paper, it has been hypothesized that different environmental objectives, considered as priority criteria in political strategies, would influence budgetary allocations and subsequently, political decision-making. Using the Analytic Hierarchy Approach and Linear Programming, this hypothesis has been proved by taking the agro-environmental measures in Poland after the accession to the European Union (EU) as an example. The results of this study can be helpful for solving the questions of planning, evaluation, and budgetary allocations in a more objective-oriented way in different countries.

Introduction

The importance of different objectives of economic systems is discussed very comprehensively in environmental sciences. The interest in for these discussions is being facilitated by the growing consciousness about the human role in ecological systems as well as the influence of human activities on natural resources. The objectives of agro-environmental measures can also influence economic objectives, as the improvement of environmental quality can definitely contribute to macroeconomic efficiency (Henrichsmeyer and Witzke, 1994). Hence, strong relations between ecological and economic objectives can be formulated. Environmental objectives and their economic importance have become relevant in Operations Research in the recent years and the relevance of environmental protection for enterprise efficiency is often discussed (Raffee and Fritz, 1995). Referring to the political decision-making processes in agro-environmental policies, separate analyses of different environmental objectives have not been discussed very extensively until now. However, different objectives of political strategies can influence political decision-making and, consequently, the financing of political measures.

In this paper, we have analysed objectives of environmental protection in agriculture, which includes biotical, abiotical, and aesthetic components. Several studies have addressed the importance of biotical and abiotical natural elements in the evaluation of agro-environmental policies. Büchs *et al*. (2003) have interpreted biodiversity as a gradual indicator in agroecosystems, which is appreciated as the overall target for the development of agricultural landscapes towards sustainability. Yliskylä-Peuralahti (2003) has explored through a study in Finland, how biodiversity and rurality are constructed in the agro-environmental policy-making processes and 'biodiversity policies'. Tahvanainen *et al*. (2002) have observed that the Finnish Agro-Environmental Protection Schemes had positive impacts on the visual quality of landscapes (thus, aesthetic elements of rural areas). Carey *et al*. (2003) have developed a multi-disciplinary approach to assess the degree to which ecological, landscape, and historical objectives for the 'Countryside Stewardship Scheme'

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in England have been met. Several analyses have also been conducted on the necessity of targeting of agro-environmental schemes. Cook and Norman (1996) have proved that targeting criteria is based on the knowledge about the place where the problem is most acute. Also, Webster and Felton (1993) have stressed that *'Targeting is needed to ensure that environmental money is directed to places where it can achieve the greatest environmental benefits. Whilst this may increase the administrative costs, undirected policies are likely to be less cost-effective and may even be damaging'*.

In this paper, we have extended the investigation on targeting agro-environmental measures and have shown how far different environmental objectives, reflecting biotical, abiotical and aesthetic aspects, can influence political decision-making on financing agro-environmental measures. We have undertaken the idea of Cook and Norman (1996) to explore the importance of experts' knowledge for effective decisions on financing agro-environmental measures. We have defined an effective (optimal/ objective-oriented) financing as a budgetary allocation for agro-environmental measures which can be achieved by the maximal environmental benefit. Additionally, referring to Webster and Felton (1993), we have attempted to prove if, and to what extent the differentiated targeting of policies can influence environmental benefit of agro-environmental measures in Poland.

The paper is structured as follows. The next section provides an overview of agro-environmental policies in Poland before and after the accession to the European Union. Following this, the case study region, viz. the voivodship Subcarpathia, has been characterized and the research methodology has been presented. Then, the results on effective budgetary allocations for agro-environmental measures by different environmental objectives and the impact of the objectives on environmental benefit have been discussed. Finally, conclusions for political decision-making on agro-environmental policy have been formulated.

Agro-environmental Policy in Poland

Agro-environmental measures have been realized in Poland since the accession to the European Union (EU) in May 2004. According to the EU regulation 1257/99 (1999), agro-environmental measures are obligatory for the rural development policy; however, these are optional for the farmers. Thus, environmental protection in agriculture supported by means of political instruments is relatively new in Poland. The first political discussions on environmental protection in agriculture were undertaken in the early-1970s and environmental protection has been included in the Polish Constitution. However, the concrete measures were defined in 1990 with the formulation of a 'National Environmental Policy' (1991). The agro-environmental measures planned within the SAPARD-Program (Special Accession Program for Agriculture and Rural Development) for the period 2000-2006 have not been realized due to changes in political strategy and missing legal rules for the planning and implementation process (MRiRW, 2002). The agro-environmental measures were first implemented successfully in 2000 and 2001 within the EU project Phare 99 in two regions in Poland: Subcarpathia (south-east of Poland) and Warmia-Masuria (north-east).

After the accession of Poland to the European Union, new chances to extend environmental protection in agriculture have appeared. During the initial years of its membership, i.e. 2004-2006, the seven agro-environmental measures financed within the National Agro-Environmental Program were: 'Sustainable agriculture', 'Organic farming', 'Extensive meadow farming', 'Extensive pasture farming', 'Soil and water protection', 'Buffer zones', and 'Domestic farm animal species'. The budgetary allocation for agro-environmental measures amounted to €349 million for 2004-2006, of which 80 per cent came from the European Agricultural Guidance and Guarantee Fund and 20 per cent was allocated through Polish Government Budget (MRiRW, 2004).

Environmental protection in agriculture is a very important issue in the sustainable development of rural areas in Poland. To ensure effective usage of natural resources in rural areas, the objectives of environmental protection should be defined according to the regional priorities which are again determined by the economic and ecological conditions. This aspect has been substantiated in this paper.

Case Study Region

The paper is based on the results of a case study conducted in the voivodship Subcarpathia in south-eastern Poland in September 2005. The voivodship was

chosen due to its specific characteristics: a large number of valuable natural resources and protected areas on the one hand, and difficult economic conditions in the rural areas, on the other. In the voivodship, 80 nature reserved areas are registered, about 16 per cent of the voivodship area is recognized as landscape parks, and about 45.5 per cent is included in 17 landscape protection areas (Soltysiak *et al*., 2005). Most of the area in the voivodship is a part of the Carpathian Euro-region (an association of Carpathian regions of five neighbouring countries of the Central and Eastern Europe, such as Poland, Ukraine, Romania, Hungary, and Slovakia). One aim of the Carpathian Euro-region, among others, is focused on efficient and sustainable use of natural resources in all its associated countries. The efficient use of natural resources has a significant importance in the voivodship Subcarpathia due to its economic situation. The voivodship can be characterized by the third largest number of agricultural farms in the country (311.855) (USwR, 2003; GUS, 2003), while the employment share in agriculture is 26-47 per cent (PUW, 2004). The agricultural production has, therefore, a large effect on the utilization of natural resources. Considering all these aspects, the voivodship was an appropriate example for analyzing how different policy targeting would influence financing of agro-environmental measures and environmental benefit.

Research Methodology

The analysis in this paper is focused on the National Agro-Environmental Program for Poland for the period 2004-2006. We have subsumed all the objectives defined in the National Agro-Environmental Program and have involved them in the analysis as follows: 'Protection of natural resources', 'Protection and conservation of biodiversity', and 'Conservation of cultural landscape'; thus considering the abiotical, biotical, and aesthetic aspects of rural areas. The investigation is based on a case study conducted in Poland. Within the case study, all the eight agricultural experts in the Marshal Office in Rzeszów in the Division for Agriculture and Rural Development were interviewed. The Marshal Office is an administrative unit in the voivodship. The experts can be considered as regional stakeholders, although without formal decision competences. By means of the AHP (Analytic Hierarchy Process) approach, according to Saaty and using the AHP ratio scale of 1-9 (Saaty, 1990; 1999; Saaty and Kearus, 1985), the interviewed experts made a pairwise comparative evaluation of the importance of the respective agro-environmental measures with regard to the environmental objectives. By means of this approach, relations between the agro-environmental measures in terms of the environmental objectives and relations between the objectives were estimated, and priority vectors were calculated. These vectors (z_{1i-3i}) were further used as objective coefficients in the Linear Programming (LP) approach according to Kirschke and Jechlitschka (2002) and Kirschke *et al*. (2007), to estimate an optimal and objective-oriented budgetary allocation for agro-environmental measures. To calculate an optimal budgetary allocation in terms of the respective environmental objectives, we defined three objective functions reflecting the environmental benefit [Formulae (1), (2) and (3)]:

$$Z_1 = \sum_{i=1}^{7} z_{1i}\ BA_i \qquad \ldots(1)$$

$$Z_2 = \sum_{i=1}^{7} z_{2i}\ BA_i \qquad \ldots(2)$$

$$Z_3 = \sum_{i=1}^{7} z_{3i}\ BA_i \qquad \ldots(3)$$

where,

Z_{1-3} = Objective functions for the respective objectives,

i = Index for the agro-environmental measures, i = 1, …., 7

z_{1i-3i} = Constant objective coefficients (for three objectives respectively) of one monetary unit of the measure i, and

BA_i = Budgetary expenditures for the measure i.

Each objective function was defined as a sum product of budgetary expenditures for the agro-environmental measures and the objective coefficients estimated by agricultural experts for the respective objectives, viz. 'Protection of natural resources' (z_1), 'Protection and conservation of biodiversity' (z_2), and 'Conservation of cultural landscape' (z_3). By the definition of the objective function, the respective environmental objectives were included separately in the analysis to prove how the different objectives can influence budgetary allocations for the agro-environmental measures.

Additionally, three constraints were also defined and included in the LP model; these were: 'Total budget for agro-environmental measures', 'Farming area under agro-environmental programs', and 'Potential income losses to farmers, resulting from implementing the agro-environmental measures'. These constraints were defined as follows [Formulae (4), (5) and (6)]:

$$\sum_{i=1}^{7} BA_i \leq 2,500,000 \quad \text{(The budget constraint)} \qquad \ldots(4)$$

$$\sum_{i=1}^{7} a_i * BA_i \geq 20,000 \quad \text{(The farming area constraint)} \qquad \ldots(5)$$

$$\sum_{i=1}^{7} b_i * BA_i \leq 2,500,000 \quad \text{(The income losses constraint)} \qquad \ldots(6)$$

where,

BA_i = Budgetary expenditures,

a_i = Coefficients for the constraints of the farming area, and

b_i = Coefficients for the constraint of the income losses.

The budgetary constraint (Formula 4) denotes that the sum of budgetary expenditures (BA_i) for all the agro-environmental measures cannot exceed €2.5 million. The restriction value reflects a situation of budgetary scarcity depicting a 20 per cent budget cut in budgetary allocation to the voivodship Subcarpathia in 2005 (€3.1 million). The presumption of budgetary scarcity was analysed with the aim to simulate the potential decrease in budget for agro-environmental measures in the European Union in future. Therefore, the question of an objective-oriented budgetary allocation under the limited budget availability was analysed.

The farming area constraint (Formula 5) was defined as the sum product of the constraint coefficients and the budgetary expenditures for the agro-environmental measures. The restriction was set to 20,000 ha, which means in this case that more than this area should be included under the agro-environmental programs. The restriction value for the constraint was calculated according to the maximal possible area which can be financed under the given conditions and it was found to be 19,000 ha. In order to maximize the farming area, the lower bound for the restriction was set to 20,000 ha. The coefficients for this constraint (a_i) were calculated as a ratio of one monetary unit (here: €1,000) and the compensation rates for the respective measures in 2005.

The constraint of income losses (Formula 6) was defined as the sum product of the budgetary expenditures and coefficients for this constraint. The restriction was set to €2.5 million. The coefficients were defined as the ratio of implementation costs resulting for farmers and the current compensation payments in 2005. The cost calculation of agro-environmental measures included such components as additional costs, additional benefits, and direct income losses resulting for farmers from the realization of agro-environmental measures. The additional benefit was defined by the Ministry as a decrease in production costs in the traditional agricultural production as well as improvement in the soil quality. The additional costs were the costs to farmers resulting from the implementation of agro-environmental measures, e.g., investment costs or labour costs. The direct income losses were defined as the lost revenue that could be achieved with the traditional agricultural production if the agro-environmental measures were not implemented. The direct costs for each measure per unit (1 ha farming area, 1 m^2 for the measure 'Buffer zones' and 1 head for the measure 'Domestic farm animal species') were calculated as the sum of the estimated direct income losses and additional costs of implementation of the agro-environmental measures. The sum was minimized by an additional benefit to omit the potential offset of benefits and costs. The direct costs per unit of the agro-environmental measures were then multiplied with the farming area under the agro-environmental measures in the voivodship Subcarpathia in 2005. Thus, total costs of agro-environmental measures in the voivodship were estimated.

Additionally, a non-negativity constraint was assumed as $BA_i \geq 0$ for $i = 1,...,7$, which excluded the negative budgetary expenditures.

The constraints were estimated according to statistical data from the Ministry of Agriculture and Development of Rural Areas and from the Agency for Restructuring and Modernization of Agriculture in Poland. Table 1 displays the model variables, constraints,

and data analysis under the base scenario such as: allocation in 2005 (row 2), optimal allocation in the reference scenario (row 3), objective coefficients estimated with the AHP approach (rows 4-6), upper and lower bounds (rows 7 and 8), and constraint coefficients (rows 9 and 10).

The upper budgetary bounds (row 7) were set to 200 per cent of the allocation in 2005 for agro-environmental measures (row 2) due to missing legal requirements for the maximal expenditures for the respective measures. The lower budgetary bounds were set to 0, as there were no governmental regulations in this term (row 8).

Under the given restrictions, the objective functions were maximized separately and the optimal budgetary allocations for agro-environmental measures in terms

Table 1. Coefficients and model variables in the base scenario for agro-environmental measures in the voivodship Subcarpathia in Poland in 2005

Particulars	Sustainable agriculture	Organic farming	Extensive meadow farming	Extensive pasture farming	Soil and water protection	Buffer zones	Domestic farm animal species	Sum	
Current allocation	143.7	733.7	1435.9	142.8	571.3	1.1	56.3	3084.8	Allocation in 2005 (Thousand €)
Optimal allocation	48.3	79.8	1114.4	0.0	1142.6	2.2	112.7	2500.0	Upper bound for total budget (Thousand €)
Objective 1: Natural resources	15.8	22.4	10.5	12.3	15.8	13.0	10.0		Objective coefficients for the objective 1 (weight: 1)
Objective 2: Biodiversity	9.7	14.3	12.0	12.5	17.5	14.7	19.2		Objective coefficients for the objective 2 (weight: 1)
Objective 3: Cultural landscape	11.7	13.3	15.7	12.6	17.5	16.8	12.4		Objective coefficients for the objective 3 (weight: 1)
Upper bounds	287.3	1467.4	2871.7	285.6	1142.6	2.2	112.7	6169.6	Total upper bound for the measures (Thousand €)
Lower bounds	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Total lower bound for the measures (Thousand €)
Income losses	1.0	4.1	0.8	0.8	0.9	0.8	0.9	2500.0	Upper bound for income losses (Thousand €)
Farming area	29.4	5.3	6.1	12.6	9.9	0.0	0.0	20000	Lower bound for the farming area (ha)

Source: Author's calculations

of each objective were calculated. An optimal budgetary allocation was estimated by means of the Simplex-algorithm (Chiang, 1984; Ohse, 1984). Using this algorithm, the objective function is maximized and solutions are looked for in an iterative (stepwise) process. The consecutively new and better (higher) value of an objective function reflects a higher benefit that could be achieved with the objective function under the same constraints. The estimated optimal solution value is the alternative with the highest objective value. Thus, the term "optimal/ effective budgetary allocation" means the solution with the highest possible environmental benefit under the given constraints.

Results and Discussion

Optimal Budget Allocation for Agro-environmental Measures Subject to Environmental Objectives

According to the optimization results, targeting of agro-environmental policies can widely influence political decision-making processes with regard to optimal budgetary allocations for agro-environmental measurers (Figure 1). The results of the investigation have shown significant differences in budgetary allocations for agro-environmental measures when maximizing the objective functions separately for the objectives: 'Protection of natural resources', 'Protection and conservation of biodiversity', and 'Conservation of cultural landscape'. The only similarity was found for the 'Extensive meadow farming' and 'Soil and water protection' that were financed as priority measures apart from the fact to which environmental objective the priority was given.

In the political strategies, different objectives can be followed, depending on the regional constraints and priorities with regard to ecological and economic issues. Considering the objective 'Protection of natural resources' as a leading objective of agro-environmental measures, the budget is allocated mostly to the measures 'Soil and water protection' and 'Extensive meadow farming', while the measures 'Sustainable agriculture', 'Extensive pasture farming', 'Organic farming', and 'Buffer zones' are financed at a lower level. The measure 'Domestic farm animal species' is not supported.

A completely different budgetary allocation appears in the scenario of maximizing the objective 'Protection and conservation of biodiversity'. In this case, all agro-environmental measures, excluding 'Sustainable agriculture' and 'Organic farming', are supported. The measures 'Extensive pasture farming', 'Soil and water protection', 'Buffer zones', and 'Domestic farm animal species' are financed up to the upper bounds. Considering the objective 'Conservation of cultural landscape' as the only decision criterion, four of the seven measures would be financed: 'Extensive meadow farming', 'Soil and water protection', 'Sustainable agriculture', and 'Buffer zones'.

The analysis has proved that different environmental objectives can significantly influence decision-making processes in financing agro-environmental measures.

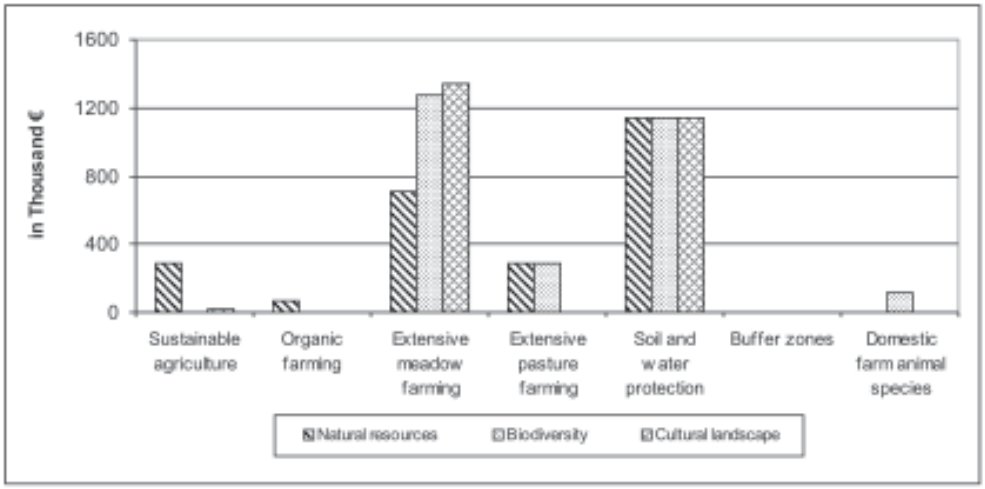

Figure 1. Optimal budgetary allocations for different environmental objectives in Poland
Source: Author's calculations

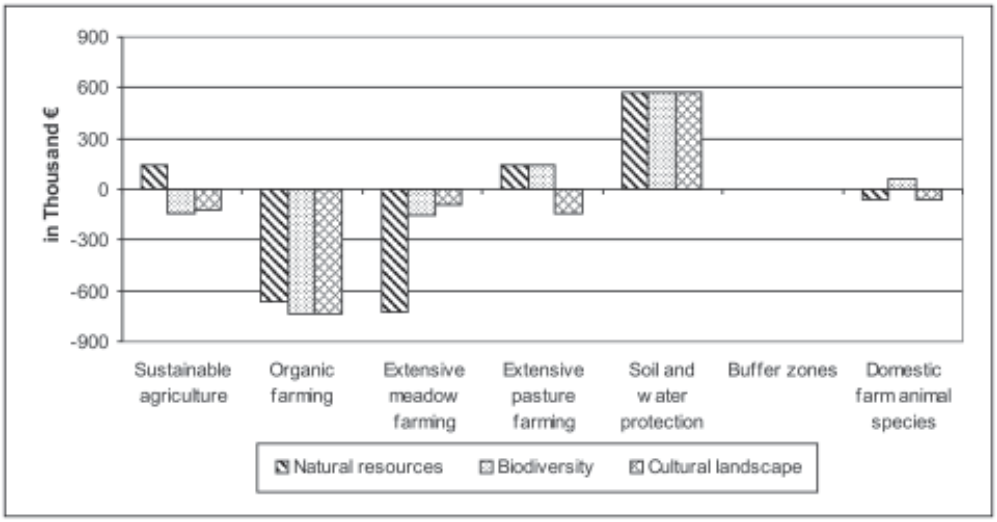

Figure 2. Difference between the given and optimal allocations in 2005 for different environmental objectives in Poland
Source: Author's calculations

This can be also confirmed by the difference between the optimal and the given budgetary allocations in 2005 in Poland (Figure 2).

The estimated changes in the budgetary allocations for agro-environmental measures are necessary to maximize the potential environmental benefits. Thus, considering the objective 'Protection of natural resources', the budget should be extended for the measures 'Soil and water protection', 'Sustainable agriculture', 'Extensive pasture farming', and 'Buffer zones', and shortened simultaneously for the other measures. The maximum increase in the financial support was found for the measure 'Soil and water protection' (€571,300), while the maximum decrease was for the measures 'Extensive meadow farming' (€723,000) and 'Organic farming' (€664,400). Considering 'Protection and conservation of biodiversity' or 'Conservation of cultural landscape' as the priority objectives, the budgetary allocation would be similar for the five measures, viz. an increase in 'Soil and water protection' and 'Buffer zones', a decrease in 'Sustainable agriculture', 'Organic farming', and 'Extensive meadow farming'. However, in terms of the measures 'Organic farming' and 'Soil and water protection', the same budgetary allocation should be adopted regardless the environmental objective considered as a priority criterion. While the allocation for the measure 'Organic farming' should be shortened by €733,000, the allocation for the measure 'Soil and water protection' should be extended by €571,000.

The results have shown that according to targeting of agro-environmental measures, different financing strategies should be recommended to maximize the environmental benefit. The results have underpinned the findings of Cook and Norman (1996) and have proved that an effective financing and budgetary allocation for agro-environmental measures are affected by the experts' knowledge about environmental issues. Thus, the opinions of regional experts and other stakeholders should be taken into account in designing more effective and objective-oriented agro-environmental policies.

Optimal Budgetary Allocation for Agro-environmental Measures Subject to Changes of Environmental Objectives

The objectives of agro-environmental policies are generally defined without any differentiation between biotical, abiotical, and aesthetic aspects. However, different importance of the respective aspects of the environmental protection can significantly influence results and outcomes of projects and political strategies. We have investigated how far a change in the importance of the environmental objectives can influence an optimal budgetary allocation for agro-environmental measures in Poland. Consequently, we have analyzed relations between the respective environmental objectives to find the possible solutions for the maximal environmental benefits. For this purpose, we conducted parameterization (weighting

objectives) and investigated optimal budgetary allocations under different scenarios. In this paper, we have presented the parameterization between the objectives 'Protection of natural resources' and 'Protection and conservation of biodiversity' to show, by this example, the importance of biotical and abiotical objectives for an effective budgetary allocation. The third objective 'Conservation of cultural landscape' (objective of aesthetic aspects in rural areas) was primarily not considered in the objective function; however, it was included as a restriction in the LP model with the aim to consider comprehensively all the aspects of rural areas. This proceeding was necessary to avoid a three-dimensional space that would impede the interpretation of the results. By parameterization, the weight for the objective 'Protection and conservation of biodiversity' was stepwise changed between 0 per cent and 100 per cent (0 and 1), while the weight for the objective 'Protection of natural resources' was changed in the reverse direction, between 1 and 0. Thereby, an optimal budgetary allocation for different weights of the objectives was estimated (Figure 3).

According to the results, different weights, and thus a change in the importance of objectives, influence the budgetary allocations for four measures, particularly for the 'Extensive meadow farming' and 'Sustainable agriculture'. All other measures are either influenced only to a limited extent ('Domestic farm animal species' and 'Organic farming') or are not influenced at all. The change of weight of the objective 'Protection and conservation of biodiversity' between 10 per cent and 20 per cent, brings about a decrease in the financial support for the measure 'Extensive meadow farming', which is compensated by the increasing support for the measure 'Domestic farm animal species'.

On changing the weight of the objective 'Protection and conservation of biodiversity' between 20 per cent and 60 per cent, the measure 'Extensive meadow farming' is supported at the unchanged level of €604,000. Further, budgetary shifts result at a high importance level of the objective 'Protection and conservation of biodiversity' (weight of 70 per cent) and simultaneously a low importance of the objective 'Protection of natural resources' (weight of 30 per cent). Thus, the budget should be reallocated and shifted from the measure 'Sustainable agriculture' to the 'Extensive meadow farming'. The financial support for 'Organic farming' should be extended; however, by a very small, optically unnoticeable amount. By changing the objective weight for 'Protection and conservation of biodiversity' to more than 70 per cent, all the measures should be financed at their unchanged levels, which means that no objective conflicts exist in terms of the measures. A conflict between the objectives:

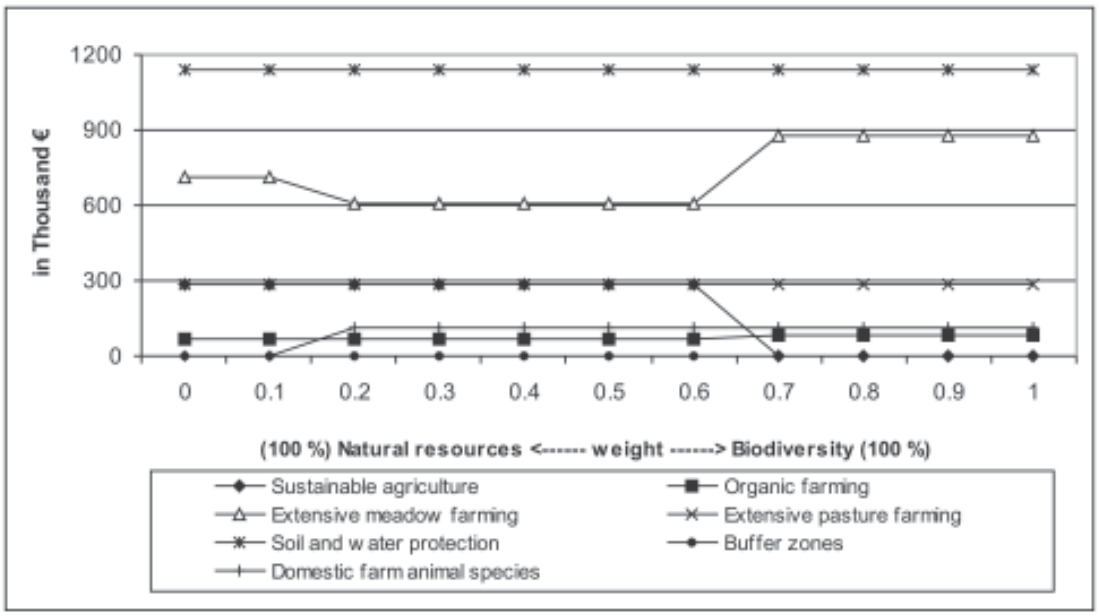

Figure 3. Parameterization of the objectives 'Protection of natural resources' and 'Protection and conservation of biodiversity'

Source: Author's calculations

'Protection of natural resources' and 'Protection and conservation of biodiversity' was found for the measures 'Extensive meadow farming', 'Sustainable agriculture', and 'Domestic farm animal species', which was visualized by the analogous budgetary decrease or increase.

The results have proved that the level of importance of the environmental objectives can influence optimal budgetary allocations for agro-environmental measures. Thereby, different targeting of agro-environmental policies is necessary to devise an optimal solution for the maximal environmental benefit.

Further, we have also proved relations between the objectives (achievement of the environmental benefit) and have visualized them with trade-off functions. In the base scenario, the trade-off function shows three possible solution values that can be achieved while weighting the objectives 'Protection of natural resources' and 'Protection and conservation of biodiversity' ($Z3 \geq 93$ %), without considering the third objective 'Conservation of cultural landscape' (Figure 4).

In the base scenario, losses of the objective 'Protection of natural resources' of €1,425 (4%) are to be expected by the maximal weight of the objective 'Protection and conservation of biodiversity'. On the contrary, at the maximal weight of the objective 'Protection of natural resources', the achievement of the objective 'Protection and conservation of biodiversity' will decrease similarly by €1,502 (4%). Thus, the changes of the objective achievement are similar apart from the objective weights. A comparison of the absolute values of the respective objective achievements is, however, not suitable as the environmental benefit has no monetary units and cannot be interpreted in economic values in this case.

In order to analyze the importance of aesthetic aspects, the third objective was included in the Linear Programming model as a constraint. The restriction value for the objective was set according to the calculated utilization value of this objective for the objective function of 'Protection of natural resources' and 'Protection and conservation of biodiversity'. Then, changes in the budgetary allocations and of the environmental benefits were estimated using different weights of the objective 'Conservation of cultural landscape'. According to the results, the increasing importance of the objective 'Conservation of cultural landscape' brings about a limitation on the objectives 'Protection of natural resources' and 'Protection and conservation of biodiversity'. These changes were visualized with the shift of the trade-off function to the left (Figure 4). At the weight of 95 per cent of the objective 'Conservation of cultural landscape', four different budgetary allocations can be found. By weighting the objective more than 95 per cent, the number of possible solutions decreased. If the objective

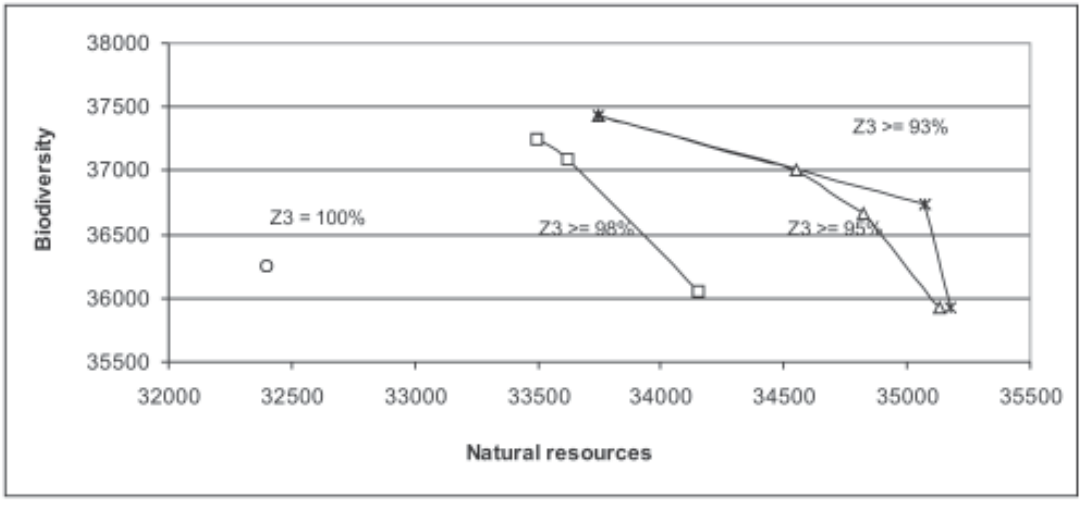

Figure 4. Trade-offs between the objectives 'Protection of natural resources' and 'Protection and conservation of biodiversity' by different weights of the objective 'Conservation of cultural landscape'

Source: Author's calculations

'Conservation of cultural landscape' has the maximal importance and is weighted by 100 per cent, only one solution value for the objective function (thus only one financing solution) could be found.

The results have shown that the objective function (reflecting the environmental benefit) is influenced only at the high importance level of the objective 'Conservation of cultural landscape' (objective weights between 93% and 100%). Each other weight of this objective lower than 93 per cent has been found to have no influence on the environmental benefit of the objectives 'Protection of natural resources' and 'Protection and conservation of biodiversity'. In such a case, the trade-off function has the same trend as in the situation without considering the objective 'Conservation of cultural landscape'. Analyzing the environmental benefit values, the results have shown that on weighting the objective between 93 per cent and 100 per cent, the environmental benefit of the objectives 'Protection of natural resources' and 'Protection and conservation of biodiversity' decreased by €1,578. As the objective values have no monetary units, the losses of the environmental benefit were expressed in percentage changes (Figure 5). As a reference base, the objective function value was assumed in the situation without considering the objective 'Conservation of cultural landscape'.

Assuming the maximal importance of the objective 'Conservation of cultural landscape' (100%), a decrease in the environmental benefit by almost 4.5 per cent was expected. Therefore, this objective has no significant impact on the environmental benefit value. The objective weight of 98 per cent resulted in a decrease of the environmental benefit by 1.5 per cent, which means that the growing importance of 'Conservation of cultural landscape' results in an over-proportional decrease in the environmental benefit reflected with the objectives 'Protection of natural resources' and 'Protection and conservation of biodiversity'. These relations have also been confirmed by changing the objective weights between 95 per cent and 98 per cent.

The presented analyses have confirmed, again, that different targeting of the agro-environmental policies can definitely influence the environmental benefit. Therefore, an interactive analysis with regional stakeholders is required to assess the importance of the respective objectives for the voivodship Subcarpathia and to create, on this basis, an optimal budgeting of the agro-environmental measures.

Conclusions and Policy Recommendations

Since the accession of Poland to the European Union, agro-environmental measures are the new political instruments to protect natural resources in rural areas. Therefore, there is little experience in the evaluation, designing and financing of these measures. In this paper, we have analyzed the impact of environmental objectives on optimal budgetary allocations and have investigated to what extent the respective aspects of rural areas (biotical, abiotical and aesthetic aspects) would influence budgetary allocations and consequently, the environmental benefit of the agro-environmental measures. The results have shown

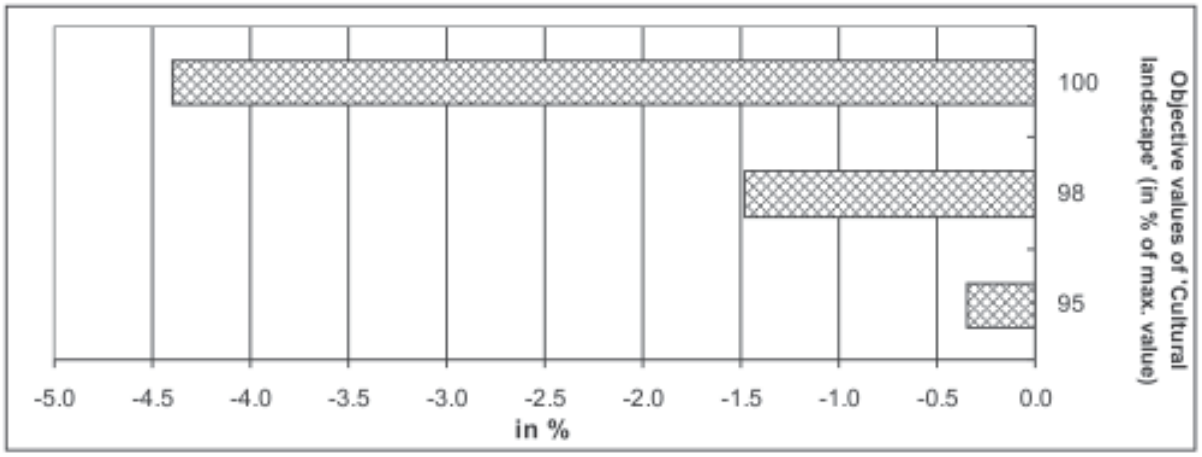

Figure 5. Losses in environmental benefit by different weights of the objective 'Cultural landscape'
Source: Author's calculations

that targeting of the agro-environmental policies is decisive for the political decision-making processes to effectively set financing priorities. Thus, while considering different environmental objectives, the budgetary allocation for the agro-environmental measures can be influenced to a wide extent. The environmental objectives considered in political strategies as the decision criteria would result in considerable changes in the financing scenarios for the agro-environmental measures. Additionally, the results have confirmed that experts' knowledge on environmental issues can be very helpful in political decision-making processes.

Moreover, the study has shown that different weights of the agro-environmental objectives 'Protection of natural resources' and 'Protection and conservation of biodiversity' can influence an optimal budgetary allocation and lead to the reallocation of the available budget for the measures 'Extensive meadow farming', 'Sustainable agriculture', and 'Domestic farm animal species', while other measures would not be affected significantly. However, the changes resulting from different objective weights of the agro-environmental measures and for environmental benefit are not substantial. Also, the objective 'Conservation of cultural landscape' has no significant impact on the environmental benefit.

The study has shown that different targeting of agro-environmental policies can considerably influence the optimal budgetary allocation for the agro-environmental measures in Poland after the accession to the European Union. However, further analyses are required to engage regional experts in an interactive cooperation to support the decision-making process with scientific methods and to maximize, therefore, the environmental benefits from the agro-environmental measures.

The results and the methodology presented in this paper can be helpful for political stakeholders in different countries for solving similar questions in planning, evaluation and budgetary allocations. The interactive implementation can be realized in the form of organizing seminars and plenary forums by eliciting preferences reflected with priority vectors, upper bounds or other vectors and variables, and including them in the LP approach.

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