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**Multicriteria analysis on effective financing of agri-environmental
measures and conflicts between environmental objectives**

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Multicriteria analysis on effective financing of agri-environmental measures and conflicts between environmental objectives

Abstract

The main objective of the paper is to investigate effective financing scenarios for agri-environmental measures with regard to the environmental benefit, considering regional policy priorities. By means of the Analytic Hierarchy Process (AHP) and a Linear Programming (LP) approach we conduct multicriteria analysis and investigate conflicts between environmental objectives as well as their influence on financing scenarios for agri-environmental measures. The analysis is based on an explorative case study conducted in Poland in the Subcarpathia region and on interviews with agricultural experts. The results show that the budget allocation for agri-environmental measures is considerably dependent on preferences given to environmental objectives within political strategies, and visible conflicts between the objectives exist in different financing scenarios. The findings can be helpful in supporting political decision-making processes interactively and can also be transferred to other countries in order to scientifically support planning and financing of agri-environmental measures in future.

Keywords: Agri-environmental policy; evaluation; environmental protection

JEL classification: Q51, Q57, C61

1 Introduction and problem setting

Since Poland accessed the European Union (EU) in May 2004 agri-environmental programmes are obligatory for the policy of rural areas. Due to the short membership in the EU little experience with financing the agri-environmental policy and agri-environmental programmes is given. The decisions on how to create agri-environmental programmes are taken centrally by the Ministry for Agriculture and Rural Development in Warsaw while regional stakeholders in voivodships (administrative regional units) have no decision authorities. However, natural conditions in the voivodships are differentiated and thus different environmental priorities are given in different regions of the country. Therefore, regional priorities of environmental protection in rural areas are not directly considered in national financing plans.

In this paper we discuss the importance of regional preferences for effective financing of agri-environmental measures and consider multicriteria aspects of the environmental protection in rural areas. The investigation is based on results of a case study in the Subcarpathia region in South-Eastern Poland. Within the case study, agricultural experts were interviewed and asked to assess regional policy preferences with regard to environmental objectives defined in the National Agri-Environmental Programme 2004-2006. In order to consider multicriteria aspects a hierarchical network model (AHP model) was developed. The model results were further incorporated in a Linear Programming (LP) approach to estimate effective budget allocations and different financing scenarios for agri-environmental measures as well as conflicts between environmental objectives from a regional perspective.

The paper is structured as follows. The next chapter provides an overview of the agri-environmental policy in Poland since 1990. Following, the Subcarpathia region is characterised and methodology and data are presented. Next, results of model calculations with Linear Programming are presented. Finally, conclusions on the importance of considering multicriteria issues and regional preferences in political decision-making processes in rural areas in Poland are drawn.

2 Agri-environmental policy in Poland

Since May 2004 agri-environmental measures have been obligatory for the policy of rural areas in Poland according to the EU regulation 1257/99 (Europäische Kommission, 1999). The first political measures to protect natural resources in the Polish agriculture were established in 1990 with the “National Environmental Policy“ (Ministry of Environmental Protection, Natural Resources and Forestry, 1991). The agri-environmental measures planned for the pre-accession phase with the Programme SAPARD (Special Accession Programme for Agriculture and Rural Development) were not realised due to political strategy changes and missing legal rules (Ministerstwo Rolnictwa i Rozwoju Wsi, 2002). The first successful agri-environmental measures were conducted in 2000 and 2001 with the EU project Phare99. In the first membership years in the European Union (2004-2006) seven agri-environmental measures were realised: ‘Sustainable agriculture’, ‘Organic farming’, ‘Extensive meadow farming’, ‘Extensive pasture farming’, ‘Soil and water protection’, ‘Buffer zones’, and ‘Protection of domestic farm animal species’. The main objectives defined for these measures can be subsumed as follows: ‘Protection of natural resources’, ‘Protection and conservation of biodiversity’, and ‘Conservation of cultural landscape’. The available budget for these measures amounted to 348.9 million € in 2004-2006 which was 9 % of the total budget for all measures for development of rural areas in Poland. The agri-environmental measures were co-

financed by 80 % from the European Agricultural Guidance and Guarantee Fund and by 20 % from the Polish state budget (MRiRWa, 2004 pp. 111).

As agri-environmental measures, as obligatory political instruments, are new in Poland little experience and information is given on an effective implementation and evaluation. The paper aims at extending the current knowledge by multicriteria issues and at analysing effective (objective-oriented) financing of agri-environmental measures and conflicts between environmental objectives, considering regional preferences with regard to the environmental protection.

3 Research region

The discussion in the paper is based on a case study conducted in the Subcarpathia region in South-Eastern Poland in 2005. The region was chosen due to its specific environmental, economic and social conditions. The region is characterised by a large number of valuable natural resources and protected areas (almost 45.5 % of the voivodship area is under landscape protection) (Soltysiak et al., 2002). Most areas in the voivodship are involved in the Carpathian Euro-region (an association of Carpathian regions between five neighbour countries of the Central and Eastern European Countries such as Poland, Ukraine, Romania, Hungary and Slovakia) which has the aim to efficiently and sustainably use natural resources in all associated countries. The problem of an efficient usage of natural resources has such a big importance in this region also due to its economic situation. The region is characterised by the third largest number of agricultural farms in Poland (311.855) (Urząd Statystyczny w Rzeszowie, 2003 pp. 20; Główny Urząd Statystyczny, 2003 pp. 171), while the employment share in agriculture amounts to about 47 % (Podkarpacki Urząd Wojewódzki, 2004). Considering these aspects, the voivodship seems to be a good example to analyse questions of the budget allocation with regard to the objectives of environmental protection in agriculture.

4 Methodical approaches and data

To answer the research questions two methodical approaches were implemented: Analytic Hierarchy Process (AHP) according to Saaty (1990) and a Linear Programming (LP) approach according to Kirschke and Jechlitschka (2002). Using the AHP approach we develop a hierarchical network model for agri-environmental measures in Poland including the main goal to be achieved (improvement of the environmental protection), criteria – environmental objectives ('Protection of natural resources', 'Protection and conservation of biodiversity, and 'Conservation of cultural landscape'), and alternatives (agri-environmental measures realised in 2004-2006: 'Sustainable agriculture', 'Organic farming', 'Extensive

meadow farming', 'Extensive pasture farming', 'Soil and water protection', 'Buffer zones', and 'Domestic farm animal species'). In order to operationalise the model variables and to consider regional priorities with regard to the environmental protection in agriculture, all 8 agricultural administration experts in the Marshal Office in Rzeszów in the Division for Agriculture and Rural Development in the region Subcarpathia were interviewed. The experts can be acknowledged as regional political representatives in the region, thus we show how regional priorities with regard to environmental protection could influence budget allocations for agri-environmental measures in the region. Using the AHP ratio scale 1-9 the stakeholders assessed in pairwise comparisons the importance of the agri-environmental measures with regard to the environmental objectives. On this basis, priority vectors for the agri-environmental measures were calculated with the eigenvector method. The priority vectors were further incorporated as objective coefficients in the Linear Programming approach to estimate effective budget allocations for agri-environmental measures (providing maximal environmental benefit) in different scenarios. For this reason an aggregated objective function was defined as a sum of separate objective functions for the three analysed objectives. Each objective function was calculated as a sum product of the expenditures on the respective measures and of objective coefficients (formula 1).

$$(1) \quad \max_{BA_1, \dots, BA_7} Z = \alpha_1 \sum_{i=1}^7 z_{1i} BA_i + \alpha_2 \sum_{i=1}^7 z_{2i} BA_i + \alpha_3 \sum_{i=1}^7 z_{3i} BA_i$$

with: Z – aggregated objective function

$i = 1, \dots, 7$ – index for the agri-environmental measures

z_{1i}, z_{2i}, z_{3i} – constant objective coefficients (for the three objectives respectively) of one monetary unit of the measure i

BA_i – expenditures for the measure i ,

α – weighting factor for the objectives,

and $\alpha_1 = \alpha_2 = \alpha_3 = 1$.

The objective weights of 1 included in the objective function denote that we assume the same importance of the environmental objectives in the basis scenario.

Additionally, three constraints were defined: total budget for agri-environmental measures (formula 2), income losses (formula 3), and farming area under agri-environmental programmes (formula 4).

$$(2) \quad \sum_{i=1}^7 BA_i \leq 2\,500\,000,$$

$$(3) \quad \sum_{i=1}^7 a_i * BA_i \leq 2\,500\,000,$$

$$(4) \quad \sum_{i=1}^7 b_i * BA_i \geq 20\,000.$$

with:

BA_{1-7} – expenditures for the measures,

a_{1-7} – coefficients for the income losses constraint,

b_{1-7} – coefficients for the farming area constraint.

The budget constraint (formula 2) denotes that the sum of the expenditures for all measures can not exceed 2.5 million €. The restriction reflects a simulated situation of budget scarcity and a budget cut of 20 % compared to the total available budget in the Subcarpathia region in 2005. We exemplarily simulate the budget scarcity to analyse an effective budget allocation in terms of the future changes in financial plans.

The income losses constraint (formula 3) denotes that the sum product of the expenditures for agri-environmental measures (BA_{1-7}) and coefficients for this constraint (a_{1-7}) may not exceed the amount of the available budget of 2.5 million €. The constraint coefficients were estimated as an index of total costs resulting for farmers from the implementation of agri-environmental measures and budget transfers to farmers (compensation payments) according to calculations of the Ministry for Agriculture and Rural Development in Warsaw (MRiRW, 2004b).

Additionally, the farming area constraint was considered (formula 4). The left side of the constraint was defined as a sum product of the constraint coefficients (b_{1-7}) and expenditures on agri-environmental measures (BA_{1-7}). The coefficients were calculated as a ratio of one monetary unit (here: 1,000 €) and compensation payment rates for the respective measures in 2004-2006. The right side of the constraint was set to 20,000 ha. It was estimated with regard to the minimal farming area (19,000 ha) which guarantees the maximal environmental benefit in the defined LP approach. Moreover, a non-negativity constraint was assumed in order to exclude negative budget allocations. The coefficients, model constraints and variables in the basis scenario are presented in table 1.

The upper budget bounds for the respective agri-environmental measures were set to a level of 200 % of the budget amount for the measures in 2005 in order to define the possible solution space for the objective function, which corresponds with the actual interest in agri-environmental measures in the region. The lower budget bounds were set to zero. This arbitrary presumption of the upper and lower bounds was necessary due to missing legal rules on the maximal or minimal expenditures for the respective measures.

Table 1: Model variables in the basis scenario

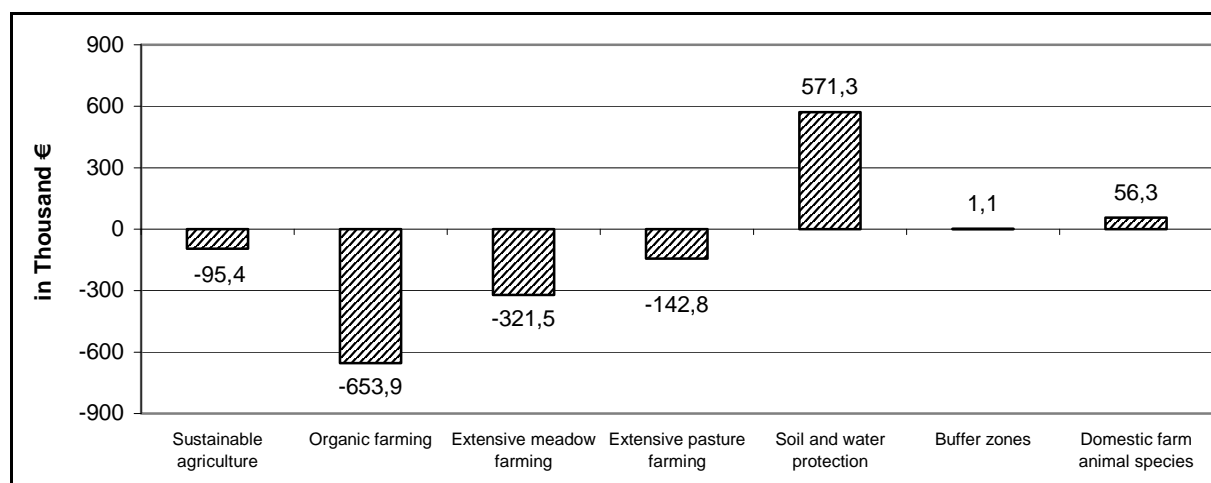
1.		Sustainable agriculture	Organic farming	Extensive meadow farming	Extensive pasture farming	Soil and water protection	Buffer zones	Domestic farm animal species	Sum	
2.	Current allocation	143,7	733,7	1435,9	142,8	571,3	1,1	56,3	3084,8	Current allocation (Thousand €)
3.	Optimal allocation	48,3	79,8	1114,4	0,0	1142,6	2,2	112,7	2500,0	Upper bound for total budget (Thousand €)
4.	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)
5.	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)
6.	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)
7.	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 €)
8.	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 €)
9.	Income losses	1,0	4,1	0,8	0,8	0,9	0,8	0,9	2500,0	Upper bound for income losses (Thousand €)
10.	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 calculation

5 Results and discussion

Given the model constraints and variables, an effective budget allocation for the agri-environmental measures was calculated in the basis scenario (table 1, line 3). Figure 1 shows the difference between the effective (objective-oriented) and the budget allocation in the region Subcarpathia in 2005.

Figure 1: Difference to the given allocation for agri-environmental measures in the Subcarpathia region



Source: Author's calculation

According to the results, considerable changes in financing of the agri-environmental measures are necessary to maximise the objectives 'Protection of natural resources', 'Protections and conservation of biodiversity', and 'Conservation of cultural landscape'. Compared to the given allocation, the budget should be extended for the measures 'Soil and

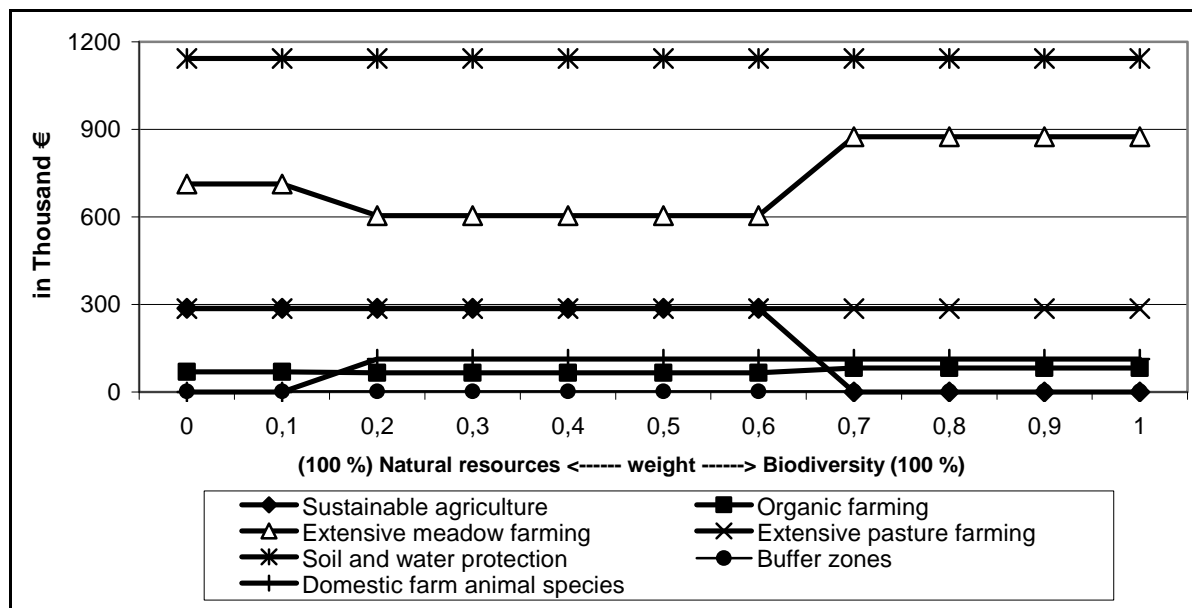
water protection', 'Buffer zones' and 'Domestic farm animal species' while all other measures should be reduced. The budget increase for the measure 'Soil and water protection' is similar to the decrease of the measure 'Organic farming'.

The presented allocation applies to the basis scenario (reference scenario) in which the analysed environmental objectives have the same importance. In the reality, environmental objectives have different importance in different regions. Changing the objective priorities and their weights can considerably influence the objective function and thus also budget allocations for agri-environmental measures, which makes necessary to reallocate the budget between the measures. The more trade-offs between the measures, the more conflicts can be found for the environmental objectives by different financing scenarios.

In order to operationalise these conflicts, the objective function was modified and the environmental objectives were included in pairs in the following order: 'Protection of natural resources' (objective 1) and 'Protection and conservation of biodiversity' (objective 2), 'Protection of natural resources' (objective 1) and 'Conservation of cultural landscape' (objective 3) as well as 'Protection and conservation of biodiversity' (objective 2) and 'Conservation of cultural landscape' (objective 3). While analysing the objectives in pairs, existing conflicts can be precisely interpreted in a two-dimensional space. Considering the three objectives simultaneously would provide a three-dimensional space which would complicate the interpretation of results.

In order to analyse conflicts between the objectives and changes of expenditures for agri-environmental measures, the objectives included in the defined 2-objective functions were stepwise parameterised (weighted) between 1 and 0 (100 % and 0 %). Hence, in the first objective combination, the weight for the objective 'Protection and conservation of biodiversity' was gradually set from zero to one while the weight for the objective 'Protection of natural resources' was set in the inverse sequence. According to the results (figure 2) changing the importance of the objectives can influence the budget allocation for four measures, particularly for 'Extensive meadow farming' and 'Sustainable agriculture'. All other measures are influenced only to a limited extent ('Domestic farm animal species' and 'Organic farming') or else they are not influenced by different weighting ('Extensive pasture farming', 'Soil and water protection', 'Buffer zones'). Thus, changing the weight of the objective 'Protection and conservation of biodiversity' between 10 % and 20 % brings about a decrease of the financial support for the measure 'Extensive meadow farming' which is, however, compensated by increasing support for the measure 'Domestic farm animal species'.

Figure 2: Parameterisation between the objectives ‘Protection of natural resources’ and ‘Protection and conservation of biodiversity’

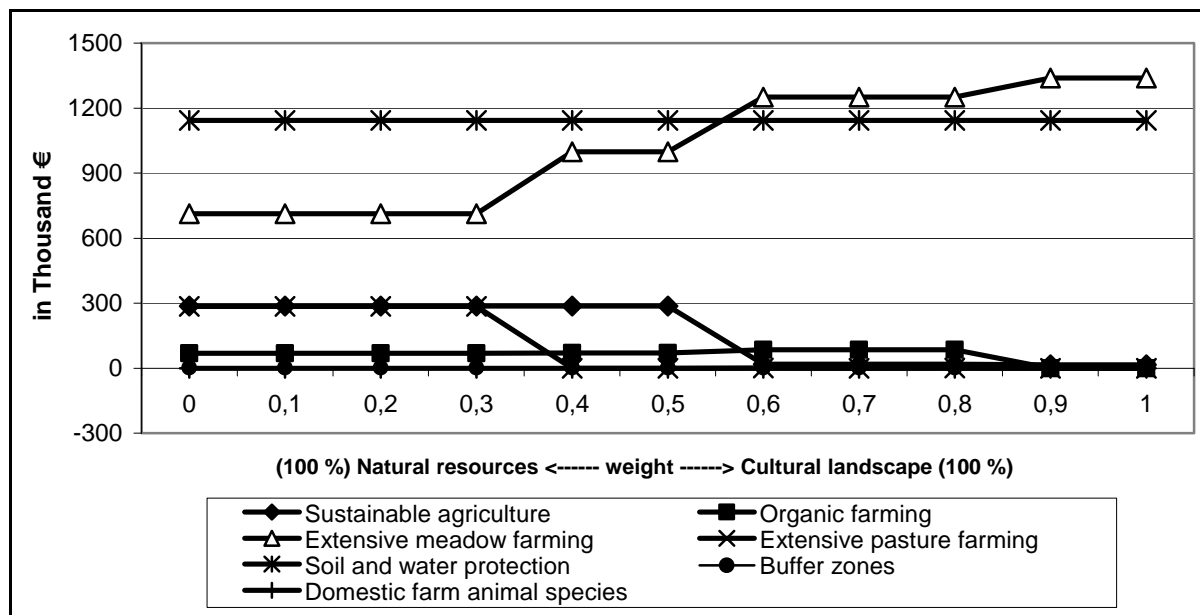


Source: Author's calculation

The objective conflicts between ‘Protection of natural resources’ and ‘Protection and conservation of biodiversity’ were thus found with regard to the measures ‘Extensive meadow farming’, ‘Sustainable agriculture’, and ‘Domestic farm animal species’. While changing the weight of the objective ‘Protection and conservation of biodiversity’ between 20-60 % the measure ‘Extensive meadow farming’ is financed at the unchanged level of 604 000 €. Further budget shifts result by a high importance of the objective ‘Protection and conservation of biodiversity’ (weight of 70 %) and simultaneously by a low importance of the objective ‘Protection of natural resources’ (weight of 30 %). In this situation, the budget should be reallocated and shifted from the measure ‘Sustainable agriculture’ to ‘Extensive meadow farming’. Also the support for ‘Organic farming’ should be extended by the weight of 70 % of the objective ‘Protection and conservation of biodiversity’, however, by a very small, optically unnoticeable amount of 13 000 €. By the objective weight for ‘Protection and conservation of biodiversity’ of more than 70 % all measures should be financed at their unchanged levels, which means that no objective conflicts exist in terms of the measures. The results prove that different importance of the environmental objectives can significantly influence objective-oriented financing of the agri-environmental measures. Thus, objective targeting is recommended for financial strategies in agri-environmental policy.

A different budget allocation and simultaneously different objective conflicts were found for the objectives ‘Protection of natural resources’ (objective 1) and ‘Conservation of cultural landscape’ (objective 3) (figure 3).

Figure 3: Parameterisation between the objectives ‘Protection of natural resources’ and ‘Conservation of cultural landscape’

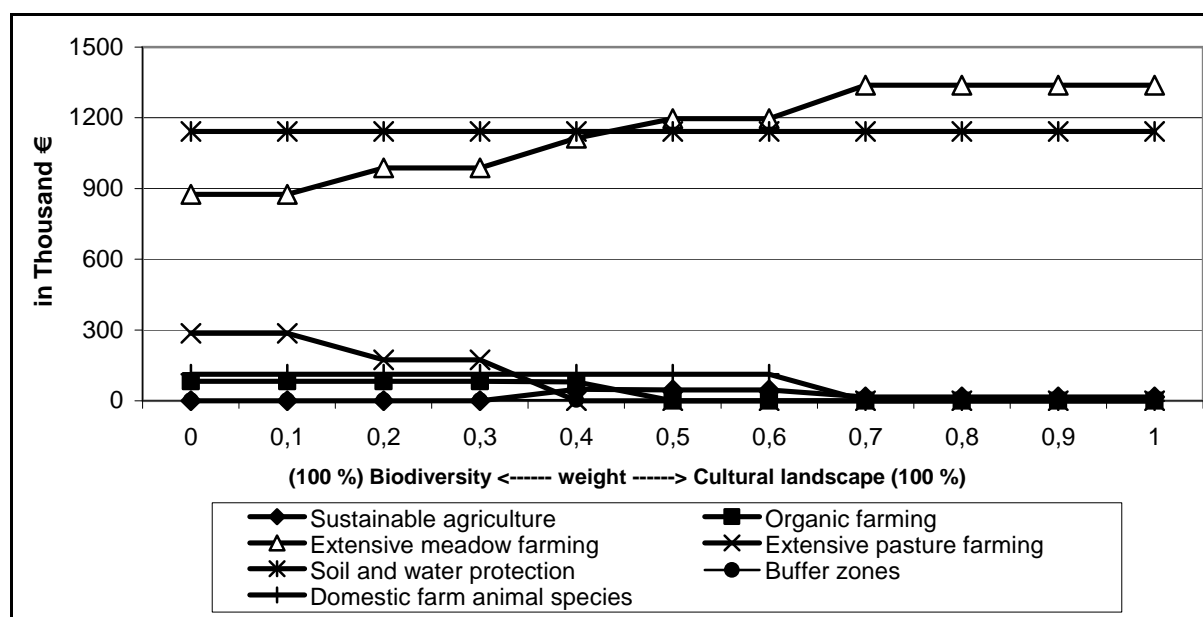


Source: Author's calculation

According to the results, objective conflicts were found with regard to the measures ‘Extensive meadow farming’, ‘Extensive pasture farming’, ‘Sustainable agriculture’, and ‘Organic farming’. At a low importance level of the objective ‘Conservation of cultural landscape’ (up to 30 %) six measures would be financed at an unchanged level. The growing importance of ‘cultural landscape’ would result in growing expenditures on ‘Extensive meadow farming’. Simultaneously, the budget would be reduced for the measures ‘Extensive pasture farming’ (at 40 % importance of ‘cultural landscape’), ‘Sustainable agriculture’ (60 %), and ‘Organic farming’ (90 %). Thus, at the level of 100 % importance of the objective ‘Conservation of cultural landscape’ and 0 % importance of ‘Protection of natural resources’ the budget would be spend only on the measures ‘Extensive meadow farming’ and ‘Soil and water protection’ by more than 1 000 €, while on ‘Sustainable agriculture’ and ‘Buffer zones’ by a very small amount of 16 000 € and 2 200 €, respectively.

A very similar situation can be observed in the third objective combination: ‘Protection and conservation of biodiversity’ (objective 2) and ‘Conservation of cultural landscape’ (objective 3). The parameterisation shows visible trade-offs between ‘Extensive meadow farming’ and ‘Extensive pasture farming’, ‘Domestic farm animal species’, ‘Organic farming’ as well as ‘Sustainable agriculture’ (figure 4).

Figure 4: Parameterisation between the objectives ‘Protection and conservation of biodiversity’ and ‘Conservation of cultural landscape’



Source: Author's calculation

However, the first changes in the budget allocation were found at the importance level of 20 % of the objective ‘Conservation of cultural landscape’. The growing financial support for ‘Extensive meadow farming’ would result in the budget reduction for ‘Extensive pasture farming’, ‘Organic farming’, and ‘Domestic farm animal species’. The support for ‘Sustainable agriculture’ would grow up to 40 % importance level of the objective ‘Conservation of cultural landscape’, would stepwise decrease between 40-70 % of the objective weight, and would remain on a very low level by the objective weight of more than 70 %. This parameterisation proves most conflicts between the objectives with regard to the agri-environmental measures, which means that the objectives of ‘biodiversity’ and ‘cultural landscape’ have a significant influence on the budget allocation. Thus, a very precise definition of the objective weights is advisable in order to optimise expenditures on the agri-environmental measures in the analysed region. Thus, the analysis proves a high importance of regional preferences for effective financing of the agri-environmental measures.

Analysing the different objective parameterisations, a clear tendency in the budget shifts between agri-environmental measures can be stated. Regardless the objective combination the measure ‘Extensive meadow farming’ can be defined as very sensitive and important in the National Agri-Environmental Programme 2004-2006 for Poland. While realising this measure only two objectives ‘Protection and conservation of biodiversity’ and ‘Conservation of cultural landscape’ can be optimised.

6 Summary and conclusions

In the paper, effective financing strategies for the agri-environmental measures and conflicts between the environmental objectives were investigated and analysed. While considering regional priorities with regard to the environmental protection in rural areas most important measures in the Subcarpathia region to optimise the environmental benefit are ‘Soil and water protection’, ‘Extensive meadow farming’, and ‘Domestic farm animal species’. This optimal allocation requires, however, to reallocate the current expenditures and to extend the budget for the measures ‘Soil and water protection’, ‘Domestic farm animal species’, and ‘Buffer zones’, and reduce it simultaneously for all other agri-environmental measures.

Maximising the environmental benefits, different financing scenarios are possible for different objective weights, and different conflicts between the objectives can be stated. The parameterisation of environmental objectives in three objective combinations shows that the measure ‘Extensive meadow farming’ is most sensitive on changes of objective weights, especially with regard to the objective ‘Protection and conservation of biodiversity’ and ‘Conservation of cultural landscape’. This means that any change of the objective importance in the National Agri-environmental Programme 2004-2006 would mostly influence this measure. While weighting the objectives ‘Protection of natural resources’ and ‘Protection and conservation of biodiversity’ visible conflicts can be stated only in case of three measures: ‘Extensive meadow farming’, ‘Sustainable agriculture’, and ‘Domestic farm animal species’. For the objectives ‘Protection of natural resources’ and ‘Conservation of cultural landscape’ conflicts with regard to ‘Extensive meadow farming’, ‘Extensive pasture farming’, ‘Sustainable agriculture’, ‘Organic farming’, and ‘Domestic farm animal species’ were found. The presented analyses prove that different importance of environmental objectives in the national programmes as well as different regional priorities can considerably influence effective budget allocations and financing of the agri-environmental measures. Hence, interactive discussions with political stakeholders are necessary to precisely define the envisaged objectives and their importance for the respective regions. Moreover, integration of other stakeholders such as environmental advisors and practitioners is recommended in order to consider existing problems more comprehensively and thus to contribute to their effective solution. The presented analysis and methodology can be used in political decision-making processes as an evaluation toll to support planning and financing of the agri-environmental policy in the following years. The results and methodology can also be transferred to other EU member states to extend the current evaluation approaches on the European level.

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