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MULTI-CRITERIA ASSESSMENT OF LESS FAVOURED AREAS: A STATE LEVEL

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Less Favoured Areas (LFAs) where production conditions are difficult.

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Multi-criteria assessment of less favoured areas: A state level

ABSTRACT: The paper present a multi-criteria decision DEXi model for assessment of less favoured areas (LFAs). The tool enables easier assessment of farming in different areas of Slovene LFAs with respect to criteria of sustainability. Analysis of LFAs and final integration of the assessment of LFAs depend upon various criteria. In this paper we analyze individual LFAs and farming systems in these areas at the state level with respect to criteria of sustainability and farming potential.

KEY WORDS: geography, less favoured areas, agricultural policy, multi-criteria decision analysis, DEXi

Večkriterijska ocena območij z omejenimi možnostmi za kmetijsko dejavnost: stanje v državi

POVZETEK: V prispevku je predstavljen večkriterijski odločitveni model DEXi za oceno območij z omejenimi možnostmi za kmetijsko dejavnost (OMD). Razvito orodje omogoča oceno načina kmetovanja s poudarkom na kriteriju trajnostnosti v različnih OMD območjih. Analiza OMD območij in modelna integralna končna oceana kažeta na odvisnost več kriterijev. Pri oceni posameznega OMD območja in načina kmetovanja na nivoju Slovenije imata tako pomembno vlogo kriterij trajnosti in potencial posamezne analizirane kmetije.

KLJUČNE BESEDE: geografija, območja z omejenimi možnostmi, kmetijska politika, večkriterijska odločitvena analiza, DEXi

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1 Introduction

The proportion of the total utilized agricultural area (UAA) classified as less favoured areas (LFAs) has raised from 33% to 65% in European Union in the last two decades. A substantial amount of the utilized agricultural area is classified as mountain areas (MacDonald et al. 2000). This situation is also seen in Slovenia, where 491.000 hectares or 72.3% of the UAA are located in mountainous and hilly areas (LFAs). Almost two-thirds of it is in permanent pasture, and arable land accounts for less than 30%. The proposed European Union indicators for defining areas less suitable for agriculture (there are eight European criteria) in Slovenia are not entirely appropriate because taking them into account would omit some distinctly and clearly unsuitable areas, i.e. karst areas (Ciglič et al. 2012). However, as other European Union Alpine regions, Slovenia is characterized by one of the most difficult conditions for agricultural production in Europe. Overutilization of agricultural land is becoming a serious problem, although the reasons for overutilization are not the same everywhere. Efforts to combat overutilization and understanding of the background to the problem are of particular importance for improvement of agricultural land quality (Borec et al. 2004). The current rural development European policy includes significant evolution of support schemes for LFAs. Agricultural production in LFAs is usually extensive and less suited for different farming systems and agri-food production. Some authors have suggested development strategies for LFAs based on interdisciplinary research of the coupling of human and natural systems approaches (Ruben et al. 2005). Sheate et al. (2008) examined the sustainability of various scenarios for reconciling biodiversity conservation with declining agriculture use in mountain areas of Europe. Their methodology was grounded in baseline of ecological and socio-economic data. Terluin et al. (1995) examined agricultural incomes in LFAs from an economic perspective. In their scenario, income was based on the typology of European countries and the relationship of regional gross domestic product per inhabitant and farm net value added per annual work unit. They confirmed that within the analyzed geographical areas, farmers in LFAs receive a higher amount of direct income subsidies than farmers in regions not classified as LFAs. The links between size, subsidies and performance for Slovenian farms were presented by Bojnec and Latruffe (2013). The study concludes that Slovenian farms have always been small and highly subsidized. Further, a conception of developmental types of mountain is presented regarding the state of developmental potentials on farms by Kerbler (2003). Assessment of farming potential on individual LFA is usually related to multiple criteria (Pažek et al. 2010). Tiwari et al. (1999) asserted that the rural reality system is complex and that the use of economic or environmental criteria alone may be insufficient. Multiple competitive criteria are likely to influence the decision-making process. A decision model must be able to evaluate all the options when considering those factors influencing the decision. A multi-criteria decision analysis approach was used in this paper to assess different organizational and planning decisions in farm management, such as the DEXi methodology (Bohanec et al. 1995; Bohanec, Zupan and Rajkovič 2000; Pažek et al. 2006; Rozman et al. 2006; Bohanec, Džeroski and Žnidaršič, 2004; Bohanec et al. 2007; Pavlovič et al. 2011, Pažek, Rozman and Irgolič 2012a). The theoretical background of hierarchical multi-attribute decision models is based on the dissection of a complex decision problem into smaller and less complex subproblems. In this context, the DEXi method uses qualitative variables and utility functions in the form of decision rules and provides qualitative assessments of alternatives. Subproblems are represented by variables, which are organized into a hierarchy (Pažek et al. 2012b).

The aim of this paper is to present a DEXi multi-criteria decision support tool for assessment of LFAs and farming systems in these areas at the state level.

2 Materials and methods

The DEXi method is a combination of traditional multi-attribute decision-making processes and specific elements of expert system and machine learning techniques (Bohanec 2003). Computer program for multi-attribute decision making is called DEXi. It is aimed at interactive development of qualitative multi-attribute decision models and the evaluation of options. This is useful for supporting complex decision-making tasks, where there is a need to select a particular option from a set of possible ones so as to satisfy the goals of the decision maker (Bohanec 2014). Variables are connected by utility functions. Utility functions in DEXi are adjusted to qualitative variables and, therefore, represented by »if/then« decision rules (elementary decision rules), which are usually given in a tabular form. The DEXi method can be used for solving various decision problems regarding real-world decisions (Bohanec et al. 1995; Bohanec and Rajkovič 1999; Bohanec, Zupan and Rajkovič 2000; Bohanec et al. 2006).

The DEXi models are developed by defining:

- attributes (a): qualitative variables that represent decision subproblems (for instance farm size, as demonstrated in Table 1);
- scales: ordered or unordered sets of symbolic values that can be assigned to attributes (for instance for farm size: small to 6.00 ha, average (between 6.00 and 7.00 ha) and big (farm size is over 7.00 ha; as demonstrated in Table 2);
- tree of attributes: a hierarchical structure representing the decomposition of the decision problem;
- utility functions: rules that define the aggregation of attributes from bottom to the top of the tree of attributes.

In the evaluation and analysis stage, DEXi facilitates:

- description of options: defining the values of basic attributes (terminal nodes of the tree);
- evaluation of options: a bottom up aggregation of basic attributes values based on utility functions;
- analysis of options: »what-if« analysis, »plus-minus-1« analysis, selective explanation and comparison of options, and
- reporting: graphical and textual presentation of models, options and evaluation results.

The hierarchical model structure for the assessment of LFAs that represents the decomposition of the decision problem into subproblems, was defined by the policy decision maker expert group of the Agency of the Republic of Slovenia for agricultural markets and rural development (AKTRP 2012; Irgolič 2011). The main criteria included in the model structure are: description of the farm, farm holder age structure,

Table 1: Hierarchical model structure for assessment of LFAs.

Attribute (a)
Final assessment
├ Farm description
├ Farm size
├ Usage type of agricultural land
├ Number of assigned points
└ Amount of LFA payments
├ Social structure
├ Farm holder´s age
├ Successor or not
└ Successor´s age
├ Amount of natural handicap payments
├ Number of payment entitlements
├ Value of payment entitlements for arable land
├ Value of payment entitlements for pasture
└ Amount of payment entitlements
├ Amount of agri-environment payments
├ Organic farming
├ Integrated crop production
├ Implementation of other agri-environmental measures
└ Amount of payments
└ Amount of direct payments
├ Amount of protein crops payments and nuts payments
├ Amount of additional payments for milk
└ Amount of additional payments for beef

amount of natural handicap payments, amount of agri-environmental payments, and amount of direct payments. Aggregate criteria were divided into groups of criteria (as seen in Table 1) and in the final evaluation of the LFAs areas: other areas, hill areas, karst areas, steep slopes, and mountain areas.

The attributes at the lowest level are basic descriptors of options (in our case individual LFAs), These represent model inputs and must be provided by the decision maker. Table 2 presents the sets of scales that were defined for all attributes in the model.

The decision rules are presented in a so-called complex form, with headings displaying approximate weights assigned to the attributes (second row in Table 3). The so-called »weight-based strategy« of defining decision rules was used. In terms of the subattributes and the number of points assigned, if the value of the assessment points by the agency for the observed farm was less than 310, this subattribute was assigned the discrete value »bad« by the the DEXi model. If the farm was awarded between 311 and 350 points, then the discrete value was »good.« Finally, if the farm received more than 351 points, the discrete value assigned by the DEXi model was »excellent.« The symbols »≤«, »≥« define value intervals for the relevant attribute. The asterisk »*« defines any possible value. The relative importance of the attributes was expressed by weights (as seen at the top of Table 3). These weights were estimated by DEXi using a linear regression method (according to Rozman et al. 2009), where DEXi interpolates the values of previously undefined rules in the table. Linear coefficients respond to the required weights, and its surface lies as close as possible to the initially specific subset of rules (Pavlovič et al. 2011). In practical use, this means the higher the weight, the more important the attribute.

After each attribute was assigned to a scale, the utility functions were defined (Table 3). The utility functions evaluate and define individual attributes with respect to their immediate descendants in the hierarchy. The utility function procedure was derived for each level in the hierarchy (partial utility function for aggregate attributes and overall utility function for the whole model, except for the lowest level in the

Table 2: Basic structure of the decision model, with sets of values (scales).

Attribute (a)	Scale
Final assessment	INAPPROPRIATE; RATHER INAPPROPRIATE; APPROPRIATE; EXCELLENT
├ Farm description	BAD; GOOD; EXCELLENT
│ ├ Farm size (ha)	SMALL; AVERAGE; BIG
│ ├ Usage type of agricultural land	Meadows; Plantations; Fields
│ ├ Number of assigned points (points)	< 310; 310–350; > 350
│ └ Amount of LFA payments (€)	< 500; 500–1000; > 1000
├ Social structure	BAD; GOOD
│ ├ Farm holder´s age (years)	> 55; 40–55; 18–25; 25–40
│ ├ Successor or not	No; Yes
│ └ Successor´s age(years)	> 55; 40–55; 18–25; 25–40
├ Amount of natural handicap payments	Bad; Good; Very good
│ ├ Number of payment entitlements	< 6,5; 6,5–7,5; > 7,5
│ ├ Value of payment entitlements for arable land (€)	< 380; 380–400; > 400
│ ├ Value of payment entitlements for pasture (€)	< 160; 160–180; > 180
│ └ Amount of payment entitlements (€)	< 1000; 1000–1500; 1500–2000; > 2000
├ Amount of agri-environment payments	Bad; Good; Excellent
│ ├ Organic farming (%)	< 2; 2–4; 4–6; > 6
│ ├ Integrated crop production (%)	< 2; 2–4; 4–6; > 6
│ ├ Implementation of other agri-environmental measures (%)	< 20; 20–30; 30–40; > 40
│ └ Amount of payments (€)	< 1200; 1200–1600; 160–2000; > 2000
└ Amount of direct payments	Bad; Good
├ Amount of protein crops payments and nuts payments (€)	< 150; 150–250; > 250
├ Amount of additional payments for milk (€)	< 500; 500–1000; > 1000
└ Amount of additional payments for beef (€)	< 650; 650–750; > 750

hierarchy). According to Pavlovič et al. (2011), for each attribute y, whose descendants in the hierarchical tree of attributes are $x_{1,} x_{2,} \dots x_{n,}$ the corresponding utility function *f* defines the mapping:

$$f\colon x_1 \times x_2 \times \dots x_n \rightarrow y,$$

where $x_1, x_2, \dots x_n$ and y denote values in the domains of the attributes $a_1, a_2, \dots a_n$ and y. These rules define the mapping of four subattributes and the assessment of the cumulative descriptive attributes of the farm in the overall final assessment of the LFAs according to defined decision rules.

Table 3: Example of decision rules, with a utility function of the presented case.

	Decision rules				
	Farm size	Usage type of agricultural land	Number of assigned points	Amount of LFA payments	Farm description
	26%	26%	31%	17%	
1	SMALL	Meadows	< 310	*	BAD
2	SMALL	Meadows	*	< 500	BAD
3	SMALL	*	< 310	< 500	BAD
4	≤ AVERAGE	≤ Plantations	≥ 310–350	≥ 500–1000	GOOD
5	*	≤ Plantations	310–350	≥ 500–1000	GOOD
6	≤ AVERAGE	Plantations	*	≥ 500–1000	GOOD
7	*	Plantations	≤ 310–350	≥ 500–1000	GOOD
8	*	≥ Plantations	< 310	≥ 500–1000	GOOD
9	≤ AVERAGE	Plantations	≥ 310–350	*	GOOD
10	≤ AVERAGE	≥ Plantations	≥ 31–350	< 500	GOOD
11	*	Plantations	310–350	*	GOOD
12	*	≥ Plantations	310–350	< 500	GOOD
13	AVERAGE	≤ Plantations	*	*	GOOD
14	AVERAGE	*	*	< 500	GOOD
15	≥ AVERAGE	≤ Plantations	≤ 310–350	*	GOOD
16	≥ AVERAGE	*	< 310	*	GOOD
17	≥ AVERAGE	*	≤ 310–350	< 500	GOOD
18	*	Fields	≥ 310–350	≥ 500–1000	EXCELLENT
19	BIG	*	> 350	*	EXCELLENT

The single line in Table 3, i.e., single decision rule, defines the value of the final assessment of LFAs for one combination of values of the former four attributes. The description of the farm, amount of natural handicap, and agri-environmental payments can take three different discrete values (part of the decision rules for the farm description attribute with the utility function is presented in Table 3), and the age structure and amount of direct payments can take two different values. Consequently, there are 108 possible combinations ($3 \times 3 \times 3 \times 2 \times 2$) and thus 108 decision rules.

In the next step, the attribute values for each options were placed in the DEXi evaluation table, and the evaluation analysis of the LFA assessment was evaluated.

Data for specific criteria compiled by the Agency of the Republic of Slovenia for agricultural markets and rural development were used. The sample size was 42.856 Slovenian farms that are registered and financial supported by the government through different environmental programs, including support for farming in LFA areas (D – 8.413 farms, H – 13.193 farms, K – 5.975 farms, S – 2.269 farms and V – 13.006 farms). The average value of attributes from this database was used as input in the DEXi multi-criteria model (attributes at the leaves of the hierarchical tree as presented in Table 1).

3 Result and discussion

The following Slovenian LFAs were included in the analysis (Irgolič 2011): hill areas (H), karst areas (K), steep slopes (S), other areas (D), and mountain areas (V). Numerical and qualitative data compiled by the Agency of the Republic of Slovenia for Agricultural Markets and Rural Development were employed. The data were divided into five aggregate attributes (Table 4) according to the utility function, and an integrated assessment of a particular LFA was performed at the end as the last step in the analysis.

The classification of particular areas was enabled by the multi-criteria decision model. The developed DEXi model shows that the mountain areas were assigned a value of »excellent,« the best possible outcome. As seen in the integrated assessment (Table 4 and Figure 1), most of the main attributes in this scenario were assigned the highest value, except the attribute amount of agri-environmental payments, where the utility function was assigned a value of »good.« This outcome is expected because there are more than 6% of organic farms in mountain areas (awarded the highest discrete value) but less than 2% of integrated farms (awarded the discrete value bad). Consequently, the implementation of other agri-environmental measures by those farms is between 30–40%, and the total amount of payments are €1.200–1.600/farm. Both attributes intervals are assigned a neutral value in the model. The karst areas and steep slopes received the worst assessments score (Figure 1 and Figure 2). Other areas and hill areas were evaluated as »appropriate,« as seen in Table 4.

According to the lowest value assigned to two attributes in the assessment (amount of agri-environmental and direct payments in the karst areas, where meadows predominate (33.133 ha meadows in comparison with 9.791 ha of fields), the karst areas (K) results with the inappropriate final assessment. Steep slopes (S) areas were assessed as »rather inappropriate.« In the hierarchical model, the farm description attribute was assessed as »excellent.« Besides the subattribute »usage type of agricultural land« where meadows predominate, all other subcriteria were assigned the highest discrete value.

In contrast to the karst areas, the neutral value (»very good«) was determined by the amount of natural handicap payments attribute. On the other site, two main attributes received the worst assessment (»bad«), i.e., the amount of agri-environmental payments (weight 38%) and the amount of direct payments (weight 11%).

The same integrated assessment was determined for the other areas and hill areas. In both alternatives, the assessment of the attributes was the same. The description of farms in both areas was »excellent,« the age structure criteria was assigned the value »good« (age of farm holder was between 40 and 55 years, the farm has a successor), and amounts of both attributes were assessed as »good.«

The DEXi software also enables »what-if analysis.« For instance, one might consider how the overall assessment can be improved. Table 5 shows the sensitivity (so called ± 1 analysis) for the areas K that was originally assessed as »inappropriate«. The analysis shows, for example, which attributes considerably affect the evaluation of areas *K.* When attribute Number of payment entitlements or Integrated crop production increase the overall assessment of areas K improves to »rather inappropriate«.

The final assessment of the areas confirmed that selecting specific types of farming and other socio-economic parameters in a particular LFA depends on various criteria, which were taken into consideration in the multi-attribute decision model.

The developed model enabled a final assessment of the LFAs based on the defined attributes and the decision rules within the defined utility functions for the observed problem. Moreover, the results show that the developed decision model could be a suitable methodological tool to aid the practical evaluation of different farming systems in LFAs and aid future political decision making. As this seems the use of program desirable for many practical problems such as assessment of the service quality that embeds many qualitative attributes or that cannot be easily numerically quantified further study should be particularly focused on the integration of qualitative and quantitative modeling techniques in the assessment of service quality as well as the inclusion of direct farm activities in the DEXi tree. However, despite the use of qualitative data only, we found that the approach fulfilled most of our expectations and revealed considerable advantages in comparison with other approaches. In particular, we emphasize the use of the qualitative multi-criteria DEXi model, which was suitable in a field where judgment prevails, thus making it difficult to give numeric answers. This kind of model is comprehensible to a wide range of users in the evaluation process.

Table 4: Integrated final assessment of LFAs.

Attribute (a)	EVALUATION RESULTS				
	D	**H**	**K**	**S**	**V**
Final assessment	APPROPRIATE	APPROPRIATE	INAPPROPRIATE	RATHER INAPPROPRIATE	EXCELLENT
Farm description	EXCELLENT	EXCELLENT	GOOD	EXCELLENT	EXCELLENT
Farm size (ha)	AVERAGE	SMALL	AVERAGE	BIG	BIG
Usage type of agricultural land	Fields	Fields	Meadows	Meadows	Meadows
Number of assigned points (points)	> 350	310–350	< 310	> 350	> 350
Amount of LFA payments (€)	500–1000	500–1000	> 1000	> 1000	> 1000
Social structure	GOOD	GOOD	GOOD	GOOD	GOOD
Farm holder´s age (years)	40–55	40–55	40–55	40–55	40–55
Successor or not	Yes	Yes	Yes	Yes	Yes
Successor´s age(years)	40–55	40–55	40–55	40–55	40–55
Amount of natural handicap payments	Good	Good	Good	Very good	Very good
Number of payment entitlements	6,5–7,5	< 6,5	6,5–7,5	> 7,5	> 7,5
Value of payment entitlements for arable land (€)	< 380	> 400	380–400	> 400	> 400
Value of payment entitlements for pasture (€)	< 160	> 180	160–180	> 180	> 180
Amount of payment entitlements (€)	> 2000	1000–1500	1500–2000	> 2000	1500–2000
Amount of agri-environment payments	Good	Good	Bad	Bad	Good
Organic farming (%)	< 2	2–4	2–4	2–4	> 6
Integrated crop production (%)	> 6	2–4	< 2	< 2	< 2
Implementation of other agri-environmental measures (%)	20–30	20–30	< 20	20–30	30–40
Amount of payments (€)	> 2000	< 1200	1200–1600	1200–1600	1200–1600
Amount of direct payments	Bad	Bad	Bad	Bad	Good
Amount of protein crops payments and nuts payments (€)	150–250	> 250	150–250	< 150	150–250
Amount of additional payments for milk (€)	< 500	< 500	< 500	500–1000	> 1000
Amount of additional payments for beef (€)	> 750	< 650	< 650	> 750	650–750

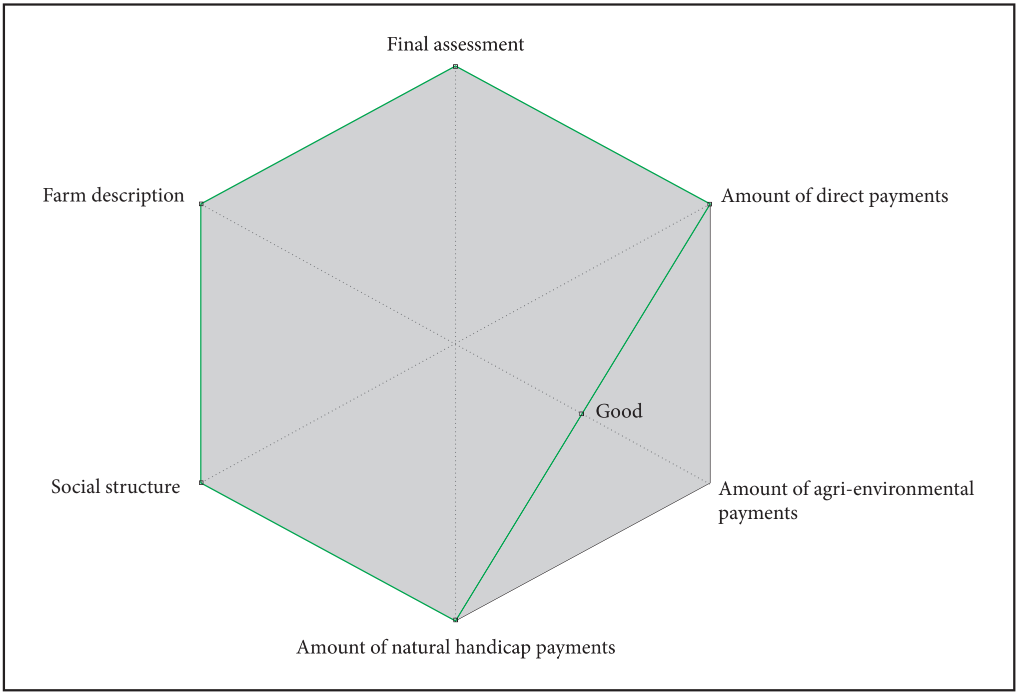

Figure 1: Graphical presentation of the final assessment mountain areas (V)/gafični prikaz končne ocene gorsko-višinskih območij.

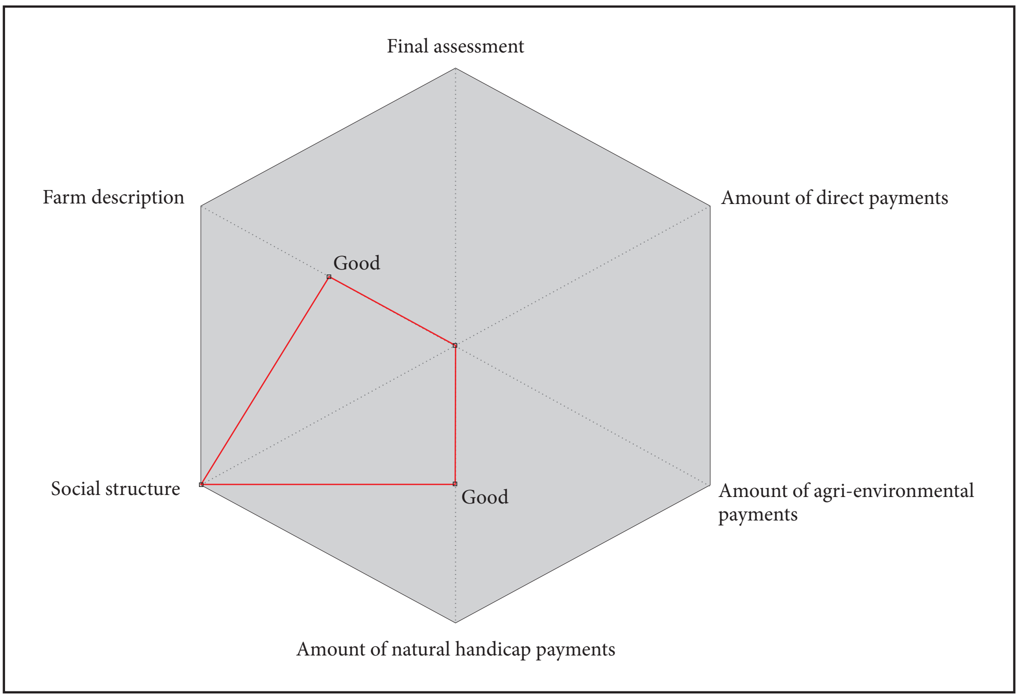

Figure 2: Graphical presentation of the final assessment of the karst (K) areas.

Table 5: The sensitivity analysis (± 1) for the karst areas (K).

Attribute (a)	**Plus-minus-1 analysis**		
	−1	K	+1
Final assessment		INAPPROPRIATE	
Farm description			
Farm size (ha)		AVERAGE	
Usage type of agricultural land	[	Meadows	
Number of assigned points (points)	[	< 310	
Amount of LFA payments (€)		> 1000	]
Social structure			
Farm holder´s age (years)		40–55	
Successor or not		yes	]
Successor´s age(years)		40–55	
Amount of natural handicap payments			
Number of payment entitlements		6,5–7,5	RATHER INAPPROPRIATE
Value of payment entitlements for arable land (€)		380–400	
Value of payment entitlements for pasture (€)		160–180	
Amount of payment entitlements (€)		1500–2000	
Amount of agri-environment payments			
Organic farming (%)		2–4	
Integrated crop production (%)	[	< 2	RATHER INAPPROPRIATE
Implementation of other agri-environmental measures (%)	[	< 20	
Amount of payments (€)		1200–1600	
Amount of direct payments			
Amount of protein crops payments and nuts payments (€)		150–250	
Amount of additional payments for milk (€)	[	< 500	
Amount of additional payments for beef (€)	[	< 650	

4 Conclusion

According to the results the multi – attribute DEXi model can be regarded and applied practically to smaller number of farms as well as to a broader sphere of scientifically research work. The developed model may also be used in further development of agricultural policy, it also can be upgraded with the latest information and adopted it to specific requirements. The multi – criteria methodology cannot replace or exclude the policy decision maker experts but can serve as an additional instrument that enables faster analysis. The model can be good basis and support tool for further development of more complex models that are designed primarily for planning and decision-making process in agricultural policy especially by definition of different payments types in agriculture.

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