TESTING MCDM MODEL FOR EVALUATING THE POTENTIAL OF COORDINATED AGRI-ENVIRONMENTAL APPROACHES AMONG FARMERS ON TWO CASE STUDIES FROM NETHERLAND

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Abstract: In this article a test version of multi-criteria decision-making model for investigating the potential of coordinated agri-environmental measures (AEM) among farmers in EU is presented. Its analysing the parameters included in the test Decision Expert (DEX) model, the sensitivity of the test DEX model and suggesting corrections for the final DEX model. It was showed that the test DEX model lacks in sensitivity of the parameters which can be tackled with a group decision making approach-the Delfi method-for levelling the importance ratio between parameters and an analytical hierarchical process (AHP) pair wise technique weighting.

Keywords: collective approach, agri-environmental public goods, group decision making approach, weighting techniques

1 INTRODUCTION

The use of Multi-Criteria Decision Making (MCDM) is suitable for solving problems of agri-environmental programs and multifunctional issues of agriculture [8]. MCDM is also an appropriate tool for assessing environmental services and for comparing types of land use in relation to their implementation of environmental services [4]. Furthermore, MCDM methods are used in the field of environmental management and stakeholder involvement [2] and help many stakeholders to assess often conflicting criteria (objectives), communicate their different preferences and classify or prioritize goals, strategies, opportunities, etc. [7]. These methods can facilitate the resolution of trade-offs between environmental objectives [10]. This research is exploring the potential of using the MCDM method for ranking suitability of different types of coordinated agri-environmental measures (AEM) among farmers in providing agri-environmental public goods. The first section of this preliminary research is an overview of the input data for the selected Decision Expert (DEX) method [3], the second section is to present the test DEX model with the results. In the third and last section, based on test results and literature review we discuss how to improve the methodology for the final DEX model.

2 METHODS

The DEX method was chosen because we can use qualitative data from already existing SWOT analyses [9] of selected cases (hereinafter alternatives). Alternatives (Oost Groningen and Limburg) are based on collective approaches and result oriented AEM and have similar characteristics [5]. The DEX method enables the classification of attributes, criteria and sub-criteria into a decision tree and the weighting of criteria at all levels. In the test model, we used the equal weights and individual decision-making approach, as Ahtainen et al. [1] argue that social, economic and environmental objectives of agriculture are equal for stakeholders. This was done to examine the weaknesses of the test model and decide on potential weighting methods and group decision making approaches for the final DEX model.

In the first part of the modelling, a decision tree was made with individual decision-making approach based on qualitative analysis of the relevant literature [1,5,9]. A hierarchical top-down approach has identified the main objective, attributes, criteria and sub-criteria that should influence the level of potential of coordinated agri-environmental measures among farmers to provide agri-environmental public goods in the EU. The characteristics were systematically entered into Excel spreadsheet. Fig. 1 shows an excerpt from Excel spreadsheet at the level of the S_BENEFITS criterion, which indicates the objective "social benefits of coordinated approaches". At the level of sub-criteria, the table is filled in by determining the qualitative value of the sub-criterion or the absence / presence of it (see yellow circle in Fig. 1) for each sub-criterion (black circle). If there is no information about the sub-criterion, it is marked "don't know" (blue circle), otherwise the qualitative value (blue circle) is selected from the drop-down list. In the black square, qualitative data for each alternative is presented (derived from existed SWOT analyses [9]). Each selected answer is transformed into a value of 1, 2 or 3 (green circle), where 1 means bad, 2-medium and 3-good characteristics. The arithmetic mean of the numerical factors of the sub-criterions (green asterisk) are considered for the evaluation of S_BENEFITS criteria. The result is then transformed into qualitative values of 1-poor, 2-medium or 3-good (red asterisk) via the IF function. The rule for this IF function is as follows; if the result of arithmetic mean of sub-criterions is in the first quartile (Q1) then it is changed to the factor 1, if the result of mean is in the 2nd and 3rd quartiles (Q2 or Q3), then it is changed to the factor 2 and if the result of mean is in the 4th quartile (Q4) then it is changed to the factor 3.

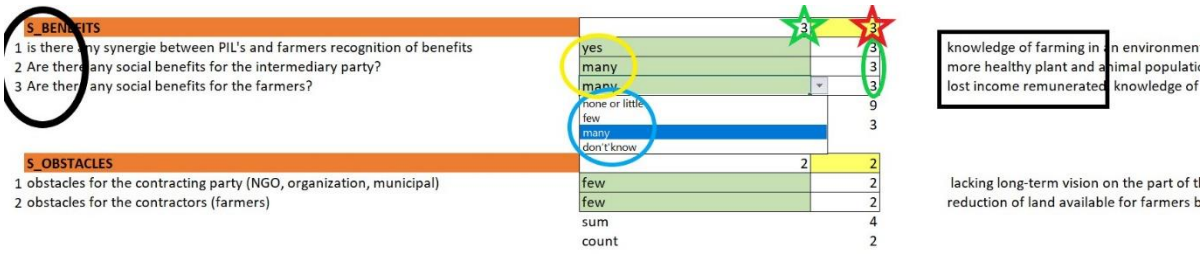


Figure 1: The example of systematic gathering of qualitative data for alternative in the Excel spreadsheet

Fig. 2 shows the decision tree of the selected attributes and criteria in DEXi. The decision tree is built from the main evaluation aim, five attributes, and ten criteria.

The evaluation aim has three values: "low", "medium" or "high", which indicates the level of potential of coordinated agri-environmental measures among farmers. The main goal is to study four objectives (hereinafter attributes) that can affect the level of potential: "Social", "Agri-environmental", "Economical" and "Political and monitoring".

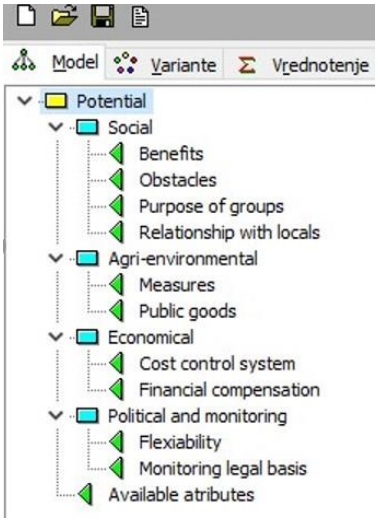


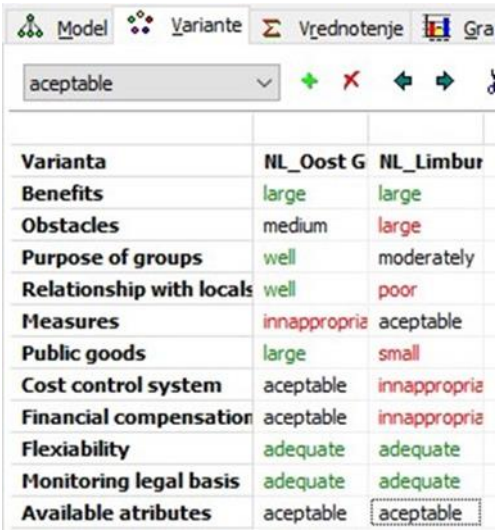
Figure 2: Showing the decision tree of the test DEX model for evaluating the potential of coordinated agri-environmental measures among farmers

Numeric factors 1, 2 or 3 of criterion were transferred from Excel spreadsheet into the test DEX model as descriptive values following specific transformation rules as shown in table 1.

Table 1: Transformation rules of numeric factors from the Excel spreadsheet into qualitative values for the criteria in the test DEX model

Criteria in the test DEX model	**Transformation rules of numeric to descriptive values**
Benefits, Public goods	1-small, 2-medium, 3-large
Obstacles	1-large, 2-medium, 3-small
Purpose of groups, Relationship with locals	1-poor, 2-moderately, 3-well
Measures, Cost control system, Financial compensation, Flexiability, Monitoring legal bases, Available attributes	1-innapropriate, 2-aceptable, 3-adequate

For each alternative (NL_Oost Groningen and NL_Limburg), a formation of its own range of values (see Fig. 3) was based on the output of the Excel spreadsheet. Green, black and red colour visually emphasize the qualitative data from the range of values, red colour means 1 or poor, black colour means 2 or medium and green colour means 3 or good characteristic.



Varianta	NL_Oost G	NL_Limbur
Benefits	large	large
Obstacles	medium	large
Purpose of groups	well	moderately
Relationship with locals	well	poor
Measures	innappropria	aceptable
Public goods	large	small
Cost control system	aceptable	innappropria
Financial compensation	aceptable	innappropria
Flexiability	adequate	adequate
Monitoring legal basis	adequate	adequate
Available atributes	aceptable	aceptable

Figure 3: Characteristics of alternatives and their range of values in the test DEX model

The value of alternative characteristics in the DEXi program is mapped to the upper level with a system of "if-then" rules, which were determined in the test DEX model by individual decision-making approach, considering the general order of data and the same level of weights for all criteria. The bold letters in Fig. 4 show the qualitative values of the attributes following the “if-then” rules. “If-then” rules for the attributes were as follows: a value “inappropriate” was assigned to lower 25 % of possible combinations, a value “acceptable” to middle 50 % of possible combinations and a value “adequate” to upper 25 % of possible combinations of criteria characteristics. “If-then” rule for the main objective/goal was as follows: a value “low” was assigned to lower 25 % of possible combinations, a value “medium” to middle 50 % of possible combinations and a value “high” to upper 25 % of possible combinations of attribute’s values.

3 RESULTS

The Fig. 4 shows the consequences of the “if-then” rules for qualitative determination of attributes and the goal of the test DEX model. We can see that the potential is evaluated as “medium” for both alternatives. According to the “if-then” rules, DEXi program also allows the comparison of alternatives by its attributes and criteria as shown in Fig. 4. Here we see that the attributes “Social”, “Agri-environmental” and “Economic” are for alternative NL_Oost Groningen in advantages over NL_Limburg, while the attribute “Political and Monitoring” has equivalent value for both alternatives.

Varianta	NL_Oost Groningen	NL_Limburg
. Potential	medium	medium
.. Social	aceptable;adequate	aceptable
... Benefits	large	large
... Obstacles	medium	large
... Purpose of groups	well	moderately
... Relationship with locals	well	poor
.. Agri-environmental	aceptable	innappropriate;aceptable
... Measures	innappropriate	aceptable
... Public goods	large	small
.. Economical	aceptable	innappropriate
... Cost control system	aceptable	innappropriate
... Financial compensation	aceptable	innappropriate
.. Political and monitoring	adequate	adequate
... Flexiability	adequate	adequate
... Monitoring legal basis	adequate	adequate
.. Available atributes	aceptable	aceptable

Figure 4: Consequence of the "if-then" rules for qualitative determination of attributes and the goal of the test DEX model

3.1 Spider webs of the decision model

It is clear from the spider web that the weakness of the collaborative form of the NL_Limburg case is mainly in the economic factor (Fig. 5), where the model shows poor target pursuit. In the case of NL_Oost Groningen, on the other hand, we can observe that all factors have at least a positive effect on the main objective, with society and politics being the strongest factors (Fig. 6). The model suggests that the differences between these two forms of cooperation are mainly in social and economic factors.

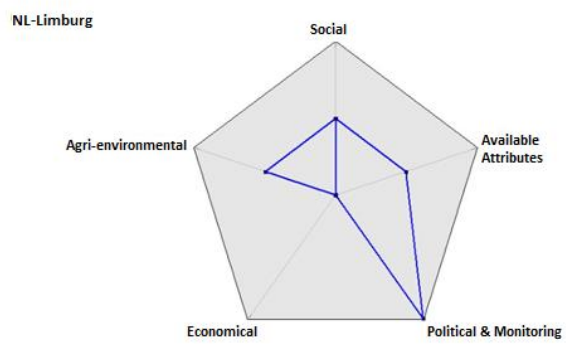


Figure 5: Spider web for the NL_Limburg alternative – level of attributes

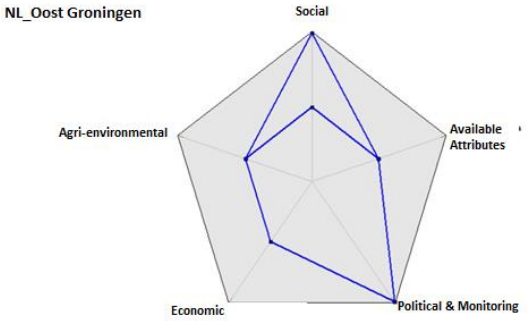


Figure 6: Spider web for the NL_Oost Groningen alternative – level of attributes

Fig. 7 and 8 show a more detailed breakdown of the differences by criteria.
If we take a closer look at the economic factor in both cases, we see that the NL_Limburg case has both criteria very poorly assessed. Namely, the SWOT analysis showed that there are practically no systems of collective cost reduction for farmers due to their inclusion in the cooperative form of farming in this case. In contrast, the NL_Oost Groningen case has an organized group purchase of seedlings and seeds to ensure a better price.

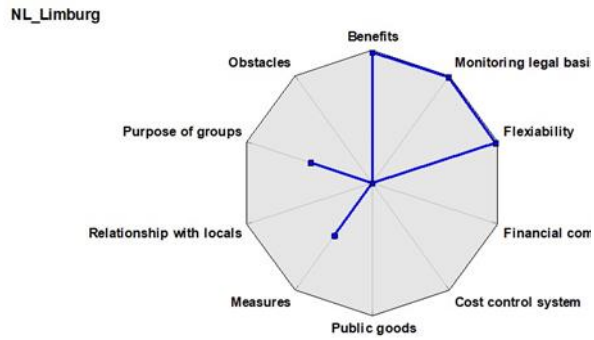


Figure 7: Spider web for the NL_Limburg alternative – level of criteria

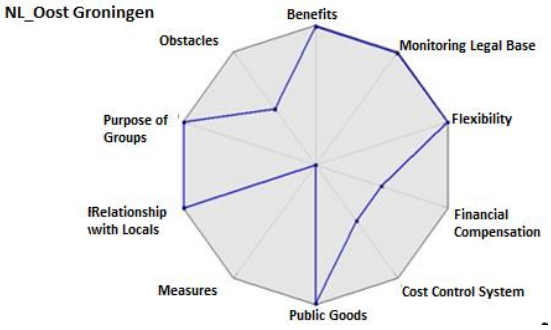


Figure 8: Spider web for the NL_Oost Groningen alternative – level of criteria

4 DISCUSSION

As expected, the test DEX model showed weaknesses, especially in the lack of sensitivity of the model, as it does not detect differences between the collaborative forms in the main goal. We will tackle the sensitivity of the model in two ways. The first way is to increase the number of levels from three to seven in the main objective. The second way is by weighting attributes and criteria using two methods, DELFI and AHP pair wise comparison. This can be done because the DEX method allows the inclusion of other MCDM methods, especially at the level of attribute weighting [3], as part of the DEX method is based on the AHP method [6].

Usually the combination of DEX/AHP is used to better separate between alternatives that receive the same DEX assessment which was a problem showed also in this model. However, alternatives will not be compared by decision makers through the AHP or Delfi methods. The qualitative priority calculation of alternatives will be made only through the final DEX model. The AHP priority calculation will be used only at the stage of assigning different weights to attributes and criteria. Therefore, the best DEX feature: determination of utility function through decision rules will still play its role.

In the final DEX model, we will study nine different forms of collaboration between farmers, some of which are very similar in terms of characteristics and environments, and some significantly different. The final DEX model itself will be based on individual decision-making approach, i.e., it will be repeated only once, and the input data will not change. However, because of uncertainty of importance of parameters that are included in the final DEX model, it is extremely important that we include group decision making approach in the stage of deciding of which parameters will be included/excluded in the model. This will be done through DELFI method. After that, an AHP pair wise comparison weighting method of the attributes and criteria will be done through the DELFI process, so at the end, the consensus of weights will be made. The results of consensus for weights of parameters will be put in the final DEX model. At the last step, the adjustment of "if-then" rules will be made.

For the end, it should be noted that there is lack of knowledge about the factors that affect the potential of different forms of cooperation between farmers in coordinated agri-environmental measures, as collective agreements and other forms of cooperation between farmers are

relatively new forms of activity (the oldest was established in 2016 [5]) and experts do not yet have any comparable data to decide on. This model is thus the first MCDM model to try to address the issue presented.

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This project has received funding from the European Union`s Horizon 2020 research and innovation programme under Grant Agreement No. 818190.